A RETROSPECTIVE STUDY OF THE LOCAL IMPACTS RESULTING FROM THE SHELLMOUTH RESERVOIR

The Use of Cost Benefit Analysis in Pre-Development Reservoir Assessment

by
Leanne Shewchuk

A Practicum Submitted in Partial Fulfillment
of the Requirements For the Degree,
Master of Natural Resources Management

Natural Resources Institute
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ABSTRACT

One compelling rationale for *ex-post* development review is to improve current and future practices in resource management by assessing the strengths and weaknesses of past analyses, conducted to review project options and identify impacts. The Shellmouth Dam, near the Manitoba-Saskatchewan border, is an example of a water resource project that was predicated on a series of engineering and economic studies. Thee were designed to assist decision-makers in selecting between various flood control measures for the Assiniboine and Red Rivers. An *ex-post* development review of the Shellmouth project reveals a variety of limitations with cost-benefit analysis (CBA) in its role as a pre-development assessment tool. This ex-post study includes an assessment of local impacts, a literature review of CBA , and a review of the Shellmouth CBA conducted between 1958 and 1961. It would be inappropriate to criticize the project's original CBA on the basis of today's perspectives on environment, equity and other social values. However, this *ex-post* review considers today's value system and experience with reservoir projects. This is not to pass judgement on the original CBA, but to provide valuable insight into opportunities for improving the use of CBA for the assessment of future reservoir projects.

The *ex-post* review of the Shellmouth Reservoir noted a number of positive and negative environmental and socio-economic impacts, that have accrued to the local area as a result of the project, but were not identified in the CBA. The study looks at the Shellmouth CBA, in an effort to determine where improvements can be made that would better address local costs and benefits, to ensure a more comprehensive CBA of future reservoirs.

ACKNOWLEDGEMENTS

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A LIST OF COMMON ABBREVIATIONS

CBA	cost-benefit analysis
DO	dissolved oxygen
EIA	environmental impact assessment
PFRA	Prairie Farm Rehabilitation Administration
PPWB	Prairie Province Water Board
SEIA	socio-economic impact assessment

CHAPTER 1

1.0 INTRODUCTION: *EX-POST* DEVELOPMENT REVIEW

Ex-post development reviews were conceived as a means of appraising the success of pre-development assessments conducted for natural resources projects. An *Ex-post* development reviews in the natural resource sector generally involve a comprehensive evaluation of a project once it has been in existence long enough for the majority of impacts to be identified and/or measured (Serafin et al 1991). One primary rationale for conducting such reviews is to improve current and future practices in resource management by evaluating the strengths and weaknesses of pre-development project assessments. Similarly, they may further characterize impacts in greater detail, and/or identify and document unanticipated impacts that resulted from the particular project under assessment.

An *ex-post* development review can provide information on the:

- accuracy and reliability of the original impact prediction,
- strengths and limitations of the pre-project assessment technique, and
- overall completeness and appropriateness of the pre-project analysis, such as whether all positive and negative impacts were considered in the assessment. This includes unanticipated impacts not addressed by mitigation measures.

Ex-post development review is consistent with the sustainable development paradigm that is increasingly dominating development frameworks. This is particularly true in the public sector where sustainable development policy and legislation are becoming more mainstream. Manitoba for example, has recently adopted a sustainable development strategy that has been interpreted for the management of a number of resources such as water (Sustainable Development Coordination Unit. ND; Sustainable Development Coordination Unit 1994). *Ex-post* review supports one of the key principles of sustainable development: the conservation and enhancement of the resource base (WCED 1987) promoted by improvements in pre-development assessment techniques. These techniques are decision tools influencing which projects are developed and how they evolve.

A lack of knowledge of how successfully a pre-project assessment tool has been applied, and where it has failed, inhibits improvements in pre-project planning and provides opportunities for repeating errors. Evaluation of predevelopment assessment tools provides a feedback function enabling improvements in the application of the tool in the future, and/or demonstrating where changes to the tool itself should be considered (Locke and Storey 1997). For example, comparing impacts anticipated in the pre-project assessment phase with those observed after development, helps improve future impact prediction and project design by highlighting where forecasting was accurate and project planning was successful. Better forecasting and planning ultimately results in improved project design. Thus *ex-post* review facilitates sustainable development by helping to adjust assessment frameworks as new insights are gained. It also entails a form of collective learning through documentation of the successes and failures of applied pre-development assessment tools, which feeds back into the system by promoting better overall decision-making with respect to resource development (Bellagio Principles1996)[1].

In the Canadian context, *ex-post* development review has been primarily applied to two pre-development assessment techniques: environmental and socio-economic impact assessments (EIA and SEIA). For these relatively new assessment tools, *ex-post* review offers a means of assessing how effectively planning tools have been applied in the past, and where improvements can be made in the prediction of impacts and their mitigation. Another pre-development assessment and planning tool, cost-benefit analysis (CBA), has been used for 70 years, but has not been extensively reviewed in Canada since the early 1970s. However, in the last ten years, there has been a resurgence of interest in examining the application of CBA in general and with respect to reservoir projects.[2]

CBA is a planning tool used prior to development to compare various project or policy alternatives in an effort to identify options that maximize the return on public expenditures. It assesses the costs and benefits of proposed projects, such as reservoir development or programs and policies, and evaluates the options for allocating public money between various alternatives. It was first used by the United States Corps of

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[1] The Bellagio Principles, Guidelines for the Practical Assessment of Progress Toward Sustainable Development, are 10 principles of sustainability developed in November, 1996 at conference of researchers and practitioners. The conference was held at the Rockefeller Foundation Study and Conference Centre in Bellagio, Italy.

[2] Of particular interest are the recent reviews of Canadian Dams: Rafferty Alameda, Saskatchewan (Townley 1998) and the Oldman River Dam Alberta (Canada-Federal Environmental Assessment Panel. 1992), and High Ross Dam, B.C. (Zerbe and Dively 1994).

Engineers in the 1930s to assess flood control project options, and it remains the main investment analysis technique for assessing public project and policy options (Howe 1971).

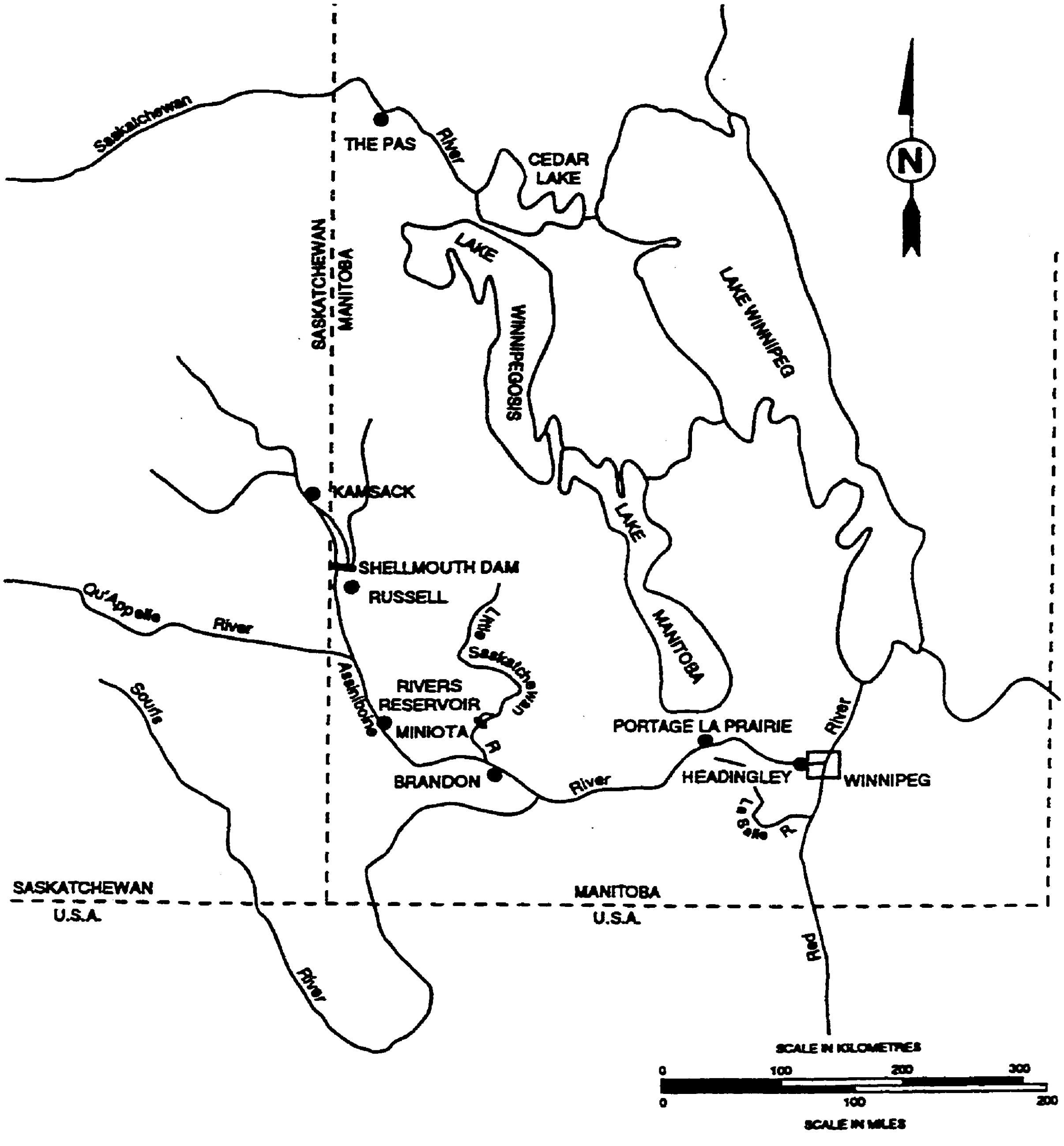
CBA has historically played an important role in the planning and evaluation of water resource projects such as reservoirs. Since there is no obvious equivalent process to assess public expenditure choices, CBA will likely continue to influence the evaluation of future proposed projects (James 1994). A review of the effectiveness of past CBAs of reservoir developments provides some perspective on how effective past approaches have been and where improvements or alterations to the application of CBA should be considered.

This study proposes to conduct an *ex-post* review of a Canadian prairie reservoir, the Shellmouth Reservoir (Figure 1.1). It is located on the Assiniboine River near the Manitoba-Saskatchewan border and was developed as a joint federal-provincial project. It was constructed between 1966 and 1970 by Prairie Farm Rehabilitation Administration and subsequently turned over to the province of Manitoba to operate.

The Shellmouth project was designed specifically to reduce the flood risk to the City of Winnipeg in response to the 1950 flood that devastated the city. The reservoir operates as part of a larger system to control flooding at Winnipeg in conjunction with three other major components: the Winnipeg Floodway, the Portage Diversion, and a series of dikes

Figure 1.1

Assiniboine River Basin - Location of the Shellmouth Reservoir



Source: Manitoba Water Resources. Dec. 1995. Assiniboine River Flooding and Operation of the Shellmouth Dam. Presentation to the Shellmouth Flood Review Committee. Dec. 12, 1995.

on the Red and Assiniboine Rivers. The project also provides flood control for the lower Assiniboine Basin. The Shellmouth Reservoir has other secondary uses: it accommodates recreation use at the reservoir site, as well as stabilizes flow rates and increases water supply in the downstream reaches of the basin.

While the project has been an overall success, there have been concerns expressed by those living near the reservoir. The Shellmouth project has been viewed unfavourably by some municipal officials and residents of the area surrounding the reservoir. These concerns focus on the local social and environmental impacts and the limited economic development spin-offs that have resulted. Because of this concern, there has been interest in exploring the local impacts that resulted and assessing how they were addressed in the project's pre-planning studies, specifically the CBA.

For this reason, the Shellmouth Reservoir is an appropriate candidate for an *ex-post* review. The continuing concern regarding this project indicates that local impacts may have been inadequately considered in the pre-project assessment phase, and/or that mitigative measures (including policy responses) were non-existent, insufficient or inappropriate. Outside of engineering studies, CBA was the only pre-project planning tool used for the Shellmouth project,. A review may help to determine whether local impacts could have been more effectively addressed in the CBA stage. In addition, an *ex-post* review of this particular project will help identify limitations with how CBA has been applied to prairie reservoir projects in the past. In doing so, it may offer insight into potential improvements in the use of CBA as a pre-development public decision/planning tool for water resource developments.

1.1 THE STUDY

1.1.1 Issue Statement

As designed, the Shellmouth Reservoir has been successful in reducing flood risk to Winnipeg. It has also provided secondary benefits, such as reducing the flood risk to other communities along the Assiniboine River and augmenting downstream flows during low flow periods. However, the local rural municipalities and residents surrounding the Shellmouth Reservoir have had a number of long standing concerns with the local impacts of the project. The local area is defined, for the purposes of this study, as the rural municipalities surrounding the reservoir including the area just downstream of the dam site and upstream of the reservoir: the Rural Municipalities (RMs) of Shellmouth, Shell River and Russell in Manitoba and Calder and Cote in Saskatchewan. These concerns include:

- unfulfilled tourism development expectations;
- environmental conditions associated with the reservoir that do not favour tourism;
- compensation that is viewed as insufficient reimbursement for the loss of tax revenue, and for additional costs incurred by the rural municipalities; and
- personal losses that were not adequately compensated.

The question arises as to why the on-going concern? It is believed, from conversations with various stakeholders, that part of the answer lies in how the pre-project assessment was conducted in analyzing development choices, identifying impacts, and subsequently providing information for the formulation of mitigation/policy responses.

1.1.2 Purpose

The purpose of the study is to conduct an *ex-post* review of the Shellmouth Reservoir. Specifically, this will characterize the concerns of the local area and appraise the role of CBA, as a pre-development assessment tool, in influencing reservoir development. Particular emphasis is given to the consideration of local impacts in the CBA, and the capacity of this decision/planning tool to anticipate and identify the implications of investing public monies in a particular reservoir project. In doing so, the study seeks to gain a sense of how effectively CBA has been applied as a decision/planning tool in evaluating public expenditures on Canadian prairie reservoir projects, specifically the implications the tool has for the consideration of local impacts.

1.1.3 Objectives

This study addresses a number of interrelated objectives. The first is to review the Shellmouth Reservoir project, and identify the on-going concerns of local residents and the relationship of those concerns to CBA, the pre-development assessment tool. This includes assessing the environmental and socio-economic impacts of the project on the local area. Other reservoir projects are briefly discussed to identify the commonality or uniqueness of the local concerns raised for the Shellmouth project.

A second objective is to critique the Shellmouth Reservoir in order to illustrate the various factors to consider when conducting a CBA of reservoirs, as well as the advantages and limitations of using CBA as a decision/planning tool.

The final objective is to develop recommendations on the use of CBA. This will take into consideration the wide range of local costs and benefits that may result, as demonstrated through the case study. The intent is to formulate recommendations on how the analysis of future reservoir projects could be structured to better anticipate the wide range of impacts generated in the local area. The recommendations are geared to improve the capacity of the decision-maker to make a fully informed choice, and devise appropriate policy responses.

1.1.4 Method

Five methods were chosen for this study:

1. Investigate *ex-post* development review methodology to assess how best to conduct a retrospective assessment of the case study.

This *ex-post* development review of the Shellmouth Reservoir is conducted primarily using a descriptive, analytical mode of inquiry. Serafin et al (1991) identified this as the most appropriate method for evaluating an existing development's pre-project assessment when dealing with significant research cost and time constraints. This approach involves reviewing published research and monitoring data to assess the accuracy and thoroughness of the initial assessment of positive and negative impacts.

The *ex-post* review of the Shellmouth CBA is comprised of four components. The first component is to review the case study and outline baseline conditions before the development. The second is to identify positive and negative impacts resulting from the Shellmouth Reservoir. The third is a review of the pre-project assessment tool itself. The fourth component is to conduct the review of the Shellmouth Reservoir CBA, relying on the findings in components one, two, and three.

2. Outline the primary case study, the Shellmouth Reservoir, to provide general background and an overview of baseline conditions. Provide a brief introduction of other frequently referenced case studies.

This step is component one of the *ex-post* review. Describing the Shellmouth project, the physical environment, the history, and the local concerns, provides context for the review. Baseline conditions and changes since the development of the reservoir are identified in brief. Information was gathered from a variety of sources, including:

- pre-development studies pertinent to the project;
- project related studies conducted since the development of the project by such agencies as PFRA, SaskWater, Manitoba Water Resources, and Assiniboine River Management Advisory Board;
- documents outlining general historical and geographical information of the area; and
- key person interviews.

While today a comprehensive description of baseline conditions would normally be found in a project's EIA and SEIA, these types of assessments were not conducted in the 1960s, when the project was developed. However, one key source on local conditions was the proposed land use plan (McKay et al 1969), which was written during construction. It characterizes local conditions, specifically local environmental conditions and land use at the time the reservoir was developed. Three additional case studies were also discussed as supplements to the Shellmouth case study. Two criteria were used in choosing these other case studies. The first criteria was the similarity of the additional case studies to the Shellmouth project. Like the Shellmouth, all of the additional case studies are prairie reservoirs that provide flood control and water conservation benefits. None provide hydroelectric power. The second criteria was the availability of post-development project reviews. In all three case studies, some form of documented review was available.

3. Identify local socio-economic and environmental impacts resulting from the project.

This step is the second component of the project review. Two approaches were used to identify the impacts from the project. The first approach involved identifying positive and negative impacts resulting from the development of the reservoir. A literature review highlighted typical environmental and socio-economic effects associated with reservoir development, which provided insight into the range of possible impacts created by the Shellmouth project. A number of development impacts specific to the case study were identified from the documents on the Shellmouth Reservoir and Assiniboine River. Literature sources included federal and provincial documents, such as the proposed land use plan by McKay et al (1969), various engineering consulting reports, and studies by academics.

A number of specific issues were also noted in the transcripts of public consultations held over the years on management of the Assiniboine River and the reservoir, and from key person interviews conducted for the purpose of this study. In the case of the key person interviews, interviewees were chosen because of their familiarity with the Shellmouth Reservoir. Government interviewees were identified from discussions with committee members and a former interim Director of Manitoba Water Resources. Local RM and municipal representatives were identified with the assistance of local government offices, who in turn recommended long-term landowners and business people with specific knowledge of the project's history.

The second approach involved collecting information on government identified economic development opportunities arising from the reservoir project. Sources included the proposed land use plan (McKay et al 1969), Asessippi Park Plan, and key person interviews. It was important to catalogue the projected economic development opportunities detailed by government prior to completion of construction, because the local area perceives these as the benefits the local area would receive from the Shellmouth. Those proposed development opportunities were then compared to the economic spin-offs that have transpired, to determine which have or have not resulted.

4. Study CBA as a decision/planning tool through a literature review of CBA, in an effort to identify the advantages and limitations of the tool.

In this third component, two approaches were used to conduct a review of the Shellmouth Reservoir CBA:

- a literature review of CBA and its application to water resource projects and
- interviews with CBA practitioners.

The literature review of CBA focused on the use of this tool for water resource projects, particularly reservoirs. Interviews with CBA practitioners focused on the practical application of this tool in the case of reservoir developments. Frequently noted limitations of this technique were identified, including a brief discussion of other public project analysis techniques and their relation to CBA.

5. Review the Shellmouth project CBA and outline the costs and benefits included in the analysis.

This forth component of the Shellmouth *ex-post* review was comprised of three activities:

i. Literature reviews of the original project CBAs. Two CBAs were undertaken prior to the decision to develop the project: the Royal Commission in 1958 followed by an update in 1961 by Kuiper. A review of these two CBA studies was undertaken to examine how various technical issues were dealt with, and to identify which costs and benefits were excluded from the analysis. Those included in the CBA were then compared to the post-project impacts identified in Method Three (the second component of the review).

ii. As part of component four, those costs and benefits accounted for in the original analysis were compared to those identified in the *ex-post* review. A comparative analysis identified those costs and benefits not included or incorrectly characterized in the original CBA. Costs and benefits not noted in the original analysis, but otherwise identified by the interviewees or in relevant literature, were outlined. The possible implications of these omissions are highlighted.

iii. As the final step of component four, some of the advantages and limitations of employing CBA in the pre-development evaluation of reservoirs, demonstrated through the case study, is reviewed. The advantages and limitations were discussed in relation to the issues identified in the review of the case study, relevant literature, and discussions with practitioners. Recommendations for improving the pre-development analysis of reservoir projects using CBA, was developed from the literature review, and the Shellmouth case study.

1.1.5 Focus and Limitations

The primary focus of this study is not to conduct a comprehensive review of the project, which would entail looking at the entire reservoir impact area from upstream of the reservoir to Winnipeg and the overall effects of the project on the province. The reservoir provides a valuable range of benefits to the Province of Manitoba, the majority of which are attributed to the downstream basin. However, the concern of this study is the impacts occurring at the reservoir site. The focus of the study is to review the ongoing concerns of local residents and rural municipalities with respect to the development of the Shellmouth Reservoir and the relationship, if any, to the CBA. Special emphasis is given to how local impacts are addressed within the CBA. The *ex-post* development review of the Shellmouth Reservoir, where CBA was relied upon as the primary decision assessment tool, helps to illustrate some of the strengths and weaknesses of CBA as it has traditionally been applied. The purpose of the *ex-post* development review is not intended to pass judgement on whether the Shellmouth's CBA was conducted appropriately by the standard practices of the time. Rather, the *ex-post* review of the case study helps identify the limitations of applying CBA for the assessment of reservoir development in terms of its appropriateness of application, level of comprehensiveness, and overall usefulness as a decision/planning tool. The *ex-post* assessment also enables discussion of how CBA may be more effectively utilized as an analysis technique to assist decision-makers in choosing between alternative projects, anticipating impacts, and developing appropriate policy responses.

1.1.6 Client

The client consists of two identifiable groups with somewhat differing interests in the research study. The Assiniboine River Management Advisory Board is interested in the specific case study discussed in this report, the Shellmouth Reservoir. The Board has identified the need to resolve outstanding issues associated with the construction and operation of the Shellmouth Reservoir as they relate to local area residents and the surrounding RMs in Manitoba. Clarification of these issues from the perspective of the local stakeholders will assist the Board in making recommendations to the Minister of Natural Resources regarding the management of the Assiniboine River Basin.

The second client is Manitoba Hydro. Although this reservoir does not generate hydroelectrical power or directly impact the utility's operations downstream, this research study may be useful to the utility. Findings from the review of CBA and the case study of the Shellmouth Reservoir can be used to direct future assessments of other reservoir projects. Manitoba Hydro supported the project through its Research and Development Program, which offers funding support for post-graduate projects and other research. The utility is the primary funding source for the study.

1.2 ORGANIZATION OF THE STUDY

This paper deals with a diverse array of technical and policy subject matter, and in an attempt to keep the discussion succinct and on course, much of the supporting detail is consigned to the appendices. The diagram in Figure 1.2 outlines the study framework.

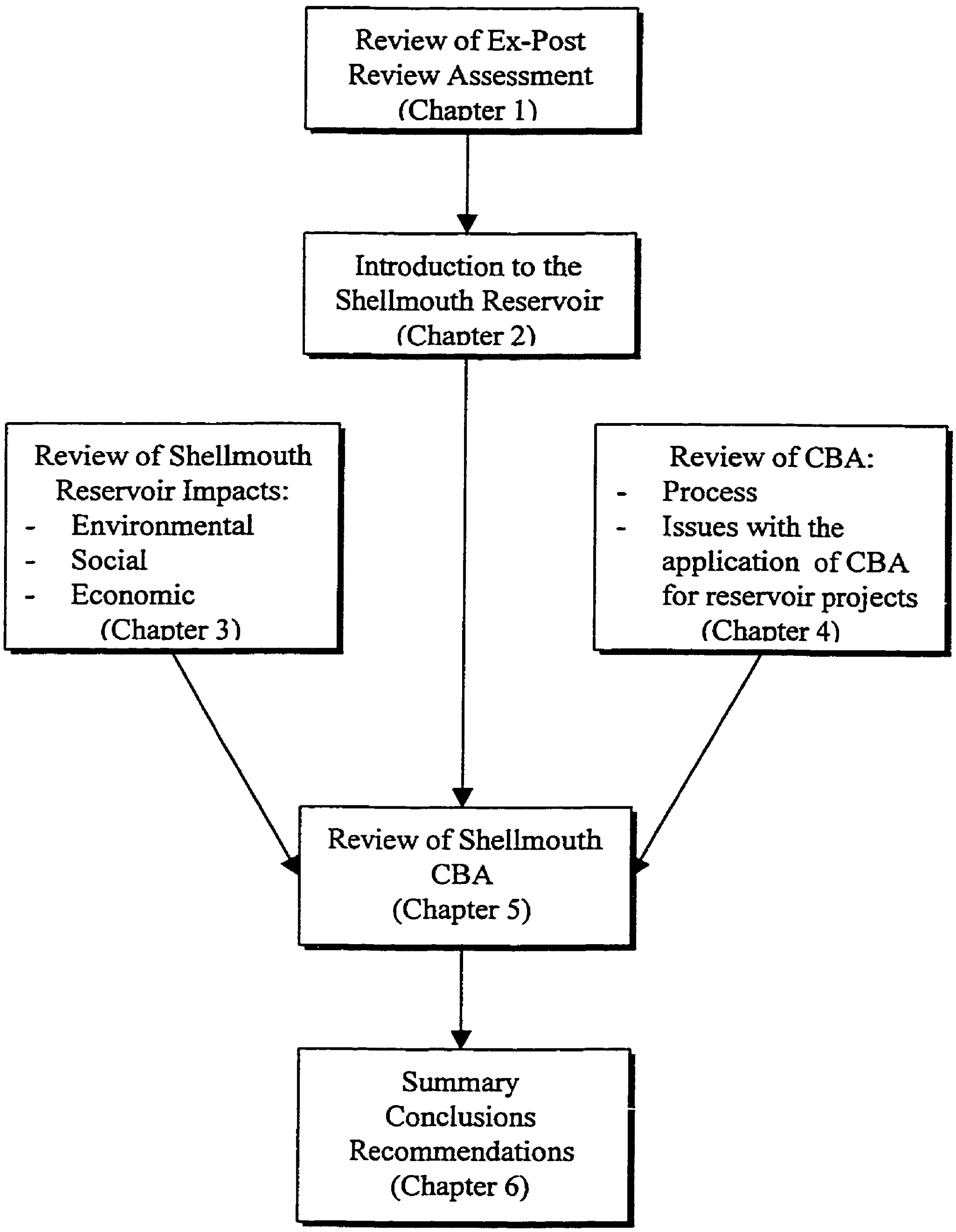
Chapter 1 introduces the study, and outlines its general purpose, objectives, and the methods used. The clients are introduced and the organization of the study is reviewed. The rationale for *ex-post* development review is discussed and the approach used in this study is presented.

Chapter 2 introduces the Shellmouth Reservoir, briefly describing the project and discussing the history and the ongoing local concerns. In addition, three other case studies are introduced with parallels to the Shellmouth project. These provided additional information on the types and nature of impacts created by reservoir projects in the prairies and some of the issues associated with the application of CBA. This is the first step in the *ex-post* development review for the Shellmouth

Chapter 3 is the second step in the *ex-post* review where the Shellmouth Reservoir's effects are identified. An overview of socio-economic and environmental impacts is discussed in relation to the detailed information found in the Appendices 4 and 5. The impacts highlighted reflect those indicated in the general literature on reservoirs, in studies conducted on the Shellmouth, in findings from transcripts from past public consultations. They are also drawn from key person interviews conducted with various government agencies, local municipal representatives, and landowners for this study. The distribution of positive and negative impacts is also reviewed.

The third component of the *ex-post* review is undertaken in Chapter 4 where CBA is briefly described, the general steps in conducting this analysis are identified, and the practical advantages and limitations of the methodology are discussed. The various aspects of CBA, including identification and valuation of various costs and/or benefits and discount rates, are discussed in greater detail in Appendix 7.

Figure 1.2: Study Framework



Chapter 5 is the final component of the review. The original CBAs conducted on the case study reservoir in 1958 and 1961 are reviewed, and the projected costs and benefits are compared to the impacts identified in Chapter 3. This is done to identify the range of positive and negative impacts included or omitted in the original CBAs. The original CBAs are also considered in light of the discussion on issues and limitations of CBAs in Chapter 4.

In Chapter 6, the limitations of CBA as applied to the assessment of water resources projects and demonstrated through the case study are summarized, and alternatives for improving pre-development analysis are identified. This study's final chapter consists of conclusions and recommendations, together with a description of general observations.

CHAPTER 2 - THE CASE STUDIES

2.0 INTRODUCTION

This chapter describes the location and operation of the Shellmouth Reservoir and reviews the history of the project, including local concerns. Other case studies used to complement and enhance the discussion of the Shellmouth Reservoir are presented at the end of the chapter.

2.1 RESERVOIRS: A GENERAL OVERVIEW

The reasons for developing a reservoir vary with each individual project. Reservoirs, in the most general sense, provide water storage for a specific purpose. The design of an individual dam and reservoir and its particular operating regime reflects the project's intended purpose. While reservoirs can be built for single or multiple purposes, they generally fall into one of three categories: power generation, water supply, and/or downstream flow regulation, which includes both flood control and flow augmentation.

Power generation has traditionally been one of the primary reasons for developing reservoir projects, particularly in Canada where hydroelectric power is a common source of electrical energy. However, this has not been a common reason for prairie reservoir development since prairie topography limits reservoir size and head, and climate limits inflow volume, both of which significantly constrain power output.

Water Supply (at the Dam Site) - Reservoirs are often constructed to provide a greater supply of water for a range of uses (commercial and economic) and activities (recreation) at the reservoir site that the natural river fluctuations would not normally accommodate. In general, high flows such as those occurring during spring run-off are captured in the reservoir through appropriate manipulations of the dam. This retained water can then be utilized for various activities such as supplying nearby irrigation projects, meeting municipal and/or industrial demands in the immediate vicinity or diverting water elsewhere. The reservoir itself can be used for recreation activities similar to those that would occur at a lake (boating, water skiing, and lake fishing).

Downstream Flow Regulation - Dams are also used to regulate downstream flows. They usually supply water for some specific activity(ies) or reduce high flows occurring during flood periods. Augmenting flows can support downstream activities by improving navigation, providing recreation opportunities, and supplying water for municipal use, irrigation, and livestock watering. In addition, flow augmentation can improve overall downstream water quality by increasing the river's capacity to assimilate treated municipal and industrial waste waters (US Army Corps of Engineers 1990). Regulatory regimes can also be structured to enhance fish and wildlife habitat by controlling the timing and amount of flow. In addition, flow regulation can serve to reduce flood peaks and thus reduce downstream property damages and risks to human life.

Multi-Purpose Reservoirs - In many cases, reservoirs are multi-purpose structures, constructed and operated to provide more than one service. Multiple purpose reservoirs increase the overall net benefits provided by the project and even the range of individuals or social groups that benefit.

A reservoir can be developed and operated for complementary activities, such as providing a guaranteed water supply for downstream irrigation activities while supplementing flow for wetlands and downstream recreation activities. It can also be utilized for purposes that require conflicting operation of the reservoir. Often these conflicts arise because of the timing in terms of filling or emptying the reservoir, or in the resulting static reservoir levels. It is important to realize that when operating a reservoir for multiple purposes, tradeoffs will be necessary. The operation of the reservoir will require a balancing of purposes in order to maximize total benefits from the project. This may mean that the reservoir is operated to maximize benefits for one primary purpose, resulting in less than maximum benefits being achieved for secondary purposes. A multi-purpose reservoir operated primarily for flood control and secondly for recreation use will compromise recreation benefits in the spring by lowering the reservoir to make way for spring floodwaters. Conversely, a balance may be struck where the operation is designed to maximize collective benefits through tradeoffs. Although the benefits achieved for each individual purpose are less than the possible maximum, the collective benefits achieved from trade-offs, are greater than could be achieved from any individual purpose.

2.2 THE SHELLMOUTH CASE STUDY

Following the flood of 1950, in which much of southern Manitoba was inundated by floodwaters from the Red River, the provincial government and the general public focused on reducing the risk of flooding and avoiding any future reoccurrence of the disruption and damages caused by the 1950 flood. The Shellmouth Reservoir was one project considered that could reduce this risk by controlling flow levels on the Assiniboine, a main tributary of the Red River. While various predevelopment assessment documents related to the Shellmouth project note the potential use of the reservoir for water conservation, the primary concern was the opportunity to reduce flood risk for the City of Winnipeg (Ball pers. comm. 1999). To this day, the official primary function of the reservoir is to provide downstream flood control for southern Manitoba, primarily Winnipeg (Bowering pers. comm. 1999). Water conservation and recreation are secondary considerations.

2.2.1 Shellmouth Project Description

The Shellmouth Reservoir is a significant water storage structure located on the Assiniboine River valley where the Shell River meets the Assiniboine just inside the Manitoba border. The reservoir was constructed between 1967 and 1970 as a joint project between the federal agency, Prairie Farm Rehabilitation Administration (PFRA), and the Government of Manitoba. It has been operated since that time by Manitoba Water Resources. Along with the Winnipeg Floodway, the Portage Diversion and diking on the Red and Assiniboine Rivers, the reservoir was designed to modify flows and reduce the level of flooding at Winnipeg, which is located at the junction of the Assiniboine and Red Rivers. The project also operates to reduce flooding and maintain minimum flows in the Assiniboine River Valley between Russell and Winnipeg. During the summer months, recreation activities are also accommodated by the reservoir.

The dam structure is located near the town of Shellmouth, Manitoba in the Assiniboine River Valley. It has created a reservoir 72.4 km (45 miles) long[3] by roughly 1.2 km (.75 miles) wide, with a surface area of 6,151 ha (15,199 acres) (PFRA 1982) and an estimated depth of 21m (69 feet) (McKay et al 1969). The reservoir's total storage capacity is 477,000,000 m^3 (386,860 acre feet) (Tkach and Simonovic 1992). While the reservoir crosses the provincial boundary, the majority of the storage volume is within Manitoba, which in terms of length, is more than three quarters (roughly 55 km or 34 miles) of the reservoir. The reservoir is bounded by the three Manitoba RMs of Shellmouth, Shell River, and Russell. The north end of the reservoir extends into the Saskatchewan rural municipalities of Cote and Calder (Figures 2.1 and 2.2).

The dam itself is a reinforced earthen structure with a gated control mechanism and a spillway for uncontrolled releases once the reservoir has reached an elevation of 429.31m (1,408 ft). A 4.6m diameter reinforced concrete conduit releases water from the reservoir during normal operation. An ungated concrete chute spillway is designed to pass the

[3] Provincial sign at dam site

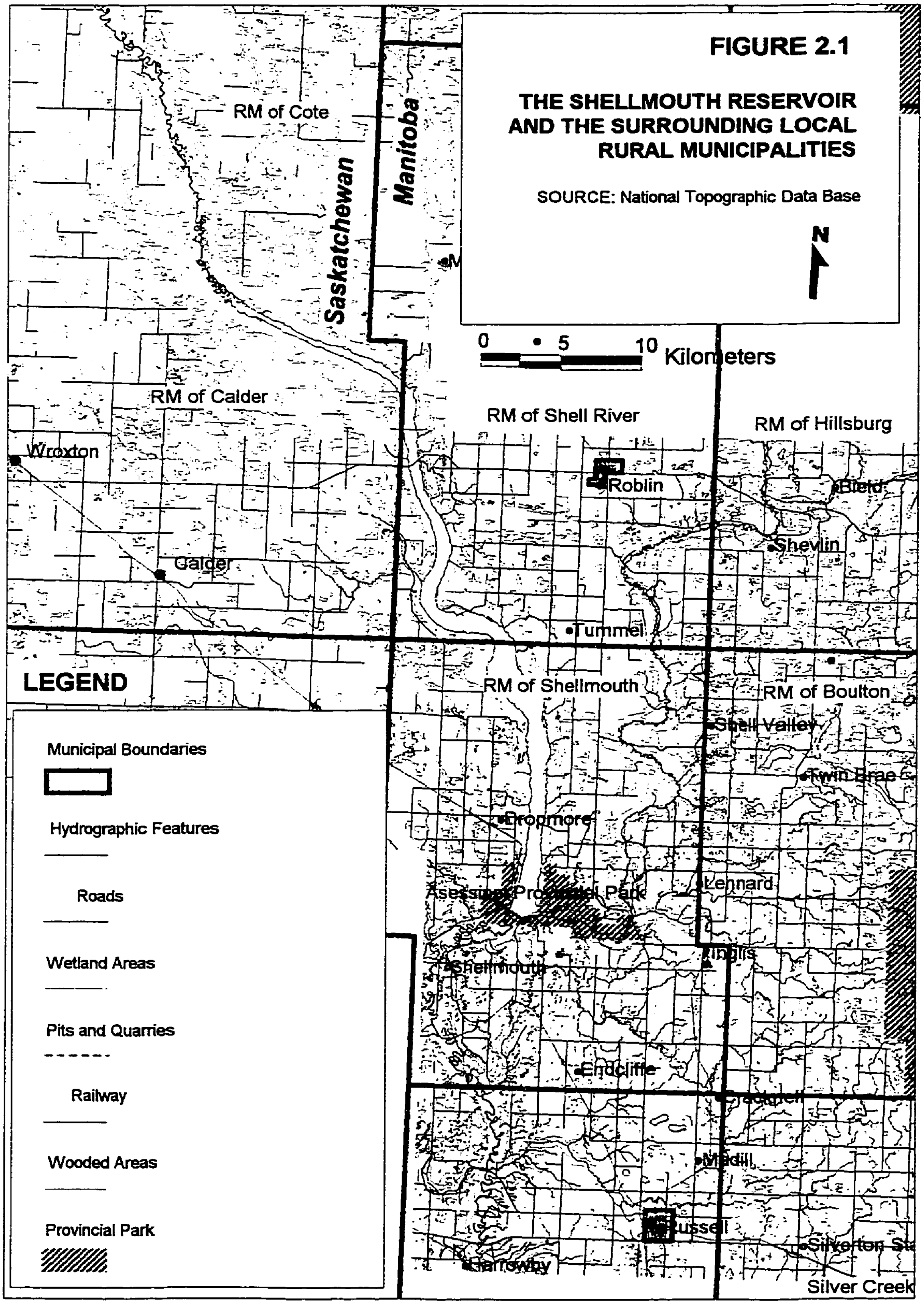


FIGURE 2.1

THE SHELLMOUTH RESERVOIR AND THE SURROUNDING LOCAL RURAL MUNICIPALITIES

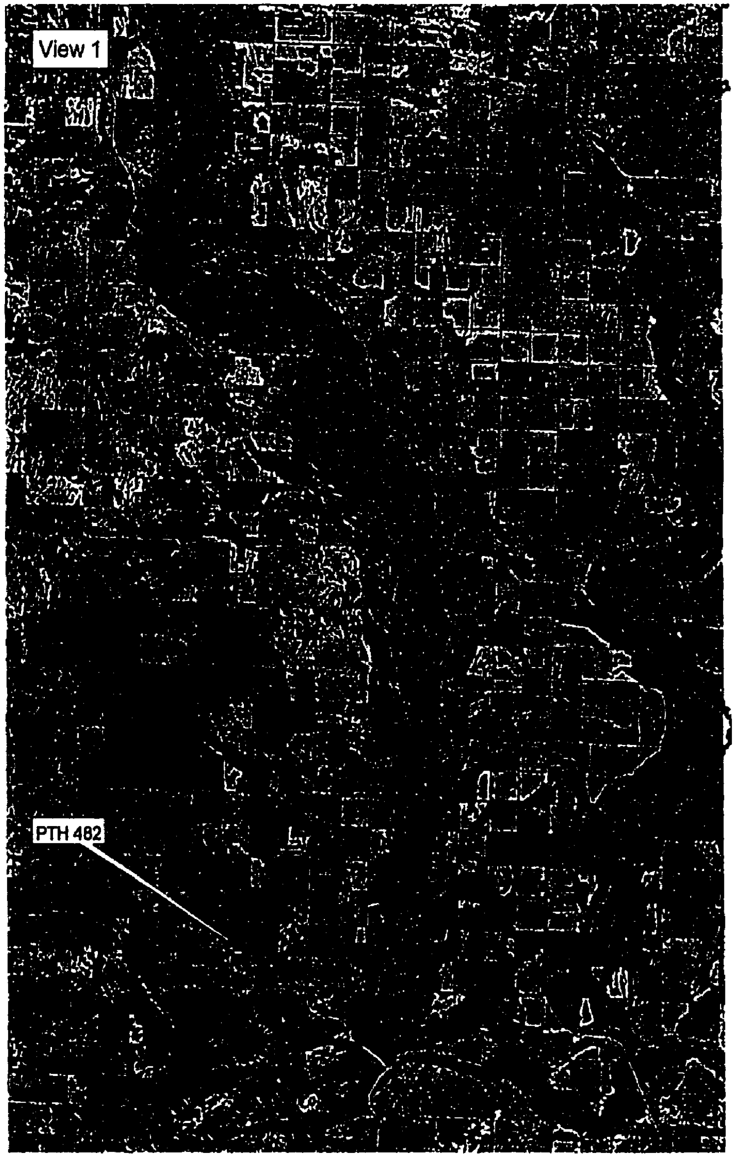


FIGURE 2.2

Shellmouth Reservoir and Dam Vector Overlay Indicating Hydrographic Features

SOURCE: Government of Manitoba, Land Information Centre 1965

N
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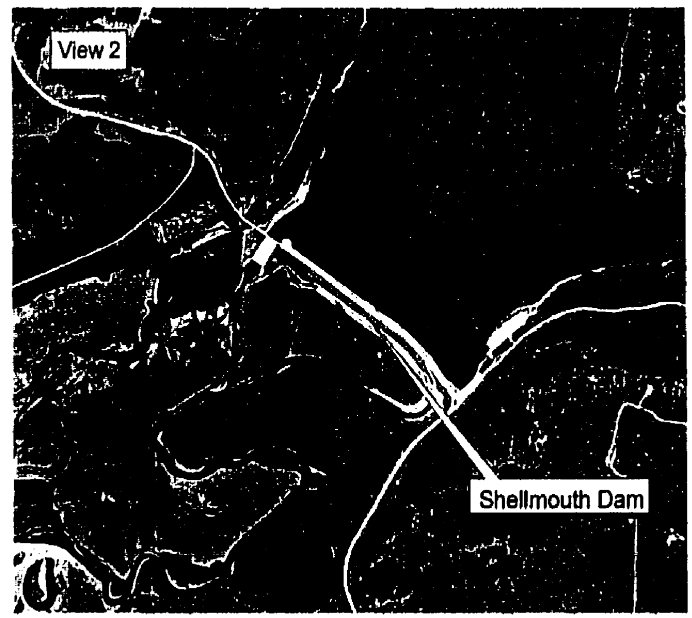
S

Scale represents that of the reservoir area (View 1)

3000 0 3000 6000 9000 Meters

Scale represents that of the Shellmouth Dam area (View 2)

500 0 500 1000 Meters



thousand-year flood (PFRA and Water Resources 1992). The dead storage elevation of the reservoir (the conduit invert) is 12 m (29 ft.) below the spillway at an elevation of 417.14 m (1,369 ft) with the top of the dam at 435.10 m (1,427 ft) (Tkach and Simonovic 1992).

The Shellmouth Reservoir was one of four undertakings constructed in the 1960s to reduce flood damage to Winnipeg and other property in southern Manitoba (Bowering pers. comm. 1999). The Shellmouth, along with the Winnipeg Floodway, the Portage Diversion and a series of dikes along the Assiniboine and Red Rivers, were designed to work in conjunction with one another to reduce the flood risk at Winnipeg. Flows on the Assiniboine can influence flood conditions on the Red River when the Red is already experiencing high flow rates.[4] For this reason, projects to reduce flow levels on the Assiniboine, were considered in conjunction with those to reduce flood risk on the Red River.

The Shellmouth, Portage Diversion, and diking on the Assiniboine River also have reduced flooding in the lower Assiniboine Basin. Major flood peaks recorded at Russell since the reservoir include 1976 (9,819 cfs or 278 m^3/sec.) and 1995 (22,616 cfs or 640 m^3/sec.) (Manitoba Water Resources 1995). Other historic flooding within the period of

[4] Major floods have been recorded on the Red River measured at peak unregulated flows at the Redwood Bridge in Winnipeg, downstream of the confluence of the Red and Assiniboine Rivers: 1826 (peak flow 225,000 cfs), 1852 (peak flow 165,000 cfs), 1861 (peak flow 125,000 cfs), 1950 (peak flow 108,000 cfs) (Government of Manitoba 1958), 1979 (peak flow 107,000 cfs), and 1997 (peak flow 162,000 cfs) (Water Resources 1999).

record for the Assiniboine occurred in 1922, 1923, 1927, 1955, and 1956 (Royal Commission 1958).

2.2.2 Operation

The Shellmouth is operated to reduce the flood peak and augment low flows for a variety of downstream uses. As demonstrated during the flood of 1995, operating the reservoir for these conflicting purposes can be difficult to balance. During the summer, reservoir levels are controlled as much as possible for recreation and fisheries purposes at the reservoir. However, downstream consumptive and instream needs have priority throughout the year. The operation of the reservoir adheres to the operating rules outlined below (PFRA and Water Resources 1992; Manitoba Water Resources 1995). These are further outlined in Table 2.1, which is a summary of the operating guidelines and Figure 2.3 showing the operating regime in graphic form.

- In the spring, outflows are controlled by storing excess runoff in the reservoir to an elevation of 429.3m. The highest water level elevation at the reservoir was 431.3 m in May 1995 during the largest flood recorded since operation of the reservoir commenced.
- After the spring runoff period, reservoir levels are gradually lowered by conduit releases to an elevation of 427.5m. Subject to downstream water requirements, this level is maintained throughout the summer to accommodate recreational use and a healthy fishery at the reservoir. Reservoir levels may also rise in the summer if storage is required for high flows resulting from summer rains. The storage between 427.5m and the spillway crest is available to reduce downstream flow rates in the event of summer rainfall floods.
- During the winter, the reservoir is lowered to approximately 424m elevation to

TABLE 2.1

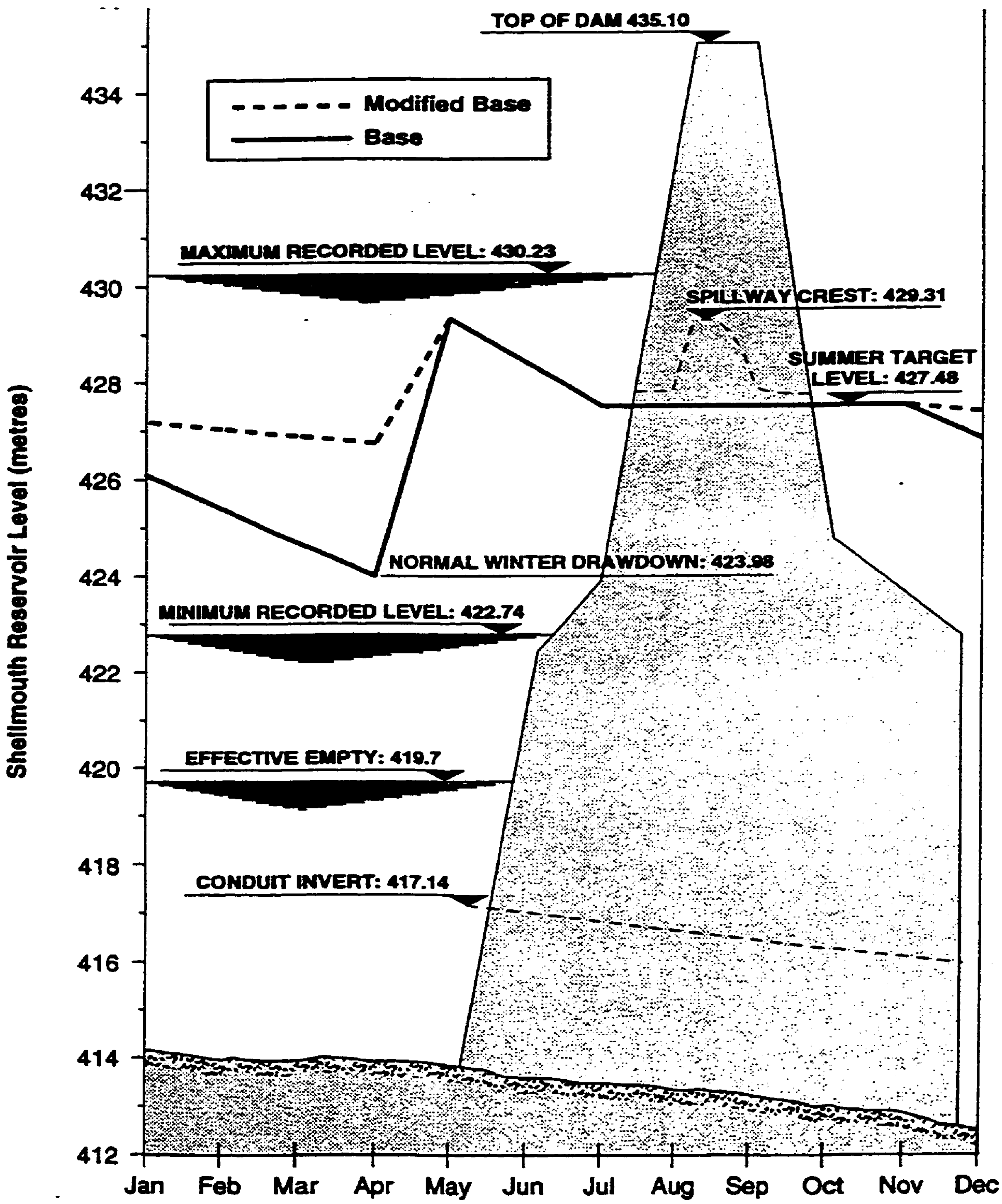
SIMPLIFIED GUIDELINES FOR OPERATION OF SHELLMOUTH RESERVOIR

Date or Condition		Existing Operation	
November 1st		Forecast winter inflows - set outflow to attain minimum winter target level elevation of 422.763m by March 31st	
December 1st		Update forecast and adjust outflow	
January 1st		Update forecast and adjust outflow	
February 1st		Update forecast and adjust outflow	
March 1st		Update forecast and adjust outflow	
April 1st		Predict next 30 days inflow and set the constant release required to attain peak elevation of 427.487m under th constraint $0.707\ m^3/s \leq$ outflow $\leq 2.83\ m^3/s$	
Elevation 426.725m reached on reservoir		Make 30-day prediction of inflow and determine the constant releases Qcons such that peak elevation of 427.487m is attained and Qpr such that peak elevation of 429.316m is attained	
	A.	If Qcons $\leq 0.707\ m^3/s$, set outflow	$= 0.707\ m^3/s$
	B.	If $0.707\ m^3/s <$ Qcons $< 42.5\ m^3/s$, set outflow	= Qcons
	C.	If Qpr $\leq 42.5\ m^3/s <$ Qcons, set outflow	$= 42.5\ m^3/s$
	D.	If $42.5\ m^3/s <$ Qpr $< 70.8\ m^3/s$, set outflow	= Qpr
	E.	If $70.8\ m^3/s \leq$ Qpr, set outflow	$= 70.8\ m^3/s$ and hold as long as possible
Falling limb of hydrograph		*Set Outflow = Inflow until Inflow $\leq 42.5\ m^3/s$	
Inflow $\leq 42.5\ m^3/s$		*Set Outflow = $42.5\ m^3/s$ until reservoir drops to elevation 427.487m	
Elevation 427.487m		*Set Outflow = Inflow maintaining elevation 427.487m until November 1st (summer operation)	

NOTE: Any of the phases marked with an asterisk (*) may be by-passed if exceedingly high or low flow conditions are encountered.
Also outflow is checked to ensure that downstream demands are met.

Figure 2.3

Generalized Reservoir Operating Regimes: Beginning of Month Target Levels



Source: Manitoba Water Resources. Dec. 1995. Assiniboine River Flooding and Operation of the Shellmouth Dam. Presentation to the Shellmouth Flood Review Committee. Dec. 12, 1995.

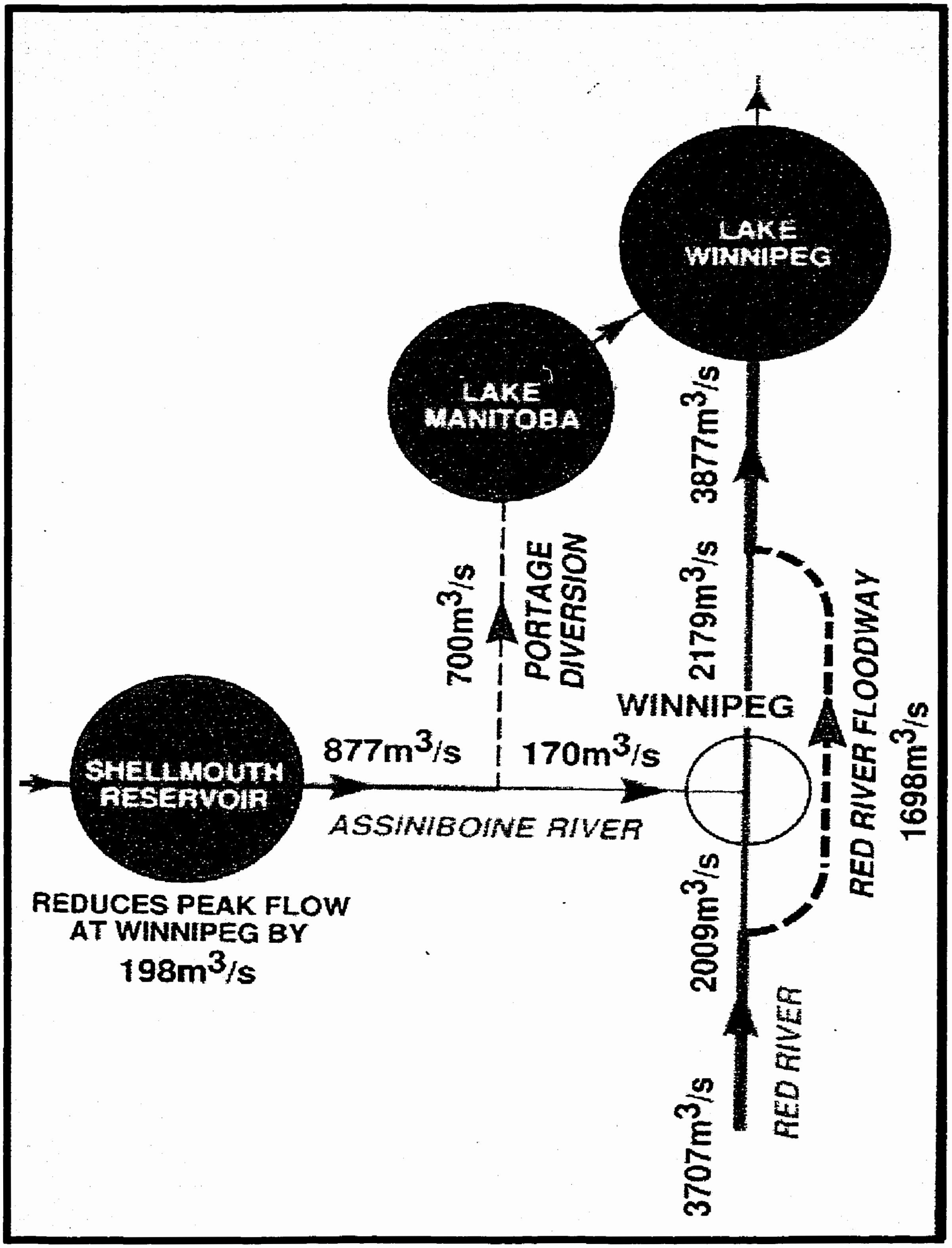
provide storage for spring run-off and hence minimize flooding downstream. Since the 1980s, this target has varied somewhat, as Natural Resources began adjusting the level in relation to forecasts of spring inflow.

When the reservoir was first constructed, the operation of the dam was geared primarily for flood control. Natural Resources drew the reservoir levels down to the winter minimum of 424m to maximize reservoir capacity for spring floodwaters. However, in the 1980s drought conditions ensued, changing the hydrological regime of the basin. Natural Resources began to vary the winter minimum based on spring run-off forecasts, in order to have sufficient water in the reservoir to provide for downstream demands. This did not constitute a shift in use priority, but simply a shift in operation to better accommodate downstream needs. However, this operational shift, which put greater emphasis on water conservation, compromised the flood storage capacity of the reservoir. In 1995, after a long period of low moisture conditions, a forecasting error occurred and Water Resources underestimated the spring run-off. Consequently, the reservoir was not drawn down sufficiently to maximize its flood control potential (Bowering pers. comm. 1999). The reservoir possibly could have reduced flooding on the Assiniboine to an even greater extent in 1995 if the forecasting prediction had been closer to the resulting flooding conditions. However, operating in this manner requires that not only that storage availability in the reservoir is known, but also that inflow is correctly predicted. This is not an easy task when trying to estimate inflow from spring rains and snow melt. Under such circumstances it is difficult to use the reservoir to maximum efficiency.

The contribution of the reservoir to downstream flood control is a function of flood conditions, both in terms of timing and nature of the flood and the capacity available for flood water retention (PFRA and Water Resources 1992). It has been calculated that, through its storage capacity, the reservoir reduces downstream flows at Winnipeg by 196 m^3/second. This is a relatively small contribution in relation to the other three projects which, with the Shellmouth, collectively work together to reduce flow rates for Winnipeg during flood conditions (Figure 2.4). The Floodway reduces flows of the Red River in Winnipeg by 1,698 m^3/second (65% of total reduction), the Portage Diversion by 700 m^3/second (27% of total reduction). In comparison, the 196 m^3/second reduction by the Shellmouth represents roughly 8% of total reduction in flows. Diking also contributes to flood control by increasing the capacity of the river channel. Collectively, this system of four projects protect Winnipeg from a 1 in a 160 year flood. In flood conditions exceeding this, which has occurred in the recorded past (1826 and 1776) and may occur in the future, the existing system would not protect Winnipeg from flood damage. The Shellmouth Reservoir also serves an important function in reducing flow rates elsewhere on the Assiniboine during flood conditions. In terms of contributions to downstream flows, it has been calculated that through its storage capacity, the reservoir makes available over 132,000 dam^3 annually for consumptive uses downstream (PFRA and Water Resources 1992).

The operating rules for the reservoir mean that under normal operating conditions, the water level elevation varies five meters. This change in elevation can be seen as the

Figure 2.4
Winnipeg Flood Control Projects



Schematic showing the contribution of the Shellmouth Reservoir, Portage Diversion and the Winnipeg Floodway to peak flow reduction at Winnipeg

Source: Water Resources, Manitoba Natural Resources August 1999.

difference between the minimum and maximum elevations of the base line in Figure 2.3. It is a result of the operating regime, which is focused on flood control in the spring and considers recreation needs at the reservoir and downstream water supply during the summer.

The change in the elevation of water stored in the reservoir, which can be more extreme than five meters under flood or drought conditions, has implications in terms of the impacts experienced at the local level. The majority of positive and negative impacts experienced by the local area are influenced by this change in elevation, as well as by the timing of the change (filling and withdrawals from the reservoir). Environmental conditions at the reservoir, the use of the reservoir for recreation, and the attractiveness of the site for vacation property development are all influenced by the changes in elevation of water stored in the reservoir. Because the operation of the reservoir has created negative impacts at the local level that have not been experienced at the basin scale, the focus of this research is to consider local impacts resulting from the operation as well as development of the project. The impacts are discussed in greater detail in Chapter 3 and Appendices 4 and 5.

2.3 AREA CHARACTERIZATION

The initial decision to develop and locate the reservoir at its present location was strongly influenced by physical geography and hydrological features. The reservoir and its operation are still influenced by the physical characteristics of the immediate surroundings and the geographic properties of its tributaries.

2.3.1 Geographic Characteristics

The Assiniboine River occupies a geographic area commonly referred to as the Interior Plains. This region is characterized by a series of steppes that gently slope from the southwest to the northeast. The Assiniboine River flows over the lower two steppes, rising in Saskatchewan in the Missouri Coteau, flowing east to the Manitoba Escarpment, down into the Manitoba Plain, and terminating at Winnipeg where it meets the Red River (Canada West Foundation 1982).

The general physical nature of the study area is a product of the last glacial period. The river and stream channels were cut by the melt waters of the Wisconsin Glacier that covered the region roughly 10,000 years ago (Marsh and Dozier 1981). The resulting steep sloping walls and flat valley floors of the Assiniboine and Shell Rivers created conditions favourable for a reservoir structure. The deposited sediments of a glacier lake created the rich lacustrine soils that form the flat agricultural areas of the Assiniboine Valley and surrounding region (Waite 1992). Chermozemic and luvisolic soils are high in organic matter, and occupy most of the upland surrounding the Assiniboine, while regosolic soils occur mainly in the river valley, and are highly fertile because of alluvial deposits during periodic floods (SaskWater 1995). Since these are easily eroded soils and the topography is gently sloped, the creeks and rivers of the watershed are characterized by high sediment loads and meandering channels.

2.3.2 Climate

The interior plain climate is classified as semi-arid, having comparatively low annual precipitation and high evaporation and transpiration rates in the summer months. The upper Assiniboine River Basin has an annual precipitation rate of roughly 400 mm, and annual runoff rates are slightly above 50 mm on average. The annual precipitation rate for the drainage basin for the Shell River is in excess of 500 mm (Canada West Foundation 1982). The precipitation in the upper Assiniboine and Shell watersheds is sufficient to maintain sufficient soil moisture to support agriculture. Consequently, irrigation is generally not required for the predominantly grain and cereal crops grown near the reservoir. Annual precipitation in the lower portion of the basin in southern Manitoba is slightly less than in the area closer to the reservoir. In this area of the basin, vegetable crops such as corn and potatoes benefit from the irrigation projects, which supplement existing moisture conditions and maintain produce quality (Canada West Foundation 1982).

Climatic conditions strongly influence the hydrology of the entire river basin. Low moisture conditions generally create low flows in the Assiniboine basin with periods of high precipitation associated with high flows.

2.3.3 Hydrology

The reservoir receives the bulk of its in-flow from the Assiniboine River in Saskatchewan; its headwaters are located roughly 120 km west of the Saskatchewan-Manitoba border. The Assiniboine is joined at Kamsack by the Whitesand River before it flows into Manitoba. Big Boggy Creek, a minor tributary, flows south into the reservoir at the Manitoba-Saskatchewan border. The Shell River joins the reservoir just north of the dam site (see Figure 1).

The Assiniboine River is a typical meandering prairie river, with flows that fluctuate considerably between seasons and from year to year. The Assiniboine River's natural flows vary between 0.3 cfs and 4176.1 cfs with a mean of 329.8 cfs (PFRA 1980). Flow rates also fluctuate considerably throughout the year, with the majority of drainage, anywhere from 30% to 40% of the total annual flow, occurring during the April melt period (Canada West Foundation 1982). Frozen soil conditions favor the runoff of melt waters from accumulated winter snow and any new precipitation during the spring months. In contrast, the summer and fall rains are more likely to be absorbed, replacing soil moisture and ground water losses, leaving minimal runoff for rivers and streams. The gentle slope of the prairie plain also contributes to this high rate of absorption in the summer and fall. A minimum 50% of natural flow is guaranteed to Manitoba from Saskatchewan by the Master Agreement on Apportionment for the Prairie Provinces (PPWB 1995). Measurements taken just upstream of the reservoir indicate Saskatchewan is diverting only 5.5% of its 50% allocation for various consumptive uses.

The conditions for the Shell River are slightly different. With its headwaters in the wooded areas of Manitoba's Duck Mountains in the escarpment, the river is less likely to see the rapid increase in spring flow conditions characteristic of the Assiniboine. Snow trapped and accumulated in the dense vegetation and forest shade of the escarpment area extends the melt period. Even though the precipitation rate is higher than the open plain geography of the Assiniboine, the winter moisture is more gradually and continuously released into the Shell River (Canada West Foundation 1982). The Shell River discharge averages 100.3 cfs with a minimum of 0.0 cfs and a maximum of 199.3 cfs (PFRA 1980).

Precipitation has also been known to vary greatly from year to year, and long-term climate cycles of high and low precipitation have been noted. During the 1930s, repeated high annual temperatures and low precipitation rates created some of the lowest flow levels on record for rivers across the prairies. In the 1980s, low precipitation rates were once again recorded, but cooler temperatures appear to have contributed to higher flow levels than those that occurred during the 1930s (Canada West Foundation 1982). In this regard, the reservoir helps to mitigate drastically low flows and allow for the development of irrigation downstream of the reservoir.

2.3.4 Water Quality

The Prairie Provinces Water Board (PPWB), SaskWater, and Manitoba Environment measure water quality variables. PPWB monitors water quality and supply at the provincial boundary. Samples taken just upstream of the Manitoba-Saskatchewan border indicate that manganese and total phosphorous exceed PPWB guidelines and dissolved oxygen levels occasionally fall below the guidelines. This may have implications for the reservoir. Phosphorous contributes to algae growth, which in turn negatively affects dissolved oxygen levels and creates other problems that can negatively impact fish and other aquatic invertebrates. Currently, Manitoba does not regularly measure water quality at the reservoir, and thus the effect of water quality on the aquatic biota is not known. Saskatchewan could significantly increase water withdrawals from the upper Assiniboine as per the Master Agreement on Apportionment for the Prairie Provinces (section 2.3.3). Future consumption increases in the Saskatchewan portion of the Assiniboine Basin have the potential to reduce inflow levels and negatively affect water quality in the reservoir.

2.3.5 Vegetation and Wildlife

The majority of the area is characterized by typical prairie vegetation and wildlife species. While much of the uplands and valley floors have been cultivated, the river valleys such as the Assiniboine and Shell offer critical wildlife habitat. Not only do river valleys offer winter shelter to wildlife, but the uncultivated valley slopes provide some of the only relatively undisturbed wildlife habitat available. Today, such areas are considered critical wildlife habitat and are used extensively as wildlife travel corridors (Bidlake pers. comm. 1997). A description of native vegetation and wildlife species found in the area is located in Appendix 1.

2.3.6 Demographic and Socio-Economic Characteristics

Prior to European settlement, the Plains Cree and the Assiniboine aboriginal peoples inhabited the area. The region provided a rich source of food, natural resources, and shelter and was a favorite wintering location for both groups (Friesen 1987). Today, the region is occupied primarily by agricultural producers and service centres.

The region is divided into five rural municipalities of varying population sizes: Russell, Shellmouth, and Shell River in Manitoba, and Cote and Calder in Saskatchewan. Settlements in the study region include the towns of Shellmouth, Inglis, and Russell in Manitoba, and Cote, Calder, and Togo in Saskatchewan. The populations for the RMs and settlements are recorded in Tables 1 and 2 in Appendix 1. In general, rural populations in the Assiniboine watershed, including the study area, have declined 24% since 1974 (SaskWater 1995). This is consistent with rural population trends elsewhere in the western Canadian prairies. However, some of the service centres in or near the study area, such as Russell, Roblin, and Yorkton have seen population numbers increase with in-migration from the rural hinterland (SaskWater 1995).

Community populations in the study area presently outnumber rural populations by two to one. However, the largest economic sector and land use activity remains agricultural production. Mixed grain and wheat farming, pasture and hay lands, and small livestock operations are common (Statistics Canada 1996). Little supplemental irrigation occurs by residents in the vicinity of the reservoir (Collins pers. comm. 1996; Fortin pers. comm. 1997). This is likely due to the significant moisture available to grow traditional grain crops, which dominate the area. Saskatchewan, for example, has no licenses issued at the present time for agricultural withdrawals from the reservoir (Collins pers. comm. 1996). The growing beef and pork production feedlot industries in the area rely on a ready source of good quality water. It is believed local demands for stock watering from the reservoir may increase in the future (Trinder submission 1995). Land use directly adjacent to the reservoir is also primarily agricultural, although most of the area adjacent to the reservoir is under Crown ownership (Township maps 1995 in Appendix 1).

Businesses in the region are primarily associated with the agricultural sector or provide services to the local community. Meat packing facilities, dairies, bakeries, and feed mills are amongst the business activities found in the study area (SaskWater 1995). Overall however, economic growth in the region has been slow for the past several years (Statistics Canada; PPWB 1995).

Other economic activities are related to recreation and travel. In Manitoba, the reservoir supports recreation activities, which has lead to the development of a few vacation cottage properties. At the south end of the reservoir, the province has developed Asessippi Provincial Park with camping, boating, sports fishing, swimming, hiking, and cross-country skiing opportunities. The park also contains playground space and the Asessippi historic town site (Government of Manitoba 1973). Recently, local representatives have secured funding for a downhill ski development within the park boundaries, in what is viewed as partial compensation for the reservoir development and associated costs. One small cottage area is starting to develop on the southwest side of the reservoir, not far from the park. Recreational use of the reservoir by Saskatchewan has been minimal due to a lack of public access and facilities, although there have been proposals for a boat launch and picnic site at the head of the reservoir and a 6,700 ha ecological reserve (SNC Group 1986).

2.4 HISTORY OF THE SHELLMOUTH

The reservoir was constructed as a joint project between the Manitoba and federal governments, through Prairie Farm Rehabilitation Administration (PFRA). A dam in the vicinity of the current structure had been discussed as far back as the 1940s, as a means of controlling frequent spring flooding (MacKenzie 1945). However, the severity of the 1950 flood that engulfed much of the Red River Valley, was the catalyst for developing the reservoir. Millions of dollars in damages were sustained by Winnipeg as well as other communities in southern Manitoba, due to the extensive spring flooding along the Red River.

The Shellmouth Reservoir was identified as one of a series of potential water retention, diking and diversion projects that would reduce the threat and intensity of flooding for Winnipeg and also for the Lower Assiniboine Basin where past flooding had been significant (Government of Manitoba 1958). A secondary consideration for the reservoir project was water conservation, providing increased river flow during drought periods (Royal Commission 1958; McKay et al 1969). CBA studies initiated by the federal and Manitoba governments shortly after the 1950 flood, concluded that the Shellmouth Reservoir would produce a benefit stream that would outweigh the project's costs.

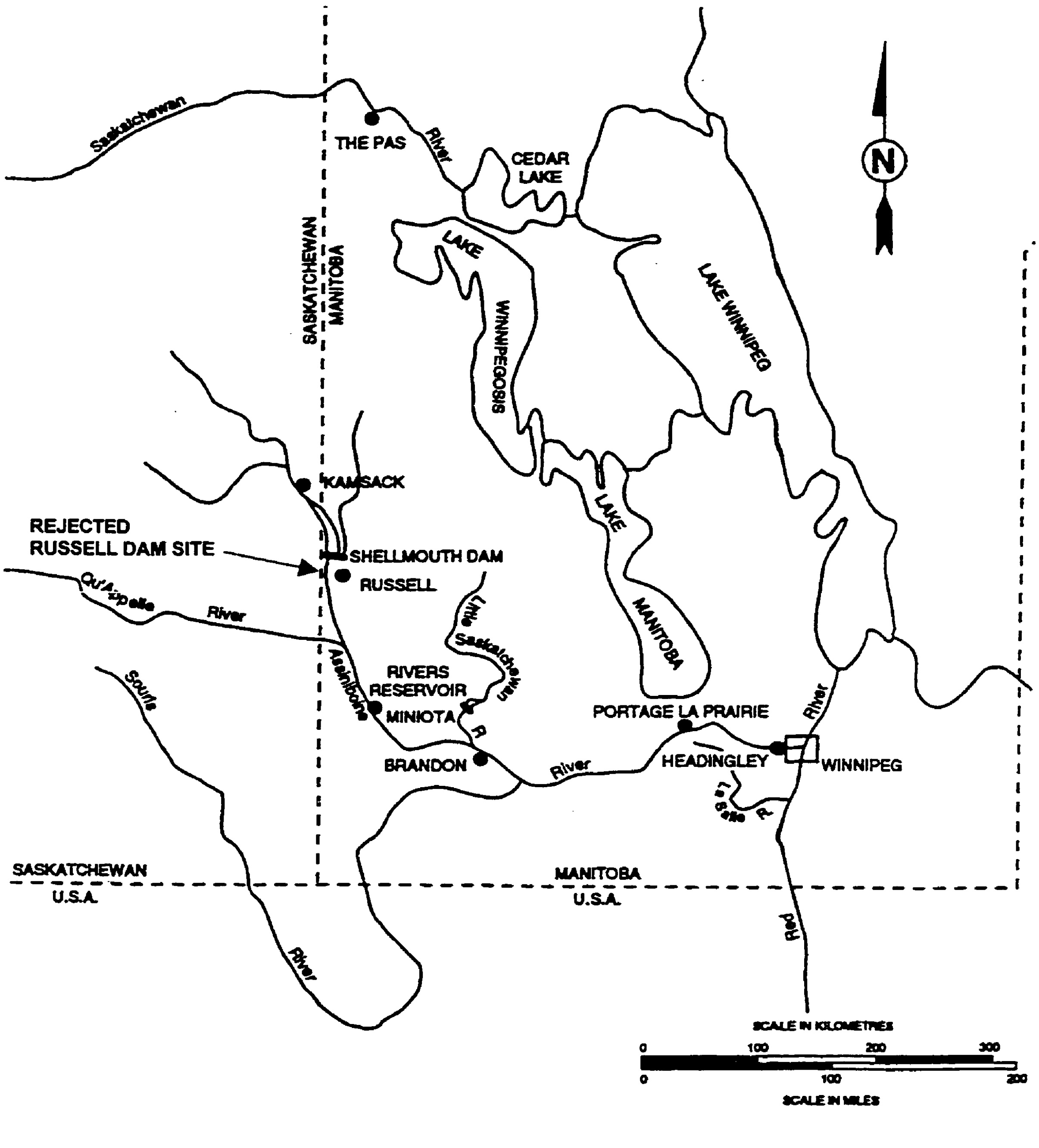
A series of studies conducted by both Manitoba and federal government departments in the 1950s examined the engineering feasibility of the project, as well as the anticipated costs of developing the reservoir in relation to the flood control benefits to downstream communities. With the exception of the CBA, no other pre-development assessment was undertaken. While pre-development environmental and/or socio-economic impact assessment studies are now generally required for such development projects, such assessments were not the norm in the 1950s and 1960s. However, a planning study was conducted on the Manitoba portion of the reservoir shortly after construction was initiated. The purpose of the study was to develop a regional plan that also included a cursory assessment of biophysical impacts (McKay et al 1969).

While the dam was originally scheduled to be located at Russell, Manitoba (Figure 2.5), it was ultimately located further north at Shellmouth because construction materials were readily available, foundation conditions were more stable and less prime agricultural land would be affected (Environment Canada, Water Planning and Management 1974). At this new location, sufficient water was available from the Assiniboine River, Shell River, and Big Boggy Creek for the reservoir to be an effective water storage mechanism. In

Figure 2.5

Assiniboine River Basin -

Location of the Shellmouth Reservoir and Rejected Russell Reservoir



Source: Manitoba Water Resources. Dec. 1995. Assiniboine River Flooding and Operation of the Shellmouth Dam. Presentation to the Shellmouth Flood Review Committee. Dec. 12, 1995.

addition, maps of the area indicate a CNR crossing north of the town of Shellmouth, just below the present dam. The prohibitive expense of rerouting the rail or raising the crossing is another likely reason for relocating the reservoir upstream.[5]

Since its construction, the Shellmouth Reservoir has provided flood control for downstream communities such as Brandon, Portage, and Winnipeg. The Shellmouth Reservoir has also served as a storage facility to augment flows in the lower portion of the basin during low-flow periods. This has supported some of the irrigation occurring in the lower basin, helping to stimulate agricultural development such as potato production in the Brandon/Carberry area (McLaren pers. comm. 1999)

The impacts occurring in the vicinity of the reservoir have differed from the benefits experienced further downstream. Similar to other reservoir development projects, the impact of the reservoir on the Assiniboine River Valley and its residents differs according to geographic location. The basin downstream of the reservoir has experienced decidedly different impacts from those occurring in the vicinity of the reservoir: those experienced immediately downstream of the dam in the spillway discharge area, at the reservoir, and just upstream of the reservoir. In this study, the area in the vicinity of the reservoir is described as the local area.[6]

[5] A very early study by MacKenzie (1945) noted this limitation with the Russell site.
[6] The local area, for the purposes of this study is the Manitoba RMs of Shellmouth, Russell and Shell River and Saskatchewan RMs of Cote and Calder. The residents, business people, and elected municipal officials of the RMs and the towns within these boundaries, are considered the local stakeholders.

Prior to development, land use in the valley at the reservoir site consisted primarily of agriculture, some local recreational activities, wood-lots, gravel and sand quarries, and natural areas (McKay et al 1969). For the RMs where the reservoir was constructed, the government predicted that the local loss of taxable agricultural land and associated agricultural activity, as well as the loss of wildlife habitat, would be offset by significant increases in recreational activity, including cottage development (key person interviews 1997,1998). In addition, it was believed that with appropriate management a productive sports fishery could be supported in the reservoir (McKay et al 1969).

2.4.1 Local Concerns

Particularly for local municipalities bordering on the reservoir, there have been a number of long-standing concerns associated with the creation and management of the Shellmouth Reservoir. Although the Shellmouth Reservoir has provided flood protection and water supply for downstream communities for more than 20 years, upstream residents suggest that their communities have suffered as a result. The issues include the possible negative impact of the reservoir on local flood conditions, and whether fair compensation for construction and current operation has been provided. Recent public inquiries into the sustainable management and future development of the Assiniboine River in Manitoba by the Assiniboine River Management Advisory Board (ARMAB) have provided a forum for local concerns. Flooding in the spring of 1995 on the Assiniboine River appeared to local people to result in damages just downstream of the dam site (ARMAB 1995; key person interviews 1996,1997). This perception reinforced local concerns regarding the operation of the reservoir (Dickson pers. comm. 1996). There is also interest in discovering what role the pre-development assessment, the CBA for the project, may have played in the prediction of local impacts (Dickson pers. comm. 1996).

The reservoir has created recreational opportunities such as boating, fishing, and swimming. Despite the recreational benefits and possibility of withdrawals for agricultural and industrial uses, there have been a number of persistent concerns by the municipalities and residents in the immediate vicinity of the reservoir. The principal concern of local stakeholders is the distribution of costs and benefits. The local perception is that the local benefits from the construction and current operation of the Shellmouth Reservoir that were anticipated to outweigh total costs incurred by the local region, were not forthcoming (key person interviews 1997,1998). These costs and benefits are various environmental, social and economic impacts derived directly and indirectly from the development and operation of the reservoir.

The RM of Shellmouth, Russell and Shell River identified four outstanding issues of local concern in commentary received by ARMAB (public consultation 1995). The RMs indicated that:

i. economic benefits, derived primarily from vacation property developments arising from the creation of the reservoir, have not been sufficient to compensate for the loss of municipal tax revenue from agricultural land flooded by the reservoir;

ii. the majority of anticipated economic benefits from tourism-associated development opportunities related to the reservoir have failed to materialize;
iii. deteriorating water quality and fluctuating reservoir levels are threatening future recreational and tourism development opportunities; and
iv. fair compensation for local residents for damages caused by the reservoir have not been forthcoming.

Residents of the RMs of Cote and Calder in Saskatchewan in the valley upstream of the reservoir are also concerned about deteriorating water quality and elevated water levels (key person interviews 1996, 1997). It has been argued that elevated water tables are a result of high water levels in the reservoir and have interfered with tillage and crop production (Gerhart pers. comm. 1996). These reservoir development issues, parallel impacts experienced by other communities elsewhere (Eugster and Duerksen 1984).

2.5 OTHER CASE STUDIES

Other case studies were reviewed to confirm findings and help substantiate the limited information available on the effects of the Shellmouth Reservoir on the local area. Three reservoir case studies were relied on extensively because they shared similar characteristics with the Shellmouth project and because post-development review documentation was available. Two of the case studies are reservoirs located on the Canadian prairies, developed after the Shellmouth project: the Oldman River Dam located in Alberta and Rafferty-Alameda Dams in Southern Saskatchewan. The other case study, the Lake Shebyville Reservoir, is located in Illinois and was constructed around the same time as the Shellmouth. Like the Shellmouth, all three are multi-purpose prairie reservoirs. Other case studies sharing similarities with the Shellmouth, such as Lake Diefenbaker, were not referenced due to a lack of available post-development documentation.

2.5.1 Oldman River Dam

The Oldman River Dam is located in the South Saskatchewan River Basin. It was considered by PFRA as far back as the 1960s, but the decision to pursue the project was not made until 1975 by the Conservative Government of Alberta. The project was intended to regulate flow on the Oldman River for water supply for downstream irrigation (primary purpose), and flood control (secondary purpose).

The dam is an earth and rock filled dam, 76 m high with a maximum storage volume of 490 million m^3 and a surface area of 24.2 km^2. Like the other case studies identified, there was significant local opposition to this project for a variety of environmental and social reasons, and its overall economic value was questioned.

2.5.2 Rafferty-Alameda Dams

The Rafferty-Alameda project was proposed in the early 1980s and construction began in 1988. It is comprised of two reservoirs developed on the Souris River Basin in southeast Saskatchewan.

The purposes of the Rafferty Reservoir were to provide:

- cooling water for a downstream thermal power unit at the Shand Generating Plant,
- flood projection for downstream Saskatchewan and North Dakota communities, and
- irrigation and municipal water supplies.

The Alameda was designed primarily to satisfy Saskatchewan's water apportionment obligation to the United States as well as irrigate 2,800 ha of upstream and downstream agricultural land. Both projects were also intended to provide recreation benefits, including large cottage developments. The Rafferty Reservoir is a 20 m high earth filled dam with a surface area of 4,900 ha, and a volume of 443,000 dam^3. The Alameda is a 38 m high earth filled dam with a surface area of 1,240 ha and a volume of 130,000 dam^3 (Stolte 1993).

The Rafferty-Alameda project is complicated by the fact that it has an interjurisdictional component: it regulates flows in North Dakota. There has been significant controversy regarding this project, much of which has to do with the development and operation agreement (Hamilton 1991). However, of interest for this study are the criticisms regarding which impacts were and were not included in the CBA as well as general problems with how CBA was applied for this project (Townley 1998). Local impacts not included in the analysis are an assessment of:

- environmental impacts such as loss of prime migratory waterfowl habitat;
- social-health impacts on local communities including disruptions to community networks;
- secondary benefits and costs of the project to the local area, such as employment losses and gains; and

- local costs to the rural municipalities because of lost tax base and possible increased maintenance costs.

2.5.3 Shelbyville Reservoir

The Shelbyville Reservoir is located in Moultrie and Shelby counties in Illinois and was developed for flood control and downstream water supply. General studies on the reservoir began as early as the 1930s, with specific studies conducted in the 1950s, leading to construction in 1964. The reservoir has a surface area of 4,490 ha, a volume of 26,700,000 dam^3, a maximum depth of 19.8 m and is located in the Kaskaskia River Basin. The Shellbyville Reservoir is a considerably larger reservoir than the Shellmouth. However, both reservoirs are located in a prairie agricultural area and constructed around the same time.

This reservoir has also been the focus of interest group conflicts, in many cases split between downstream benefactors of the project and upstream residents concerned particularly with local social and economic impacts. The Shelbyville Reservoir was extensively studied over a four year period in the late 1970s by the University of Illinois at the State's request. The State of Illinois felt certain impacts were given inadequate attention in the predevelopment planning stages and requested an *ex-post* reservoir evaluation study to provide information to policy makers for future decisions about similar projects (Burdge and Opryszek 1981).

CHAPTER 3: REVIEW OF LOCAL IMPACTS

3.0 LOCAL IMPACTS

To conduct an *ex-post* development review of the local impacts of the Shellmouth Reservoir, a review of the project impacts is needed. This will not be a basin-wide review of impacts, but rather will concentrate on the local area[7] since this has been the focus of the ongoing complaints about the project. This *ex-post* development review of local positive and negative impacts allows for a comparison of those local costs and benefits predicted in the original CBA, with those that have transpired since the project's construction.

3.1 GENERAL CHANGES IMPOSED BY RESERVOIRS

Transforming a section of a river into a reservoir introduces fundamental changes to the hydrology and ecology of the basin. The exact nature of these changes is subject to the particular physical environmental characteristics of the river section and the overall basin, as well as the reservoir design and operating regime. These changes are in turn likely to affect people's relationship with the river, altering in some way the stream of benefits and costs they receive from the resource. The changes imposed by the reservoir will vary at different spatial and temporal scales. Those experienced at the reservoir site may differ from changes occurring 100 km downstream. In a similar manner, impacts appearing

[7] The local area, for the purposes of this study is the Manitoba RMs of Shellmouth, Russell and Shell River and Saskatchewan RMs of Cote and Calder. The residents, business people, and elected municipal officials of the RMs and the towns within these boundaries are considered the local stakeholders.

during construction or in the period just following are likely to differ in some way from those occurring 20 years later.

There are a number of general changes that occur with the development and operation of a reservoir that will generate a variety of positive and negative impacts depending on the individual case. The changes manifest themselves as positive or negative, environmental and/or socio-economic impacts.

Transforming the river into a lake creates a number of changes at the local scale: the reservoir and the river reach immediately upstream and downstream of the reservoir. These are sudden and often dramatic changes to the existing environment that create unstable and transient conditions initially, followed by somewhat more long-lasting changes. The nature of these changes is determined to a large degree by the design and operating regime of the dam (Ackermann et al 1973). For prairie reservoirs in general, the changes experienced by the area surrounding the reservoir include those occurring at:

- the reservoir site as a result of filling of the reservoir and altering the water levels in the reservoir;
- just downstream of the reservoir resulting from the release of water and changes to ground water; and
- just upstream of the reservoir resulting from changes to the velocity of flows entering the reservoir and ground water levels.

Potential Impacts at the Reservoir

The initial filling of a reservoir promotes a number of environmental and socio-economic changes. The physical changes experienced often have ramifications for the aquatic and terrestrial ecology of the local area and to a lesser degree, for the overall basin.

There are a number of potential modifications to the aquatic environment at the reservoir site:

- alterations in water temperature: affect the developmental signals for aquatic biota such as altering spawning times for fish
- negative water quality changes: high nutrient loading leading to excessive algae growth, release of methylmercury from sediments and vegetation, catch basin for agricultural and industrial chemicals carried in the water column from upstream
- bank erosion: negatively affects development of the littoral zone and adds nutrients to the reservoir
- sedimentation: may negatively impact habitat for bottom species, may deposit pollutants and carry excessive nutrients, may reduce storage capacity of the reservoir

Terrestrial impacts include loss of riparian areas and prime habitat for a wide range of terrestrial species.

Filling of the reservoir may also create social and economic impacts. The local area may benefit from a local water supply that could not be supplied by natural river flows, as well as recreation, tourism, and/or vacation property development opportunities offered by the project. However, there can also be negative consequences with the loss of traditional land use at the site of the reservoir and the associated loss of tax base. Changes to the social fabric of the community can also occur because of the physical constraint of the reservoir and departure of former property owners from the community.

Impacts Directly Downstream of the Reservoir

Changes affecting the local area surrounding prairie reservoirs that occur as a result of creating the reservoir, also impact the river reach directly downstream of the dam. These impacts vary with the individual basin, but ultimately stem from changes in the hydrology imposed by the development and operation of the dam. These changes downstream may include altered water supply and/or timing of flows as a result of operation of the reservoir for hydroelectric power, irrigation, domestic and industrial water supply, dilution of pollutants, instream flow augmentation, and/or flood control (Takeuchi et al 1998).

The nature of these changes is conditional on the reservoir's operating regime, which in turn is dependent upon the reservoir's purpose(s). Different operating regimes alter downstream hydrology in various ways, with environmental and land use implications for the area just downstream of the dam. The nature and degree of effect of the operating regime on the downstream aquatic ecosystem are functions of both the impact on the hydrology and the particular ecological and physical characteristics of the watershed in question.

If the priority operation of the dam is to provide benefits far downstream, due to the time required for water to travel, water released from the reservoir will be timed to coincide with downstream needs that may be two or three weeks down the road. This can occur at an inopportune time for the ecosystem, and for property owners such as agricultural producers just downstream of the dam site who experience the change in flow immediately. For example, in acting to reduce the flood peak by storing runoff in the reservoir and thereby flooding downstream, the duration of high water levels may be elongated for those properties just downstream of the dam. This can create damages by killing permanent vegetation, eroding riverbanks, and interfering with agricultural activities. Changing the temporal redistribution of water flow in order to supply water downstream can also negatively affect aquatic species if manipulated releases do not coincide with species needs, such as providing adequate flow during the spawning season. Conversely, controlled releases can guarantee minimum flows that improve aquatic habitat for a wide range of species.

Upstream of the Reservoir

A reservoir can also create changes in the local ground water table, and the particulars will vary with each individual river basin. The exact nature of these changes will be a function of the existing ground water table and the geological conditions, as well as the water level of the reservoir. Impacts will also vary in each case, but may include raising the water table with implications for agricultural production and erosion processes both upstream of the reservoir and immediately downstream of the dam.

3.2 SUMMARY OF LOCAL RESERVOIR IMPACTS

Reservoirs in general affect the interaction of communities and individuals with the river, including the distribution of positive and negative impacts received from the river basin, as well as creating new positive and negative effects. This change is a function of the reservoir, the operating regime, and the physical/environmental particulars of the basin as well as the pattern of land use and development existing in the affected areas of the basin.

The typical changes described above, which may occur with the development of any reservoir, are responsible for a number of positive and negative impacts on the aquatic and terrestrial environment, as well as on existing social and economic conditions. These impacts include physical alterations to the land surrounding the reservoir and downstream basin in terms of bank areas, water table, vegetation, and wildlife habitat. They also impact water quality and aquatic biota, as well as alter land uses and socio-economic and social relationships within the basin.

3.3 EFFECTS OF THE SHELLMOUTH RESERVOIR

The changes created in the lower Assiniboine Basin are not explored in depth in this study. One reason for this is that concerns about the operation of the Shellmouth have not been forthcoming from downstream constituents, and the assumption has been made that the reservoir has not created undue impacts. A cursory review confirmed that while there may be the occasional environmental issue, in general the feeling is that the lower basin has received numerous benefits from the reservoir. These benefits to the lower reaches of the basin include increased flow during periods of low river levels, which has translated into improved water quality. It has also meant a more reliable supply for irrigators, industrial users and municipal users, as well as decreases in flood peaks, particularly for the City of Winnipeg (ARMAB 1995).

In contrast, the local area has expressed concerns about the development and ongoing operation of the project. Environmental and socio-economic impacts experienced by the local area stem from the development of the project and the operation for downstream flood control and water supply.

This section provides an abridged review of the effects of the project on the local study area. A comprehensive assessment of local impacts resulting from the Shellmouth project was not conducted for this study. Considerable difficulties were encountered in identifying and measuring the magnitude of a number of the local environmental and socio-economic impacts. This is because there is a general lack of documented baseline information and continuous post-development data available that discusses specific impacts and comprehensive study of the environmental and/or socio-economic effects of the project has not been undertaken. Some periodic studies on environmental conditions were published over the years, however, these are specific to one area of concern, such as algae growth. Data is also generally limited to a narrow time frame that does not correspond to the life span of the project.

There were also significant limitations with the key person interviews conducted for this study and as a result only a small sample was undertaken. This was due, in part, to difficulties in locating individuals who were sufficiently familiar with the wide range of project impacts that have occurred throughout the project's life span. In addition, the quality of data generated from key person interviews was hampered by the 30-years that have passed since development of the reservoir. In particular, impacts that occurred leading up to, during, and in the ten years following construction, were difficult to characterize.

A synopsis of local environmental effects that have been attributed to or may have occurred in the case of the Shellmouth project, are outlined below in Tables 3.1, 3.2, and 3.3. Past or ongoing socio-economic effects that have been attributed to the Shellmouth project by residents of the local area or otherwise identified are outlined in Tables 3.4, 3.5, 3.6, and 3.7. A more complete review of specific environmental and socio-economic effects that are known or are anticipated to have occurred in the case of the Shellmouth Reservoir are located in Appendices 4 and 5 respectively.

3.4 ENVIRONMENTAL IMPACTS

While a complete study of environmental impacts is not available, there have been a number of short term studies conducted on specific aspects of the environmental conditions at the reservoir including:

- nutrient loading and excessive algae growth (Fortin and Gurney 1997; Gurney and Fortin 1992; Moening and Lakatos 1976)
- fish kills (Natural Resources Creel Reports)
- significant bank erosion in specific locations (L.A. Penner, J.D. Mollard & Assoc. Ltd. June 1993a; L.A. Penner, J.D. Mollard & Assoc. Ltd. 1991)
- pollutants (PPWB 1995; Macibroda Engineering 1994)
- methylmercury (Green and Beck 1995).

In some cases, environmental impacts were noted in the key person interviews, but no studies were available to confirm the findings. In other instances, impacts that have been found to occur with regular frequency with other reservoir projects were noted. Local environmental impacts resulting from the Shellmouth project are summarized under the headings physical impact, water quality; and biotic impacts in sections: 3.4.1; 3.4.2; and 3.4.3. These impacts are discussed in greater depth in Appendix 5.

3.4.1 Physical Impacts

A number of physical impacts occurred as a result of the dam construction and flooding of the valley (the reservoir). Physical impacts in turn influence other environmental impacts such as water quality, aquatic biota and in some cases, socio-economic conditions. These impacts are summarized below in Table 3.1 and include bank erosion, which affects both the reservoir and the river just downstream of the dam. Sedimentation and evaporation affect the storage capacity of the reservoir, but are relatively minor impacts in the case of the Shellmouth (Bowering pers. comm. 1999). Sedimentation however, has created a delta at the head of the reservoir. Other physical changes are a function of water inflow and outflow from the reservoir. These include distinct stratified water levels in the reservoir that do not mix well, which then leads to water quality problems that may be responsible for fish kills. Table 3.1 provides a summary of these impacts and the location of further information in the Appendix 5.

Table 3.1
Physical Impacts Attributed to the Shellmouth Reservoir

PHYSICAL IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Erosion of reservoir shoreline	Affects land use of immediate surroundings Impacts water quality	- Wind and wave action especially during drawdown	Appendix 5, section 1.1.4
Erosion of river channel just downstream of the dam	Reduces adjacent field sizes	- Sediment-free water below dam has an increased capacity to gauge out bottom and erode sides of river channel	Appendix 5, section 3.0
Increased sedimentation - relatively slow process for the Shellmouth	Over time, sedimentation will reduce available storage area	- Dam causes the flow of water to slow and to deposit fine-textured sediments in reservoir	Appendix 5, section 2.1
Sedimentation of Assiniboine entering reservoir and formation of in-stream islets/delta	Creation of an upstream delta which changes the upstream hydrology and can impact groundwater levels	- As a consequence of river valley inundation, flow in tributaries is slowed and sedimentation occurs	Appendix 5, section 2.1
Effects of flow level and reservoir on groundwater	Raises groundwater table upstream and downstream of reservoir	- Reservoir acts as a recharge area for aquifers below river valley and affects quantity of groundwater downstream	Appendix 5, sections 3.0, 4.0
Evaporation from reservoir surface - minor	Slight reduction in stored water	- Solar radiation and dry winds may cause evaporation losses	Appendix 5, section 2.2
Stratification of water	May decrease water quality (DO) and negatively affect aquatic biota	- Circulation within reservoir is controlled by inflow and outflow which create density gradients	Appendix 5, section 2.3
Renewal time for surface water is faster than for deeper strata	Reduces DO and may contribute to build-up of toxins in lower strata - negatively impacts water quality and aquatic biota	- Surface water is usually warmer and less dense than in- or outflowing waters limiting the mixing between the strata	Appendix 5, section 2.4.3

Source: key person interviews outlined in Appendix 3 and environmental impacts identified in Appendix 5. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.4.2 Water Quality

While the project created a highly productive fishery, degraded water quality, in terms of dissolved oxygen (DO) and the potential toxin build-up from decomposing nutrients in the lower strata, has affected the long-term health of certain fish species and other aquatic biota. Compromised water quality also serves to destabilize the reservoir's aquatic ecosystem creating significant fluctuations in species numbers and composition (Kansas pers. comm. 1997). In addition, mercury build-up in the food chain has served to compromise the health of predator species higher up the food chain (Green and Beck 1995). The water quality impacts are identified and characterized, and causitive agent outlined in Table 3.2. Location of a further description of the impact in Appendix 5 is also noted.

Table 3.2
Water Quality Impacts Attributed to the Shellmouth Reservoir

WATER QUALITY IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Other chemical contaminants impair water quality in reservoir	May affect the health of aquatic biota particularly bottom fauna	- Previous land uses, e.g., use of persistent agricultural pesticides can have long-term effects on water quality - May build-up in the ecosystem	Appendix 5, section 2.4.1
Excess dissolved nutrients stimulates algae blooms which may produce eutrophication (low DO levels)	Reduces health or may cause mortality in fish and other aquatic biota	- Decomposition of flooded organic matter (vegetation and topsoil) - Fertilizer runoff or manure leaching into the reservoir may impair water quality through released nitrate or phosphate	Appendix 5, section 2.4.2
Chemical compounds in reservoir waters from decomposing blue-green algae and nutrients	May affect the health of aquatic biota	- Anoxic water in deepest part of reservoir because of toxic compounds: ammonia, hydrogen sulfide and methane produced during nutrient decomposition and toxins from blue-green algae decomposition	Appendix 5, section 2.4.2
Oxygen depletion in deeper parts of reservoir during winter	Reduces health of and may cause mortality in fish and other aquatic biota	- Decomposition of flooded vegetation - Little mixing of water with higher DO in other strata	Appendix 5, section 2.4.3
Build-up of methylmercury in reservoir aquatic biota	May affect the health of those species higher up the food chain such as waterfowl feeding on aquatic biota (particularly predator fish)	- Bacterial decomposition of flooded organic matter (vegetation and topsoil) produces soluble methylmercury which enters the food chain	Appendix 5, section 2.4.4

Source: key person interviews outlined in Appendix 3 and environmental impacts identified in Appendix 5. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.4.3 Biota

The health of the ecosystem is intrinsically linked to both the operation of the reservoir and the water quality in the reservoir. The significant fluctuations in the sports fishery populations, regular algae blooms, and the bio-accumulation of mercury indicates that the ecosystem is not stable. Table 3.3 highlights the significant biotic impacts for the Shellmouth Reservoir.

Table 3.3
Biotic Impacts Attributed to the Shellmouth Reservoir

BIOTIC IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Sedimentation	Potential negative health impacts for bottom fauna	- Pollutants carried with sediments - Sedimentation destroys habitats	Appendix 5 section 2.1
Excessive growth of plankton and algae	Affects quality of aquatic ecosystem	- Decreased flow rates and increased supply of nutrients	Appendix 5, section 2.4.2
Reduced or delayed development of littoral vegetation	Loss or change in wildlife habitat within flooded area - negatively affects some aquatic species and waterfowl production.	- Repeated water fluctuations destroy emergent and shoreline vegetation (littoral zone) reducing aquatic habitat, nesting cover and negatively impacts food supplies	Appendix 5, section 2.5
Loss of riparian vegetation in reservoir area	Reduced habitat of wildlife - ungulates, fur-bearers, birds	- Vegetation in and around the reservoir area is destroyed as reservoir is filled	Appendix 5, section 2.5
Loss of spawning habitat for fish	Negatively affects various fish species and can lead to abnormal fluctuations in fish populations	- Spawning grounds of river fish species within reservoir are destroyed through flooding and drawdowns	Appendix 5, section 2.5, 4.0
Bioaccumulation of mercury in fish, other aquatic species, and others such as waterfowl	Reduces health of species throughout the food chain	- Methylization of mercury as a consequence of decomposing plant material within the reservoir	Appendix 5, section 2.4.4

Source: key person interviews outlined in Appendix 3 and environmental impacts identified in Appendix 5. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.5 SOCIO-ECONOMIC IMPACTS

Social impacts are often overlooked, primarily because they tend to be difficult to assess, measure and quantify. They also evolve over time, changing over the life span of the project and affecting different stakeholders in various ways. Economic impacts of development are more notable and generally much easier to quantify, but at the local level, economic impacts of reservoirs like the Shellmouth may not be studied because they are not significant in relation to the larger regional perspective.

Social and economic impacts attributed to the Shellmouth project and experienced at the local level have not been formally studied in the past. Information regarding these impacts was distilled from public consultation sessions held by ARMAB in 1995, documentation of public consultation sessions by PFRA in 1978 (Barber 1978), key person interviews conducted in 1996 and 1997 of this study, and Statistics Canada information. Research into socio-economic impacts noted in case studies on other reservoir projects helped provide background information including the characterization of possible impacts experienced as a result of the Shellmouth project.

Four general categories of socio-economic impacts were identified for the Shellmouth project: property acquisition impacts, social-health effects, environmental impacts/socio-economic consequences; and economic development impacts. These are outlined in sections: 3.5.1; 3.5.2; 3.5.3 and 3.5.4 and intergenerational impacts are discussed in section 3.5.5. In each section, a table summarizes and characterizes the individual impacts and the causal agents. In addition, the location for a more detailed description of each impact in Appendix 4 is provided.

3.5.1 Property Acquisition Impacts

The purchase of privately owned agricultural land by the Crown for the project or Asessippi Park created a string of interrelated impacts in the Shellmouth local area, the majority of which were identified by local landowners and municipal representatives in the key person interviews conducted for this study. The removal of productive farmland affected not only the individual farmer, but also the entire municipality community. The market price provided for purchased property did not consider replacement costs or a number of other transaction costs, such as looking for new property, which is particularly important for displaced farmers.

In addition, reducing the supply of farmland is believed to have raised local purchase or lease prices of available land, which was not factored into the original market price. The compensation package offered to landowners whose land was purchased by the Crown also did not provide any remedy for long-term operational cost increases, which some individuals claim to have incurred. In some cases, higher operational costs from changes such as increased travel distance to fields and a less sustainable farming operation in terms of crop diversity, has been noted by some farm operations. The municipal tax base has also been affected through a reduction in tax base. Generally speaking, Crown land is not subject to taxation and thus the municipal tax revenue is reduced without any corresponding reduction in expenses. The implications are that an individual taxpayer in the RMs of Shellmouth and Shell River in Manitoba and to a lesser degree Cote and Calder in Saskatchewan, has paid higher taxes to compensate for lost revenue. While there is little information available, the purchase of farmland was likely to have strongly influenced those displaced from the area, who not only incurred monetary costs, but were also separated from their community. A description of impacts stemming from property acquisition for the Shellmouth Reservoir are summarized in Table 3.4.

Table 3.4
Property Acquisition Impacts Attributed to the Shellmouth Reservoir

PROPERTY ACQUISITION IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Reduction in supply of local agricultural land	- Reduces supply and raises purchase and lease prices for available properties - Reduces agricultural output from the local area	-Flooding productive hay and cultivated land for reservoir	Appendix 4, section 2.4
Reduced tax base for municipalities, reduced tax revenues	- Increased municipal service costs per tax payer - Raises taxes for individual tax-payers	-Crown does not pay municipal taxes on flooded lands, park lands -Crown provides grants in lieu of taxes for leased lands	Appendix 4, section 2.2
Inconsistent prices	- Individuals feel they are not treated fairly, criticize lack of process transparency	-Government land agents secure best price -Market price does not reflect real value of property to the farm operation	Appendix 4, section 2.4
Purchase of reservoir property at market prices verses full cost of replacement	- Does not cover real costs: transaction costs (looking for new property) and long-term operational costs - Does not reflect real value of property to the farm operation	-Expropriation Act requires only that fair market value be paid	Appendix 4, section 2.4
Less sustainable farm operation	- Extra travel costs to reach new property, purchase fodder for cattle instead of growing own	-Changes that increase long-term operational costs	Appendix 4, section 2.4, 2.5

Source: key person interviews outlined in Appendix 3 and socio-economic impacts identified in Appendix 4. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.5.2 Social-Health Effects

Social impacts are often overlooked, primarily because they tend to be difficult to assess, measure and quantify. More so than other impacts, they also have a tendency to evolve over time, changing during the life span of the project and affecting different stakeholders in various ways. There are two general types of social impacts: those affecting the communities at large and those impacting a specific stakeholder group. The community at large has been affected by non-compensated municipal costs, disruptions to traditional community patterns of commerce and social activity, and interference with the local social network, which may have reduced overall community resilience. The impact on the social network is likely to have dissipated over time, as individuals adjust to the development of the reservoir.

From the key person interviews conducted for this study and the review of the Lake Shelbyville reservoir *ex-post* development study, it is believed that individual stakeholders would have incurred significant stress during the initial development of the project, particularly from displacement and relocation impacts. Stress and anxiety, while likely to have dropped since the initial proposal and construction, has been ongoing for various members of the community and include concerns regarding dam failure and potential health risk (low) from contaminated fish. Significant stress levels have been associated with attempts to secure mitigation or compensation for perceived reservoir related impacts, such as upsteam backflooding of farmland, and flooding and high groundwater levels just downstream of the reservoir. Frustration levels were notably high among some current and former local municipal representatives in their attempts to deal with provincial and federal bureaucrats on compensation, operational issues, and backflooding impacts (key person interviews 1996, 1997; ARMAB public consultation

1995). Social-health impacts attributed the Shellmouth Reservoir are summarized in Table 3.5.

Table 3.5
Social-Health Impacts Attributed to the Shellmouth Reservoir

SOCIO-HEALTH IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Non-compensated municipal costs	- RMs have spent significant administrative and political resources to secure compensation and resolve specific issues - Elected representatives - stress and frustration	- Unfulfilled development expectations - Unanticipated costs arising after the project was completed - Dealing with government bureaucracy	Appendix 4, section 3.1
Community patterns disrupted	- Changes location of goods and services purchases, schools attended (some towns benefit like Russell, while other towns like Dropmore suffer) - Social activities/community interaction disrupted	- Physical barrier of reservoir separating community particularly for the RMs of Shellmouth and Shell River -	Appendix 4, section 3.2
Disruption of community social network	- Reduced resilience of the community	- Reservoir acting as a barrier - Friends and family leaving community	Appendix 4, section 3.2
Displacement and relocation of area residents (figures not available)	- Reduced household happiness - Removed from social support network - Lifestyle changes - Reduced quality of life	- Separation from family and friends - Financial strains of moving and reestablishment - Relocation to other communities	Appendix 4, section 3.3
Accident risk	- Health and safety concerns of those working just below dam	- Dam failure	Appendix 4, section 3.4
Contaminated fish (low risk)	- Reduced tourism value of fishery - Cannot consume fish over slot limit because of mercury levels	- Potential for bioaccumulation of mercury, heavy metals or pesticides in fish can be potentially hazardous to human health	Appendix 4, section 3.4 Appendix 5 section 2.4.4
Stress, anxiety, frustration	- Anxiety during planning and development of project, property acquisition, compensation negotiations - Frustration in dealing with bureaucracy to secure mitigation or compensation for impacts	- The result of uncertainty during planning stage and change imposed on the community from outside forces - Trying to obtain compensation/ mitigation for perceived reservoir related impacts	Appendix 4, section 3.4
Disruptions to community life	-Aesthetic impacts of dam construction	- Construction activities: noise, traffic, dirt, vegetation removal	Appendix 4, section 3.5

Source: key person interviews outlined in Appendix 3 and socio-economic impacts identified in Appendix 4. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.5.3 Environmental Impacts/Socio-economic Consequences

Environmental conditions can create direct or indirect socio-economic consequences. For example, water quality conditions such as algae blooms and turbidity have attributed to inhibiting recreation use and vacation property development in and around the Shellmouth. Degraded overall water quality is believed to have compromised the success of the sports fishery (key person interviews 1996, 1997; Kansas pers. comm. 1997). Some residents of the local area believe environmental impacts have reduced recreation, tourism, and vacation/cottage development opportunities (key person interviews 1996, 1997; ARMAB 1995). Table 3.6 outlines environmental impacts with socio-economic consequences that have been attributed to the Shellmouth Reservoir.

Table 3.6
Environmental Impacts with Socio-economic Consequences Attributed to the Shellmouth Reservoir

ENVIRONMENTAL IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Backflooding upstream of reservoir	Delays crop seeding which can subject the crop to frost May increase yields in dry years.	- High inflows coupled with high reservoir levels from holding back floodwaters	Appendix 4, section 4.1 Appendix 5 section 4.0
Downstream flooding in spillway catchment area and long periods of high water levels just downstream of the dam increase surrounding water table	Delays crop seeding which can subject the crop to frost and increases bank erosion May increase yields in dry years.	- Releasing water at inappropriate times to provide downstream water supply or accommodate high inflows from the Upper Assiniboine and Shell Rivers. - Lower flood peaks, but longer duration of high water	Appendix 4, section 4.2 Appendix 5 section 3.0
Dramatic reduction in the reservoir sports fishery (walleye) after initial 15 years	Reduced visitor numbers Reduced tourism spin-off benefits	- Degraded water quality - Operation of the reservoir in a manner not favourable to the fishery	Appendix 4, section 4.3
Fluctuating water levels and erosion	Aesthetic impacts of reservoir operation	- Flooded trees and exposed mudflats during drawdowns - Negative visual impacts of erosion and drawdowns - Erosion rates inhibits potential for vacation property development	Appendix 4, section 4.4
Algae blooms	Reduces the desirability and safety of using the reservoir during summer for recreation activities	- Excessive nutrient loading from decomposition of flooded organic matter - Fertilizer runoff or manure leaching into the reservoir	Appendix 4, section 4.5

Source: key person interviews outlined in Appendix 3 and socio-economic impacts identified in Appendix 4. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.5.4 Economic Development Impacts

One of the anticipated benefits of many large-scale public sector projects is economic growth for the local region. These benefits are often presented as compensation for the local costs the project will create. Unfortunately, the anticipated benefits may have a number of limitations when considered in relation to their costs (Leistritz and Murdock 1986). First of all, predicted benefits may not actually transpire or the net impact may be less than anticipated. Secondly, benefits accruing to the local area have been found to be inconsistent in their spatial, social, and temporal distribution. The distribution of benefits and costs is not likely to be uniform across the region or between individuals, and those incurring costs may not be the recipients of the project's benefits. Economic development benefits also have a tendency to fluctuate over the course of the project's lifetime. It is not uncommon for the local area to incur project costs immediately, but not see benefits such as tourism development for many years, even decades.

With respect to the Shellmouth project, significant economic development in the form of recreation and tourism was projected by the province for the local region. Many of these predicted benefits are documented in the land use study (McKay et al 1969), Preliminary Plan Asessippi Provincial Park (Parks Branch 1967), and Outdoor Recreation Master Plan (Provisional) Asessippi Provincial Park (Parks Branch 1973) and are described in Appendix 4 section 5.7. According to the key person interviews (1996, 1997) and a review of the existing development, these projected benefits either did not actually arise or were significantly delayed. The reservoir land use study completed in 1969 (McKay et al) anticipated vacation property subdivisions, campgrounds, beaches, a marina, boat launch, golf courses, picnic areas, a ski-toboggan hill, and commercial complexes (hotel and marina) for the area around the dam (Appendix 4, figure 1). The local area anticipated that this kind of development would offset lost tax revenue for agricultural properties acquired by the Crown. However, little of this anticipated development has actually been achieved to date. While two campgrounds have been operational for a number of years, only recently has a cottage resort been developed at the southwest end of the reservoir.

Asessippi Park, located at the south end of the reservoir at the dam site, was developed shortly after the Shellmouth project to stimulate recreation use of the reservoir. What actually was constructed was more conservative than originally proposed (Appendix 4, figure 2). The reconstruction of Asessippi village, proposed as a tourist attraction, was scheduled for development in a later phase. However, as noted in the key person interviews in 1996 and 1997, this project was never undertaken, and the original proposal for a ski chalet (Appendix 4, figure 2) was not included in the later park plan (Appendix 4, figure 3). Government funding for the ski development at Asessippi Park was only recently secured after intense lobbying by local stakeholders, and is scheduled to open for the winter of 1999-2000 (key person interviews 1996, 1997; Green Spaces Environmental Consulting 1994). Local vacation property development benefits from the project are only now beginning to arise, many years after local costs have been incurred.

Benefits in terms of business development have not been evenly distributed throughout the study area. The RMs of Shellmouth, Shell River, Cote and Calder, which have incurred the majority of significant costs including lost tax base, have not been able to capitalize on the visitor traffic to the reservoir in any significant way. The Town of Russell, which has incurred minimal negative impacts as a result of the project, has been able to capitalize on the project by providing visitor services (ARMAB public consultation 1995). It is a widely held opinion of the local area that Russell's businesses; bait and tackle shop, food, gas and accommodation have captured the majority of visitor spending in the area (key person interviews 1996, 1997; ARMAB 1995).

The distribution of benefits and costs has not been uniform, with the agricultural sector seeing a reduction in activity due to the loss in local agricultural productivity from the reduction in agricultural properties (over 9,000 ha). In contrast, the service sectors related to tourism and recreation have experienced growth, due in part to the development of the reservoir. Whether the service sector gains, in relation to the lost agricultural productivity, create similar or greater multiplier effects in the study area is difficult to assess, but since service sector employment tends to low paying, this is not likely. Table 3.7 provides a summary of the economic development impacts attributed to the Shellmouth.

Table 3.7
Economic Development Attributed to the Shellmouth Reservoir

ECONOMIC DEVELOPMENT IMPACTS	CHARACTERIZATION	CAUSATIVE AGENTS	LOCATION OF DESCRIPTION
Construction related employment and business sales	Local employment, sale of construction supplies and services to workers and contractors	-Influx of workers to the area -need for workers - local -supply and service needs of contractors and workers	Appendix 4, section 5.0
Reduced development opportunities near reservoir in relation to local expectations	Less that anticipated vacation property development and other recreation/tourism development	-Recreation and tourism development takes time to evolve -Requires planning and infrastructure investment -Negative aesthetic qualities of reervoir reduce attractiveness for development	Appendix 4, section 5.0
Development costs for municipalities	Increased administrative/ maintenance costs - road maintenance, transportation costs Changes goods and services purchasing patterns	-Uncompensated municipal costs stemming from reservoir development -Loss of future economic benefits from flooded land	Appendix 4, section 5.1
Business development spin-offs	Business developing to fulfil needs of recreation users and tourists	-The development of the reservoir and facilities to support recreation and tourism opportunities (Asessippi Park) camping supplies, tackle, gas, restaurants etc.	Appendix 4, section 5.2
Employment and income impacts	Some shift in employment sector from agriculture to service sector (low wage)	-Loss of agricultural production in the area and implications for employment in the service sector	Appendix 4, section 5.3
Recreation and tourism opportunities	Water based activities, sports fishing, camping, horse stables, cross-country skiing, snowmobiling	-The development of the reservoir and facilities to support recreation and tourism opportunities -Maximum benefits not achieved because reservoir not operated primarily for recreation	Appendix 4, section 5.6
Vacation property development	Resort properties and spin-off development of business to provide services.	-The development of the reservoir creates recreation opportunities -Aesthetic value of man-made lake -Maximum benefits not achieved because reservoir is not operated primarily for recreation	Appendix 4, section 5.4, 5.6, 5.7

Source: key person interviews outlined in Appendix 3 and socio-economic impacts identified in Appendix 4. Format adapted from M. Sadar and H. Dirschl. 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. pp. 41-57.

3.5.5 Other Impacts

The other critical type of impact on the local area will be future socio-economic effects, including those stemming from environmental impacts of the project. These effects will be a function of the project's life span and how future generations choose to respond to the project. However future generations approach the project, they will be faced with project costs, such as the need to retrofit and/or remove the existing dam, which otherwise would not have occurred if river had been left in its natural condition. One other possibility currently being considered are alterations to the dam structure that would create more reservoir storage and effectively increase the reservoir size (PFRA and Water Resources 1992). Future changes will have social, economic and environmental impacts at the local level that will likely have both positive and negative implications for the area.

3.6 CONCLUSIONS

Time and budget did not permit a comprehensive study of local impacts arising directly and indirectly from this project. However, what has been outlined are those impacts that have been documented in published reports or otherwise attributed to the project by local stakeholders and/or government representatives. The variety of positive and negative environmental and socio-economic impacts of this project on the local area are compared with those included in the formal Shellmouth Reservoir CBA in Chapter 5.

CHAPTER 4: COST-BENEFIT ANALYSIS - THE PROCESS AND ISSUES

4.0 INTRODUCTION

Cost-benefit analysis (CBA) is used as a means of assessing the allocation of public fiscal resources among alternative investment options, including various programs or projects (Sewel et al 1961). It was first used in the United States in the 1930s[8] to evaluate water development projects undertaken by the U.S. Army Corps of Engineers (Field and Olewiler 1994). It is still widely used today and is now generally considered a required component in the analysis of public projects, including water works projects such as reservoirs. The goal of CBA is to determine the efficient allocation of resources among competing alternative expenditures, in a manner that furthers public economic and social objectives (Treasury Board Secretariat 1976). CBA provides a logical framework for collecting, analyzing, and interpreting information and thus has become a standard component of the investigation process proceeding large-scale natural resource projects (James 1994). In its capacity as a planning tool, CBA offers a means of integrating the management of resources and public sector development goals by providing a structured framework for reaching balanced decisions on development and the use of natural resources (James 1994). As a planning tool, CBA should ideally also help identify aspects of a development that may require further program, policy, or infrastructure responses such as distributional inequities experienced by specific groups.

[8] CBA became a requirement of the U.S. Flood Control Act of June 22,1936.

CBA is a technique that is generally employed to evaluate and rank public investment projects to determine how public funds should be invested (Mishan 1972; Perman, Ma and McGilvray 1996). Costs and benefits of possible projects are identified, valued, and compared. The project producing the greatest amount of benefits in relation to costs, provided that the total benefits exceed total costs, is categorized as the preferred alternative (Treasury Board Secretariat 1976; Mishan 1972; Zerbe and Dively 1994).

4.1 CBA BASIC MECHANICS

CBA compares alternative projects/policies by calculating the total societal costs and benefits associated with a particular project to determine what net benefit the project will provide (Pass, Lowes and Davies 1988). The net costs and benefits are compared as either a ratio of benefits to costs or as differences between benefits and costs. A value greater than one for the benefit-cost ratio or a positive value for the analysis of net benefits (benefit minus costs) means that the project will provide society with a net social benefit (Szonyi et al 1989). By evaluating the relative merits of alternative public investment projects, CBA identifies the most efficient project(s) and ensures that the net social benefit derived from public expenditures is maximized (Mishan 1972). Efficiency is the underlying criterion on which CBA has traditionally been based. This concept and its implications are discussed in greater detail in section 4.2.3-a on evaluation/appraisal criteria.

CBA is not unlike financial analysis conducted by private firms. However, the analysis conducted on public projects considers costs and benefits in broader terms than does the private firm. Public sector assessment entails adjusting conventional private sector profitability analysis to reflect specific social objectives (Planning Branch, Treasury Board Secretariat 1976).[9] The private firm conducts profit-loss calculations to determine if proposed private sector investment outweighs private costs. In contrast, the public sector assesses whether the social benefits from public sector activity outweigh total costs to society (Anderson and Settle 1977).

4.1.1 CBA Criterion

It is necessary to have a criterion that provides a framework from which to judge and rank public expenditures. CBA has traditionally derived that criterion from its theoretical underpinnings in welfare economics. This criterion is efficiency, or more specifically, Pareto efficiency (Hettich 1971). In relation to CBA, efficiency is essentially about maximizing social welfare by allocating public resources to maximize benefits and minimize costs. Choices between various resource allocations are made based on which

[9] The private firm usually restricts its cost analysis to capital expenditures, labour, and financing. In contrast, public project analysis focuses on the opportunity cost or the value foregone by not being able to use the resource for other activities. The private and public sector analyses also differ in their consideration of benefits. The private firm focuses on a narrow range of benefits, specifically related to generated revenue, while the public sector analysis substitutes revenue for the less precisely defined concept of social benefit (Mishan 1972). Unlike the private sector which tends to focus on a short time frame, the public sector analysis is characterized by the consideration of costs and benefits in terms of years: analysis over a twenty year period or longer is not unusual (Layard and Glaister 1994). Public sector analysis considers projects in extensive long-term perspectives of the costs and benefits to society (Pass, Lowes and Davies 1988).

choice maximizes the return on social investment. The importance of the appraisal criterion is discussed in more detail in section 4.2.3-a.

4.1.2 CBA Process

Bojö et al (1990) and Szonyi et al (1989) have identified the following basic steps for conducting a traditional cost-benefit analysis.

i. Decide which development options are to be analyzed for costs and benefits.

Upon definition of a problem or desired outcome, a number of alternate solutions are devised. These solutions or projects are reviewed for their feasibility, often in terms of technical workability. Those perceived as feasible become a set of alternative projects to be reviewed from an economic net benefit stand point. A "do nothing/status quo" alternative should be included.

ii. Define the accounting stance

The accounting stance determines the context in which costs and benefits are identified and analyzed: local, regional, national, and so on. It is generally accepted that the accounting stance should be the smallest area of concern that takes into consideration all of the significant benefits and costs. Confining the CBA to the smallest area of concern minimizes the level of analysis required, and thus the time and financial outlay necessary. However, the choice of the accounting stance can also be influenced by who is paying for the project. While this is likely to be the level of government planning the proposed project, the accounting stance chosen will reflect their primary interest: the impacts the project will have on their constituency

(Anderson and Settle 1977). If the accounting stance is municipal, then only those costs and benefits that accrue locally will be considered in the analysis, and those occurring outside of the jurisdiction will likely be ignored.

iii. Discounting - using the real social rate of discount

A project generates costs and benefits over a period of time. Individual costs and benefits that occur in different time periods cannot be directly compared to one another, due to the inflationary forces that affect actual value. Therefore, to compare those occurring in different years, all costs and benefits are adjusted to reflect values in one time period, usually the initial year of the project. This allows for valid comparison of costs and benefits that accrue in different time periods.

Discounting is the method for adjusting these values to one point in time. There are two popular choices of which discount rate to use to convert future costs and benefits to present values: social opportunity cost and the rate of social time preference. The social opportunity cost is based upon consumer preferences for consumption today versus tomorrow, as measured by investor returns such as risk-free bonds. The social time preference rate approach bases the discount rate on per capita income growth in relation to diminishing utility of increases in marginal income (Bojö et al 1990).

iv. Define the time horizon

A time horizon will determine the time frame over which the economic analysis is conducted, and defines the stream of costs and benefits that will be factored into the CBA. The anticipated life-span of the project is one option that would incorporate the entire stream of costs and benefits generated by the project, particularly if decommissioning costs are also included. However, the analyst may choose a shorter time frame within which to conduct the economic analysis. Rationale for limiting the time horizon varies. It may be related to the tendency for the effects of a project to decline over time, the amortization period of the loan, or the uncertainty with regard to distant impacts. The time horizon, within which costs and benefits are assessed, may also be defined by the discount rate. Discount rates can essentially factor distant costs and benefits out of the equation by discounting them to such a great extent that their present value is minimal to nothing at all (Sewell et al 1961).

Limiting the time horizon also has pragmatic implications. By eliminating uncertain costs and benefits that may occur in the distant future from consideration in the CBA, attention is focused on those that can reasonably be assessed. In addition, restricting the time horizon ensures that study resources are not squandered on trying to estimate the value of highly uncertain future costs and benefits.

v. Identify the affected parties

This activity is not usually identified as a specific step in CBA. However, it is an important aspect as outlined in the description below. The proposed project(s) will impact a variety of individuals and groups within society and in different ways. In order to recognize and quantify the impacts created by the various alternatives, the affected parties must be identified. Identification of those likely to be affected can occur through a variety of means, including research into similar projects and identification of stakeholders within a certain distance of the proposed project(s). A review of municipal, regional, provincial and federal government agencies, and governing bodies, along with relevant non-government organizations may also provide a list of those affected by the project.

vi. Identify costs and benefits

To determine the net benefit of the project(s) to society, the costs and benefits incurred by all affected members of society, including individuals, groups and government, must be identified, in order to recognize the impacts created by the various alternatives. Costs are the expenditures made and disbenefits created by the specific project including fees, construction costs, labour costs, and various negative impacts arising from the project. Benefits are calculated by identifying the positive effects generated from the proposed project for society, and include any savings in terms of expenditures avoided and income generated by the project. The process of scoping costs and benefits is described later in the chapter in greater detail. Essentially, costs and benefits can be determined in a manner similar to those used for identifying affected parties.

vii. Quantify and value costs and benefits

Once costs and benefits have been identified, they are to be quantified in monetary terms so that the benefit cost ratio can be calculated. Some costs and benefits will already be expressed as market prices, which are believed to reflect their true value. Others will require the use of various techniques to calculate the monetary value of costs and benefits that do not have an associated market value. In these cases, a shadow price representing the value of non-monetary costs and benefits must be identified or calculated for non-market goods and services. Non-market valuation techniques are discussed in Appendix 7, section 4.0.

viii. Calculate the cost-benefit ratio and compare the various project alternatives

Calculate the cost-benefit ratio and compare the various project alternatives using the formula in Appendix 6. The project with the largest cost-benefit ratio is considered to be the most socially efficient alternative.

4.2 THE ISSUES: APPLYING CBA

CBA is a standard economic assessment tool that can be applied to a wide variety of projects and has more recently been used for policy and program assessments. How it is applied does not substantially differ from one application to the next. Therefore, the issues associated with the use of CBA for a specific application like a reservoir project, are likely to be generic to all applications.

An assessment of CBA as a planning tool needs to be made from the perspective of how effective CBA is in providing guidance for public decisions. This should include whether the tool provides information relevant for the formulation of policy that responds to changes and impacts created by a decision. According to Howlett and Ramesh (1995), the context in which the effectiveness of a public decision tool such as CBA should be considered, is its ability to:

- anticipate impacts;

- assess and quantify impacts;
- determine what patterns of costs and benefits will be generated by the various alternatives;
- outline what these patterns will mean for society; and
- compare and rank the alternatives.

The effectiveness of CBA when applied to reservoir or other projects (in reference to the five aspects outlined above) hinges on a number of conditions that can influence the final benefit-cost ratio. These conditions will also affect the quality of the overall assessment in terms of its value to the decision-maker. The conditions influencing the effectiveness of a CBA can be summarized into four main topic areas: accuracy of assessment, asymmetry, inherent policy variables, and understandability. Accuracy of assessment is a function of four elements: omission, valuation, measurement, and forecasting errors. Asymmetry refers to the opportunities for bias within the assessment itself and in the ranking of alternatives. Inherent in the assessment are policy-type variables/choices made by the CBA analyst that influence how costs and benefits are considered and ultimately the ranking of projects. Lastly, the understandability of the assessment affects how the assessment itself and the results are interpreted and used by decision-makers.

4.2.1 Accuracy

There are four types of errors that can affect the accuracy of the CBA:

a) omission;
b) valuation;
c) measurement; and

d) forecasting errors.

a) Omission Errors

Omission errors may stem from a variety of sources. They may arise because the analyst did not believe the impact would occur, or be influential if it did occur. Other possibilities are that the analyst did not anticipate the impact or that the information regarding an impact was inconclusive, contradictory, or not available because it was not anticipated (Broadman et al 1994). One such example is the release of methylmercury from organic matter as a result of inundation of land that occurs with the development of reservoirs. This phenomenon was not originally anticipated by scientists and thus not included in assessments prior to the 1970s, but later became one of the most significant impacts identified with reservoir development. Another omission error results when the analyst neglects to fully explore the opportunity costs of items such as the lost land base (Boardman et al 1994) or the money outlay for the project development (Buss and Yancer 1999).[10]

Scoping Costs and Benefits

Another kind of omission error is generated by the application framework of CBA itself. While proper CBA methodology involves the identification of all direct gains and losses created by the project (Mishan 1972; Anderson and Settle 1977), there is little discussion in the literature on how to go about identifying the full range of costs and benefits resulting from a project. The result is that primary costs and benefits can be missed and secondary gains and losses, including externalities, not assessed for inclusion in the analysis where appropriate.

In a pre-project assessment, scoping is the process by which issues to be addressed are identified and priorities are established for consideration (Everitt and Colnett 1987). While scoping is an important component of other pre-project assessment tools such as, EIA, in the CBA literature there has been little attention given to the scoping process to identify costs and benefits. Rather, the literature has focused primarily on the evaluation of costs and benefits (Conopask and Reynolds 1977; Sassone and Schaffer 1978). Because CBA is almost always conducted in advance of impact studies (Sinclair pers. comm. 1998), it cannot benefit from the scoping of impacts in other pre-development assessments, such as EIA, conducted for the project. This is a concern because the analyst has a responsibility to present all costs and benefits to enable the decision-maker to make a fully informed decision (Sassone and Schaffer 1978). The potential is that inadequate scoping of impacts results in the understatement of costs and benefits or being missed entirely in the analysis, which may significantly affect the benefit-cost ratio or be of particular interest to the decision-maker.

[10] Some economists assert that opportunity costs (benefits forgone by not investing public moneys elsewhere) are also often overlooked in the calculation of CBA (Buss and Yancer 1999).

Secondary Costs and Benefits

One of the most difficult questions is determining which cost and benefit values should be included in the CBA. This in itself has led to some omissions of costs and benefits that for various reasons should have been included in the assessment (Sinden and Worrell 1979). One particular area of controversy is secondary costs and benefits, which as a general rule, have not been factored into traditional analysis because they stem indirectly from the project (Sassone and Schaffer 1978; Sewell et al 1961). The rationale for this approach is to avoid multiple counting and attributing costs and benefits to the project that stem in full or in part from elsewhere (Anderson and Settle 1977).

However, noting the full range of costs and benefits, including secondary costs, assists the decision-maker in making an informed decision based on full disclosure of impacts. A comprehensive scoping of costs and benefits facilitates a more thorough understanding of impact distribution and provides for the development of appropriate policy to address issues regarding distribution of income and other benefits as required (see Appendix 7 section 1.1 for a further discussion).

Evaluation of secondary effects tends to be more important for local and regional CBA where secondary effects are more likely to be significant. When the inclusion of secondary costs and benefits is problematic, some analysts have suggested treating secondary costs as additional considerations. They can be separate from and less precisely quantified than primary effects (since the quantification of secondary effects is often more difficult than for primary effects), but still addressed in the analysis.

Secondary benefits were inappropriately included in the case of the Rafferty-Alameda CBA. Both forward linkages (secondary benefits stemming from the project) and backward linkages (secondary benefits induced by the project) were included (Townley 1998). In this case, an example of forward linkages inappropriately included as a benefit was the increased demand for local goods and services attributed to the construction of meat processing plants. The development of meat processing plants were a potential benefit anticipated from increased livestock production, a possible benefit of the project arising from a guaranteed water supply. Inappropriate backward linkages included increased economic activity (purchases of herbicides and other agricultural inputs) from projected increases in agricultural production. These inclusions of indirect or secondary benefits served to inflate the benefit-cost ratio for the Rafferty-Alameda Project (Townley 1998). Similarly, in the Oldman River Dam CBA, secondary benefits such as employment benefits that only represented a redistribution of economic activity and not new economic growth, were incorrectly included in the assessment (Canada-Federal Environmental Assessment Panel 1992). However, secondary costs and benefits, including local employment benefits, should be discussed in the CBA because they may represent significant gains or losses for the immediate project area (Sewell et al 1961).

Externalities

A similar difficulty to secondary costs and benefits is determining whether externalities should be included in the CBA. Externalities are costs and benefits that traditionally have not been included in the assessment because they are external. That is they accrue to a party other than the project owner/user and are costs or benefits that the owner/user will not incur directly. More recently, analysts have suggested that they should be considered for inclusion in the CBA because they arise directly from the project (see Appendix 7, section 1.3).

b) Valuation Errors

Valuation errors occur in two contexts:

i. accepting given market values; and

ii. calculating values for non-market items and services.

Market Items

Values for goods and services traded on the open market are often accepted at market prices.[11] However, occasionally a distortion in the price can occur and the market price should be readjusted to reflect its true value (Layard and Glaister 1994). This distortion can arise from subsidies, taxes, price ceilings and floors, unemployment, and other market distortions (Anderson and Settle 1977), or simply because the market value does

[11] For goods and services with existing market values, a benefit is valued as an increase in revenue or a decrease in monetary outlay. Similarly, a cost is valued as an increase in monetary outlay or a reduction in revenue (Sewell et al 1961).

not reflect the true value society places on the good, service, or impact (Randall 1987).[12] Valuation errors result when adjustments are not undertaken or values are not adjusted correctly.

Non-Market Items

CBA requires that all costs and benefits be converted to monetary figures in order to calculate the benefit-cost ratio. However, sometimes costs and benefits, such as many environmental and social goods and services, are without a monetary value because they are outside the market structure (Pass, Lowes and Davies 1988). Shadow price is given to a good or service where the price or value cannot accurately be determined, due to a distortion in or an absence of a market-established price for that good or service. The best economics can do with many non-market items is to estimate human perception of values (Serageldin 1993), for which numerous techniques have been developed.[13]

Irrespective of the technique used, establishing the value of costs and benefits that are without a market value can present difficulties. Non-market prices are "complex, unfamiliar, richly multi-dimensional involving a broad range of scientific, aesthetic, life-support, ecological, religious, recreation and/or economic values", and thus their monetary value is difficult to accurately estimate (Gregory and Slovic 1997). Valuation

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[12] A general description of the techniques available to identify true social values of items with existing market prices, focusing on those used for water resource projects/reservoirs, is located in Appendix 7 section 3.0.

[13] Appendix 7, section 4.0 contains a brief description of some of the available techniques for valuing non-market goods and services, with special attention given to those commonly used for water resource projects/reservoirs such as travel cost method, contingent valuation, benefit transfer, and hedonic pricing.

techniques work best when market conditions can be simulated effectively (Markandya 1998). Unfortunately, individuals who are asked to value these goods or services may not have a frame of reference for monetary valuation of the non-market item (Gregory and Slovic 1997). In addition, location can impact how costs and benefits are valued. Residents in one locality are likely to have a different perspective from those in a different locality, possibly related to how costs and benefits are distributed (Layard and Glaister 1994).

There are also limits to the extent to which economic values can be estimated for particular environmental and social resources where market prices do not already exist. Many of the techniques available to provide prices to non-market goods and services, while considered theoretically sound, are questionable as to their actual ability to produce valid equivalent market prices. One limitation is the skill and experience required for calculating non-market values, which may impede their proper use. For example, sophisticated statistical skills may be required to analyze and interpret results (Izmir 1993). It is not uncommon for non-market items such as environmental changes to be discussed, but not quantified in the CBA. Such was the case in the Oldman River Dam CBA where the Assessment Panel was critical of the inadequate attention given to environmental considerations (Canada-Federal Environmental Assessment Panel 1992).

Data is one of the most limiting factors in achieving an acceptable degree of accuracy with valuation methods. Data requirements tend to be low when closely associated market prices or costs can be applied, but greatest when dealing with non-market goods for which there is no closely associated market price. As a general rule, the greater the amount of applicable data, the greater the precision of the estimated net benefits and costs (Sinden and Worrell 1979). Unfortunately, the detailed level of data required and the costs for acquiring the data for many of these techniques also inhibits their correct use and provides opportunities for valuation errors (Department of Environment, Sport and Territories, Government of Australia 1996).

c) Measurement Errors

In some respects, measurement errors are the result of problems similar to those noted for valuation errors. Measurement errors deal specifically with the observation, recording, interpretation, and simple computation required to describe and quantify an event or impact. The extent of the problem may depend on the technology and/or the statistical or methodological approach used for measurement. In general, these problems have received little attention in the CBA literature perhaps because they are perceived as being relatively minor in comparison to other issues (Boardman et al 1994). Another reason is that there is already an existing body of literature on data requirements and statistical error (Chapman 1986).

Multipliers, which are used to calculate the induced change in the economy from an increase in the level of spending such as on project jobs, are one example of a potential measurement error. Multipliers are often drawn from input/output tables for various economic sectors or otherwise devised by the analyst, but have been known to be unrealistic in magnitude and direction of impact (Buss and Yancer 1999).

In the Rafferty-Alameda case study, due either to a valuation error or a measurement error, the value of flooded farm land is suspected of being calculated incorrectly. Rather than using the market value of land, the analyst calculated the value of farm land based on the annual net return after expenses per acre. The estimated value of $6.68 per acre, translates into a profit of less than $5,000 per section of land in 1987 dollars. This profit margin is quite small considering commodity prices at the time, which were producing high profit margins for farmers (Canadian Wheat Board 1999).

d) Forecasting Errors

Forecasting errors arise because future conditions are difficult to predict and changes to values, even market values, can be very difficult to assess (Bojö et al 1990). Anticipating the future value of costs and benefits over a long time horizon is problematic because values may change over time in response to changing market structures and societal perspectives. Indeed, Hagarth and Makridakis (1981) have argued that even forecasting beyond a few months is usually inaccurate, regardless of the context.

One source of forecasting error is unknown cause-effect relationships whereby the response of natural systems and people to changing circumstances over the long term is unknown and therefore difficult to forecast with any real precision (Boardman et al

1994). In this context, valuations of future items, particularly non-market items which in themselves are subject to error, can be very problematic.

Another source, particularly for a project with costs and benefits spanning more than one generation, is whose perspective is to be used in valuation. Should costs and benefits reflect today's, tomorrow's, or yesterday's views? These are critical questions, since the value of specific benefits and costs changes over time as society's perspectives evolve (Value-Impact Analysis 1979). For example, the perspective of present governments with respect to sustainable use of the environment[14] differs significantly from the governments of the 1960s. Even a seemingly neutral perspective is biased in one manner or another (Mishan 1972) by such things as changing views on the environment.

Forecasting is a relatively common error. The Canada-Federal Environmental Assessment Panel's (1992) review of the Oldman River Dam CBA discovered that the value of irrigated land and the attractiveness of the area for industry due to the project's water conservation benefits were overstated. With the Rafferty-Alameda project CBA, concerns have also been raised about questionable forecasting practices, particularly since the project was $58 million over budget (Townley 1998).

[14] Sustainable Development Coordination Unit. No Date. Sustainable Development Strategy for Manitoba. Government of Manitoba, Winnipeg.

4.2.2 Asymmetry

Asymmetry refers to the opportunities for bias within the assessment itself and in the ranking of alternatives. The three prominent sources of asymmetry in CBA are the dominance of market-valued goods and services, the favouring of costs and benefits in the near future and subjective or other bias decisions throughout the process.

One of the potential pit-falls of any CBA is asymmetry of market valued costs and benefits versus non-market valued costs and benefits. Non-market values are often ignored or understated in decision-making because they are not easily valued in monetary terms (Gray 1978). The result is that intangibles, such as social dislocation and foregone aesthetic and recreational opportunities, may be ignored (Daneke and Priscoli 1979). Valuation of non-market items is difficult, potentially unreliable, and because of the time and monetary requirements to undertake proper valuations, may not be comprehensive. Thus the implication is that the market values, or those more easily valued monetarily, are more heavily weighted in the decision-making process. This is likely to be even more pronounced when anticipating the future value of items that currently do not have a market price. In practice, easily quantifiable indexes prevail over non-market goods and services (Daneke and Priscoli 1979).

When conducting a CBA, the natural tendency, due to familiarity, is to favour costs and benefits occurring in the near future over more distant considerations. One example is the lack of attention given to the irreversibility (or reversible only at a great cost with a long wait) of a project as would be the case in a reservoir development (Gray 1978). Because of the long-term impacts such as risks to the environment, option values are not fully considered in relation to more tangible present costs and benefits of developing the project. Often such long-term considerations are not factored into the analysis, perhaps because of the difficulty with estimation. Another reason is that distant costs, even if estimated, can essentially be eliminated from consideration in the CBA through discounting.

Asymmetry also arises because there are too many opportunities for subjective and/or bias decisions throughout the CBA process can affect a decision outcome, particularly with complex undertakings such as reservoir assessments (Farrow and Toman 1999). There are three kinds of bias: cognitive (optimistic) bias, strategic bias, and input bias. Cognitive and strategic under-estimation of costs is not unheard of in CBA of water resources projects (Daneke and Priscoli 1979; Boardman et al 1994). One reason for this may be that benefits are more easily quantified and costs, particularly those occurring over the course of the project or are in the distant future may be more difficult (Troutt pers comm. August 1999). A review of World Bank projects for example, found that there tends to be benefit over-estimation and cost under-estimation. This bias was also found by Townley (1998) in the Rafferty-Alameda CBA.

Another opportunity is through input bias, where the analyst unknowingly receives biased information and thereby generates errors indirectly. This may explain the over estimation of water supply benefits from the Rafferty-Alameda project for the Shand Generating Station. The anticipated savings of supplying the Shand Generating Station with water from the project were not achieved because insufficient water was captured in the Rafferty Reservoir (Townley 1998). This error may have resulted from the analyst relying on engineering analysis, which anticipated the reservoir would consistently be able to supply a quantity of water to the power plant.[15] Water supply had to be supplemented from treated groundwater, which was significantly more expensive. This type of bias, generated from incorrect technical information, can be very difficult to detect except by other experts in the field in question (Boardman et al 1994). Ultimately, what makes asymmetry disconcerting is that the likelihood of these biases being transparent to the user of CBA is not great (Campen 1990).

4.2.3 Policy-Type Choices

Inherent in the assessment are a number of choices made by the CBA analyst that influence how costs and benefits are considered and ultimately the ranking of projects themselves. These choices have been recently described by one CBA practitioner as policy variable choices made by the analyst, but are not often readily apparent to the user of the assessment (Boardman et al 1994). There are arguably three inherent policy choices that are made by the analyst in conducting a CBA: the choice of criteria used for evaluation/appraisal (the efficiency criterion), methods for dealing with risk and certainty,

[15] Filling the reservoir and maintaining water levels is problematic in the case of the Rafferty Reservoir because of the high evapotranspiration rate, periods of severe drought in the basin and groundwater losses (Stolte 1993).

and the choice of the time horizon and discount rate. The implications of these choices on the assessment's outcome may not be well understood or represent the preferred choice of the decision-maker if given the option. This hidden quality is fundamentally what makes these policy choices problematic.

a) Evaluation/Appraisal Criteria

The evaluation criteria on which CBA is judged is quite clear when an individual has a well-grounded understanding of economics. However, it can be argued that a significant number of decision-makers may not understand that traditionally CBA has only evaluated a project on the basis of its social well-being in terms of efficiency. An even lesser number would fully recognize the impact of this criterion with respect to the results of the assessment.

When conducting a CBA, a project is considered in terms of its total social welfare and not aggregate welfare: it is considered socially beneficial if the benefit-cost ratio for society and not the individual is positive (net benefits exceed the net costs). When choosing between alternatives with positive benefit-cost ratios, the project that delivers the greatest net benefits to society is viewed as the project that will deliver the greatest social welfare. This idea of greatest social welfare is critical to understanding exactly what CBA is measuring and what it is not. Traditional CBA judges a project solely on its efficiency. To understand exactly the implications of this, it is necessary to discuss efficiency as an economic criterion as it pertains to CBA.

CBA has drawn its origins from welfare economics. One of the fundamental concepts of this stream of economics is the idea of Pareto Efficiency (Hettich 1971). An allocation of resources is said to be Pareto efficient if it is not possible to make one person(s) better off without making at least one other person worse off (Perman et al 1996). Primarily due to market failure however, the preconditions for Pareto efficiency are seldom if ever met. As a result, the potential Pareto criterion was developed. It deems a project desirable if the gainers, in principle, are able to compensate the losers, but it is not necessary that the gainers actually do compensate the losers. The implication is, in the absence of well-defined property rights and processes for transferring those rights, that compensation for harm is less likely to occur, particularly where CBA does not attempt to consider the distributional impacts (Mishan 1972; Randall 1987).[16] Thus the basic criterion of CBA is that change is acceptable as long as the gains are sufficient to compensate the losses, regardless of who loses or gains. Equity therefore, is not a consideration in CBA, and the result is that a project approved on the basis of CBA may create distributional inequities in terms of who receives project benefits and who incurs project costs (Zerbe and Dively 1994).

Many have criticized CBA as being instrumental in convincing decision-makers to accept projects that allocate benefits to the haves and costs to the have-nots because the projects have passed the efficiency test (Mishan 1972; Howe 1971; Campen 1990) without considering distributional effects. The analysis is indifferent as to whether the gainers are already well off and the losers badly off. It also ignores the distribution of the costs and benefits in terms of location, group or even generations (Anderson and Settle 1977; Randall 1987). Projects evaluated using efficiency criteria, without any consideration of distribution, may favour collective action that imposes harm on individuals. Furthermore, the decision-maker is not provided with an assessment of the distribution of costs and benefits, and thus does not have the opportunity to consider the project based on other criteria, such as distribution issues.[17]

As a result, an economic assessment based solely on traditional CBA efficiency criteria is an interesting policy choice by the analyst. Only one of society's criteria for allocating public moneys (efficiency) is selectively adopted and deemed objective, but distribution/equity issues are ignored. However, from a policy standpoint in a social

[16] In many cases, compensation only readily occurs in those instances of well-defined property rights and processes for transferring those rights. Real property is well defined in jurisprudence and mechanisms are provided for dealing with the transfer of that property such as through sale or property expropriation (e.g. expropriation is legislated in Manitoba under the Expropriation Act).

[17] The counter argument to this perspective is that EIA and SEIA address this limitation of CBA. However, CBA precedes the decision to develop a project and thus influences whether or not to develop the project, while EIA and SEIA often proceed the decision to develop and therefore in practice only influence the mitigation of impacts (Sinclair pers. comm. 1998).

welfare state like Canada, other issues such as distribution/equity issues may be more important than efficiency.[18]

One of the arguments for relying solely on efficiency is that other criteria are difficult to operationalize and/or may require that the analyst make an overt value judgement. For example, there have been some attempts to address the criticisms regarding distribution within the existing CBA by assigning a distributional weight to costs and benefits in relation to income levels (Zerbe and Dively 1994). However, critics have viewed this methodology as cumbersome, subjective and complex (Brent 1996). Also it does not address distributional concerns between geographic locales, groups of people, or between generations.

One way to address this policy choice issue is to develop multi-objective criteria in conjunction with the decision-maker. A multi-objective framework provides for the inclusion of other objectives outside of efficiency, such as distribution, regional economic development, and/or environmental quality (Burdge and Opryszek 1981). Using a multi-objective criteria, a project is ranked on the maximization of social benefits subject to the chosen constraints. In the hearings on the Oldman River Dam, project participants argued that other criteria beyond efficiency, such as equity and regional development considerations, should have been included in the decision criteria. The Panel reviewing

[18] Henderson (1974) and Townley (1998) argue that equity is one of the most important goals in the context of Canadian society, as indicated by the large number of policies and programs at all levels of government aimed at achieving a greater degree of social equality.

the project were also concerned about the lack of attention given to distributional issues. In the case of the Oldman River Dam, the farming community downstream acquired irrigation benefits from the reservoir, but high costs were incurred by the Peigan Indian Band at the reservoir site (Canada-Federal Environmental Assessment Panel 1992).

Schofield (1987) has suggested that projects could be ranked within the CBA framework using any of the following:

- maximum efficiency subject to minimum conditions to be met regarding the distribution of income and benefits
- maximize distribution goals subject to an efficiency constant
- maximize a multi-dimensional social welfare function whereby decision-makers maximize a weighted sum of net benefits accruing to various groups in society. The weights are designed to reflect the relative importance of creating a unit of net benefit for each group. One dollar of benefit, produced for a disadvantaged group ranks higher than for an advantaged group (social pricing)
- at the very minimum, assess and itemize the anticipated distributional impacts.

b) Risk and Uncertainty

Policy decisions, more commonly referred to in the literature as decision rules, may be required to deal with the inherent risk and uncertainty of various aspects of the analysis, particularly cost and benefit valuations. Risk, such as the potential for project failure, is described as knowing the set of all possible outcomes of an action and the probability distribution of those possible outcomes. Uncertainty represents incomplete information. The set of all possible outcomes of an action is unknown and the probability distribution is also unknown (Perrings 1995).

Methods of dealing with risk and uncertainty vary, but one common choice involves eliminating costs and benefits outside a certain range of risk or uncertainty. One method is to use a higher discount rate and thereby eliminate distant uncertainties from the analysis (Sewell et al 1961). However, this widely practiced approach (i.e. the UK Treasury) is not well regarded by many economists, because it is arbitrary and the use of the discount rate in this manner assumes the risk or uncertainty will increase exponentially over time. Another method is to adjust the time-line to remove future uncertain distant costs and benefits from consideration (Anderson and Settle 1977), but this is also an arbitrary approach. A third option is to adjust cost and benefit streams, as in the Game Theory Max/Min Strategy, which evaluates outcomes extremely conservatively by assuming the worst possible outcome. This will have the effect of valuing a benefit less, the greater the uncertainty or risk, and valuing a cost more, thereby helping to ensure that the benefit-cost ratio is not artificially inflated (Markandya 1998).

Any of these tacks are the equivalent of a policy decision with which the decision-maker may not necessarily agree. One means of addressing this issue is to incorporate a sensitivity analysis whereby costs and benefits for upper and lower values are included in the assessment. In this way, the decision-maker has a sense of the effect that a method for dealing with risk or uncertainty will have on the assessment's outcome (Anderson and Settle 1977).

c) Discounting

The third policy-type decision that is made by the economist is discounting (Boardman et al 1994). The role of discounting is to resolve the dilemma presented by costs and benefits that do not all occur in the same time period, and thus do not have values that are comparable (one dollar in year two is worth less than a dollar in year one). This technique is standard for reservoir assessments because costs and benefits are distributed across a number of time periods. For example, construction costs for a dam are limited to the early phases of a project, while operating and a number of socio-economic and environmental costs and benefits will occur some time in the future. This creates difficulties when trying to compare the value of total costs and benefits as the value of $1 during construction, is greater that the value of a $1 later in the project's life-span. To circumvent this problem of comparing benefits and costs with others arising in different time periods, future benefits and costs are adjusted by way of discounting individual values so that they reflect common equivalent present values (Sewell et al 1961; Onybuchi pers. comm. 1998). Calculating the net present value (NPV) through the discounting of all benefits and costs, allows for the comparison of values occurring over multiple years (Howe 1971) (see Appendix 6 for formula).

Choice of a Discount Rate

The policy-type decision that is made with respect to discounting is choosing a rate, called the discount rate, to discount future benefits and costs to yield present social values (Field and Olewiler 1994). The discount rate is essentially the interest rate at which a unit of capital today decreases in value next year to reflect the current price of one dollar in a year from now (Bojö et al 1990).

There are primarily two means to determine the discount rate: the Social Time Preference Rate (STPR) and the Social Opportunity Cost Rate (SOCR).[19] The rationale for using STPR or SOCR varies. Each is likely to generate a different discount rate, with the STPR tending to be lower than the SOCR (Sassone and Schaffer 1978; Brent 1996). The project itself may help to provide some indication as to which to use, although ideally the same discount rate should be used to assess all projects undertaken by any one government (Onybuchi pers. comm. 1998). Doing so ensures that public expenditures on various project alternatives can easily be compared using the same criteria.

The importance of choosing an appropriate discount rate is demonstrated in Table 4-1, which indicates the value of $15,000 discounted over various time periods at selected discount rates. With larger discount rates, future effects quickly lose their relative importance (Anderson and Settle 1977). For example, a cost or a benefit worth $15,000 in 30 years at a discount rate of 15% has only a present value of $225. Even when a low discount rate of 3% is chosen, a cost or benefit worth $15,000 in 30 years has a present

[19] The STPR reflects the social costs of delaying present consumption in order to increase savings for future consumption. Market interest rates, the government borrowing rate, and the lenders risk (Randall 1987) have been used as the STPR of discount. The SOCR is based on the marginal productivity of investment or the real rate of return that the economy's marginal investments yield (Sassone and Schaffer 1978).

value of $6,180. The higher the discount rate, the lower the present value of future benefits and costs.

Table 4-1

Present value of $15,000 for selected time periods and discount rates

Years until $15,000 in benefit/cost received	Discount Rate				
	0%	3%	7%	10%	15%
1	$ 15,000	$ 14,563	$ 14,019	$ 13,636	$ 13,043
5	$ 15,000	$ 12,939	$ 10,695	$ 9,314	$ 7,458
10	$ 15,000	$ 11,161	$ 7,625	$ 5,783	$ 3,708
20	$ 15,000	$ 8,305	$ 3,876	$ 2,230	$ 917
30	$ 15,000	$ 6,180	$ 1,971	$ 860	$ 227

The choice of the discount rate is really a policy choice regarding sustainability in terms of distribution of costs and benefits across generations. Positive discount rates contain a built-in bias against future generations by weighing future costs and benefits less than those occurring in the present (Pearce and Turner 1990). The higher the discount rate, the less the future is valued (Bojö et al 1990) and projects generating benefits in the early years are favoured (Randall 1987). The importance of this, with respect to reservoir development, is that impacts occurring in the future are given less weight than the present. In many cases, impacts such as environmental concerns, which occur over the life of the dam or are cumulative, become marginalized. The social value of a reservoir project, particularly with higher discount rates, becomes judged on those costs and benefits occurring in the early years and not on those occurring further down the line.

Ecologists and environmentalists argue that a positive discount rate is not appropriate for long-term analysis because it effectively values the well-being of future generations below the welfare of today's generation (Serageldin 1993; James 1994). By using positive discount rates, natural resource use is encouraged and a disincentive is provided to undertake environmental protection or improvement programs (James 1994). It has also been suggested that when dealing with a decision that cannot be reversed or involves extreme expense, the discount rate be set very low to account for permanent loss. However, the downside of using a very low discount rate, is that it can be criticized for distorting resource allocation in the economy (Markandya 1998).

The use of a very low, zero, or negative discount rate also raises some practical difficulties. The most significant is that a greater number of projects will pass the benefit-cost ratio test. Thus projects that are marginal in terms of having a benefit-cost ratio close to one at a low rate, would fail at a higher rate. If a project assessed at having a low benefit-cost ratio is developed, and then during the repayment period, interest rates rise, the project may no longer be efficient. Using a higher discount rate avoids marginal projects being recommended (Randall 1987; Zerbe and Dively 1994). Low, zero and negative discount rates also introduce a great deal of uncertainty into the analysis through the inclusion of distant costs and benefits, which are more uncertain, and difficult to value (Perrings 1995). Arguments supporting high social discount rates, favour addressing the true opportunity cost of the government investment: the last opportunities for investing public money elsewhere or not spending it whatsoever (Sassone and Schaffer 1978). The actual numeric value of the discount rate to be applied to public projects seems to depend upon government policy and current social perspectives (Field and Olewiler 1995). The discount rate should be treated for what it is: a policy variable that can strongly influence the outcome of the CBA (Sassone and Schaffer 1978).

One means of addressing this problem of a policy-type choices being made by the analyst, is to include in the CBA the impact of various discount rates and highlight the implications of the various choices on the resulting benefit-cost ratio (Sewell et al 1961). In this manner, the decision-maker becomes informed of the impact a choice of discount rate will have on the result, such as whether the projects being compared are so competitive that the choice depends upon a more comprehensive assessment (i.e., calculating the actual opportunity cost of funds). Ultimately, by using more than one discount rate, the decision-maker is in a better position to make an informed decision.

This technique of calculating the benefit-cost ratio with more than one discount rate is still not consistently applied. In the Rafferty-Alameda project CBA two discount rates (5 and 10%) were compared (Souris Basin Development Authority 198?). In contrast, the Oldman River Dam CBA was criticized for only using one (Canada-Federal Environmental Assessment Panel 1992).

4.2.4 Understandability

The decision-maker must take the analysis received from the CBA and combine it with other considerations in the final step of reaching a decision (Campen 1990). Because the decision-maker is likely not an economist, the level of familiarity with CBA can impede the application of the results in the decision-making process.

Some economists are concerned that the current practice of CBA and the perceptions of users who interpret the results are not necessarily compatible (Campen 1990). The limitations of CBA are too often overlooked or unknown by the decision-maker; specifically these limitations include the uncertainty associated with forecasting, omission of some costs and benefits, shortcomings of market data, difficulties in quantifying non-market items, and inherent subjectiveness of the assessment. In addition, the inappropriateness of the use of the Pareto improvement as the sole criterion for social well-being and the failure to consider impacts on people's welfare are limitations of CBA that may not be recognized by the decision-maker

One of the arguments for CBA is that by defining project options in terms of explicit values, the process is more open to scrutiny. However, because the analysis is highly technical, it is not easily accessible by a public that may otherwise take issue with assumptions or assigned values. CBA is also arguably not thoroughly understood by decision-makers whom are unskilled in the discipline of economics and liable to not fully comprehend the technique and its limitations. In CBA, value judgements become hidden beneath extensive analysis that includes complex figures that give the impression the analysis is rational, neutral and objective. As Barbour (1980) argues:

> Value conflicts that should be resolved politically are concluded in what look like rational, neutral, objective calculations. This may appeal to administrators, but it hinders public debate of the policy issues and lessens the accountability of bureaucratic officials. Numbers carry an unwarranted authority when used to legitimate decisions that are basically political in character.

Campen (1990) argues much the same point, but goes on to note that because a number of impacts are difficult to quantify in monetary terms and their interpretation may be somewhat subjective, significant consequences of a decision may be overlooked or not stated. Thus they are not addressed in the decision-making process.

Some economists, like Campen (1990), have suggested that CBA should "...not be used when substantial uncertainties or intangibles..." exist. Because of its highly complex and technical nature, the CBA process tends to alienate citizens and unlike the newer pre-project assessment techniques EIA and SEIA, makes no accommodation for their inclusion. An improvement on traditional CBA would be to accommodate active citizen participation in the process in an effort to both empower through understanding and provide an opportunity to influence the technocratic process.

Another issue associated with understandability, is the clarity in presentation of the CBA (Farrow and Toman 1999). In order for the reader to be clear on how the assessment was conducted and what assumptions were made, all aspects of the analysis should be presented in an organized and transparent fashion. A lack of clarity is a criticism raised against both the Oldman River Dam project (Canada-Federal Environmental Assessment

Panel 1992) and the Rafferty-Alameda Dams (Townley 1998). In both cases, the reader was left with questions because the analyst had not explicitly stated all assumptions, nor clearly explained how all calculations were derived (Canada-Federal Environmental Assessment Panel 1992; Townley 1998).

4.3 CONCLUSIONS

While there has been significant criticism with the methodology and application of CBA, it must be noted that the majority of critiques acknowledge that although flawed, there is no better alternative (Campen 1990). Its strengths are that it provides a rigorous, systematic approach to decision making and rests on a defined set of economic principles that are relatively consistently applied. It also helps to provide valuable quantitative information on the effect of a decision on social well-being when defined as efficiency (Farrow and Toman 1999). CBA focuses careful consideration of issues and highlights costs and benefits of various options, thereby helping to provide information on tradeoffs. A comprehensive CBA is capable of highlighting uncertainties, and with the help of sensitivity analysis, further illustrate their significance (Farrow and Toman 1999).

However, one of the drawbacks is that decision-makers themselves sometimes forget that CBA is merely a tool to aid decision-making, not a decision mechanism itself (Campen 1990). One way of improving the practice of CBA is through *ex-post* review that identifies limitations and areas for improvement as well as misuse and abuse (Broadman et al 1994).

This review of the inherent constraints in the use of CBA has primarily been generic because the issues are generally not focused on one type of application, such as reservoirs or water resource projects in general. That said, all of the issues discussed are relevant to water resource project assessments including those conducted for reservoirs. The considerations of primary importance for a reservoir project CBA are:

- Identify the range of costs and benefits that should be included in any analysis of a reservoir project
- Address how impacts occurring in various time periods are to be appropriately dealt with
- Successfully factor in non-quantifiable impacts/benefits and consider the impact over time of changing attitudes on valuation
- Identify and translate risk and uncertainty
- Communicate the criteria for project appraisal (efficiency criterion)
- Include public participation in the process
- Ensure decision-maker understanding of the assessment and avoid hidden policy-type choices that will affect the outcome of the CBA.

CHAPTER 5: OVERVIEW AND ASSESSMENT OF THE ORIGINAL SHELLMOUTH RESERVOIR CBA

5.0 INTRODUCTION

This chapter is divided into two sections. The first is an overview of the original CBA conducted for the Shellmouth Reservoir that was undertaken in the late 1950's and early 1960's. The second is the review of the CBA in relation to the project impacts discussed in Chapter 3, the issues associated with the application of CBA discussed in Chapter 4, and the original project CBA presented as the first section in this chapter.

The original CBA conducted by the Province of Manitoba was used as an analysis tool to evaluate the various flood control project options available for the protection of Winnipeg. Specifically, the CBA was undertaken to help determine whether the benefits of the project warranted its development using public money. With the exception of engineering feasibility studies, the CBA was the only formal pre-development assessment tool used to appraise the various development options. The original CBA of the proposed reservoir was influential in persuading the governments of the day that a dam on the upper Assiniboine River would save millions of dollars in flood damage for Winnipeg. It was also recongnized that the project would produce valuable flood control benefits for the southern portion of the Assiniboine River basin and provide a more constant supply of water for downstream activities.

A review of the original Shellmouth CBA provides an opportunity to discuss CBA as it has been put into practice in the past. It is not conducted in an attempt to question the CBA from the standpoint of today's value system, but to demonstrate the potential strengths and limitations of CBA as it has traditionally been applied to prairie reservoir projects such as the Shellmouth. This review helps illustrate the potential long-term implications that can result when pre-project analysis provides insufficient and/or inappropriate information to the decision-maker, such as not considering all relevant costs and benefits. The review of the Shellmouth CBA also provides insight into the ongoing controversy of the project for local area, as well as characterizes numerous practical limitations with utilizing CBA.

5.1 THE ORIGINAL SHELLMOUTH RESERVOIR CBA (1958 & 1961)

5.1.1 Overview

The original CBA for the Shellmouth Reservoir was undertaken by Kuiper in 1961 for the Province of Manitoba and was an update of the Royal Commission CBA conducted in 1958. The Royal Commission's CBA (1958) assessed the Russell Dam site, which was to have been located a short distance downstream from where the existing Shellmouth Dam now stands. Along with a number of infrastructure flood control options for Winnipeg, much of the analysis in Kuiper's CBA on the Shellmouth Reservoir was based on that conducted for the Russell Reservoir by the Royal Commission. The Russell project was compared on its own, as well as in combination with other flood control projects, to determine the most cost-effective means of achieving the desired flood protection for

Winnipeg. At the time, the potential for the reservoir to provide flood control to the lower Assiniboine basin and downstream water supply was also considered. Shortly after the Royal Commission Study in 1958, the decision was made for technical reasons to reject the Russell Dam location in favour of the Shellmouth site.

Since the basic analysis used by the Royal Commission for the CBA of the Russell Dam was still relevant for the Shellmouth project, it was heavily relied on by the Kuiper study (1961). Revisions were made in the Kuiper study to the capital costs used in the Royal Commission study on the Russell Reservoir to reflect the new location and associated design revisions. Changes were also made to the calculation of benefits to reflect a reduction in storage capacity of the Shellmouth project as compared to the Russell Reservoir.

Three other documents, while not economic assessments, are also relevant: the *Shellmouth Designated Reservoir Area Proposed Land Use Plan* (McKay et al 1969), the *Preliminary Plan Asessippi Provincial Park* (Parks Branch 1967), and the post-construction park plan; *Outdoor Recreation Master Plan Asessippi Provincial Park* (Parks Branch 1973). These planning documents provide an indication of the benefits that were projected by the province for the Manitoba portion of the local area.

5.1.2 Review of the Original Shellmouth CBAs

While the Russell project was substituted for the Shellmouth Reservoir, the computational procedures used for the Russell Reservoir CBA (Royal Commission 1958) to calculate benefits and costs were also utilized for the Shellmouth Reservoir CBA (Kuiper 1961), with one notable exception. A more precise engineering modeling technique was used to measure flood control benefits from the Shellmouth Reservoir in the Kuiper study. Rather than relying on arbitrary peak flow reductions used in the Royal Commission study, the level of flood control was determined on the basis of routing flood hydrographs through the reservoir to determine peak flow and resulting damages (Kuiper 1961).

Table 5.1 compares the CBAs of the Russell (Royal Commission study) and the Shellmouth (Kuiper study) Reservoirs. The table shows the estimated costs, benefits and cost-benefit ratio for the Russell and Shellmouth projects. The benefit-cost ratio in both cases is positive. However, the Shellmouth benefit-cost ratio is less than one half the ratio calculated for the Russell project by the Royal Commission. There are four reasons for this. The first is that the total capital costs were estimated to be higher for the Shellmouth Reservoir (Table 5.1, line a). Second, under the new flood impact calculation method used by Kuiper, there was a significant reduction in the annual flood control benefits generated by the reservoir (Table 5.1, line c). Third, while water supply benefits were noted, they were not included in this follow-up analysis conducted for the Shellmouth Reservoir. Fourth, the variation between the two CBAs can be partially accounted for by the difference in the storage capacities of the two reservoirs. The Russell Reservoir benefit calculations were based on a flood storage capacity of 600,000 acre feet (Kuiper et al 1952). The Shellmouth CBA was calculated for a reservoir capacity of 540,000 acre feet, 60,000 acre feet less than the Russell Reservoir (Kuiper 1961). Annual operation costs were somewhat elevated for the Shellmouth project as compared to the Russell estimate, but no reason was given for the difference (Table 5.1, line b).

Table 5.1

Comparison of CBA Estimates for Russell and Shellmouth Reservoirs

	Types of Costs and Benefits	Russell Reservoir Estimates - 1958 (Royal Commission 1958 Study)	Shellmouth Reservoir Estimates - 1961 (Kuiper 1961 Study)	Difference in Estimated Values* between the Russell and Shellmouth Reservoirs CBA
a	total capital costs	$6,450,000	$7,500,000	$1,050,000
b	annual operating costs	$ 333,900	$ 390,000	$ 56,100
c	annual benefits	$2,062,000	$ 900,000	$1,162,000
	benefit cost ratio	6.18	2.3	

*No adjustment made for comparing dollar estimates in different time periods.

a) Capital Costs: Original CBA

Capital costs, outlined in a background PFRA document (1961) and used by Kuiper, included construction and land purchase cost estimates for the Shellmouth project. For the Shellmouth, these costs include the estimated construction costs for the earth dam and the spillway, as well as reconstruction and reorientation of two highways. Development related costs including purchase of land and buildings, reservoir clearing, and the removal of four bridges and associated roads. These costs are found in Appendix 8.

b) Annual Operating Cost: Original CBA

The annual operating costs used in both CBAs includes interest on the cost of the project estimated at 4%.[20] The amortization charges were calculated over a 50-year period.[21] Also included in these annual costs were general maintenance and operating costs.

c) Annual Benefits: Original CBA

Annual benefits represent a combination of flood protection and water supply benefits, and are outlined in detail in the Royal Commission CBA document. These were also utilized by Kuiper in his Shellmouth CBA. A reduction in the natural peak flow and the associated reduction in damages resulting from flood protection provided by the reservoir, is considered an annual benefit created by the project. Reductions in peak flows were recalculated in the Shellmouth CBA (Kuiper 1961), but damage estimates were drawn directly from the Royal Commission study. Calculations for damages were estimated based on the flooding damages of the 1950 flood and confirmed with the U.S. Army Corps of Engineers for accuracy.

Flood prevention benefits were calculated by way of frequency-damage analysis for the southern portion of the basin: Greater Winnipeg, Millwood to Portage, Portage to Headingley, and Brandon City. In the Royal Commission Study, flood control benefits were based on the frequency-discharge, outlining the reduction in peak flow levels provided by the reservoir in relation to natural conditions. In the Shellmouth CBA, the

[20] Based on the average interest rate paid by the Government of Manitoba between 1945 and 1958.

level of flood control was determined on the basis of routing flood hydrographs through the reservoir to determine peak flow and resulting damages (Kuiper 1961). Flood damage to residential dwellings and their contents caused by a flood of the 1950 magnitude were an estimate of total damages. This estimate was substantially higher than the payments actually made by the Red River Valley Board and Manitoba Flood Relief Fund for losses of this type. The estimates were based on the number of properties that would be damaged without any flood fighting measures and additional new dwellings in areas subject to flooding. Items included in the urban and rural flood damage calculations are discussed below.

Urban Flood Damage Calculations

Annual benefits from flood prevention outlined in the Royal Commission study (1958) and subsequently inferred in the Kuiper study, were calculated as an estimated reduction in flood damages to urban areas (as a result of the reservoir project). A list of the types of urban damages avoided as a result of the reservoir project listed in the Royal Commission study, is outlined in Figure 5.1. Categories of items included were damage to buildings and contents, infrastructure repairs, extra costs to individuals, and flood fighting costs.

[21] An amortization period longer than 50 years has only a small effect on the annual cost.

Figure 5.1

Items Included in Flood Damage Calculations for Urban Areas*

Damage to Buildings and Contents[1]	Infrastructure Repairs	Extra Costs to Individuals	Flood Fighting Costs
- Dwellings	- Streets/roads	- Evacuation costs: distance traveled and mode to leave city	- Pumping water out of basements
- Apartments	- Bridges	- Extra food costs: eating away from home	- Building dikes
- Farm buildings	- Sewer and water	- Extra labour costs: clean up and furniture moving	- Public utilities/railways: flood fighting costs
- Business and institutional buildings	- Public utilities and railways flood protection and repair	- Extra car mileage: detours as a result of flooded or damaged roads and bridges	
- Schools and public buildings		- Income loss[2]	

1. Damages multiplied by the estimated number of buildings flooded
2. Calculated over the period of inundation, and reconstruction, and the gradual return to 100% pre flood conditions estimated at a total of 6 months.

* Table derived from Chapters 6 and 8 of the Royal Commission study (1958)

Rural Flood Damage Calculations

Reductions in flood damages for rural areas in the Royal Commission study (1958) on the Russell Reservoir and subsequently included in the Kuiper CBA on the Shellmouth, are calculated based on the items outlined in Figure 5.2. General categories of items included in the assessment are the same as those for urban areas, but specific items differ. The methods used for calculating loss of rural income (loss of crop, dairy, livestock, non-farm and rental property income) are outlined in Table 5.2.

Figure 5.2

Items Included in Flood Damage Calculations for Rural Areas*

Damages to Property	Infrastructure Repairs	Extra Costs to Individuals	Flood Fighting Costs
- Non-farm residential - Farm Buildings - Personal property - Grain, livestock and machinery losses - Business stocks and fixtures - Business property - Schools and churches	- Road and highway repairs: government - Bridges: government - Public utilities and railways infrastructure repair	- Evacuation costs: distance traveled and mode to leave rural area - Extra food costs incurred for eating away from home - Extra work for clean up - Extra feed for livestock based on the number of livestock and time affected - Moving livestock costs - Loss of rural income (see Table 5.2)	- Flood fighting costs: government - Public utilities and railways: flood fighting costs

*Table derived from Chapter 8 of the Royal Commission study (1958)

Table 5.2

Items Included and Means of Calculating Loss of Rural Income*

Income Loss	Calculation Method
Crop income	Cost of lost land already seeded <u>and</u> gross crop income lost = (yield expected without flooding x pri ce per bushel of the particular crop) - (yield expected with flooding x price per bushel of the particular crop) – (operating expenses)
Dairy income	Value of lost dairy production per cow x number of animals affected x period of non-production
Livestock income	Calculated loss of weight x number of flood days x value of loss per pound
Non-farm income	75% of Winnipeg estimated values
Loss of rental property	Calculated on average estimated cost of agricultural rental property

*Table derived from Chapters 6 and 8 of the Royal Commission study (1958)

The Kuiper's CBA on the Shellmouth discussed water conservation benefits in terms of future irrigation development in southern Manitoba, basing estimates on irrigation of 150,000 acres in the southern portion of the basin (15,000 acre feet per year or 200 cfs).

The ability of the project to contribute to the provision water for municipal and industrial use was also considered. The estimated future of water demand for municipal and industrial use was calculated as follows: between Shellmouth and Brandon (20cfs), Brandon (40cfs), Portage la Prairie (40cfs), and dilution of industrial and municipal wastes (100cfs) downstream of Brandon and Portage la Prairie. The project's ability to contribute to this estimated flow requirement were considered part of the recommendation on which project option to consider, but not part of the benefit-cost ratio calculation.

In the earlier CBA by the Royal Commission, certain downstream benefits were included in the CBA calculation. Increases in flow levels downstream of the reservoir were estimated to provide benefits through better sewage dilution for Winnipeg's core, thus eliminating the need to construct a secondary treatment system by the City. A benefit of $118,000 (1958 dollar value) was assigned to the Russell Reservoir for the sewage dilution effects for Greater Winnipeg. For Brandon and Portage la Prairie, a value of $0 was given for sewage dilution, because the natural river flow was sufficient to dilute sewage provided by existing systems or soon to be implemented upgrades. The benefits of improved sewage dilution to other towns along the Assiniboine was noted, but not calculated.

Because exceptionally low flows affecting the supply of potable water seldom occur, improvements in minimum flows were limited to the cost of the most economical method of over-coming relatively short, exceptionally low flow periods. An arbitrary estimation of $10,000 was assigned by the Royal Commission for the improvement in water supply the reservoir would provide for Brandon, Portage la Prairie, and other towns on the Assiniboine. Total benefits from flow augmentation were calculated to be worth a total estimated value of $128,000 annually (Royal Commission 1958). These water conservation benefits were noted, but not included in the follow-up CBA for the Shellmouth (Kuiper 1961). Other downstream flow augmentation benefits, such as benefits to aquatic habitat due to improved instream water quality, were not addressed in either study.

5.2 REVIEW OF THE SHELLMOUTH CBA

This section reviews the Shellmouth CBA in relation to those application issues discussed in Chapter 4 and the local impacts identified in Chapter 3. The review is conducted from the perspective that the CBAs by Kuiper (1961) and the Royal Commision (1958) together comprise a comprehensive assessment. In reality however, this is not the case: the CBAs were partial analysis aimed at finding the most effective combination of flood control projects, in terms of cost-effectiveness and maximization of flood control benefits, to address flooding concerns for the City of Winnipeg. Today such a partial assessment would not be considered sufficient in itself. That is not to say that a comprehensive analysis was not in order even for that time-period (late 1950s and 1960), but to recognize that the project's CBAs were purposefully narrow in their consideration.

As described in Chapter 4, there are essentially four areas of concern regarding the application of CBA:

1. accuracy of information inputs (costs and benefits);
2. asymmetry or bias of analysis,
3. policy-type choices made by the analyst, and
4. understandability of the assessment including the assumptions made from the user's point of view (decision-maker).

5.2.1 Accuracy

Accuracy of assessment is one of the key factors influencing the effectiveness of a CBA. Accuracy pertains to four elements: omission, valuation, measurement, and forecasting errors.

a) Omission Errors

Omission errors arise from the costs and benefits that should be included in the CBA, but are not for various reasons (see section 4.2.1). Omission errors, or scoping errors, like all of the four accuracy errors, can have a significant impact on the resulting benefit-cost ratio. The discussion of omission errors pertaining to the Shellmouth CBA in this section must be qualified: the omission errors discussed are those items that would have been included had a comprehensive CBA been conducted.

Both CBAs of the Russell and Shellmouth Reservoirs failed to include a wide range of costs and benefits. For example, a number of socio-economic costs were notably absent. The two original CBAs focused on downstream quantifiable impacts such as damage to buildings, livestock, infrastructure, and flood fighting costs. Omitted however, were a number of local socio-economic costs and benefits arising at the reservoir site. Local construction and land purchase costs were included in the project CBA, but a number of others such as loss of tax base and added maintenance costs were not. Benefits to the local area in terms of recreation opportunities and tourism used were also not included.

In addition, there was considerable inconsistency with which costs and benefits were included in the CBAs. For example, the flood control benefits downstream include the elimination of extra commuting costs created by the flooding, but the extra commuting distance created by the geographic obstacle of the reservoir for the local reservoir area residents was not. Water conservation benefits accrued to the City of Winnipeg (the avoidance of upgrading the core area sewage treatment system) were encompassed in the CBA. Conversely, the loss of the tax base and increased maintenance costs for the RMs bounding the reservoir, were not.

Also neglected were some important non-quantifiable (intangible) social impacts. However, unlike quantifiable costs, they were consistently not accounted for regardless of whether they occurred upstream or downstream of the dam. For example, a reduction in stress or the increased piece of mind the flood control projects provided for inhabitants of the lower basin, could have been one of the primary benefits of the project, but was not included. Local intangibles were also not included, such as stress and the disruption to the community social network created by the barrier of the reservoir separating the community in two. The existing economic framework was also disrupted due to the loss of agricultural production and changing patters of supply and service delivery in the area.

Table 5.3 lists local costs and benefits not included in the original CBAs. These are derived from the review project impacts on the local area highlighted in Chapter 3 and discussed in detail in Appendices 4 (social impacts impacts) and 5 (environmental impacts). Costs and benefits are broken down into three geographical areas: the dam site/reservoir, upstream of the reservoir, and downstream of the dam in the spillway discharge area.

Impacts and/or their magnitude may vary over time. Some, such as noise associated with construction activity, have a distinct time frame. Others, such as the impact of the project on the local social network, tend to dissipate over time. Yet other costs will not change, such as higher maintenance costs for the RM stemming from the longer commuting distance required to service both sides of the reservoir.

Recreation, tourism, and vacation property values are qualified by negative factors, decreasing the overall value of these benefits. For example, the act of creating the reservoir and the current operating regime has promoted:

- algae blooms that reduce recreational opportunities of the reservoir such as swimming,
- low dissolved oxygen levels which stress fish populations in the reservoir and contributed to dramatic fluctuations in the sports fish populations,
- bank erosion in certain areas, and
- mercury contamination of fish and other negative water quality changes which negatively impact the sports fishery; as well as the environmental quality of the reservoir in general.

One of the interesting costs, which is really a cost to some and a benefit to others, is the re-patterning of the social and economic structure in the local area. For example, while former service centres like Dropmore suffered due to the reduced accessibility of the community, towns like Russell tended to benefit. Russell incurred relatively few direct costs, but its role as a local service centre increased, partially because the reservoir inhibited access to formerly more accessible communities. It also has benefited significantly from secondary spin-offs from the tourism and recreation use of the park and reservoir.

Another cost that possibly should have been included as project capital and operating costs was Asessippi Park. According to local stakeholders (key person interviews 1996, 1997), Asessippi Park was developed as a means of compensating the local Manitoba area for the cost of having the reservoir at this site. If Asessippi Park was developed as a form of compensation to the local area for the reservoir development, then the capital and operating costs of Asessippi Park should also have been included as part of the total project cost, as was the case with the Rafferty-Alameda project (Townley 1998). The

Table 5.3
Local Costs and Benefits Not Included in the Original CBAs
(Derived from the Identification of Local Impacts in Chapter 3)

Costs	Benefits*
Dam site	
• Environmental Costs (non market items) - Shoreline erosion of reservoir slopes - loss of riparian and littoral region vegetation - sedimentation damaging bottom habitat fauna and depositing heavy metals/other chemicals - loss of prime wintering wildlife habitat of valley slope areas - reduced DO - algae blooms, stratification of the water column - mercury contamination, toxins and other negative water quality changes - stratification of water column - water quality impacts (low dissolved oxygen) • reduced supply of farm land - market prices paid by the Crown does not reflect replacement costs in market with reduced supply of land - loss of tax base and tax revenue for the local RMs • productive valley agricultural land given up for reservoir - loss of farm income from local economy - reduced local agricultural production with reduced associated spin-off benefits • RM increase in administrative and political costs • increased prices for availaible land • socio-health costs from stress and environmental impacts • disruption of community network, re-patterning of community social and economic structure • aesthetic value of natural landscape • noise, traffic and other disruptions during construction	• vacation property development - cottage/resort developments - campsite development opportunities • recreation use benefits including sports fishery • spin-off benefits of increased recreation/tourism visitation (secondary) - recreation rentals - cottage rentals, boat rentals, horse rides, cross country skiing, ski-doo and sea-doo rentals - purchases from local businesses: tackle, gas, souvenirs, camping supplies, restaurants • employment and other spin-offs from construction and operation of recreation/tourism services • local employment from construction of reservoir/dam • sale of construction supplies and services • use of local services restaurants, bars, hotels, gas, groceries • property tax benefits of recreation property development to the local RM • aesthetic value of man-made lake
Upstream of Reservoir	
• occasional upstream back-flooding of agricultural land decreasing yields from backflooding • tributary sedimentation negatively affecting spawning	• Possible increased yields from higher water table
Just Downstream of Dam in the Spillway Discharge Area and Flood Plain	
• Environmental costs - Decreased sediment load and corresponding scouring of downstream river bed - negative habitat impacts • bank erosion reducing size of agricultural land • lower flood peak occasionally increasing flooding duration (1995) damaging permanent cover and affecting seeding dates	• Possible increased yields from higher water table

* some local benefits do not achieve maximum potential because of operation of reservoir for downstream flood control and water supply

benefits generated from the park would be calculated as annual benefits. However, Asessippi Park appears to have been a later consideration, after the CBA was conducted. Thus, the analyst did not err, but because the CBA was not revisited, unanticipated costs or benefits that became clearer as the planning for the project progressed, were not included in the assessment.

Opportunity Cost

While both of the original CBAs explored various engineered options, neither addressed the option value of not developing flood control structures in terms of the foregone opportunities at the reservoir site. Similarly, future agricultural earnings or other uses of the land and the spin-offs in the local economy were not discussed.

Reasons for Omission Errors

One reason why environmental and aesthetic effects such as those described in Chapter 3 are sometimes not included in a CBA of this sort, is because they may have been perceived as secondary costs and as a result do not warrant inclusion in the CBA. However, Bojö et al (1990) has recommended that such costs and benefits be internalized in order to achieve a comprehensive analysis.

Another possible argument for ignoring local and environmental benefits and costs at the reservoir site in the original CBAs, is that benefits and costs were believed to be too small in relation to those that were addressed, to be worth pursuing. However, this argument runs counter to the perspective put forth by today's practitioners that the decision-maker should be given all of the facts in order to make a fully informed decision (see section 4.2.4). The most probable reason why environmental and local social costs and benefits were not included was because of the mindset of the time. These costs would either have not been considered important, and/or not considered whatsoever. Including environmental costs and benefits in general and local socio-economic costs and benefits in the analysis, was not part of the state of the art of CBA in 1960.

The Externality Issue

Another omission error resulted from the practice of not including external costs and benefits in the calculation (see section 4.2.1-a). Because the analysis is conducted from the perspective of Manitoba, costs occurring outside this jurisdiction would be considered external. For example, the cost and benefits of backflooding[22] and the opportunity cost of flooded farmland in Saskatchewan are externalities. The Province of Saskatchewan and its residents would not be considered the "user" or the beneficiary of the reservoir and therefore, all accrued costs and benefits experienced outside of Manitoba should be considered externalities.

While arguably all Manitoba residents would benefit from flood protection of southern Manitoba in terms of lower taxes, the argument could be presented that local people were

[22] cost = reduced production because crops could not be seeded due to wet conditions
benefit = increased water table in dry years leading to an increased crop yield

not the true resource users of the project, and thus any local costs and benefits were indeed externalities. One notable external cost not included in the CBA was the resulting environmental effects created during the construction phase, filling phase, and/or operation of the reservoir. While such a perspective on the environment would be questioned today, at the time of the project environmental impacts were not generally recognized as a cost or benefit to society. Thus, a number of costs and benefits would be excluded because, as primarily local or environmental costs and benefits, they represent externalities. Other local costs, such as the fragmentation of the community due to the loss of direct road access from one side of the valley to the other, could also be construed as an externality.

b) Valuation Errors and Measurement Errors

Valuation errors generally result from the use of market values that should be adjusted to accommodate distortions, or incorrectly calculated values for non-market goods and services. There were no apparent adjustments made to market prices for typical price distortions such as taxes. Non-market goods and services were not included in the assessment, and as a result there are no non-market valuation errors to consider. The effect of valuation errors on the overall analysis is perceived to be small in the case of the Shellmouth CBAs, relative to the other issues such as omission errors.

Measurement errors refer to problems in the observation, recording, interpretation, and simple computation used to describe and quantify an impact. This type of error in the case of the Kuiper and Royal Commission CBAs has the potential to be far greater in significance than the valuation errors noted above. One measurement error made in the Royal Comission CBA (1958) was corrected in the second CBA (Kuiper 1961) and served to significantly lower the benefit-cost ratio. The use of routing flood hydrographs through the reservoir to determine peak flow and resulting damages improved the accuracy of the flood benefit calculation (Kuiper 1961).

c) Forecasting Errors

Forecasting is a particularly difficult aspect of CBA. Since no documentation of final project costs was located and a post-development assessment of flood benefits provided by the reservoir was also unavailable, the accuracy of these original estimates is unknown.

In the original CBAs, some attempt had been made to consider forecasting future changes that would impact the benefit-cost ratio. While a number of costs and benefits were not included in the analysis, the original CBA (Royal Commission 1958) did factor in growth of income and property values in the downstream portion of the basin into the assessment and outlined the assumptions that accompanied this forecast.

5.2.2 Asymmetry

Asymmetry refers to the opportunities for bias within the assessment itself and in the ranking of alternatives. There are believed to be three types of bias that permeate the assessment. One of the prominent biases of the Shellmouth CBA is the focus, in terms of costs and benefits, on southern Manitoba specifically in the city of Winnipeg. The bias manifests itself in the assessment in a number of different ways, but primarily on the focus given to impacts in southern Manitoba, to the exclusion of impacts elsewhere in the basin. For example, growth forecasts in terms of income and property value were included for assessment of flood control benefits in the lower basin. In contrast, no similar attempt was undertaken to consider a growth forecast for the local area. This would have provided a partial estimate of the opportunity costs of developing the reservoir at its current location.

The second kind of bias, found in both the Royal Commission study and Kuiper's CBA, is the overt focus on flood protection benefits. While this is the primary purpose of the reservoir, the focus excluded consideration of underestimated benefits. Water conservation benefits for southern Manitoba, in terms of a more reliable instream flow, are not given anywhere near the attention of flood control benefits in the Royal Commission study (1958), and are not included in the calculation of the Shellmouth CBA by Kuiper (1961). Instead, Kuiper compared potential project contributions to water supply in a non-quantified manner. This flood control bias is believed to be a direct consequence of the focus of society at that point in time, having just experienced the impacts of a significant flood event. It is anticipated that conservation benefits would have received far greater attention if a significant drought period had recently been experienced.

The third bias observed is in the choice of flood control alternatives, all of which are engineering solutions. No apparent effort was made to consider alternatives such as land use planning approaches whereby development in the flood plain would be restricted. It may have been cheaper to move existing at risk structures in the Assiniboine and Red River Valleys and restrict further development in flood risk areas, than to construct the Shellmouth and the other flood control projects. A more probable option is that planning approaches coupled with engineering solutions represented a real alternative to the engineering options exclusively explored. A comprehensive CBA that included a wide range of costs and benefits for the project may have concluded that this was indeed the cheaper alternative. SaskWater has taken this approach whereby development is restricted in the 600-year flood zone. Why a planning approach was not contemplated at the time of the CBA is unclear. However, society's tendency at that time was to rely on the large scale, technical engineered solutions as the only possible viable option (Kates and Burton 1986).

5.2.3 Policy-Type Choices

Inherent in the assessment are policy-type choices made by the CBA analyst, that influence how costs and benefits are considered and ultimately the ranking of projects.

Evaluation/appraisal criteria

Consistent with evaluation criteria based solely on efficiency, as compared to multi-objective considerations such as the inclusion of equity/distribution issues, the project's CBAs made no reference to distributional issues. The original analysis did not look at the distribution of costs and benefits between various individuals, groups, or downstream and upstream communities, or the impacts of the project on long-term community development. Thus the CBA did not assess the positive or negative impacts of the project on those living next to the reservoir in relation to benefits downstream. Recognize however, that for this analysis to have addressed the issue of equity, would have been highly unusual for the time period in which the reservoir's CBAs were conducted.

Risk and Uncertainty

One method for dealing with uncertainty used in the Shellmouth project CBA, whether intentional or not, was to limit the consideration of impacts to a 50-year time horizon. Doing so effectively eliminated any discussion of costs and benefits that may have been highly uncertain because they occurred so far in the distant future. It also served to eliminate from discussion, the necessary costs of decommissioning or upgrading the dam when the project reached the end of its physical life span. This will be a significant cost to future generations, particularly if decommissioning is required (Windsor pers. comm. 1999) and one that becomes important if the development criteria is sustainability. Investing the present value cost so that funds would be available for decommissioning or retrofit of the reservoir, would be a mechanism for internalizing a cost that would otherwise be an externality for future generations.

Discounting - Choice of a Discount Rate

The implications of various discount rates on the benefit-cost ratio have been addressed in Chapter 4, section 4.2.3. In this case, a discount rate of 4% was chosen by the analyst, with the rationale for this choice being clearly stated. The relatively low discount rate chosen helped to give more weight to distant flood control benefits. A higher discount rate would have had the effect of lowering the benefit-cost ratio. Using the figures presented for the Shellmouth Reservoir in the Kuiper study, at a discount rate of 10%[23], the benefit-cost ratio declines to close to 1. At this discount rate the project is marginal in terms of social value. However, it must be remembered that a number of benefits and costs were not included in the CBA, and a more comprehensive assessment would alter the benefit-cost ratio at both rates.

Calculating the benefit-cost ratio using two rates demonstrates to the decision-maker the impact of the discount rate on the CBA. Because of the importance of the discount rate to the overall assessment, the decision-maker should arguably be involved in its selection. By showing both calculations in the CBA, indirectly involves the decision-maker in the choice of the rate.

[23] 10% is the discount rate recommended by the Treasury Board (1965).

5.2.4 Understandability

Understandability refers to the transparency of the assessment and ability of the decision-maker to recognize and/or comprehend the assumptions behind the assessment and the interpretation of costs and benefits, as well as the benefit-cost ratio itself.

With respect to the understandability of the assessment by the decision-maker/user there are four primary areas of concern. First, the implications of the omission errors may not have been obvious to the decision-makers at the time, because of the almost exclusive emphasis being placed on flood control. Since the assessment was undertaken for the explicit purpose of determining which flood protection measures would maximize flood control benefits for the investment, other costs and benefits were considered incidental. The result is the decision-maker was only provided with a partial assessment of the project's costs and benefits.

The second concern is that the decision-maker may not have fully recognized the policy-type choices that were made and/or understand their implications. The choice of the discount rate is one such issue.

The third concern is related to the lack of attention given to local costs and benefits. Without these being explicitly stated, even if they were small relative to the overall stated costs and benefits, the decision-maker is not given the opportunity to recognize and assess distribution issues arising from the project at a key decision-making stage of the pre-development assessment. Furthermore, because the full range of impacts is not valued, the decision-maker does not benefit from a quantification of these impacts, which can help in developing a policy response to distributional issues.

The fourth issue is one of clarity. Insufficient information was provided in a couple of instances. For example, Kuiper does not inform the reader of which year his dollar figures were calculated. Since the Shellmouth Reservoir was to be an "...extension and completion of the findings of the Royal Commission" (Kuiper 1961), it is probable the estimates of the benefit and costs were in 1958 dollar values, but this is not explicitly stated. How annual maintenance costs are derived in the Kuiper CBA on the Shellmouth are also not outlined.

5.3 CONCLUSIONS

A number of costs and benefits were not calculated into either analysis by the Royal Commission or Kuiper. Many of the costs and benefits not included in the analysis are accrued to the local area surrounding the reservoir, generally are environmental/aesthetic effects. In part, this is presumed to be a result of the narrow interpretation of what costs and benefits should be covered, and because of a number of biases within the assessment.

The original CBA was not a comprehensive analysis and to be fair, it was never intended to be. However, because it was not a comprehensive analysis, a number of costs and benefits were not included in the assessment. In addition to this, a certain level of bias, which is consistent with the intent of the assessment, is believed to be present. There were also certain policy-type choices made with implications for what items were and were not addressed in the assessment and/or how they were addressed. Because the analysis was not comprehensive, and was affected by bias and certain policy-type choices, the ability of the decision-maker to utilize the assessment to make a fully informed decision was compromised. The result was that the CBAs did not contribute to a full understanding of the project impacts on the local area. It should be noted that this line of reasoning assumes that at the time of the CBA, the decision-maker was interested in the full range of costs and benefits. However, in the particular case of the Shellmouth, both political and public interests were primarily focused on averting future flood damages for Winnipeg. Even if the project CBA ratio was marginal (closer to 1), the project would likely still have been given serious consideration at the decision level because of the political will at the time. Interestingly, by the time the dam construction was underway almost a decade later, the political and social atmosphere might have changed somewhat, with perhaps more interest in other impacts of the project. The fact that the McKay et al study (1969), with its partial review of biophysical impacts was undertaken, perhaps suggests a growing interest in broader project impacts.

Conducting a comprehensive assessment that factored in local costs and benefits in the assessment may not have affected the outcome of the CBA in terms of generating a positive benefit-cost ratio since a number of downstream benefits were also not factored into the assessment. Examples of some downstream benefits not included in the benefit-cost ratio are irrigation opportunities, industrial development, and the social benefits of minimizing the flood risk. A more comprehensive assessment would have been helpful, in identifying and quantifying the local and environmental costs and benefits. This would have provided much of the necessary information for a distribution assessment, and facilitated forward planning that could have lead to distribution issues being addressed.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.0 SUMMARY

This study has been undertaken to conduct an *ex-post* development review of the Shellmouth Reservoir, thirty years after its construction. The purpose has been to understand the concerns of the local area and appraise the role of CBA as a pre-project assessment tool. Particular emphasis is given to the consideration of local impacts in the CBA, and the capacity of CBA, as a decision/planning tool, to anticipate and identify the implications of development. The *ex-post* development review of the Shellmouth Reservoir identifies some of the strengths and weakness of CBA, when applied as a pre-development assessment tool for reservoir projects. Doing so, provides an opportunity to improve pre-development planning, specifically the use of CBA for reservoir assessments.

In conducting the *ex-post* development review of the Shellmouth project, the study examined the positive and negative impacts of the reservoir on the local area described as the RMs of Russell, Shellmouth, and Shell River in Manitoba, and Cote and Calder in Saskatchewan. The *ex-post* review consisted of an assessment of local impacts (Chapter 3), a discussion of recognized issues associated with the application of CBA (Chapter 4), and a review of the costs and benefits included in the original Shellmouth CBAs (Chapter 5).

Because there is relatively little documentation on the Shellmouth project's local impacts, key person interviews and a review of similar case studies were conducted to help identify and characterize impacts. A literature review of CBA was also conducted to identify and characterize issues with the use of the CBA tool in an assessment of a reservoir project. The original Shellmouth CBA documents reviewed for this study were the *Royal Commission on Flood Cost-Benefit* (Royal Commission 1958), *Benefit-Cost Analysis: Assiniboine River Flood Control and Water Conservation Projects* (Kuiper 1961), and the background documents leading up to these studies. The final aspect of the review consisted of comparing the identified local impacts with those included in the original Shellmouth CBA. It also examined the original Shellmouth CBAs in relation to issues generally associated with applied CBA.

6.1 CONCLUSIONS

Local Impacts

The ex-post development review of the Shellmouth identified a number of positive and negative environmental and socio-economic impacts incurred by the local area and individual residents. Specific environmental effects experienced by the local area, as a result of the Shellmouth project, include:

- physical impacts (bank erosion; some sedimentation)
- water quality changes (nutrient loading; pollutants; methylmercury; excessive algae growth; toxins from decomposing blue green algae; low DO), and
- biota impacts (fish kills; inhibits development of the littoral region; sports fishery habitat).

Socio-economic impacts experienced by the local area include those stemming from:

- property acquisition for reservoir project (reduced local supply of agricultural land; reduced tax base/revenues; inconsistent land purchase price; purchase price not covering replacement land costs) ,
- social-health effects (non-compensated RM administration resources; stress/ frustration/anxiety; disrupted community patterns/networks; displaced residents; construction disruptions),
- environmental impacts with socio-economic consequences (positive impacts on agriculture production--high water table upstream/downstream during drought years; negative impacts on agriculture production-backflooding upstream and flooding downstream; negative water quality impacts on recreation desirability; reduced tourism as a result of the dramatic reduction in the sports fishery roughly ten years into the project), and
- economic development effects (construction employment/sales; employment and income impacts; recreation and tourism opportunities; vacation property development; business development spin-offs).

These have arisen not only from the initial development of the reservoir, but also from its ongoing operation. For example, local benefits associated with the reservoir, such as recreation opportunities and the quality of the sports fishery, have often been compromised (the full potential not maximized) by the operation of the reservoir for downstream needs. The negative, or not fully realized positive local environmental and socio-economic impacts from the Shellmouth Reservoir, are important because they are the source of the ongoing local concerns that triggered this ex-post development review.

A conclusion gleaned from the review of local impacts is that many impacts are not static, but vary over time and space, as well as between individuals. Not only does this make it difficult to anticipate costs and benefits when conducting the CBA, but it necessitates on-going data collection to accurately characterize the project's impacts in an *ex-post* development review. Because impacts are not static, it also makes compensation for non-mitigatable costs difficult, such as for those impacts experienced at the local level in the case of the Shellmouth Reservoir.

A second comment with respect to local impacts and the findings of the review: many individuals in the key person interviews pointed out that anticipated recreation and tourism economic development had not been achieved. These anticipated benefits were surprising similar to the projectedproperty development presented in the land use plan by McKay et al (1969) and were seen by the local area as offsetting the local costs. The slow progress in achieving recreation and tourism development related to the reservoir, was not anticipated by local RMs, nor apparently by the decision-maker. Had this been identified as an impact, plans and policies could have been developed early on to more actively promote the desired development, rather than assuming it would occur without intervention.

CBA

The *ex-post* development review demonstrated that impact prediction is strongly influenced by the knowledge base at the time of analysis. In the case of the Shellmouth Reservoir, impacts were not well understood at the time of the CBA. Even today, 40-years after the project was initially assessed, there are major deficiencies in the knowledge of a wide range of biophysical, economic, and social systems potentially affected by reservoir development (Takeuchi et al 1998). This inherent uncertainty in prediction means that inevitably, unanticipated impacts will occur.

The review also highlighted that changing perspectives affect how individual impacts are viewed over time, and alter what is considered acceptable in terms of reservoir development and operation. One of the criticisms of the Shellmouth CBA was the inadequate consideration given to local environmental costs. However, this omission is a function of the time period in which the assessment was conducted. Consideration of environmental issues is a relatively recent focus of general social concern, and one that post-dates the Shellmouth CBAs. Environmental issues were only beginning to be considered when the project was being constructed, as seen in the brief discussion of bio-physical impacts in the McKay et al study (1969). Thus another inherent shortcoming of pre-development assessment is that while impacts themselves are hard to predict, the concern of future generations and the weighting this gives to various costs and benefits, is even more difficult to anticipate.

The literature on reservoir impacts and CBA literature examined for this study, and the *ex-post* development review of Shellmouth Reservoir's CBAs, revealed a number of potential limitations with the application of CBA for reservoir assessments. Those limitations noted specifically with respect to the Shellmouth CBA are:

- accuracy of the assessment-omission errors (not including externalities, secondary costs and benefits),
- certain biases (focus on the City of Winnipeg, only engineering solutions),
- policy type choices (the use of only one low discount rate, focus on southern Manitoba, and reliance on equity as the sole criterion for assessment and the associated lack of consideration of distributional issues), and
- understandability (lack of clarity regarding choices made by the analyst).

Because of these limitations, the Shellmouth CBA did not provide the decision-maker with a comprehensive assessment. This ultimately inhibited the usefulness of the pre-development assessment, particularly with respect to the decision-maker's understanding of distributional issues affecting the local area.

The Shellmouth's ex-post review highlighted the importance of including the secondary costs and benefits in a CBA. Traditionally, secondary costs and benefits are eliminated from the assessment based on the argument that they only represent redistribution in the economy, and are not new benefits or costs generated directly by the project. However, by not including secondary impacts in the project CBA, significant economic gains or losses, and/or effects on the well-being of the immediate project area, are not considered. For example, changes in the type and availability of local employment, is an important consideration for the local area, particularly if employment options are scarce. Not knowing the distribution of such costs hinders the capacity of the decision-maker to identify mitigation and compensation measures to address impacts. Many of the economic benefits (supplies and services to visitors) that accrued to Russell as a result of the Shellmouth Reservoir are classified as secondary benefits. While they were excluded from the provincially oriented CBA, the local area sees them as important contributions to the local economy.

This study of the Shellmouth, also demonstrated that there are drawbacks to conducting a pre-development assessment that focuses only on the issues of the day. In the Shellmouth case, the CBA was purposefully narrowed to focus almost exclusively on flood control benefits for the City of Winnipeg, which was the preoccupation of society following the damages from the 1950s flood. If the same logic were applied to an assessment of the Shellmouth today, the emphasis of the CBA would include water supply issues related to economic development in southern Manitoba. The problem with taking a narrow perspective, is that society's interests with respect to a reservoir are likely to change over time in a way that is difficult to predict.

This *ex-post* development review concluded that potentially significant costs and benefits were eliminated from the assessment by way of the time horizon chosen by the analyst. As a result, the CBA did not take into consideration distant costs and benefits generated by the project. In the case of the Shellmouth, and often with reservoirs in general, decommissioning and/or retrofitting costs are often eliminated from the scope of the assessment. However, even if these distant impacts were included in the CBA, does not completely resolve the issue. Present-value calculations render distant costs and benefits meaningless in the CBA because their dollar value, when discounted, approaches zero.

Thus, these otherwise significant impacts have a marginal effect on the overall benefit-cost ratio.

Another issue noted in the Shellmouth CBAs was the assessment criteria. Shellmouth CBA is a by-product of a time-period where single-objective pre-development analysis was based solely on efficiency. The problem in using this criteria is that distributional issues, which are the source of local concern with the Shellmouth Reservoir, are not included. This single criterion approach is also not compatible with today's society that is increasingly focussing attention on sustainability, which lends itself to other considerations such as intergenerational costs.

In the final analysis, the Shellmouth Reservoir was one of a series of flood control projects considered through the CBAs. Had the Shellmouth not been chosen, another reservoir development elsewhere was likely, because society was focused on reducing the flood risk to Winnipeg. Thus the CBA was not used as a tool to decide whether to develop a flood control project or not. Rather, the choice to achieve a certain level of flood protection for Winnipeg was already made at the political level, and the CBA only helped the decision-maker choose between the various identified options.

Today, within the framework of sustainable development, a more integrated approach would likely be taken at the pre-project assessment stage and consideration of local issues through a comprehensive CBA. This would help identify and fully characterize all costs and benefits, facilitating appropriate planning. However, as late as a decade ago, reservoirs such as the Rafferty-Alameda and the Oldman River projects were still being developed without have an integrated assessment undertaken.

While CBA is not perfect assessment tool, it does offer an organized method of evaluating projects and policies for their contributions to society in terms of net benefits. CBA, when applied appropriately, can define changes against baselines, assesse alternatives, and identify potential changes in outcomes, and possible risks. As one critical economist stated, it is still one of the best decision tools that we have (Cappen 1990). How vigorously CBA is applied in individual cases, will determine its value as a pre-development assessment tool.

6.2 RECOMMENDATIONS

The key question is how might CBA evolve to accommodate the new social sustainability criteria, as well as maximize its usefulness as a pre-development assessment tool? A number of mechanisms should be implemented to improve the application of CBA for such projects as reservoirs, and the following are provided as recommendations:

1. Assess impacts in a logical and consistent manner.

Using consistent methods for such activities as calculating benefits and costs can improve accuracy and the overall quality of the analysis. One of the problems with the Shellmouth CBA was that a significant number of costs and benefits were omitted. Part of this may be explained by the scoping process used, which did not adequately capture local impacts. In specific applications of CBA, accuracy may be improved by thoroughly scoping impacts and identifying stakeholders. For example, it is common to incorporate public participation in the scoping process for EIA and SEIA (Cattrysse 1990). This is done to improve the identification and characterization of impacts.

2. Consider all impacts, including local costs and benefits, even if they appear minor in relation to the overall project/assessment or not of importance (outside the existing social area of concern).

In order for the decision-maker to be fully informed, all impacts should be included in the CBA such as externalities, distant costs and benefits, and secondary impacts. Technically, CBA should be value free, incorporating all costs and benefits and not just those that are of concern at the time of the assessment. Incorporating all costs and benefits recognizes that society's value systems and needs are liable to change over time. The Shellmouth CBA with its focus on downstream flood control, to the exclusion of other costs and benefits, is an example of selectively including impacts.

All costs and benefits, including externalities, should be internalized in the CBA, to ensure a full-cost accounting. Where possible, distant impacts should also be addressed in a way that ensures they are included in the CBA in a meaningful manner. For example, if a fund had been created at the time of the project construction to cover distant future costs, such as decommissioning or retrofit of the reservoir, then the cost would be internalized, but not discounted to near zero. By establishing a fund, the true cost is borne by the society making the decision, and not passed onto future generations.

In addition, secondary impacts should be addressed. Unlike direct impacts, secondary impacts represent redistribution in the economy, or conversely are only partially a result of the project, and therefore are not new costs or benefits generated exclusively by the project. However, secondary local impacts can be particularly important to the well-being of the local area. One way of including secondary impacts without skewing the analysis results, is to address them separately from the costs and benefits arising directly from the development and thus not included them in the benefit-cost ratio calculation (Sewell et al 1961).

The ongoing local concerns in the Shellmouth case, demonstrate the importance of addressing the issue of secondary the costs and benefits. If significant distributional impacts arise, a separate assessment may be necessary to assist with the development of appropriate policy, program, or infrastructure responses that will effectively mitigate and/or compensate for distributional inequities. Identifying and including all of the costs and benefits at the CBA stage, would facilitate such an assessment.

Lastly, local costs and benefits are important to include in the assessment because even if they are minor in relation to the entire project, they are important to the local area. Large-scale resource projects have a history of changing the fabric of communities and profoundly affecting the lives of individuals. If pre-development assessments are not comprehensive, then these impacts are never truly known or understood, loosing the opportunity to choose appropriately or develop compensation or mitigation measures to significantly reduce any negative effects and enhance positive ones.

3. Ensure the assessment is understandable and useful for the decision-maker by presenting results in a standardized format that is as clear as possible.

Clearly explain how the CBA was conducted, including all assumptions and omissions, as well as any implications of those assumptions and omissions. Identify costs and benefits excluded from the assessment and the rationale for doing so. Improve the process by highlighting decisions, particularly policy-type choices that might affect the analysis and document these and their implications so the decision-maker is clear on the assumptions and their effect on the final outcome. Address potential uncertainties and biases and identify distribution and equity implications of the costs and benefits. Most importantly, ensure that decision-makers have a clear understanding of the CBA process, the limitations, and the meaning of the conclusions generated.

4. Revisit the CBA throughout the planning stages to ensure a full accounting of costs and benefits.

A testament to the growing recognition of the limitations of traditional CBA is that EIAs are now generally required by law and SEIAs, either as a component of EIAS or as a stand-alone assessment, are growing in importance. CBA alone is no longer considered sufficient as a pre-development assessment tool, but the use of EIA and SEIA are still often relegated to the mitigation/compensation phase of the decision process (Priddle 1991). The political decision as to which project to pursue is still generally made at the CBA stage.

Revisiting the CBA, following the intermediate and/or final design stage may help improve the accuracy of the CBA by ensuring that construction and other development costs reflect the project design. Revisiting the CBA after the completion of the EIA/SEIA would help ensure that significant environmental and socio-economic costs and benefits, including mitigation and compensation, have been addressed and properly characterized in terms of their value. In the case of the Shellmouth project, revisiting the CBA may have resulted in a fuller cost-benefit accounting. For example, the development costs and resulting benefits of Assesippi Park would likely have been included in the project CBA had the CBA been revisited.

5. Apply multi-objective criteria to assess the project on criterion that is representative of the wide spectrum of social values, and not simply whether it is efficient.

While there is considerable merit in identifying projects that are efficient (social benefits outweigh costs), society also considers other criteria important. Sustainability is an increasingly fundamental concept of public sector development, particularly because efficiency, as a single objective, is not reflective of the wide spectrum of society's values. Sustainability as a criterion, recognizes that society is concerned not only with economic efficiency as an objective, but also other criteria such as equity. The benefits of applying multi-objective criteria in CBA are to factor in other important social concerns, such as the distribution of benefits, both between and within generations, and the avoidance of irreversible conditions.

Using a multi-objective criterion in the CBA would provide the advantage of including other social concerns, at a stage in the pre-development assessment where projects are chosen for further review or eliminated from consideration. Methods have been developed in recent years for incorporating multi-objective criterion into a CBA. For example, equity objectives could be incorporated into CBA by assessing the efficiency of a project, subject to meeting conditions regarding income and benefit distribution. The application of these methods would need to be assessed on a case by case basis.

6. Conduct an *ex-post* development review

Making *ex-post* development reviews a required part of the assessment process, improves the application of CBA by comparing the pre-development assessment with actual long-term project results. Documentation of common pitfalls in the application of CBA provides an opportunity to improve the pre-development assessment of future projects. A lack of feedback on the other hand, propagates ineffective and unreliable procedures and approaches, leading to the same errors being repeated with the next project assessment (Locke and Storey 1997, Takeuchi 1998). Since medium to large scale reservoir projects do not occur very often, and the lessons learned from one project can be lost by the time the next project is proposed, it becomes even more imperative to document the pre-construction analysis verses the post-construction conditions.

The choice of whether to conduct an *ex-post* development review is best made before construction begins to ensure base line conditions are adequately documented. This requires some decisions to be made about the scope and format of the *ex-post* development review, even before the project is developed. Data collection should ideally begin at the start of construction to measure impacts of the project during this phase. Data collection would continue until such time as a comprehensive ex-post review of the project is conducted. However, this does not preclude undertaking an interim assessment every three to five years, which would focus on whether appropriate data is being collected and whether impacts have evolved which should be mitigated. The timing of the actual *ex-post* development review would likely occur a minimum of ten years after the project had been developed. However, the exact time line would be a function of the individual reservoir project: the available budget, the study's framework, specific study goals, and the time required for a significant percentage of impacts to be measurable.

6.3 ADDITIONAL OBSERVATIONS

There were three additional observations made with respect to this study on the Shellmouth Reservoir project. These observations are presented on:

i. the importance of managing local expectations of benefits from large-scale development, such as reservoirs,

ii. difficulties in addressing distributional issues through compensation, and

iii. issues with conducting an ex-post development review of reservoir projects.

Management of Local Expectations

Overall, local governments are at a distinct disadvantage with large-scale development, a point that has not been lost on a number of scholars who have considered the dynamics of large scale development on communities (Leistritz and Murdock 1987, Logan and Mulotch 1987). Because this type of development is outside the experience of local rural governments, they are unlikely to have a good understanding at the outset of the project's implications for their communities and individual citizens. In addition, staff support is limited for small rural municipalities. Thus, they are likely to lack the expertise of how to plan appropriately to maximize development benefits for their communities in relation to the specific project, and to anticipate and address impacts effectively. This also means they are at a disadvantage when negotiating with higher levels of government for mitigation/compensation measures.

Many individuals in the key person interviews pointed out anticipated recreation and tourism economic development that had not been achieved. This highlights an issue that is associated with large-scale projects in general, not just reservoirs: the need to manage expectations. The slow progress of recreation and tourism development related to the reservoir, was something that should have been drawn to the attention of the local RMs as well as the decision-maker. In this way, plans and policy could have been developed early on to promote the desired development, rather than assuming it would occur without active intervention.

Compensation question

The key to ongoing local concerns of a project once it is already in place is to address the negative impacts and perhaps augment benefits through mitigation, empowerment, and/or compensation.

Mitigation and empowerment are closely connected. Mitigation serves to reduce the magnitude or eliminate an impact. Empowerment allows affected individuals to be part of the decision-making process with respect to project planning and/or operation. Empowerment is a form of redress, providing the community an opportunity to control somewhat, the impacts of the project on the local area, which is why consensus building has been advocated as a concept for promoting sustainable development. Empowering local people by providing them with the authority, skills and information needed to affect change, gives local people power over their own future and the capacity to address impacts that are important to them.

Of the three however, compensation presents the most interesting dilemmas. It is an interesting concept in relation to traditional CBA, because it goes against the basis premise of the modified Pareto Improvement Criteria, which requires only that benefits be sufficiently large to be able to cover losses, not that losses are actually compensated.

Compensation is an idea more closely related to the equity criteria, where losses are compensated by those who benefit. Within certain constraints this is a basic premise of the Canadian legal system. It is these certain constraints that have posed the problem for the local area. Compensation within the legal framework is available primarily when there are defined property rights including effects on personal health or well-being. It can be more difficult to obtain compensation when property rights are not clear.

This is the root of the problem regarding a number of local Shellmouth impacts: is that they do not fall in the traditional framework of property rights. Even when they do, as in the case of property purchased for the reservoir, the legal requirement is that market value be paid. In most cases, this does not reflect the true value of the property to someone who is not already pre-disposed to selling. The reason is that the seller incurs uncompensated, intangible or indirect costs such as sentimental loss of place or reduced sustainability of the farm operation in terms of increased operation costs or decreased flexibility to respond to market or environmental changes.[24]

As seen with the Shellmouth, less well defined in terms of property rights is community impacts. As a result there is no formal mechanism such as the law from which to secure compensation for losses. When government does provide compensation, as in the case of

[24] An interesting foil to this is how may private companies now approach development: it is not uncommon for landowners to be compensated for non-traditional transaction costs such as time spent attending meetings, and even intangibles such as noise. The reason for doing so may be regulatory and/or to secure buy-in from the local area and reduce or eliminate local resistance to a project.

Asessippi Park and more recently the Ski Hill, it does not represent compensation in the traditional legal sense that would be geared to the specific impact. Rather, community based compensation does not target individuals, but the community at large. As a result, those who incur costs are compensated in a way that is not meaningful in relation to the cost. One example is local farmers who lost farmland in the Assiniboine River Valley and now must travel greater distances to fields, received compensation via recreational opportunities from Asessippi Park and the reservoir.

Finally, in spite of being a cost stemming directly from the project, compensation along with mitigation is seldom included in project cost estimates. If pre-development assessment was required to consider compensation as a project cost, less marginal projects would pass the pre-development review.

ex-post development review

Conducting a comprehensive *ex-post* review requires planning and funding for ongoing data collection. The long time horizon between construction of the Shellmouth and project review inhibited the comprehensiveness of this review. For projects with long time horizons, such as reservoirs, there is merit for conducting an interim assessment. Doing so, can test whether the long-term data collection should be adjusted to better reflect changing impact conditions. Lessons learned can also be applied to other upcoming projects or even to the particular project being reviewed, such as modifying the operational regime or other mitigative measures.

Time played an important factor in being able to identify and characterize impacts, particularly impacts occurring relatively early in the project. While it is important to allow sufficient time for impacts to be observed and measured, too long a period between the pre-project assessment and the post-development review also creates problems. One problem is the continuity of information. Details have a tendency to become forgotten over time, unless recorded in some consistent manner such as through regular data collection or studies. Without this, it becomes difficult to track impacts, particularly in terms of magnitude. If regular data collection is not undertaken, then key person interviews become one of the few site-specific sources of information available. However, if too much time has lapsed, as experienced in this *ex-post* review of the Shellmouth Reservoir project, individuals who have observed and/or experienced baseline conditions and the resulting conditions following the project may be difficult to locate. Even those individuals who were contacted, were only to be able to provide sketchy details of many of the costs and benefits. In contrast to the *ex-post* review on the Shellmouth, the Shelbyville study started collecting data in 1973, eleven years after the reservoir's development. This provided better opportunities to research the baseline data and assess impact conditions in relation.

LITERATURE CITED

LITERATURE CITED AND REFERNECED

Ackermann, W., G. White, E. Worthington, J. Ivens, eds. 1973. Man-made Lakes: Their Problems and Environmental Effects. Geophysical Monograph 17, American Geophysical Union, Washington, D.C.

Anderson, L. G. and R. F. Settle. 1977. Benefit-Cost Analysis: A Practical Guide. D.C. Heath and Company, Toronto.

ARMAB (Assiniboine River Management Advisory Board). July 1995. Interim Report to the Minister: Manitoba Department of Natural Resources. Winnipeg, Manitoba.

Ashmore, P. 1990. Analysis and Interpretation of Assiniboine River Sediment Station Data. Environment Canada, Water Resources Branch, Winnipeg.

Barber, L.F. 1978. Shellmouth Water storage Project: Report of Interviews with Landowners and Farm Operators Regarding the Effect of the Shellmouth Reservoir on Crop Production in the Assiniboine River Valley, Southeast of Kamsack, Saskatchewan. PFRA. Regina, Saskatchewan.

Barbour, I.G. 1980. Technology, Environment and Human Values. Praegar, New York.

Baumol, W. J. On the Discount Rate For Public Projects. *in* Robert H. Haveman and Julius Margolis. Public Expenditure and Policy Analysis. 2nd edition. p.161-178.

Baxter, R.M. and P. Glaude. 1980. Environmental Effects of Dams and Impoundments in Canada. Department of Fisheries and Oceans. Ottawa. p. 6-39.

Bellagio Principles: Guidelines for Practical Assessment of Progress. 1996. www.iisd.ca/measure/

Belman, I.J. *in* K. R. Turner. Sustainable Environmental Economics and Management. Belhaven Press, New York.

Bergmann-Baker, U., J. Brotton and G. Wall. Fall 1995. "Socio-Economic Impacts of Fluctuating Water Levels on Recreational Boating in the Great Lakes." in Canadian Water Resources Journal. 20:3. p. 185-194.

Bishop, R.C. 1978. Endangered Species and Uncertainty: The Economics of the Safe Minimum Standard. American Journal of Agricultural Economics. 57. p.16-18.

Boardman, A, W. Mallery and A. Vining. 1994. Learning from Ex Ante/Ex Post Cost-Benefit Comparisons: The Coquihalla Highway Example. Socio-Economic Planning Science. 28:2. p.69-84.

Bodaly, R.A., V.L. St. Louis, M.J. Paterson, R.J.P. Fudge, B.D. Hall, D.M Rosenberg,. and J.W.M. Rudd. 1986. "Bioaccumulation of Mercury in the Aquatic Food Chain in Newly Flooded Areas." in A. Sigel and H. Sigel. Metal Ions in Biological Systems. Marcel Dekker, Inc., New York. p. 259-287.

Bojö, J., K.G. Mäler and L. Unemo. 1990. Environment and Development: An Economic Approach. Kluwer Academic Publishers, Boston.

Bolger, M. June 1995. "Methylmercury Hazard and Risk" National Forum on Mercury in Fish Proceedings. New Orleans, Louisiana. September 27-29, 1994. EPA.

Bowles, H. March 1995. "Downstream Ecological Effects of Dams." Bioscience. p. 184-189.

Brent, R. J. 1996. Applied Cost Benefit Analysis. E. Elgan Publishers, Brookfield, U.S.

Bruce, N. and R. Harris. The Compensation Principle: Reversal and Bias in Cost Benefit Tests, Discussion Paper #422. Queen's University, Canada.

Bruce, N. and R. Harris. June 1981. Cost-Benefit Criteria and the Compensation Principle in Evaluating Small Projects, Discussion Paper #437. Queen's University, Canada.

Bruce, N. and R. Harris. November 1982. The Compensation Principle and Cost Benefit Analysis: Consistency, Application and Decision Rule Error, Discussion Paper #520. Queen's University, Canada.

Burdge, R. J. and P. Opryszek. Editors. 1981. Coping With Change: An Interdisciplinary Assessment of the Lake Shelbyville Reservoir. Institute for Environmental Studies. University of Illinois. Urbana.

Buss, T and L. Yancer. 1999. Cost Benefit Analysis: A Normative Perspective. Development Quarterly. February. 13:1. p29-38.

Caccia, C. 1985. "Cost/Benefit Analysis or Otherwise Known as Cry Bitterly Afterward." *in* Economy and Ecology: The Economics of Environmental Protection. Symposium Feb. 19-20, 1985. Canadian Society of Environmental Biologists, Edmonton, Alberta. p. 121-125.

Campen, J. 1990. Benefit, Cost, and Beyond: The Political Economy of Benefit-Cost Analysis.

Canada-Federal Environmental Assessment Panel. 1992. Oldman River Dam: Report on the Environmental Assessment Panel. Federal Environmental Assessment Review Office, Hull, Quebec.

Canada West Foundation. 1982. Nature's Lifeline: Prairie and Northern Waters. Calgary.

Canadian Wheat Board. 1999. www.cwb.ca

Canter, L. W. 1977. Environmental Impact Assessment. McGraw-Hill Book Corp., Toronto.

Cattrysse, L. F. 1990. Evaluation the Potential for Scoping in the Ontario Environmental Assessment Process. University of Waterloo, Waterloo, Ontario

CCME. 1987. Canadian Water Quality Guidelines. Government of Canada, Ottawa.

Chambers, P., E. Prepas, H. Hamilton, and M. Bothwell. 1990. The Role of Current Velocity and Discharge Rate in Regulating Aquatic Macrophyte Abundance in Rivers on the Canadian Prairies. *in* R. Robarts and M. Bothwell. Aquatic Ecosystems in Semi-Arid Regions: Implications of Resource Management. NHRI Symposium No. 7. August 27-30, 1990. Saskatoon, Saskatchewan. National Hydrology Research Institute, Saskatoon. P. 269-271.

Coker, W. B. 1995. Processes Effecting Mercury and Associated Metals in Lake Sediment Columns. Proceedings of 1995 Canadian Mercury Workshop. Canadian Center for Inland Waters, Burlington, Ont.

Cole, G. A. 1983. Textbook of Limnology. third edition. Waveland Press Inc., Prospect Height, Ill.

Conopask, J.V. and R. Reynolds. 1977. Social Impact Assessment and Cost-Benefit Analysis. *in* K. Finsterbusch and C. Wolf. Methodology of Social Impact Assessment. McGraw-HillBook Corp., Toronto. p. 74-82.

Constanza, R. ed. 1991. Ecological Economics: The Science and Management of Sustainability. Columbia University Press, New York.

Daneke, G. A. and J. Delli Priscoli. April 1979. "Social Assessment and Resource Policy: Lessons From Water Planning." in Natural Resources Journal. University of New Mexico. 19. p. 359-375.

Dasgupta, P. and K.G. Mäler. 1994. "The Environment: The environment and emerging development issues". in Cost-Benefit Analysis; 2nd edition. Cambridge University Press, Cambridge. p. 319-348.

Dasgupta, P. 1994. "Exhaustible Resources: Resource depletion, research and development and the social rate of discount". in Cost-Benefit Analysis; 2nd edition. Cambridge University Press, Cambridge. p. 349-374.

Department of Environment, Sport and Territories, Government of Australia. 1996. A Handbook of Environmental Evaluation. http:// w w w.envionment .gov.au/ portfolio/esd/handbook

Dillon Consulting Limited. August 1998. Upper Assiniboine River Basin Water Quality. Water Quality Technical Committee, Upper Assiniboine River Basin Study.

Dinar, A. and D. Zilberman. 1991. The Economics and Management of Water and Drainage in Agriculture. Kluwer Academic Publishers, Massachusetts.

Dougherty, T.C. and A.W. Hall. 1995. Assessment of Irrigation and Drainage Projects. Food and Agriculture Organization of the United Nations. Rome. p.31-63.

Dumont, C. 1995. Mercury and Health: The Jame Bay Cree Experience. Proceedings of 1995 Canadian Mercury Network Workshop. Canadian Center for Inland Waters, Burlington, Ont.

Environment Canada, Water Planning and Management. Sept. 1974. Assiniboine River Basin: Reference Binder. Government of Canada, Regina, Saskatchewan.

Eugster, J. G. and C. J. Duerksen. 1984. A Citizen's Guide to River Conservation. The Conservation Foundation, Washington, D. C.

Everdingen, R. 1970?. Diefenbaker Lake Effects of Bank Erosion on Storage Capacity. Inland Waters Branch, Department of Energy, Mines and Resources. Government of Canada.

Everitt, R. and D. Colnett. 1987. Methods for Scoping Environmental Impact Assessments. Vancouver: ESSA Ltd.

Farrow, S. and M. Toman. March 1999. Using Benefit-Cost Analysis to Improve Environmental Regulations. Environment. 41:2. p. 12-22.

Federal Environmental Assessment Panel. 1992. Oldman River Dam: Report of the Environmental Assessment Panel. Federal Assessment Review Office, Hull Que.

Fisheries Branch. 1995. Lake of The Prairies, 1995 Index Fishing - Summary Report

Fisheries Branch. 1989. Lake of the Prairies Creel Census Report-1989. Manitoba Natural Resources Memo.

Fisheries Branch. 1995. Lake of the Prairies Creel Census Report-1995. Manitoba Natural Resources Memo.

Fisheries and Oceans. 1992. Troubled Waters: Threats to Fishing Habitat in the Prairie Provinces. Minister of Supply and Services, Canada.

Field, B. C. and N. D. Olewiler. 1995. Environmental Economics. McGraw Ryerson Limited, Toronto. p. 103-174.

Fortin, R.V. and S.E. Gurney. September 1997. Phosphorus Loading to Shellmouth Reservoir, Manitoba Canada (draft). Manitoba Environment, Winnipeg. No. 97-05.

Fowler, J. A. No Date. Effects of Reservoir Upon Fish.

Friesen, G. 1987. The Canadian Prairies: A History. University of Toronto Press, Toronto.

Frost, M. J. 1975. How to Use Cost Benefit Analysis in Project Appraisal. John Wiley and Sons, New York.

Goldsmith, E., and N. Hildyard. 1984. The Social and Environmental Effects of Large Dams. San Fransisco: Sierra Club Books.

Government of Manitoba. 1958. Report of the Royal Commission on Flood Cost-Benefit. Winnipeg, Manitoba.

Government of Manitoba. December 1973. Outdoor Recreation Master Plan (Provisional) Asessippi Provincial Park. Department of Tourism, Recreation and Cultural Affairs Parks Branch. Winnipeg, Manitoba.

Government of Manitoba. 1989. Dauphin Lake: Opportunities for Restoration. Submitted to the Dauphin Lake Advisory Board.

Government of Manitoba, Crown Lands Classification Committee. January 1994. Operational Crown Land Plans 1994.

Gravelines, L. and H. Schellenberg. August, 1985. Benefit Cost Guidelines for Land Use Allocations in Manitoba (Part 1). Government of Manitoba, Canada.

Gray, J. A. 1978. The Economics of Natural Environments: Evaluation of the Preservation Alternative in the Churchill River Diversion of Northern Manitoba. Paper presented at the Public Meeting and Seminar, Water Resource Planning in the Yukon. Whitehorse, Yukon. Dec. 8,9, and 10, 1978.

Green, C. Spring 1997. "Water, the Environment and Economics: What Does Experience Teach Us So Far." in Canadian Water Resources Journal. 22:1 p. 57-67.

Green, D.J. and A.E. Beck. July 1995. Mercury and Other Metal Residues in Fish from the Assinboine River. Manitoba, Canada, 1978-1992. Report No. 95-0. Manitoba Environment, Government of Manitoba, Canada.

Green Spaces Environmental Consulting. 1994. Environmental Impact Assessment for the Proposed Asessippi Ski Hill. Winnipeg.

Gregory, R. and P. Slovic. 1997. A Constructive Approach to Environmental Valuation. Ecological Economics. 21. p. 175-181.

Gurney, S. and J. Jones. 1997. "Toxic Algae Occurrences and Distribution in Manitoba Surface Waters." Proceedings of the Rural Water Quality Symposium. March 25-26, 1997. Winnipeg, Manitoba.

Gummer, W. 1979. Pesticide Monitoring in the Prairies of Western Canada. Inland Waters Directorate, Western and Northern Region, Water Quality Branch. Regina.

Gurney, S. and R. Fortin. January 1992. Shellmouth Reservoir/ Assiniboine River Study: Interim Report. Water Quality Management Section Environmental Management Division Manitoba Environment, Winnipeg, Manitoba.

Hamilton, A. L. September, 1991. Rafferty Alameda: An Assessment of the Agreement Between Canada and the United Sates for Water Supply and Flood Control in the Souris River Basin. Rawson Academy of Aquatic Science, Ottawa.

Hanley, N. 1992. "Are There Environmental Limits to Cost-Benefit Analysis?" Environmental and Resource Economics. 2. p. 33-59.

Harker, D. Brook. 1997. Nonpoint Agricultural Effects on Water Quality PFRA, Regina, Saskatchewan.

Helweg, O. J. 1985. Water Resources Planning and Management. John Wiley and Sons Inc.: Toronto.

Henderson, D.W. 1974. Social Indicators: A Rationale and Research Framework. Economic Council of Canada, Ottawa.

Hettich, W. November 1971. Why Distribution Is Important: An Examination of Equity and Efficiency Criteria in Benefit-Cost Analysis. Information Canada, Ottawa.

Hinote, H. 1969. Benefit-Cost Analysis for Water Resource Projects. Revised edition. University of Tennessee, USA.

Hitzhusen, F. 1996. Economic Analysis of Reservoir Sedimentation. In Proceedings of International Conference on Reservoir Sedimentation. Ft. Collins, CO. September 9-13. volume 1. p. 35-52.

Hogarth, R. and S. Makridakis. 1981. "Forecasting and Planning: an evaluation. Management Science 27. p. 115-138.

Hotchkiss, R. and F. Bollman. 1997. Socioeconomic Analysis of Reservoir Sedimentation. in Holly, F . and A. Alsaffar eds., Energy and Water: Sustainable Development, Proceedings of Theme D, 27th Congress of the International Association for Hydraulic Research San Francisco, CA. August 10-15, 1997 American Society of Civil Engineers, New York, N.Y. p. 78-83.

Howe, C W. 1971. Benefit Cost Analysis for Water System Planning. American Geophysical Union, Washington, D.C.

Howlett, M and M. Ramish. 1995. Studying Public Policy. Oxford University Press, Toronto, Ontario.

Hyman, E L. and B Stiftel. 1988. Combining Facts and Values in Environmental Impact Assessment. Westview Press, London, England.

Industry, Trade and Tourism. 1999a. Manitoba Accommodation and Camping Guide 1999. Government of Manitoba, Canada.

Industry, Trade and Tourism. 1999b. Manitoba Explorers Guide 1999. Government of Manitoba, Canada.

Industry, Trade and Tourism. 1999c. Manitoba Fishing and Hunting Adventures 1999. Government of Manitoba, Canada.

Izmir, G. 1993. Valuation of Environmental Impacts. Technical Paper. Environment Protection Authority of New South Wales, Sydney.

Jacobs, M. 1990. The Green Economy: The Environment, Sustainble Development and the Politics of the Future. UBC Press, Vancouver. p. 62-71, 195-221.

James, D. 1994. The Application of Economic Techniques in Environmental Impact Assessment. Kluwer Academic Publishers, Massachusetts.

Jansson, A., M.Hammer, C. Folke, and R. Costanza. Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, Washington, D. C.

Kapp, W. K. 1983. Social Costs, Economic Development and Environmental Disruption. University Press of America, Lanham, MD.

Kates, R.W. and I. Burton. eds. 1986. Geography, Resources and Environment: Selected Writings of Gilbert F. White. Volumes 1 and 2. University of Chicago Press, Chicago. p. 100-105, 278-290.

Kuiper, E., G. MacKay, K. Renger, and A. McGregor. 1952. Report Conservation and Flood Control Assiniboine River: Appendix 2 Headwater Storage. PFRA, Regina, Saskatchewan.

Kuiper, E. 1961. Cost Benefit Analysis: Assiniboine River Flood Control and Water Conservation Projects. Department of Agriculture and Conservation, Water Control and Conservation Branch, Province of Manitoba, Winnipeg, Manitoba.

L.A. Penner, J.D. Mollard and Assoc. Ltd. August 1991. Shoreline Erosion and Slumping on Western Canadian Lakes and Reservoirs - A Methodology for Estimating Future Bank Recession Rates Phase 1. Environment Canada, Water Resources Branch. Regina, Saskatchewan.

L.A. Penner, J.D. Mollard and Assoc. Ltd. June 1993 (a). Shoreline Erosion and Slumping on Western Canadian Lakes and Reservoirs - A Methodology for Estimating Future Bank Recession Rates Phase 6 and 7. Environment Canada, Water Resources Branch. Regina, Saskatchewan.

L.A. Penner, J.D. Mollard and Assoc. Ltd. November 1993(b). Shoreline Erosion and Slumping on Western Canadian Lakes and Reservoirs - A Photographic Catalogue For Three Western Canadian Prairie Reservoirs. Environment Canada, Water Resources Branch. Regina, Saskatchewan.

Lansford, N. and L. Jones. September 1995. Effect of LCRA Lakes on Riparian Property Values: Recreational and Aesthetic Components of Lakeside Housing in the Colorado River Basin. Technical Report No. 170. Texas Water Resources Institute, Texas A&M University, Texas.

Layard, R. and Stephan G. 1994. Cost-Benefit Anlaysis 2nd edition. Cambridge University Press, Great Britain.

Leistritz, L. and S. Murdock. 1981. Socioeconomic Impact of Resource Development: Methods for Assessment. Social Impact Series No. 6. Westview Press Inc., Boulder CO.

Leistritz, L. and S. Murdock. 1987. "Socioeconomic Impacts of Large-Scale Development Projects in the Western United States: Implications for Synthetic Fuels Commercialization." in E. Yanarella and W. Green eds. The Unfulfilled Promise of Synthetic Fuels: Technological Failure, Policy Immobilism, or Commercial Illusion. Contributions in Political Science Greenwood Press. No. 179. p. 146-170.

Little, I.M.D. and J.A. Mirrlees. 1994. "The Costs and Benefits of Analysis: Project appraisal and planning twenty years on." in Cost-Benefit Analysis; second edition. Cambridge University Press, Cambridge. p. 199-234.

Locke, J. and K. Storey. 1997. "Socio-Economic Assessment Auditing: A Hibernia Case Study" in John Sinclair ed. Canadian Environmental Assessment in Transition. Department of Geography Publication Series Number 49. Department of Geography, University of Waterloo. p. 157-192.

Logan, J. and H. Molotch. 1987. Urban Fortunes: The Political Economy of Place. University of California Press. Berkeley.

Lowood, J and H. Riesen. July, 1960. Assiniboine river Project: Shellmouth Reservoir Preliminary Engineering Report. PFRA. Winnipeg, Manitoba.

Macibroda Engineering. 1994. Report on the Northern Petroleum Refinery Contaminated Site at Kamsack. Saskatoon.

MacKenzie, G.L. 1945. Assiniboine River Development Post-War Project: Preliminary Report.

Manitoba Water Commission. November, 1980. Review of the Red River Floodway: Portage Diversion and Shellmouth Reservoir.

Manitoba Water Resources. 1995. Presentation to the Assiniboine River Management Advisory Board, Water Supply Workshop. November 24, 1995.

Manitoba Water Resources. Dec. 1995. Assiniboine River Flooding and Operation of the Shellmouth Dam. Presentation to the Shellmouth Flood Review Committee. December 12, 1995.

Markandya, A. 1998. Methodology for Evaluative Environmental Damages Over Time and the Progressive Benefits of Prevention and Mitigation: Application to the Mining, Mineral Processing and Metallurgy Industries. MERN Working Paper 130. University of Bath, United Kingdom.

Marsh, W. and J. Dozier. June 1981. Landscape: An Introduction to Physical Geography. Addison-Wesley Publishing Company, Inc. Don Mills, Ontario.

McDonnell, R. A. and W. D. MacMillan. April 1993. "A GIS-based hierarchical simulation model for assessing the impacts of large dam projects" in HydroGIS 93: Application of Geographic Information Systems in Hydrology and Water Resources. Proceedings of the Vienna Conference. IAHA Publication. 211: 1993. p. 409-416.

McKay, M.C., A. Fedoruk, R. Goulden, H. Goulden, J. Hodgson, G. Jenkins, and R. Peiluck. 1969. Shellmouth Designated Reservoir Area Proposed Land Use Plan. Manitoba Department of Mines and Natural Resources. Canada Land Inventory Project, Winnipeg.

McNaughton, R. B. 1994. "Economic Benefits of Recreation Sites on Irrigation Reservoirs in Southern Alberta." in Canadian Water Resources Journal. 19:3. p. 3-15.

Mikesell, R. F. 1992. Economic Development and the Environment. Mansell Publishing Limited, London, England.

Mishan, E.J. 1972. Elements of Cost-Benefit Analysis. Unwin University Books, London, England.

Moening, J. T. and B. Lakatos. 1976. Algae Induced Water Quality Changes in the Assiniboine River Below the Shellmouth Reservoir as Related to Fish-Kill Potential. Government of Manitoba.

Mrena, C. 1999. Re-vegetating Drastically Disturbed Land. Masters Practicum. NRI, Unversity of Manitoba, Winnipeg.

National Water Commission. March, 1972. Economic Value of Water: Concepts and Empirical Estimates. Colorado State University, USA.

Newbery, R. and G. McCullough. 1984. Shoreline Erosion and Restabilization in South Indian Lake, Canada. in 3rd International Conference on Permafrost, volume 1. National Research Council of Canada, Ottawa.

OECD. 1994. Project and Policy Application: Integrating Economics and Environment. Organization for Economic Co-operation and Development. Paris.

Oshoway, R. 1984. Sedimentation in the Lake of the Prairies Reservoir. Manitoba Department of Natural Resources, Water Resources Branch, Winnipeg.

Parks Branch. January, 1967. Preliminary Plan Asessippi Provincial Park. Manitoba Department of Tourism and Recreation, Government of Manitoba.

Parks Branch. December 1973. Outdoor Recreation Master Plan (Provisional) Asessippi Provincial Park. Preliminary Plan Asessippi Provincial Park. Manitoba Department of Tourism and Recreation, Government of Manitoba.

Pearce, D.W. and R. K. Turner. 1990. Economics of Natural Resources and the Environment. The John Hopkins University Press, Baltimore.

Perman, R., Y. Ma and J. McGilvray. 1996. Natural Resources and Environmental Economics. Longman, New York.

Perrings, C. 1987. Economy and Environment: A Theoretical Essay on the Interdependence of Economic and Environmental Systems. Cambridge University Press, New York.

Perrings, C. 1995. "Economic Values of Biodiversity" in V.H. Heywood and R. T. Watson eds. Global Biodiversity Assessment. United Nations Environment Programme, Cambridge University Press.

Petts, G. and I. Foster. 1985. Rivers and Landscape. Edward Arnold Press, London, Great Britain.

PFRA (Prairie Farm Rehabilitation Administration). January 1961. Proposed Shellmouth and Holland Reservoirs and Portage Diversion: A study of Flood Control and Conservation Benefits of These Projects Alone and in Combinations. Government of Canada. Winnipeg, Manitoba.

PFRA (Prairie Farm Rehabilitation Administration). November 1980. Assiniboine River at Saskatchewan Manitoba Boundary. Government of Canada.

PFRA (Prairie Farm Rehabilitation Administration). 1982. History of Irrigation in Western Canada. Government of Canada. p. 57.

PFRA and Water Resources. 1992. Assiniboine River Flow Enhancement Shellmouth Reservoir Water Supply Study. Manitoba Water Resources, Winnipeg, Manitoba.

Ploskey, G. R. 1985. Impacts of Terrestrial Vegetation and Preimpoundment Clearing on Reservoir Ecology and Fisheries in the United States and Canada. FAO Fisheries Technical Paper no 258. FAO, United Nations, Fayetteville, Arkansas.

Pollock, D. H. February 1986. Report on the Effects of the Shellmouth Reservoir on Seeding Dates Upstream of the Takeline. PFRA. Regina, Saskatchewan.

PPWB (Prairie Provinces Water Board). March 1995. Trends in Water Quality Variables at the Saskatchewan/Manitoba Boundary: Draft Report No. 131. PPWB, Regina, Saskatchewan.

Priddle, G. 1991. Class Environmental Assessment: The Experience of Forest Management in Ontario. Environmental Assessment Conference Proceedings. February 12 1991. University of Waterloo: Heritage Resource Centre.

Souris Basin Development Authority. 198?. Rafferty-Alameda Project: Environmental Impact Statement. Chapter 3.

Randall, A. 1987. Resource Economics: An Economic Approach to Natural Resource and Environmental Policy. 2nd edition. John Wiley and Son, Toronto.

Rosenberg, D., F. Berkes, R. Bodaly, R. Hecky, C. Kelly, and J. Rudd. 1997. "Large-scale impacts of hydroelectric development." Environmental Review. 5. pp. 27-54.

Rosenberg, D., R. Bodaly, R. Hecky, R. Newbury 1987. "Environmenal Assessment of Hydroelectric Impoundments and Diversions in Canada." *In*. M. Healey and R. Wallace eds. Canadian Aquatic Resources. Canadian Bulletin Fish and Aquatic Sciences. 2:5 p.71-104.

Rosenberg, D., R. Bodaly and P. Usher. May 1995. "Environmental and Social Impacts of Large Scale Hydroelectric Development: Who is Listening?" Global Environmental Change. 5:2 p. 127-148.

Royal Commission. December 1958. Royal Commission on Flood Cost-Benefit. Winnipeg, Manitoba.

Sadar, M. and H. Dirschl. March 1996. Generic Environmental Impacts Identified from Water Impoundment Projects in the Western Canadian Plains Region. Impact Assessment 14:1. p. 41-57.

SaskWater. 1995. Assiniboine River Basin Overview. Government of Saskatchewan, Moose Jaw, Saskatchewan.

Sassone, P. G. and W. A. Schaffer. 1978. Cost-Benefit Analysis: A Handbook. Academic Press, New York.

Saunderson, Dr., J. Arnason, A. Crosier, A. Scarth. May 12, 1980. Manitoba Water Commission: Public Hearing. Brandon.

Scaife, B. May 13, 1993. Internal memo. Manitoba Department of Natural Resources.

Scheuhammer, A.M. 1995. Methylmercury Exposure and Effects on Piscivorous Birds. Proceedings of 1995 Canadian Mercury Network Workshop. Canadian Center for Inland Waters, Burlington, Ontario.

Schmid, A. 1989. Benefit Cost Analysis: A Political Economy Approach. Westview Press, Boulder, CO.

Schofield, J.A. 1987. Cost-Benefit Analysis in Urban and Regional Planning. Unwin Hyman Ltd., Massachusetts.

Serafin, R., J. G. Nelson, and R. W. Butler. 1991. "Post Hoc Assessment in Resource Management and Environmenal Planning." Environmental Assessment Conference Proceedings. February 12 1991. University of Waterloo: Heritage Resource Centre.

Serageldin, I. December 1993. "Making Development Sustainable" Finance and Development. p. 6-10.

SERM. 1997. Surface Water Quality Objectives. Environmental Protection Branch: Government of Saskatchewan.

Sewell, W. R. D., J. Davis, A. D. Scott, D. W. Ross. 1961. Guide to Benefit-Cost Analysis. Resources for Tomorrow Conference Proceedings, Montreal. October 23-28, 1961.

Sinden, J. A. and A.C. Worrell. 1979. Unpriced Values: Decision without market prices. Wiley, New York.

Smith, C. D. January 1975. Analysis of Backwater Produced by Shellmouth Dam. Government of Saskatchewan, Department of Environment. Saskatoon, Saskachewan.

Smith, R. L. 1992. Elements of Ecology. 3rd Edition. HarperCollins Publishers Inc., New York.

SNC Group. December, 1986. Assiniboine River Basin: Design of a Planning Study. Saskatchewan Water Corporation.

Statistics Canada. 1976. Census of Canada. Population: Geographic Distributions Municipalities, Census Metropolitan Areas and Census Agglomerations.

Statistics Canada. 1986. Census of Canada. Census Divisions and Subdivisions Population.

Statistics Canada. 1996a. Census. www.statcan.ca/english/census96/table

Statistics Canada. 1996b. Census of Agriculture. Government of Canada.

Statistics Canada. 1998. 1996 Census Profiles of Manitoba and Saskatchewan. Government of Canada.

Stevens, J. B. May 1996. "John Locke, Environmental Property and Instream Water Rights." in Land Economics. 72: 2. p. 261-268.

Stiglitz, J.E. 1994. "Discount Rates: The rate of discount for benefit-cost analysis and the theory of the second best". in Cost-Benefit Analysis; second edition. Cambridge University Press, Cambridge. p.116-159.

Stolte, W. J. 1993. "The Hydrology and Impacts of the Rafferty-Alameda Project." in Canadian Water Resources Journal. 18:3. p. 229-245.

Stolte, W. J. and M. H. Sadar. Spring 1993. "The Rafferty-Alameda Project and Its Environmental Review: Structures, Objectives and History." in Canadian Water Resources Journal. 18:2. p. 1-12.

Sustainable Development Coordination Unit. No Date. Sustainable Development Strategy for Manitoba. Government of Manitoba, Winnipeg.

Sustainable Development Coordination Unit. 1994. Applying Manitoba' Water Policies. Government of Manitoba, Winnipeg.

Szonyi, A., R. Fenton, J. White, M. Agee, and K. Case. 1989. Principles of Engineering Economic Analysis. Wall and Emerson, Inc. Toronto.

Takeuchi, K., M. Hamlin, Z. Kundzewicz, D. Rosbjerg, and S. Simonovic. 1998. Sustainable Reservoir Development and Management. IAHS Publication no. 251.

Thampapillai, D. J. 1988. "The Value of Natural Environments in the Extraction of Finite Energy Resources - a Method of Valuation." International Journal of Energy Research. 12. pp.527-538.

Tietenberg, T. 1994. Environmental Economics and Policy. Harper Collins College Publishers, New York. p. 52-71.

Tkach, R. J and S. Simonovic. September 1992. Reevaluation of the Shellmouth Reservoir Management Policy: Water Resources Research Report No. 24. Department of Civil Engineering, University of Manitoba, Canada.

Tones, P. September, 1987. Evaluation of the Effects of Nutrients on the Quality of Flowing Water. Environment Canada, Government of Canada.

Townley, P. 1998. Principles of Cost-Benefit Analysis in a Canadian Context. Prentice-Hall Canada Inc. Scarborough, Ontario.

Township maps. 1995. Township 23 Range 29 West. Maps. 181-3, 181-4 Shellmouth.

Township maps. 1995. Township 24 Range 28 West. Maps. 181-5, 181-6. Shellmouth.

Treasury Board Secretariat, Planning Branch. 1976. Benefit-Cost Analysis Guide. Crown Copyrights, Ottawa.

Turner, K. R.· 1988. Sustainable Environmental Economics and Management. Belhaven Press, New York.

U.S. Army Corps of Engineers. December, 1990. Preliminary Assessment of Corps of Engineers' Reservoirs, Their Purposes and Susceptibility to Drought. Research

Document No. 33. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Davis, California.

Value-Impact Analysis. November, 1979. Scientific Applications, Inc. Palo Alto, California.

Van Everdingen, R.O. Diefenbaker Lake: Effects of Bank Erosion on Storage Capacity. Inland Waters Branch, Department of Energy, Mines and Resources, Government of Canada.

Veeman, T. S. 1985. "Benefit-Cost Analysis in Environmental Decision-Making: Procedures, Perils, and Promise." *in* Economy and Ecology: The Economics of Environmental Protection. Symposium Feb. 19-20, 1985. Canadian Society of Environmental Biologists, Edmonton, Alberta p. 129-137.

Waite, D. T. 1992. Stretching Water Supplies: Alternative Technologies and Strategies. Canadian Plains Research Centre, University of Regina. Canada. p. 2.

Wallis, C. 1985. "The Extravagance of Wilderness: Whose Values, Whose Dollars and Sense?" *in* Economy and Ecology: The Economics of Environmental Protection. Symposium Feb. 19-20, 1985. Canadian Society of Environmental Biologists, Edmonton, Alberta. p. 45-51.

Warkentin, A. A. No Date. Assiniboine River Watershed: Evaluation of Data Networks for Water Supply Monitoring. Manitoba Water Resources.

Water Resources Branch, Manitoba Natural Resources. 1999. www.gov.mb.ca/natres/watres/spring.html Government of Manitoba.

Watson, D. O., W. L. Adamowicz and P. C. Boxall. 1994. "An Economic Analysis of Recreational Fishing and Environmental Quality Changes in the Upper Oldman River Basin." in Canadian Water Resources Journal. 19:3. p. 213-224.

WCED (World Commission on Environment and Development). 1987. Our Common Future. Oxford University Press, Oxford.

Williamson, D. A. and W. E. Ralley. 1993. A Summary of Water Chemistry Changes Following Hydroelectric Development in Northern Manitoba, Canada. Manitoba Environment, Government of Manitoba.

Yapp, T. P. 1989. The Costs of Degradation to the Community: Issues and Estimates. Australian Journal of Soil and Water Conservation. 2:3. p.389-393.

Zerbe, R. O. Jr. and D. D. Dively. 1994. Benefit-Cost Analysis: In Theory and Practice. HarperCollins College Publishers, New York.

Personal Communication

ARMAB (Assiniboine River Management Advisory Board) Public Consultation. Open House on the management of the Assiniboine River Basin. Russell Manitoba. Personal notes. Spring 1995.

Ball, Dr. T. Former chair of ARMAB. Personal Communication. Saskatoon, Saskatchewan. June 1999.

Bidlake, L. Wildlife Branch. Natural Resources. Brandon, Manitoba. 1997.

Blackwell, R. SaskWater. Personal Communication. Saskatoon, Saskatchewan. June 1996.

Bowering, R. Water Resources Branch. Natural Resources. Winnipeg. Manitoba. July, August 1999.

Christie, R. Dillon Engineering. Personal Communication. Winnipeg, Manitoba. February, 1998

Collins, B. SaskWater. Telephone Personal Communication. Moose Jaw, Saskatchewan. August, 1996.

Dickson, I. Assiniboine River Management Advisory Board. Personal Communication. Winnipeg, Manitoba. October 1995, March 1996, July 1999.

Fortin, R. Manitoba Environment. Personal Communication Winnipeg, 1997.

Gerhart, J. SaskWater. Personal Communication. Saskatoon, Saskatchewan. August, 1996.

Groves, B. Forest Technologist. Chatham, Ontario. November, 1998.

Kansas, K. Fisheries Branch, Manitoba Natural Resources. Personal Communication Roblin. 1997.

McKay, H. Retired, Prairie Farm Rehabilitation Administration. Personal Communication. Winnipeg, Manitoba. April, 1996

McLaren, R. Association of Irrigators of Manitoba. Personal Communication. Carberry, Manitoba August, 1999.

Onybuchi, E. Manitoba Hydro. Personal Communication. Winnipeg, Manitoba. May 1998.

Rozedeba, B. Ducks Unlimited and Crescent Lake Outfitters. Personal Communication. Yorkton, Saskatchewan. December 1997.

Sinclair, J. Natural Resources Institute. Personal Communication. Winnipeg, Manitoba. May, 1998.

Trinder, D. Rural Municipality of Russell. Submission, Assiniboine River Management Advisory Board Public Meeting. Russell, Manitoba. February, 1995.

Troutt, Dr. B. University of Manitoba, Department of Economics. Personal Communication. August 1999.

Windsor, D. Manitoba Hydro. Personal Communication. Winnipeg, Manitoba. April 1998.

Windsor, D. Manitoba Hydro. Personal Communication. Winnipeg, Manitoba. July 1999.

APPENDIX 1:

SUPPLEMENTAL INFORMATION ON THE LOCAL AREA

VEGETATION AND WILDLIFE
DEMOGRAPHIC DATA
CROWN LAND: LAND USE CLASSIFICATIONS

1.0 INTRODUCTION

This appendix provides detailed data on local vegetation and wildlife, and demographics. A description of land use classifications for Crown Lands surrounding the reservoir are also provided.

1.1 Vegetation and Wildlife

The native vegetation is grassland in the uplands and valley floor, interspersed with aspen groves. Valley slopes have traditionally supported a wide variety of tree species including balsam poplar, white birch, bur oak, Manitoba maple, green ash, American elm and cottonwoods. Understory shrubs include red osier dogwood, willow varieties, pin cherry, highbush cranberry, saskatoon, and snowberry, amongst others. This vegetation provides fodder and shelter for a number of animals, including ungulates such as white-tailed deer and the occasional moose. Other large mammals seen in the area of the reservoir include red fox, coyotes, and black bear. As well, beaver, red squirrels, Franklin ground squirrels, badgers, raccoons, porcupines, snowshoe hares, and skunk can be found. Common bird species include great horned owl, ruffed and sharp-tailed grouse, hawks, geese and ducks (McKay et al 1969). Threatened species that have been seen in the vicinity of the reservoir include loggerhead shrike, burrowing owl, baird's sparrow, and the ferruginous hawk (SaskWater 1995).

Fish species found in the reservoir include northern pike, walleye and yellow perch, which are supplemented through stocking programs. Mooneye, carp, white sucker, silver and northern redhorse, blacknose dace, brook stickleback, chestnut lamprey, emerald and spottail shiner, and blackside and johnny darter are also found. The variety of fish found in the reservoir has made it a popular area for angling (SaskWater 1995).

1.2 Demographic Data

The study area is divided into five rural municipalities of varying population sizes according to Statistics Canada (Table 1).

Table 1

Populations of Rural Municipalities in the Local Study Area

Rural Municipality	Population by Year					
	1956	1966	1976	1986	1996	% loss
Shellmouth, Manitoba	1,502	1,294	958	805	733	51
Russell, Manitoba	1,088	1,087	710	634	553	51
Shell River, Manitoba	2,099	1,668	1,274	1,222	1,050	50
Cote, Saskatchewan	1,958	1,016	950	790	687	65
Calder, Saskatchewan	1,811	1,238	917	773	542	70

Source: Statistics Canada. 1996 Census. www.statcan.ca/english/census96/table

Statistics Canada. 1976 Census of Canada. Population: Geographic Distributions Municipalities, Census Metropolitan Areas and Census Agglomerations.

Statistics Canada. 1986 Census of Canada. Census Divisions and Subdivisions Population.

Settlements in the study region include the towns of Shellmouth, Inglis, and Russell in Manitoba and Cote, Calder, and Togo in Saskatchewan. The populations according to Statistics Canada are recorded in Table 2.

Table 2

Population of Urban Centres in the Local Study Area

Town	Population By Year						
	1956	1966	1976	1986	1991	1996	% Change
Shellmouth, Manitoba	N/A	N/A	N/A	N/A	30	N/A	N/A
Russell, Manitoba	1,227	1,511	1,524	1,669	1,616	1,605	+30
Inglis, Manitoba	N/A	N/A	N/A	N/A	225	N/A	N/A
Cote, Saskatchewan	N/A	N/A	N/A	N/A	102	N/A	N/A
Calder, Saskatchewan	227	225	158	160	141	106	-53
Togo, Saskatchewan	302	284	197	176	151	138	-54

Source: Statistics Canada. 1996 Census. www.statcan.ca/english/census96/table
Statistics Canada. 1976 Census of Canada. Population: Geographic Distributions Municipalities, Census Metropolitan Areas and Census Agglomerations.
Statistics Canada. 1986 Census of Canada. Census Divisions and Subdivisions Population.

1.3 Crown Land

Land adjacent to the reservoir is held by the Crown. This property is assigned land use classification that restricts property use. Figures 1 and 2 depict the Crown Land Classification Plan for the Reservoir. The land use categories are similar to those proposed in the McKay et al (1969) land use planning study (for map see Appendix 4, Figure 1). The dominant land use classifications outside of agricultural are recreation (RM), outdoor recreation (B) and wildlife (C). These classifications usually permit limited agricultural use such as grazing and haying and would be leased to local farmers on an annual basis for this purpose. Some parcels are labelled Provincial Parks, which are order-in-council designations. A small percentage are designated Natural Areas-Development Reserve (N).

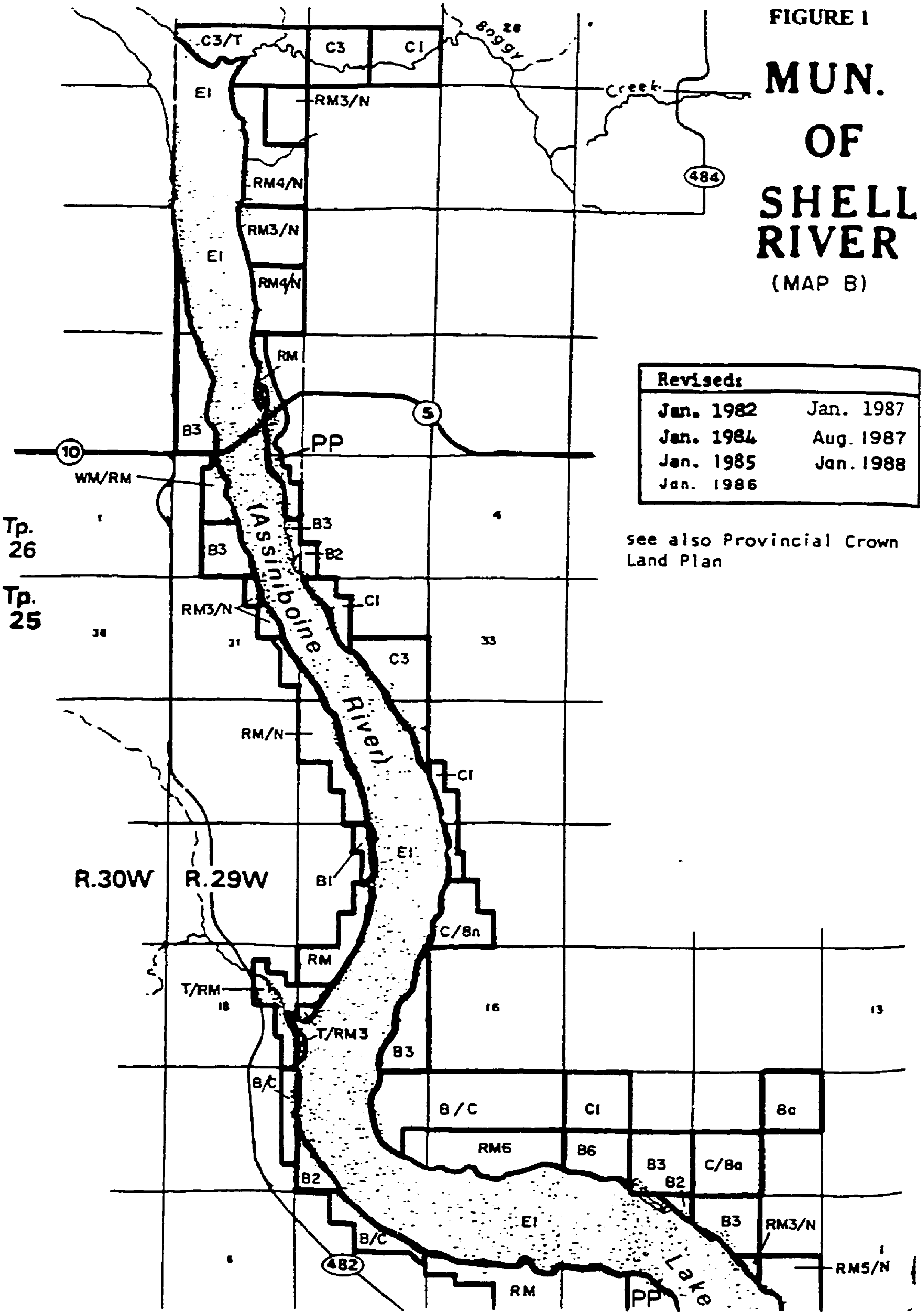

FIGURE 1

MUN. OF SHELL RIVER

(MAP B)

FIGURE 2

MUN. OF SHELLMOUTH

(MAP B)

Revised:

Jan. 1982	Aug. 1987
Jan. 1985	Jan. 1988
Jan. 1986	Jan. 1994
Jan. 1987	

see also Provincial Crown Land Plan

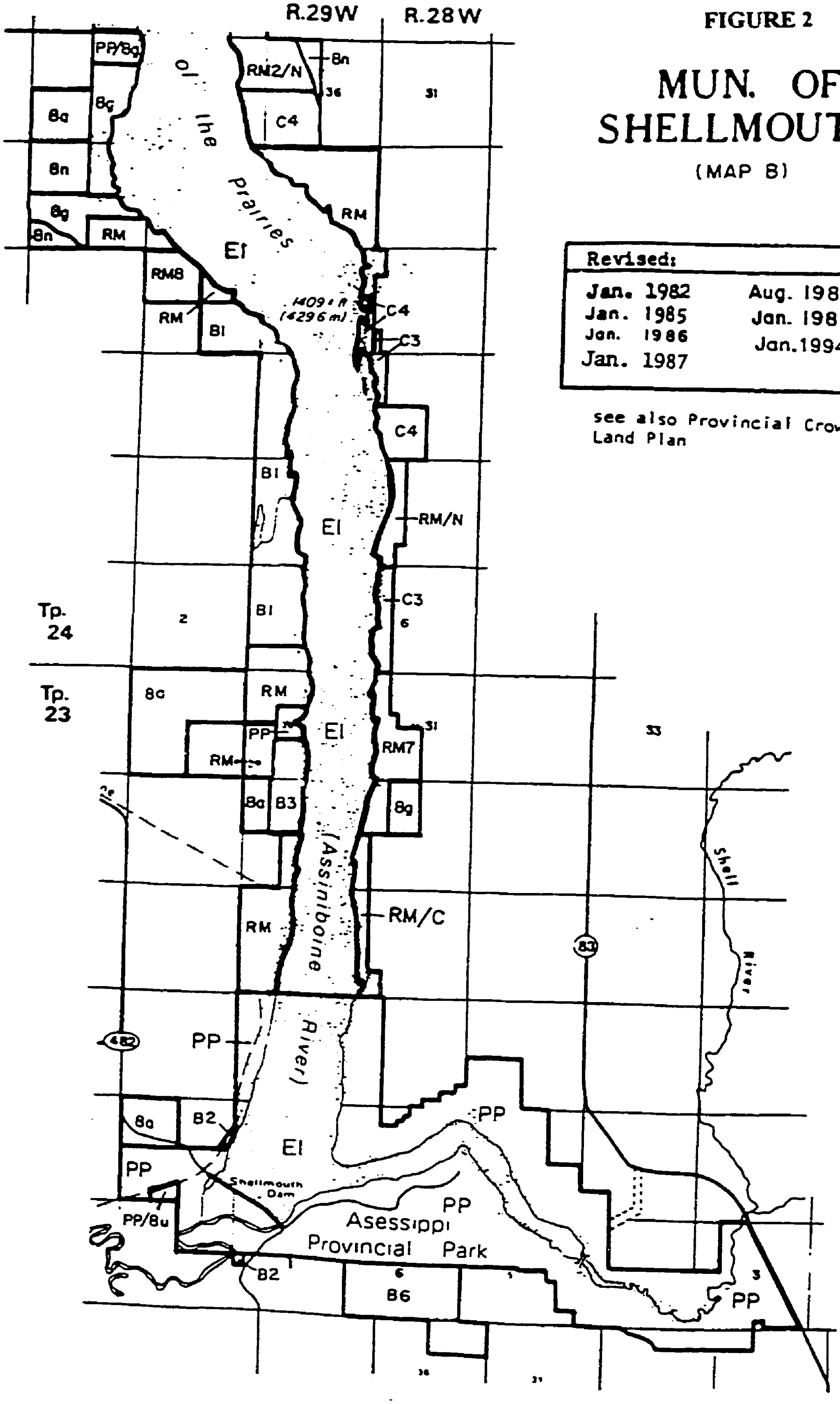

Figure 1 and 2

Crown Land Classification Committee

Interdepartmental Operation Crown Land Plans

Operational Crown Land Use Codes

Order In Council Designations	
Community Pastures	CP
Provincial Parks	PP
Provincial Forests	PF
Wildlife Management Areas	WW
Ecological Reserves	ER
Special Forest Area	SF
Flooding	
Subject to general flooding	F1
Subject to the 100 year flood	F2
Subject to the 10 year flood	F3
Subject to the 5 year flood	F4
Other	
Site plan filed	SP
Project Area	PJ
Urban Use	UU
Utility Sites	UT
Timber Removal Priority	X
Significant Shoreland	O
Wild Rice	Q

Operational Crown Land Use Codes, Con't

Land Use Descriptions and Code		No. Agric.	No Development - Yearly Use Only				No Development - Yearly Use Only Manager Approval Required			
			Hay	Grazing	Hay/ Grazing	Cultivation	Hay	Grazing	Hay/ Grazing	Cultivat
Forest Management	(A)	A1	A2	A3	A4	N/A	A6	A7	A8	N/A
Outdoor Recreation	(B)	B1	B2	B3	B4	B5	B6	B7	B8	B9
Wildlife	(C)	C1	C2	C3	C4	C5	C6	C7	C8	C9
Mineral Extraction	(D)	D1	D2	D3	D4	D5	D6	D7	D8	D9
Water Management	(E)	E1	E2	E3	E4	E5	E6	E7	E8	E9
Unique/Rare Sites	(G)	G1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Natural Lands a) Erosion Prone/ Fragile/and Hazard Lands	(J)	J1	J2	J3	J4	J5	J6	J7	J8	J9
b) Bedrock	(K)	K1	K2	K3	K4	K5	K6	K7	K8	K9
c) Marsh/Swamp/ Bog/Fen	(M)	M1	M2	M3	M4	M5	M6	M7	M8	M9
Development Reserve	(N)	N1	N2	N3	N4	N5	N6	N7	N8	N9
Fisheries	(T)	T1	T2	T3	T4	T5	T6	T7	T8	T9
Intensive Uses a) Agricultural	(AM)	N/A	AM2	AM3	AM4	AM5	AM6	AM7	AM8	AM9
b) Forestry	(FM)	FM1	FM2	FM3	FM4	FM5	FM6	FM7	FM8	FM9
c) Recreation	(RM)	RM1	RM2	RM3	RM4	RM5	RM6	RM7	RM8	RM9
d) Mineral	(MM)	MM1	MM2	MM3	MM4	MM5	MM6	MM7	MM8	MM9
e) Wildlife/ Fisheries	(WM)	WM1	WM2	WM3	WM4	WM5	WM6	WM7	WM8	WM9
f) Other	(XM)	XM1	XM2	XM3	XM4	XM5	XM6	XM7	XM8	XM9

Operational Crown Land Use Codes, Con't

Land Use Descriptions		Agricultural - No Time Restriction	Agricultural - No Time Restriction Joint Decision For Clearing	Agricultural - No Time Restriction Joint Decision For Drainage	Agricultural Yearly Use Only
HAY and GRAZING					
- No development restrictions		1a	N/A	1c	1d
	120A .	2a	2b	2c	2d
- Providing 40 acres of native woody	100A .	3a	3b	3c	3d
vegetative remain, the amount of	80A .	4a	4b	4c	4d
development allowed is	60A .	5a	5b	5c	5d
	40A .	6a	6b	6c	6d
- No development allowed		7a	N/A	7c	7d
- Improvement of "Go Back" Fields allowed . .		8a	8b	8c	8d
HAY ONLY					
- No development restrictions		1g	N/A	1i	1j
	120A .	2g	2h	2i	2j
- Providing 40 acres of native woody	100A .	3g	3h	3i	3j
vegetative remain, the amount of	80A .	4g	4h	4i	4j
development allowed is	60A .	5g	5h	5i	5j
	40A .	6g	6h	6i	6j
- No development allowed		7g	N/A	7i	7j
- Improvement of "Go Back" Fields allowed . .		8g	8h	8i	8j
GRAZING, HAY and CULTIVATION					
- No development restrictions		1n	N/A	1q	1r
	120A .	2n	2p	2q	2r
- Providing 40 acres of native woody	100A .	3n	3p	3q	3r
vegetation remain, the amount of	80A .	4n	4p	4q	4r
development is allowed	60A .	5n	5p	5q	5r
	40A .	6n	6p	6q	6r
- No development allowed		7n	N/A	7q	7r
- Improvement of "Go Back" Fields allowed . .		8n	8p	8q	8r
CULTIVATION ONLY					
- No development restrictions		1u	N/A	1w	1x
	120A .	2u	2v	2w	2x
- Providing 40 acres of native woody	100A .	3u	3v	3w	3x
vegetative remain, the amount of	80A .	4u	4v	4w	4x
development allowed is	60A .	5u	5v	5w	5x
	40A .	6u	6v	6w	6x
- No development allowed		7u	N/A	7w	7x
- Improvement of "Go Back" Fields allowed . .		8u	8v	8w	8x

Source: Manitoba Crown Land Classification Committee. 1994. Interdepartmental Operational Crown Land Plans. Government of Manitoba, Manitoba

APPENDIX 2:
KEY PERSON INTERVIEW QUESTIONS

APPENDIX 2 - INTERVIEW QUESTIONS

Date

Leanne Shewchuk
Natural Resources Institute
70 Dysart Road
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Winnipeg, Manitoba, R3T 2N2

To
address

Dear *name*;

I am conducting a retrospective study on the development and operation of the Shellmouth Dam and Reservoir to clarify the background and history of the reservoir. The study area is the region upstream of the Shellmouth Dam, including the Shellmouth (Lake of the Prairies) Reservoir and the surrounding rural municipalities of Shellmouth, Russell, and Shell River in Manitoba and Cote and Calder in Saskatchewan. One of the objectives of the study will be to identify benefits or costs incurred by local individuals and rural municipalities resulting from the development and ongoing operation of the reservoir. In addition, the study will outline possible economic development opportunities associated with the reservoir for local residents and rural municipalities.

The purpose of this interview is to poll local residents, representatives of local rural municipalities, government bureaucrats, and politicians on both historical events and current issues with regard to the Shellmouth Reservoir. In total, approximately twenty interviews are proposed. Answers will be indicated in tabular form and will be kept confidential where requested.

This study is being undertaken as a Masters Thesis in Natural Resources Management at the University of Manitoba. It has been sanctioned by the Assiniboine River Management Advisory Board and funding support for the research has been provided by Manitoba Hydro. It is anticipated that the study will span roughly a year and a half and the resulting report will be available to the public through the university. Ethics approval, in accordance with university guidelines, has been obtained. If there are any concerns in this regard, please contact Dr. John Sinclair at (204) 474-8374.

I will be speaking with you in the near future with regards to setting up a convenient time for a personal interview. Included with this letter is a copy of the topics to be discussed during the interview to provide you with time to consider the questions at your leisure. Although it will not be necessary to respond to every question, any comments you can provide will be greatly appreciated.

Thank you for your time and cooperation. If you have any questions or further comments, please do not hesitate to contact me through the Natural Resources Institute, University of Manitoba at (204) 474-8373.

Sincerely,

Leanne Shewchuk
Masters of Natural Resources Management Candidate

Your comments will be requested on the following questions. Please feel free to answer the questions in a broad fashion and elaborate using details or examples to further explain your opinions.

Interview Questions

1. From your perspective, what was the rationale for developing the reservoir?

2. What reasons were given by the developers for locating the dam and reservoir at its present location?

3. What economic gains or development did government authorities predict would result from the reservoir for the municipalities and residents in the area? To what degree have they occurred? (*provide particulars*)

4. Have you, other individuals, or businesses in the community benefited from the reservoir? If so how? *(provide particulars)*

5. In your opinion, have the municipalities benefited from the reservoir in ways which were not initially predicted? (*provide particulars*)

6. In your opinion, have the municipalities surrounding the reservoir incurred any direct or indirect costs associated with the construction or operation of the reservoir? (*provide particulars*)

7. Have local individuals or businesses incurred any direct or indirect costs associated with the construction or operation of the reservoir? (*provide particulars*)

8. What forms of compensation were offered to individuals (local residents affected by the construction and operation of the reservoir)?

9. What kind of compensation was offered to local rural municipalities affected by the reservoir?

10. Have the affected communities tried to obtain further compensation or secure development initiatives? If yes, what kind of compensation and how much was requested? *(provide particulars)*

11. Are there economic development opportunities related to the reservoir or land adjacent to the reservoir from the municipalities, businesses, or individuals in the community could profit? *(provide particulars)*

12. Do you have or know of any particular correspondence, news articles, or reports that should be reviewed for the study? *(please list)*

13. Is there anyone that you suggest I speak with regarding this study? *(please list)*

14. Is there anything you wish to add (such as details and personal perspectives which may be relevant to this study)?

15. Do you wish this information to remain anonymous, or may I cite you personally in my final report?

APPENDIX 3:

KEY PERSON INTERVIEW RESPONSES

1.0 KEY PERSON INTERVIEWS

Key person interviews were conducted with representatives from federal (PFRA) and provincial government (SaskWater, Manitoba Water Resources) agencies, as well as rural municipal elected officials, agricultural landowners, and business people from the local study area. Individuals were interviewed on their perception of historical events and issues surrounding the Shellmouth Reservoir. Respondents were not randomly selected, but were chosen because of their knowledge of the project. A list of persons interviewed is located in Table 1.

Some interview candidates were identified through discussions with the then interim head of Manitoba Water Resources Branch, the Chairman of the Assiniboine River Management Advisory Board (ARMAB), or from lists of individuals appearing at public hearings on the management of the Assiniboine basin held in 1995 by ARMAB. The list of landowners and farm operators interviewed by PFRA in 1978 regarding the impact of the Shellmouth on crop production in the Assiniboine Valley at Kamsack, Saskatchewan (Barber 1978) was reviewed to identify long term Saskatchewan landowners. Local representatives were specifically selected due to their status in the community. Other individuals contacted to participate in the interview process were suggested by local landowners, municipal reeves, or business people. While the interview process was not intended to be comprehensive, the key person interviews provided a broad overview of stakeholder opinions on the history and issues surrounding the reservoir.

Table 1
List of Key Interviews

Name	Relationship to Project	Interview Location	Date of Interview
Agricultural Landowners			
Cliff Trinder	Landowner downstream of the Shellmouth Reservoir	Russell, Manitoba	January 25, 1997
Jerry Moriarty	Landowner upstream of the Shellmouth Reservoir	Near Kamsack, Saskatchewan	December 24, 1996
Anonymous	Landowner 1	Manitoba	July 10, 1997
Anonymous	Landowner 2	Manitoba	July 10, 1997
Local Representatives			
Albert Nabe	Reeve, R. M. Shell River	Roblin, Manitoba	January 25, 1997
Alex Leis and Wilbert Filpchuck	Reeve, R.M. Cote	Kamsack, Saskatchewan	February 19, 1997
Alvin Zimmer	Reeve, R.M. of Shellmouth	Inglis, Manitoba	July 26, 1997
Joe Soloninko	Reeve, R.M. Calder	Wroxton, Saskatchewan	January 20, 1997
L. Boguski	Mayor, Town of Roblin	Roblin, Manitoba	January 24, 1997
Bill Russell	Mayor of Russell	Russell, Manitoba	
Provincial and Federal Government Representatives			
Ken Kansas	Fisheries Biologist, Manitoba Natural Resources	Roblin, Manitoba	January 25, 1997
John Towle	Water Resources, Manitoba Natural Resources	Winnipeg, Manitoba	January 29, 1997
Smithson	Water Resources, Manitoba Natural Resources	Winnipeg, Manitoba	January 29, 1997
Candice Vanin and Ted Daneluk	PFRA, Melville (Vanin formerly of Saskatchewan Agriculture and Food, Agriculture District 18)	Melville, Saskatchewan	June 22, 1997
Ron Woodvine	PFRA, Regina	Saskatoon, Saskatchewan	December 23, 1996
Local Business Owners			
Daymon Guillas	Hotel Manager, Russell Inn	Russell, Manitoba	July 10, 1997
Lorne and Myra Kilkenny	Kilman Enterprises (cottage development, Shellmouth Reservoir)	Russell, Manitoba	January 25, 1997

The interview questions used in this survey were developed, in part, from the commentary of local residents at the public hearings held in 1995 on management of the Assiniboine. Three primary issues emerged from the presentation of local community officials and residents. Presenters indicate that in their opinion:

1. A number of predicted local benefits did not materialize, with the majority of benefits accruing a considerable distance downstream of the dam in southern Manitoba.
2. The local area has and continues to incur a number of costs from the development and ongoing operation of the reservoir.
3. Inadequate compensation was provided by government to address the costs generated directly or indirectly from the reservoir project.

The interview format was developed from these issue themes and consisted of a total of fifteen questions, which were approved by the practicum committee and the University Ethics Committee. The interview questions primarily sought to identify the rationale for the project, the specific costs and benefits that were created by the development and operation of the reservoir (predicted or not), and to determine which measures were taken to address local costs. A copy of the letter requesting an interview, and the interview questions are located in Appendix 2, with the responses located in Appendix 3. The responses to the first eleven questions are located in a response matrix at the end of this appendix.

2.0 Analysis of the Responses

The first three questions were designed to sample views on why the dam was constructed. The first question asked to identify the rationale for constructing the reservoir, to which all respondents identified flood control in southern Manitoba. All government representatives and two local representatives noted the supply of water to downstream locations as another rationale. One government representative and one local business owner also identified recreation as another reason for developing the reservoir.

There were a variety of responses to the second question, which queried respondents about rationale for the present reservoir location. Most individuals listed technical reasons such as engineering criteria (3 respondents) and geographic location (7 respondents) as the deciding factors in the location of the reservoir. Some individuals (4 respondents) outlined various economic reasons for the present location, such as minimizing the impact on high quality agricultural land, and avoiding the high cost of relocating a railroad bridge located just downstream of the present reservoir site. One respondent felt a political agenda determined where the reservoir was located.

The third question asked respondents to identify local development benefits arising from the reservoir that were predicted by government. Opinions differed as to what benefits government actually identified for local communities and residents. Six individuals did not answer the question, including three government agency representatives who felt that they were not in a position to respond. One respondent could not recall.

Of those who did respond to the question (11 respondents), all identified recreation and tourism benefits as predicted gains that would offset local costs. A number specifically noted the following as predicted benefits: sports fishery (4 respondents), golf course (4 respondents), ski hill (4 respondents), cottage developments (5 respondents), non-specific economic spin-offs (3 respondents), campgrounds (2 respondents) and jobs (4 respondents). Others identified marinas (1 respondent), motels (1 respondent), and riding stables (1 respondent). Those responding to this question, felt that identified benefits had either not materialized (4 respondents) or only partially materialized (7 respondents). Those benefits described as having been partially achieved were general recreation tourism benefits (3 respondents), sports fishery (2 respondents), cottage developments (3 respondents), campgrounds (2 respondents), and other non-specific economic spin-offs (2 respondents).

Questions 4 to 7 asked respondents to identify benefits and costs incurred by municipalities and local individuals as a result of the reservoir development. In the fourth question, interviewees were asked to identify benefits accruing from the reservoir development to local individuals. All of the local representatives, one business owner and all local agricultural landowners with the exception of one, indicated that some landowner benefits were generated. The response of the one landowner who stated that there were no benefits generated, may be explained by this particular individual's high level of frustration with the compensation provided in 1995 for land flooded just below the dam site.

Federal government representatives noted that relatively few benefits had actually accrued to local Saskatchewan residents and communities. The majority of government representatives (80%) believed that local individuals had benefited in some way from the reservoir. The benefits most often cited were general recreation and indirect spin-off benefits in terms of goods and services. Other benefits referred to by the respondents were land sales (6 respondents), cottage development (7 respondents), increased upstream water table (5 respondents), park concession (3 respondents), and local student jobs (2 respondents). Other benefits commonly indicated by the respondents were the development of campgrounds and Manitoba's Asessippi Provincial Park (8 respondents). Landowners and local representatives from Saskatchewan did not identify any of these three benefits as being achieved in their jurisdiction. The sports fishery was the only benefit identified by Saskatchewan local representatives.

The next question, number 5, requested respondents to identify non-predicted benefits. The majority indicated that there were no such benefits, declined to respond, or were not certain. One local representative noted that the non-predicted benefits generated from the project were in the form of spin-off benefits for Russell's economy. One government representative cited taxes generated from recreation property and other private development as non-predicted benefits.

For question number 6, the respondents were unanimous in their agreement that the municipalities incurred costs from the development of the reservoir. The key cost identified by the majority of landowners (4 respondents), business people (2 respondents), and local representatives (6 respondents) was a loss of tax base. Other costs cited were increased road maintenance (5 respondents), erosion upstream – downstream flooding (4 respondents), loss of community (4 respondents), reduced recreation benefits due to operation of the reservoir (3 respondents), environmental costs (3 respondents), extra transportation costs (1 respondent), and loss of prime agricultural areas (1 respondent).

In question 7, many of the costs identified for the municipalities were reiterated as costs facing individuals. All respondents concurred that individuals incurred costs as a result of the reservoir development with the exception of one government representative who declined to answer. Another respondent responded in a qualified manner by stating that the costs incurred were limited. The most common complaint from local landowners and representatives was that compensation for property purchased for the reservoir development, was insufficient to cover land replacement costs (7 respondents). Erosion and upstream/downstream flooding were frequently mentioned as costs incurred by individuals (6 respondents). Other concerns were a reduction in environmental quality (3 respondents), loss of prime agricultural areas (3 respondents), community social costs (3 respondents), and increases in travel costs (3 respondents). Higher municipal taxes arising from higher maintenance costs and a smaller tax base as a result of the reservoir project, were also cited (2 respondents).

In question 8, the majority of respondents indicated that there was no compensation outside of land purchases provided to individual landowners affected by the reservoir development. Local representatives and Saskatchewan landowners commented that the valley landowners upstream of the reservoir were currently negotiating a compensation settlement for back-flooding problems reportedly caused by the reservoir operation (2 respondents). A number of respondents (6 respondents) did not reply or indicated that they were unaware of what compensation may have been offered at the time of development or after.

A description of the compensation provided for municipalities was requested in question 9. The responses were divided between no compensation (3 respondents, predominantly local representatives), one time payment or grants in lieu of lost taxes (4 respondents), and recreation development (4 respondents). However, these last respondents noted that compensation in the form of recreation development was insufficient or not attained.

The respondents in question 10 indicated that government has been solicited for additional compensation (10 respondents). These requests include monetary compensation for upstream back-flooding (2 respondents), downstream flooding (2 respondents), and funding for recreation facilities (6 respondents), specifically the ski hill (4 respondents), as well as water rights for future development (1 respondent). This last request was made to Manitoba Water Resources in the early 1990s, in an attempt to secure a local water supply for future development in light of a downstream request to divert 25 cfs from the Assiniboine basin for agricultural development in the Pembina Valley area. In the early 1990s fish hatchery was also requested (1 respondent) to ensure a constant supply of walleye in the reservoir. The provincial government agreed to this request, provided that it would be staffed with volunteers. This hatchery has yet to materialize and for environmental reasons is not recommended by the local Natural Resources biologist.

In question 11, respondents were asked to identify future development opportunities that may be generated from the reservoir. The majority of respondents (13/17 respondents) indicated that there were opportunities, although some qualified this by stating that there were only a few potential development options for the area (4 respondents). Nine respondents saw potential for recreation/tourism development. Most landowners however, did not see this as a viable development option (75% of respondents). Local and government representatives, business owners, and one landowner saw potential in developing the sports fishery, hunting, and outfitting sector (6 respondents). Other possible developments mentioned included a golf course (1 respondent), a ski hill (6 respondents), ecotourism (1 respondent), cottage and campground developments (5 respondents), rural water supply pipelines (2 respondents), agricultural development and irrigation (3 respondents), and industrial processing (1 respondent) as potential development options.

Questions 12 and 13 were posed to identify other sources of information. While few individuals identified actual documents or articles relevant to the study, suggestions were followed-up. Not all individuals identified as possible sources were contacted because the key person interviews were only intended to be a representative sample of stakeholders. Some individuals that were contacted declined an interview, because they did not believe that they were the appropriate contact or had sufficient insight to contribute to the study.

In question 14, a request for any additional information on the reservoir project solicited a wide variety of responses. Local representatives specifically noted that an economic plan for the area needed to be developed by the province. Many landowners spoke of the government not fulfilling its early agreements and the need for a basin wide management plan. Both of these groups indicated that operating the reservoir for downstream concerns creates additional local costs with benefits accruing downstream. All stakeholder groups agreed that installing gates to increase the storage capacity of the reservoir, as has recently been discussed (PFRA and Manitoba Water Resources 1992), would meet with strong objections from Manitoba and Saskatchewan local stakeholders. Environmental problems arising from the reservoir were also reiterated as an ongoing concern of many stakeholders.

The final question, number 15, asked if individuals could be cited in the report as appropriate. The majority of those interviewed agreed to be cited.

3.0 Summary of Responses

The first two questions provided information on the individual's understanding of the historic background and solicited opinions on why the reservoir was developed and situated at its present location. Most interviewees were knowledgeable about the historic background and offered insights into possible explanations for the reservoir's location.

The responses show that on the issue of benefits generated for individuals, there is generally a difference of opinion between local stakeholders and provincial and government representatives, with the former identifying few achieved benefits for local stakeholders and the later strongly indicating that local benefits were generated. Saskatchewan respondents tended to identify fewer benefits for local individuals and municipalities than did their Manitoba counter-parts.

All interviewees indicated that local municipalities incurred various costs, although federal and provincial representatives did not readily identify the loss of tax base in contrast to the local stakeholders. Another cost not identified by federal or provincial government representatives was a loss of community, which four local stakeholders identified as a community cost. A number of costs noted as municipal were also identified as individual costs.

Compensation for local costs was widely viewed as inadequate by local stakeholders, and a number identified compensation requests, primarily by local municipal officials or business people, that were aimed at improving recreation or other development opportunities with spin-off economic benefits for the local area.

Interview Matrix

question number	question	response matrix	agricultural landowners	local representatives	Prov. / Fed. Government representatives	business owners	total responses
total number of respondents			4	6	5	2	17
1	rational for reservoir	flood control - southern Manitoba	4	6	5	2	17
		water supply - southern Manitoba	2	2	5		9
		recreation development at reservoir			1	1	2
2	reason for location	economic	1	1	1	1	4
		geographic location		2	4	1	7
		political			1		1
		logistical/engineering criteria			3		3
		N/A		3			3
		not sure	3				3
3	predicted gains	development/jobs	2	1		1	4
		recreation/tourism benefits	2	4	2	2	10
		sports fishery		2	1	1	4
		golf course	2	1		1	4
		ski hill	2	1		1	4
		marinas				1	1
		motels				1	1
		riding stables/trails		1		1	2
		cottage developments		2	1	2	5
		campgrounds		2			2
		economic spin-offs		2	1		3
		N/A	2		3		5
		does not recall		1			1
							0
	actual gains	gains partially achieved		4	2	1	7
		gains not achieved	2	1		1	4
		recreation tourism benefits		2	1		3
		sports fishery		1		1	2
		cottage developments		2		1	3
		campgrounds		2			2
		economic spin-offs - partically achieved		2			2

Interview Matrix

question number	question	response matrix	agricultural landowners	local representatives	Prov. / Fed. Government representatives	business owners	total responses
4	individual benefits	yes			4	1	5
		no	1				1
		few/temporary	3	6	1	1	11
							0
	details	commercial fishing		1	1		2
		recreation benefits	2	5	4	1	12
		indirect economic (spin-offs) food/gas/alcohol/hotel/tackle shops	1	4	3	2	10
		direct economic (land sale)	1		4	1	6
		cottages	1	1	4	1	7
		increased water table upstream	1		4		5
		flood control		1			1
		park concession	1	1		1	3
		campgrounds/park	1	3	3	1	8
		sports fishing/hunting		2	3		5
		jobs (student)		2			2
		quality of life			1		1
5	non-predicted benefits	yes			1		1
		no	2	5	1	1	9
		N/A	1		3		4
		not sure	1			1	2
		few		1			1
							0
	details	tax/permit revenue			1		1
		Russell's economy		1			1
		private development			1		1

Interview Matrix

question number	question	response matrix	agricultural landowners	local representatives	Prov. / Fed. Government representatives	business owners	total responses
6	cost to municipalities	yes	4	6	4	2	16
		no					0
		N/A			1		1
							0
	details	loss of tax base	3	6	1	2	12
		road maintenance	2	1	2		5
		loss of prime agriculture area		1			1
		erosion/upstream - downstream flooding	1	1	2		4
		loss of community - family/friends	1	2		1	4
		reduced recreation development benefits	2		1		3
		extra transportation costs		1			1
		environmental costs	2		1		3
		other	1	1	2		4
7	cost to individuals	yes	4	6	3	2	15
		no					0
		N/A			1		1
		few			1		1
							0
	details	reduction in fish/game/ environmental quality	2		1		3
		loss of prime agriculture area	2	1			3
		loss of income (travel costs/feed)	3				3
		insufficient compensation	4	3	1*		7
		back - flooding	1		2		3
		increase in mill rate/taxes	1			1	2
		downstream flooding/erosion	2	2	1	1	6
		relocation costs/social costs/loss of community	1	1	1		3
8	compensation to individuals	N/A		2	2	2	6
		none (except land purchase)	4	4	2		10
		back flooding compensation (not yet negotiated)	1		1		2

Interview Matrix

question number	question	response matrix	agricultural landowners	local representatives	Prov. / Fed. Government representatives	business owners	total responses
9	compensation to municipalities	N/A	1	1	3		5
		none		3	1**		3
		not sure	1				1
		one-time payment/grant for lost taxes		1	1	2	4
		recreation development (insufficient/not attained)	2	1		1	4
10	requests for additional compensation	yes	2	2	5	1	10
		no		3			3
		not sure				1	1
		N/A	2	1			3
							0
	type requested	fish hatchery			1		1
		upstream flooding compensation			2		2
		compensation for downstream flooding	1		1		2
		recreation facilities	1	1			2
		funding for ski hill	2	1		1	4
		water rights for future development	1				1
11	future development opportunities	N/A	2				2
		not sure			1		1
		no	1				1
		yes		4	3	2	9
		few	1	2	1		4
							0
	details	tourism/recreation facilities	1	3	3	2	9
		sports fishing/hunting/outfitting	1	2	3		6
		golf course		1			1
		ecotourism			1		1
		cottages/campgrounds		3		2	5
		ski resort/winter activities		3	2	1	6
		rural pipeline/levy on downstream users	1	1			2
		agricultural development/irrigation		3			3
		industrial processing		1			1
		other		3	1	1	5

Legend:

x* = insufficient compensation provided to some individuals to enable them to purchase similar land

x** = none was offered by PFRA

APPENDIX 4:

SOCIO-ECONOMIC IMPACTS OF RESERVOIRS
WITH REFERENCE TO THE SHELLMOUTH CASE STUDY

1.0 INTRODUCTION

From responses to key person interviews and the records of public consultation sessions, some limited information is known about the socio-economic impacts of the Shellmouth project on the affected rural municipalities and individuals. This section is not intended to be a comprehensive study of these effects, but an overview of the socio-economic impacts of this specific project discovered in the course of this study and previously documented. However, since information from these sources is not comprehensive, other reservoir case studies were referenced in order to highlight the kinds of impacts that can be expected, and characterize both positive and negative effects as appropriate.

Other case study reservoirs that parallel the Shellmouth project in location, economic activity, and/or social structure are referenced to help characterize impacts. Other developments, including non-reservoir large-scale projects have also been referenced. Three key reservoir projects, discussed in greater detail in Chapter 2 section 2.5, are:

i. **Lake Shelbyville**: a multi-purpose reservoir located in Moultrie and Shelby counties, Illinios in the Kaskaskia River Basin, which was developed for flood control and downstream water supply (Burdge and Opryszek 1981).

ii. **The Oldman River Dam**: constructed in the mid-1980s, the dam is located in a prairie region just downstream from the confluence of the Oldman, Crowsnest and Castle Rivers in Alberta. The project was intended to regulate flow on the Oldman for the primary purpose of water supply for downstream irrigation, but also flood control.

iii. **Rafferty-Alameda Dams:** formally proposed in 1986 with construction starting in 1988. It is comprised of two reservoirs developed on the Souris River Basin in southeast Saskatchewan to primarily provide water supply, but also flood control (Stolte 1993).

There are four general areas of socio-economic effects, which have been organized under the categories of property acquisition, community social impacts, environmental related impacts, and economic development.

2.0 PROPERTY ACQUISITION

2.1 Land Purchased by the Crown

A review of PFRA et al (1967) Manitoba Status of Land maps indicate that roughly 6,956 ha[1] was purchased in the RMs of Shell River and Shellmouth, Manitoba for the project. This purchase includes surplus land that was not required for the dam project, but was purchased at the request of the landowner or for other reasons, such as the development of Asessippi Park. Another 275 ha[1] was already held by the Crown, 1,300 ha[1] was owned by the Department of Mines and Natural Resources Lands Branch, and 680 ha[1] was school lands. Of the land that was flooded for the reservoir project (valley lands), roughly 5,018 ha[1] was productive cultivated field or hay land. The background document (PFRA 1961) for the Shellmouth CBA (Kuiper 1961) estimated purchase requirements of 1,983 ha (4,900 acres) of cultivated land and 7,689 ha (19,000 acres) of hay/miscellaneous land for a total of 9,672 ha (23,900 acres) in both Manitoba and Saskatchewan.

Land in the uplands that was not incorporated into the park or otherwise retained by the Crown for a specific reason, is considered surplus land. In most cases, surplus land previously used for agricultural purposes, has been leased back to farmers, or in some select cases, sold to the private sector. However, rents paid to the Crown represent a capital drain from the local area. The Status of Land maps (1967) also show that roughly 20 buildings were affected by the property sale. However, it is not known whether these were dwellings, granaries, barns, or other buildings.

2.2 Impact of Crown Land Purchases on the Tax Base

One of the drawbacks of large scale development has been the negative impact on local governments in terms of lost tax revenues and an increase in service costs on a per tax-payer basis (Leistritz and Murdock 1986).

Crown Land is generally exempt from municipal taxes. However, in the case of land that is leased from the Crown for agricultural or other reasons, the province usually pays a grant in lieu of taxes. Taxes are not paid on park land or land flooded by the reservoir. In the case of the Shellmouth development, a significant portion of taxable land was removed from the municipal tax role, particularly for the RM of Shellmouth, resulting in a significant loss of tax dollars for the RM. The McKay et al (1969) planning study anticipated significant cottage and vacation development along the edge of the reservoir. As indicated in the key person interviews conducted for this study, local residents and the municipal representatives

[1] Calculated from PFRA and Department of Highways, Water Control and Conservation Branch. July 21, 1967. Maps - Status of Land Pertaining to Shellmouth Reservoir.

expected that such recreation development would compensate for the tax loss from agricultural land purchased by the Crown.

The RM of Shellmouth has calculated that the property purchased for the development of the reservoir represented an assessed property loss of $90,050 in 1970, $118,600 in 1972, and $147,100 in 1982. This assessment jumped to $522,200 in 1990 when the RM tax assessment was changed to include buildings. The RMs of Shell River, Cote and Calder have not undertaken the same exercise to determine what the loss to the tax base may have been. No property in the RM of Russell was sold to the Crown for this project. Some government officials spoke of a one-time payment to cover the tax losses, but this could not be confirmed through discussions with local municipal representatives or government officials from PFRA or the Government of Manitoba.

The reduction in the tax roll from the sale of formerly taxable property, did not lead to a corresponding drop in municipal expenses. According to the municipal representatives, the RMs of Shellmouth and Shell River increased the mill rate, which raised property taxes of the remaining municipal property owners to compensate for the lost revenue. The change in the mill rate and tax implications for individual property owners was not readily available from any of the rural municipalities.

2.3 Land Acquisition

In general, not very much is known of the specific social impacts created by the Shellmouth Reservoir development on local individuals and rural municipalities. Some information is known about the impacts of land purchase on individuals who continued to farm in the area. Little to no information is available on those individuals who were displaced from the area. Since so much time has passed since the construction of the reservoir, the opportunities to research the impacts on this specific group would be difficult at best. However, by relying on the extensive research from the Lake Shelbyville Reservoir, some effort is made to try to characterize the possible impacts on both displaced families and those who sold only a portion of their farm holdings.

2.4 Land Purchase

In the Lake Shelbyville and Oldman River Dam case studies, many affected landowners felt they were not treated properly during the acquisition and relocation phase and criticized the acquisition process for lacking transparency. This criticism was also reflected in comments from local stakeholders from the Shellmouth project who recall inconsistent land prices for similar types of land. Another common criticism of both the Lake Shelbyville and Shellmouth reservoirs was that market prices were used as the basis of compensation for land acquisition. This price however, did not take into consideration the upward effect that reducing the supply of available farm land would have on property prices in the local area. The market price also did not cover the real costs to the landowners long-term operational expenses.

One experience relatively widespread for farmers with lands affected by Lake Shelbyville Reservoir, was the negative impact the loss of valley lands had on the sustainability of individual farms in terms of the diversification of the operation. Comments made during one of the key person interviews, indicate that the same may be true for the Shellmouth. One landowner, in an effort to maintain the diversity of his mixed farming operation, related attempts to grow fodder, which had previously been harvested from hay lands in the river valley, on grain land. The loss of the valley hay land resulted in a less sustainable operation, because in dry years he was forced to purchase hay, a practice for which there was no history when the family farm included valley hay lands (key person interviews 1996, 1997). The need to purchase fodder is an added operational cost to the landowner for which there was no compensation. In another case, the landowner acquired hay land downstream of the reservoir to compensate for property purchased for the development. This individual also experienced increased operational costs as a result of the property being a much greater distance away than the original.

In addition, finding new property or re-establishing the family farm and moving, all require a time commitment for which compensation was also not paid. Interestingly, recent developments in the private sector regarding compensation indicate that aspects such as time to attend meetings, and even disruption and noise, are financially compensated.

2.5 Marginal farms

The Shelbyville study found that, particularly for marginal farms (small, lower grade cropland), the market price may not have allowed some farmers to find comparable property and farm size because none may have been available. Tenant farmers were in a more precarious position. Their personal holdings were insufficient to support the farm operation and additional required land was rented, but the acquisition of reservoir property by the

Crown, removed existing rental property from the market and decreased the available supply. In the case of the Shellmouth Reservoir, this level of detail has been lost over the last 30-years.

3.0 COMMUNITY SOCIAL IMPACTS

3.1 Non-compensated Municipal Costs

Outside of those municipal impacts mentioned in section 2.0 of this Appendix, the RMs have also spent significant administrative and political resources trying to secure perceived outstanding compensation and resolve specific issues associated with the development (key person interviews 1996, 1997). The reservoir has been a source of stress for the communities and their elected representatives.

3.2 Disruption to Social Networks

The land purchases, families moving away from the community, and the physical barrier of the reservoir all served to fragment the community and disrupt the existing social patterns and structures. In the case of Lake Shelbyville, the affected communities were described as stable rurally orientated farming communities, with strong social interrelationships between neighbours and families where the loss of community created by the redevelopment was keenly felt. It was believed this disruption to the existing social networks served to reduce the resilience of the community, and remove the support networks that had built up between neighbours, friends and extended family over time. This type of social disruption was similarly described by respondents in the Shellmouth key person interviews.

3.3 Families Displaced by Reservoir

Displaced families interviewed for the Lake Shelbyville study perceived themselves worse off in terms of taxes, cost of home, amount of land, happiness in the household, economic security, closeness of relatives and friends, and general social well-being.

Displaced people face changes in lifestyles, financial strains, reductions in access to social networks of family and friends. Some would be restricted by age in adapting to new lifestyles. The ex-post study of Lake Shelbyville discovered that some of the displaced were too elderly to start again and chose instead to move to nearby communities and take early retirement. Whether this also occurred in the case of the Shellmouth project is not known. In the Lake Shelbyville Reservoir case, it was discovered that most displaced families tried to relocate as close as possible to old residences. Anecdotal evidence from the Shellmouth key person interviews seems to confirm this was likely the case with the Shellmouth project. However, for displaced families it is often difficult to find an adequate farm land base in the vicinity.

In both cases where family farms or specific parcels were purchased, individuals may have experienced a feeling of loss as was extensively recorded in the Shelbyville case. Attachment to an area can also be a function of having extended families residing in the same community, and/or having a family or personal history in the area. Thus, leaving the area would have separated them from their social support network.

3.4 Health

During both the Oldman and Shelbyville projects, landowners were reported to have experienced significant distress as a result of the land purchase and relocation process, and the community at large experienced significant anxiety over the projects. The failure of the local area to come to terms with the Oldman River Dam, was defined as one of the most significant and unacceptable features of the project by the Federal Environmental Assessment Panel (1992). Similarly, some local stakeholders from the Shellmouth project appear to have experienced significant levels of stress. Property acquisition is believed to have created anxiety, with at least one landowner being expropriated (key person interviews 1996, 1997). A source of ongoing stress has come from channelling, in some cases years of energy, into trying to obtain compensation or mitigation for what was perceived locally as reservoir related impacts. Dealing with frustrating bureaucratic systems was highlighted as one of the associated problems in the Lake Shellbyville case.

Although, mercury poisoning is not considered a serious threat, those who regularly fish and consume their catch may be at a higher risk of health problems. A slot limit has been imposed on fish taken from the reservoir, both as a conservation measure and a means of minimizing human health risks from larger fish with higher concentrations of mercury. Individuals farming in the area just downstream of the dam have expressed concern over the lack of an emergency warning signal when the dam is opened and the risk of a dam breach when reservoir levels are high.

3.5 Other

The construction of the reservoir has not been focused on to any great extent, primarily because it represents a short-term impact for which there is little information and too long a time has passed for it to be significant to the local area. However, post-construction landowner interviews for a natural gas pipeline company in Ontario indicated that during construction noise, traffic, and the general disruption are all considered negative impacts affecting nearby landowners (Groves pers. comm. 1998).

4.0 ENVIRONMENTAL RELATED IMPACTS

4.1 Backflooding

A phenomenon referred to as backflooding has created impacts upstream of the reservoir. The backflooding effect occurs when water is receding from a major flood and the reservoir is operating for downstream flood control. As the reservoir rises, the rate of recession in the river above the dam is reduced further and further upstream. The river levels are still falling, but the rate of decline is less than it would otherwise be without the reservoir. This influence on the rate of decline is greatest closest to the reservoir and decreases to zero at a point just upstream of Kamsack. This retarded level of recession is believed to negatively affect the operation of Kamsack's sewage lagoon and increase the potential of flooding highway No.8 bridge leading into Kamsack (Smith 1975).

In addition, studies have shown that this retarded level of recession affects the timing of seeding in the low-lying areas in the river valley (Pollock 1986). The higher river levels impact ground water levels, reducing the fall of the water table, which can then delay seeding in areas in the river valley between elevations 430.4 and 432.8 meters. The total land area affected by backflooding has been calculated to be roughly 356 ha. Maximum backwater impacts occur when the river inflow is at about 2,000 cfs.

Delays in seeding as a result of the reservoir operation and flood conditions occurred four times between 1969 and 1985, delaying seeding by two to three days in 1972 and 1976, and seven to eight days in 1975 and 1979. Comments made by a resident of the area to the Manitoba Water Commission, also indicate that farmers may have adjusted their long-term farming practices in response to the changing conditions, by planting permanent cover which is not as financially lucrative as grain production would have been (Saunderson et al 1980). No studies have been undertaken on this issue since 1986, but PFRA recently negotiated a settlement with affected upstream property owners to compensate for the backflooding affect (Blackwell pers. comm. 1996).

4.2 Downstream Flooding

The operation of the reservoir to control downstream flooding in the lower reaches of the Assiniboine occasionally serves to exacerbate flood conditions immediately below the dam. The current operating regime minimizes flooding downstream of the Town of Russell by holding back spring run-off. When the reservoir reaches an elevation of 429.31 m, water passes the spillway, creating flood conditions or higher water levels that raise ground water levels just downstream of the dam. An improvement in flood control just downstream of the dam would require that water be released earlier in the runoff period, but this approach would aggravate the flooding in the Assiniboine River Valley downstream of Russell (Manitoba

Water Commission 1980). The result is that farmers downstream of the reservoir are facing conditions which interfere with spring seeding that are not unlike conditions faced by farmers upstream of the dam (key person interviews 1996, 1997). These conditions however, have not been studied as extensively as backflooding upstream of the reservoir.

A number of downstream landowners have noted losses, which are claimed to be due to the operation of the reservoir. Ongoing bank erosion in the spillway discharge area, which is eating into the adjacent farm fields, is believed to be one offshoot of the dam's operation regime (see Appendix 5 for a further description). Another source of loss occurred during the 1995 Assiniboine flood, where the reservoir reduced the downstream crest height, but increased the flood duration. This long period of inundation had the effect of killing permanent cover as well as eroding and depositing large quantities of till and gravel. The reclamation process was extensive and time consuming, and landowners said they were not fully compensated for their damages by Manitoba Crop Insurance. According to the recollection of one individual with a long history of farming in the area, such flood damage was not previously reported in the river valley prior to the dam. This perceived increase in flood damages could not be easily proved or disproved, primarily because government insurance, for which compensation pay-outs would provide some scale of comparison, has not been in place long enough to undertake a pre- verses post-development assessment.

4.3 Sports Fishery

The popularity of fishing in the reservoir is determined to a large degree by the productivity of the walleye fishery. As has been observed in numerous reservoirs, the populations of predator fish, such as walleye, tends to reach a peak in the early years following construction of the reservoir. In the case of the Shellmouth, these numbers were somewhat influenced by walleye stocking programs in the 1970s and early 1980s.

The productivity of the walleye fishery in terms of number of fish harvested dropped by a significant 78% between 1989 and 1995 (Table 1). The walleye is the favourite of sports fishermen and when numbers declined substantially after 1989, there was a corresponding drop in the number of non-local fishing visits to the Shellmouth (Kansas pers. comm. 1997). Total angler hours dropped by an estimated 47%. This drop in the number of angler hours represents a decline in the economic value of the sports fishery to the area, as visitors and angling related purchases also declined.

Table 1

Changing Productivity of the Walleye Fishery

Creel Census Years	1984	1989	1995
No. of walleye harvested	26,200	47,704	10,510
Estimated angler hours	89,200	76,903	40,827
Catch/angler hour	.29	.62	.26

Source: Fisheries Branch. Lake of The Prairies, 1995 Index Fishing - Summary Report
Fisheries Branch. Lake of the Prairies Creel Census Report- 1989. Manitoba Natural Resources Memo.
Fisheries Branch. Lake of the Prairies Creel Census Report- 1995. Manitoba Natural Resources Memo.

The annual total value of the Lake of the Prairies fishery for the local area (Table 2) is therefore estimated to be $1,334,416 in 1990 and $654,444 in 1995, based on the average expenditures[2] per angling day (using 1990 expenditure figures).

[2] Average expenditures are direct expenditures that include food, lodging, travel costs, fishing supplies and services, and boat costs.

Table 2
Value of the Lake of the Prairies Fishery

	Manitoba Residents 1989	Saskatchewan Residents 1989	Manitoba Residents 1995	Saskatchewan Residents 1995*
Estimated number of angler days (based on a 3 hour day)	25,634	11,773	13,609	6,240
Average expenditure per angler day	$ 31.95	$ 35.20	$ 31.95	$ 35.20
Estimated expenditures	$ 819,006.00	$414,410.00	$434,808.00	$ 219,636.00

* estimated reduction based on percentage drop in Manitoba angler days
Source: based on a memo by Barb Scaife. May 13, 1993. Internal Memo. Manitoba Department of Natural Resources and figures from the Creel Census for 1989 and 1995

4.4 Fluctuating Levels and Erosion

Frequent water level fluctuations also impact the recreational appeal of the reservoir. The frequent and rapid fluctuations expose mud flats during drawdowns and contribute to bank erosion. Bank erosion reduces potential recreational benefits of the reservoir by decreasing aesthetic value, increasing water turbidity, making it difficult to maneuver boats in the shallows, and inhibiting access to the water's edge.

4.5 Algae

Algae growth is a common occurrence in prairie reservoirs due to high nutrient levels. Algae growth reduces the desirableness of using the reservoir for recreation by making the water body less attractive and safe for recreational use (Tones 1987). Unpleasant odours emitted during algae growth and changes to water texture also deters recreation. Large blooms may cause skin irritations and reduce clarity and hence safety for swimmers (Tones 1987).

5.0 ECONOMIC DEVELOPMENT

One of the anticipated benefits of many large-scale public sector projects is local economic growth. However, there are offsetting development costs beyond a loss of tax base for the local municipalities. In addition, benefits have been found to be neither consistent across projects in terms of distribution, nor guaranteed (Leistritz and Murdock 1986). Economic development benefits have a tendency to fluctuate over the course of the project's lifetime and the interjurisdictional distribution of benefits and costs is not uniform.

5.1 Development Related Costs

One good example of limits on economic benefits derived from reservoir development is road construction and maintenance. As in the case of the Shellmouth project, the state pays for new roads and repair of existing roads following construction, with the local government being responsible for on-going maintenance. With the Lake Shelbyville project, a greater requirement for road maintenance due to increased in seasonal visitor traffic was noted. While this impact was not specifically identified by local Shellmouth stakeholders in the key person interviews, concern was raised about the need and associated costs to maintain municipal roads to allow public access to the reservoir. These municipal roads originally provided access to valley agricultural fields and were supported by taxes paid by those properties.

Because the Shellmouth Reservoir served to put a physical barrier between the west and east sides of the reservoir, travel distance from one side of the valley to the other was substantially increased. The removal of Pyott's Bridge located in sections 2 and 3 in township 25 range 29, and the Dropmore Bridge in section 36 township 23 range 29 west, affected both the RM of Shellmouth and Shell River. The removal of the Dropmore Bridge cut off a major service centre for the local area (Ball pers. comm. 1999). For both RMs, but particularly the RM of Shellmouth, the reservoir served to split the jurisdiction in two, which had and continues to have, economic and administrative implications. Maintenance has become more expensive because greater time and energy is required to service both sides of the reservoir. School children on the west-side are bused outside the RM of Shellmouth because it is no longer feasible or efficient to transport them to schools inside the municipality. In a similar fashion, the reservoir influences the purchase of goods and services: west-side residents now travel outside of the RM for their purchases. In addition, families have a tendency to relate to the community where children attend school, which also serves to restructure the community social network.

5.2 Local Businesses Related to the Reservoir

Some private businesses are believed to have developed as a direct result of the reservoir project, while others have seen some increase in business from the tourist traffic associated with the reservoir. The majority of these businesses provide recreation or tourism oriented services. Businesses related to the reservoir fall in two categories: those directly related to the reservoir and those that receive spin-off benefits. Businesses that have developed as a direct result of the reservoir include tourism accommodation and services including outfitters and fishing supplies. Local Manitoba outfitters use the reservoir for angling trips for clients (Manitoba Vacation Guide 1999), Crescent Lake Outfitters from Saskatchewan take clients to hunt waterfowl in the vicinity of the delta forming upstream of the reservoir, and a bait and tackle shop operates out of nearby Russell. Two private campgrounds that have been operational for a number of years are a direct result of the reservoir development. One local picnic/boat launch site has been developed in Saskatchewan on the reservoir, but has not been very successful.

Another business directly resulting from the reservoir is Kilman Resorts, a relatively recent project situated at the southwest end of the reservoir. It was developed by local entrepreneurs, who have sold a number of cottage properties since 1996. The resort was planned as a full season cottage sub-development and includes a boat and tackle shop, boat rentals, ice fishing shacks, and a convenience store with a lunch bar. Cottages are also available for rent. Depending on the success of this endeavor, this development could indirectly help support other service industries in nearby communities. One associated indirect result is the concession at Asessippi Park, which is operated by a local business person.

Table 3
List of Current Reservoir Related Businesses

Type of Business	Operated by	Period of Operation	Location and Characteristics
Cottage Resort, Kilman Resort	Russell business people	all year	cottage subdivision with cottage rentals on lake, marina, pontoon boat tours, boat rental, ice shacks, convenience store, tackle
Pyotts Campground	operated by local business person	summer	leased crown land
Ricker's Campground	N/A	summer	private - near Roblin
Concession stand at Asessippi Park	operated by local business person	summer	leased from province
Bait and tackle supplies Outfitting: Mike's Bait and Tackle	operated by local business person	primarily summer	Russell - private ownership
Outfitters: ▪ Boggy Creek Outfitting ▪ Vestby Angling Adventures ▪ Parkland Outfitters ▪ Crescent Lake Outfitters	local people from Roblin Roblin Inglis Yorkton	 year round spring, summer fall fall	 fishing at reservoir partially fishing at reservoir partially fishing at reservoir primarily duck hunting - upstream delta
Rockin Horse Stable	Local	summer	Asessippi Park
Asessippi Ski Hill	Local consortium	winter	Asessippi Park- open 1999
Food, gas and accommodation	Spin-offs from tourist visits	primarily summer	private business at Russell and Roblin, some at Inglis

Source: key person interviews 1996, 1997 and Industry Trade and Tourism 1999a, 1999b, 1999c

The local area believes some spin-off benefits have occurred from the tourist traffic associated with the reservoir for certain service businesses, such as food, gas and accommodation in nearby communities such as Russell, Roblin, and Inglis. The Church Café near Inglis, for example, has seen some increase in reservoir visitor related business over the years (key person interviews 1996, 1997). The distribution of visitor benefits has not been evenly dispersed through the community. Visitor needs for commercial and retail services have generally been provided in Russell, where there have been minimal costs associated with the project, but not in the RMs of Shellmouth, Shell River, Cote or Calder where project related costs have been significantly higher. Cote and Calder have seen essentially no tourism development from the project (key person interviews 1996, 1997). Businesses which may have closed as a result of the reservoir development is not known.

5.3 Employment and Income

Employment and income figures can provide an indication as to the economic impact of a project on the local area. The construction of the reservoir likely created some net benefit to the local economy. However, the number of local jobs created or the goods and services purchased is not known. In the key person interviews, long time residents do recall some local people working on the construction project, but had no knowledge of the extent of local hiring practices. Whether local contractors were hired for any specific construction activity is also not known.

Employment figures or income figures for reservoir related businesses were not available from any published source and it was beyond the scope of this study to undertake a comprehensive collection and review of this data. However, it is generally believed by local stakeholders that the reservoir has not contributed significantly to the number of local individuals employed, or generated significant income for those individuals. The reservoir development may have actually reduced net employment by decreasing the land base and the associated agricultural sector employment. This is difficult to assess, because agricultural populations and employment figures across the prairies have steadily declined due to mechanization well before the reservoir's development (Statistics Canada 1996).

While the actual employment numbers would fluctuate from year to year, the majority of both direct and indirect employment positions created as a result of the reservoir is believed to be relatively low paying, seasonal positions. The possible exceptions would be senior park personnel and the local Natural Resources Fisheries Biologist. Significant long-term employment benefits that would have offset the loss of resources and project related stress are generally not realized by reservoir projects (Rosenberg et al 1995).

Table 4 shows estimated employment positions related to the reservoir project, estimates of the probable value of the employment positions to the local economy based on the duration of employment and anticipated income (Statistics Canada 1998), and identifies whether they are indirect or direct results of the reservoir project.

Table 4
Estimated Local Employment Generated from the Shellmouth Reservoir

Employment*	Direct or Indirect Benefit of Reservoir	Duration of Employment	Potential Impact on the Local Economy by Wages
Wildlife Fishery's Biologist	direct (partial)	year round	high
Campground / Cottage Resort Summer Staff	direct/ indirect	seasonal	minimal
Outfitters - reservoir fishing	direct	seasonal primarily	minimal
Park concession	indirect	seasonal	minimal
Senior Park Positions	indirect	seasonal	medium
Junior Park Positions/Green Team	indirect	seasonal	minimal

*does not estimate owner profit/salary
*construction employment from 1966 to 1970 is not included as no information is known about the positions for which local individuals were hired.
Minimal = annual income of less than $13,999
Medium = annual income of between $14,000 and $29,999
High = annual income greater than $30,000

5.4 Recreation and Vacation Spin-off Development

The general feeling by local stakeholders is that the government misrepresented the project in terms of the local economic benefits resulting from recreation and vacation development associated with the reservoir. This was also found to be the case in the Lake Shelbyville Reservoir, where residents did not feel that development predictions were fulfilled. The Lake Shelbyville study determined, and it is a belief shared by local stakeholders of the Shellmouth project, that the operation of the reservoir for downstream uses does not support recreation and vacation property development.

5.5 Recreation Opportunities

One of the benefits of the reservoir was to establish water based recreational opportunities nearby for use by local residents. The reservoir offers boating, swimming, water skiing, fishing in the summer and ice fishing, cross-country skiing, and snowmobiling opportunities in the winter for people in the area. While local business people, and to a lesser extent elected municipal representatives, recognized this benefit local agricultural landowners largely discounted this value (key person interviews 1996, 1997). As was found with the Oldman River Dam, the development of reservoir projects represents a loss of natural recreation and aesthetics, but a gain in artificial recreation facilities and aesthetics. Rural agricultural residents felt they could take advantage of the natural recreational opportunities afforded by the river, such as fishing and swimming holes, if desired. Prime recreational use of the reservoir also coincides with the busy agricultural season, and thus recreational time was limited for these stakeholders.

In contrast, business people from nearby communities and elected representatives of these communities generally had strong positive perspectives on the recreation opportunities for local residents and for attracting visitors to the area. However, the one noted drawback is the operation of the dam, where flood control and water supply downstream take precedence over accommodating recreation use of the reservoir (see section 4.0). The reservoir management does not favour the enhancement of local benefits, rather it tends to reduce the expected value of recreation and tourism revenues.

5.6 Reservoir Impact on Cottage Property Development

Water front properties in recognized vacation areas are generally in high demand, with purchasers willing to pay a premium for location. A number of factors affect the desirability and hence value of vacation property near a water body (Lansford and Jones 1995). Those variables directly influenced by the characteristics of a reservoir are:

- Accessibility to the water's edge
- Water quality
- Topography
- Water depth
- Aesthetic qualities.

Bank erosion on the scale that arises at the Shellmouth and other reservoirs (Appendix 5) negatively affects the desirability of vacation property for a variety of reasons including those outlined for recreational benefits. Lakeside property is highly valued for the views, primarily of the water. Due to bank instability arising from the high rates of erosion, cottages must be set far back from the edge, which limits, or eliminates altogether, views of the water from the cottage and thus reduces the property's value. Erosion is also not aesthetically pleasing and along with seasonally inconsistent water fluctuations that are characteristic of the reservoir, creates difficulties in launching boats, having docks and accessing the water's edge, which further impedes vacation property development and desirability. Erosion rates differ around the reservoir, and thus some sites with little bank erosion may be suitable for vacation property development (see Figure 1, Appendix 5).

One study looked at two Texas reservoirs: Lake Austin a single purpose reservoir experiences small water level fluctuations and Lake Travis, operated as a multipurpose storage structure for flood control and recreation, experienced significant level fluctuations. The study found that after factoring out all of the other variables, the stability of water level effected the value of vacation property. Lake Travis, which has considerable water level fluctuations, experienced between 3.4% and 9% lower waterside property values (Lansford and Jones 1995).

For recreation use and associated development at the Shellmouth Reservoir to be accommodated through a more constant reservoir level, the designated priority uses of the reservoir for flood control and water supply would be compromised (Manitoba Water Commission 1980).

5.7 Proposed Vacation and Recreation Development

One of the common complaints of reservoir developments, including Rafferty-Alameda in Saskatchewan, Lake Shelbyville in Illinois and the Shellmouth Reservoir, is that anticipated recreation and vacation property development is not achieved. Local area stakeholders believe, rightly or wrongly, that projected recreation development is to compensate for having the project in their community and incurring the associated costs. In the case of the

Shellmouth project, there were three sources of documented development projections; the reservoir area development plan by McKay et al (1969) and two Asessippi Park plans.

The McKay et al (1969) land use plan outlined extensive recreation and vacation property development opportunities along the reservoir. The land use plan was based on a review of existing land use conditions, including a characterization of the natural area in the vicinity of the reservoir. The plan (Figure 1) delineates nine intensive recreation areas (Table 5) and twelve cottage areas, six on either side of the reservoir.

Table 5

Components of the Intensive Recreation Areas*

Components of public recreation areas	Number
Beaches	4
Camping	9
Marina	3
Boat launch	1
Golf course	2
Picnicking	1
Skiing/tobogganing	1

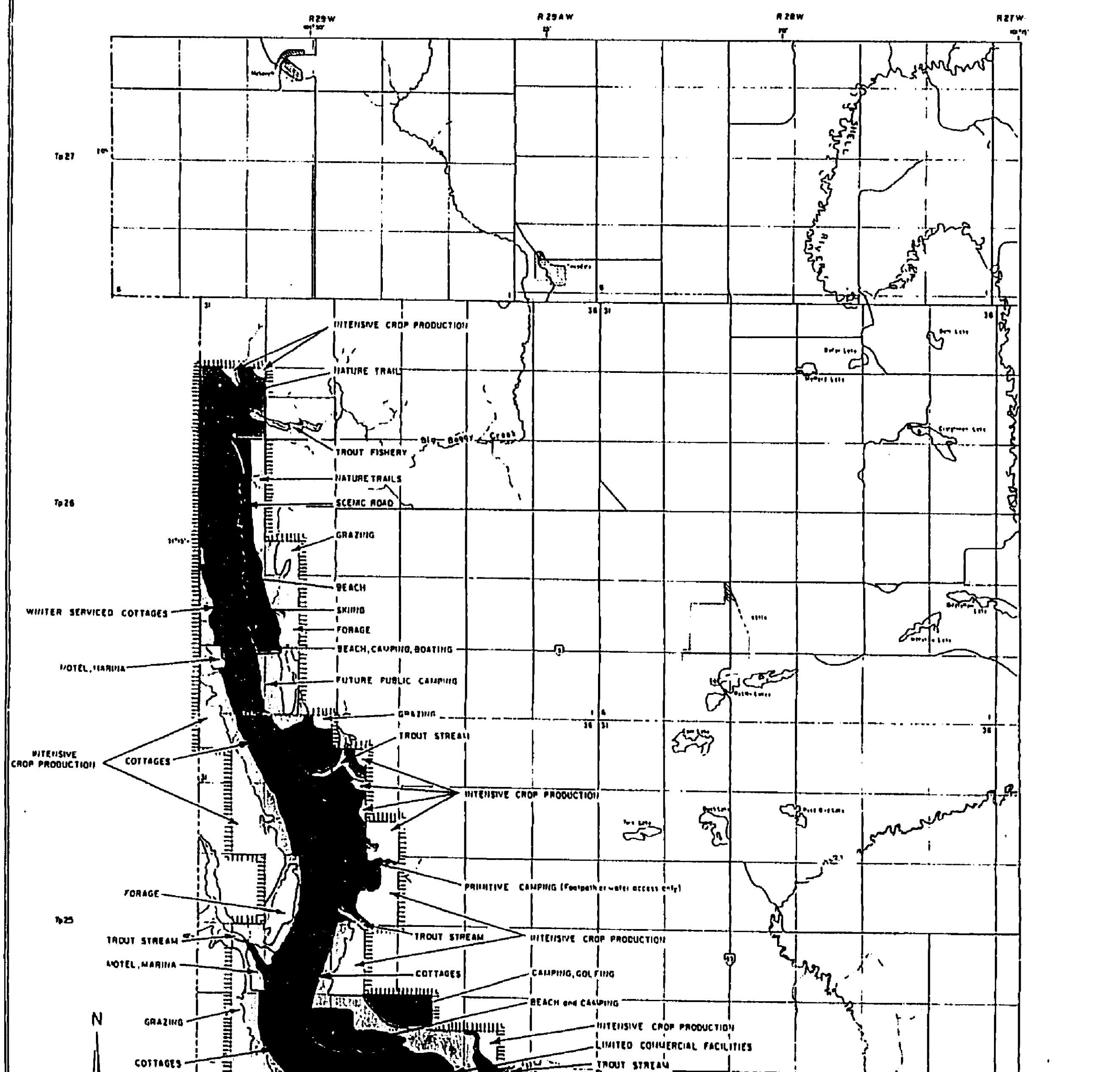
*Defined by McKay et al 1969 in the land use plan (Figure 1)

The plan also called for three commercial complexes, one of which was proposed for Asessippi Park. The other two, which included a hotel and marina, were to be located at the northwest end of the reservoir. In addition, one trout fishery was identified at the north end of the reservoir at Big Boggy Creek and a tailwater fishery at the spillway. These land use developments, that were in part expected to compensate for lost RM tax revenue, did not materialize. Only recently has there been any significant development of vacation properties.

SHELLMOUTH DESIGNATED RESERVOIR AREA

IN MANITOBA

MAP - V



FIG

Shellmout
Land U

Source: M. McKay, A.
Goulden, J. Hodgson, G. Je
Shellmouth Designated Re
Use Plan. Map V. Manitol
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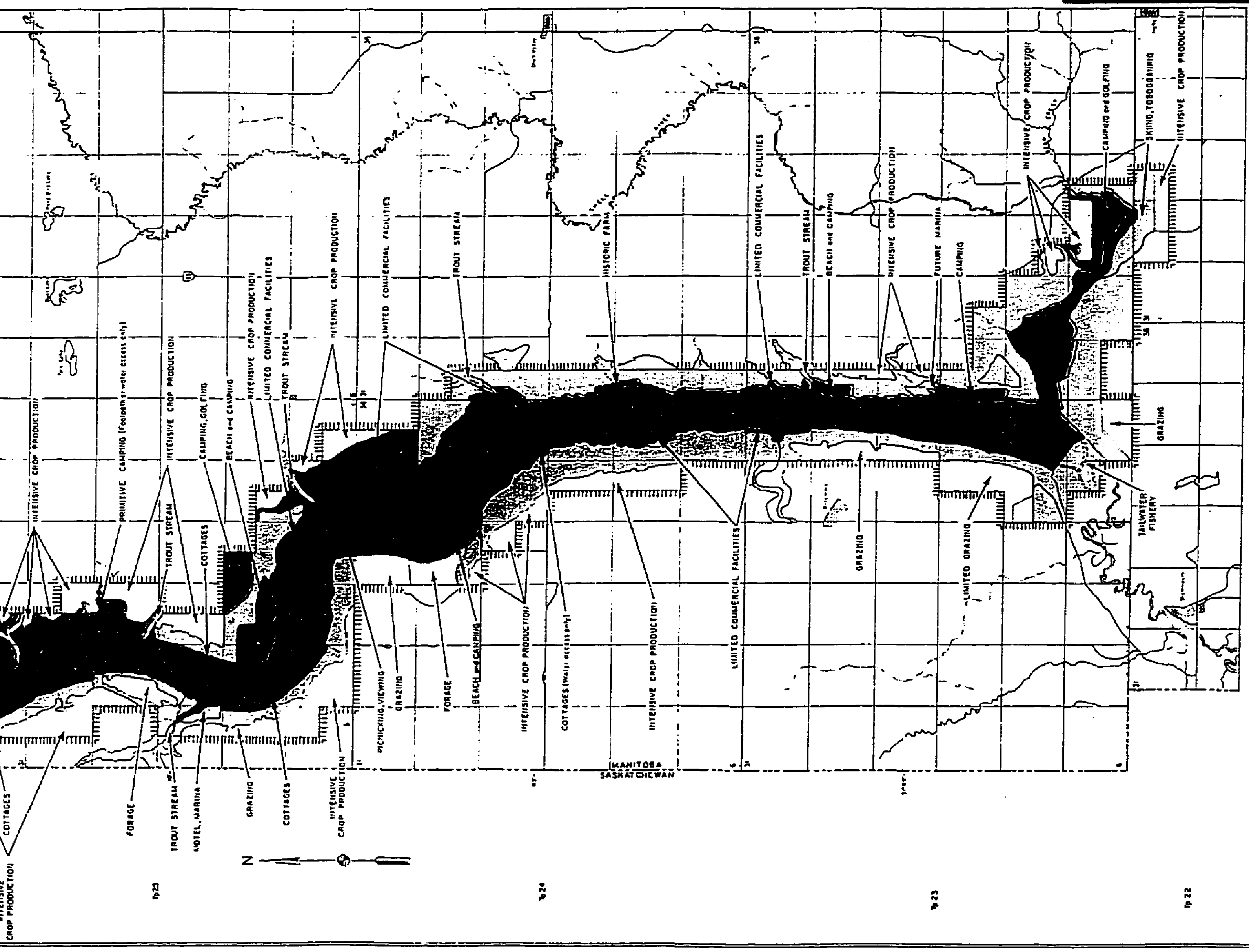
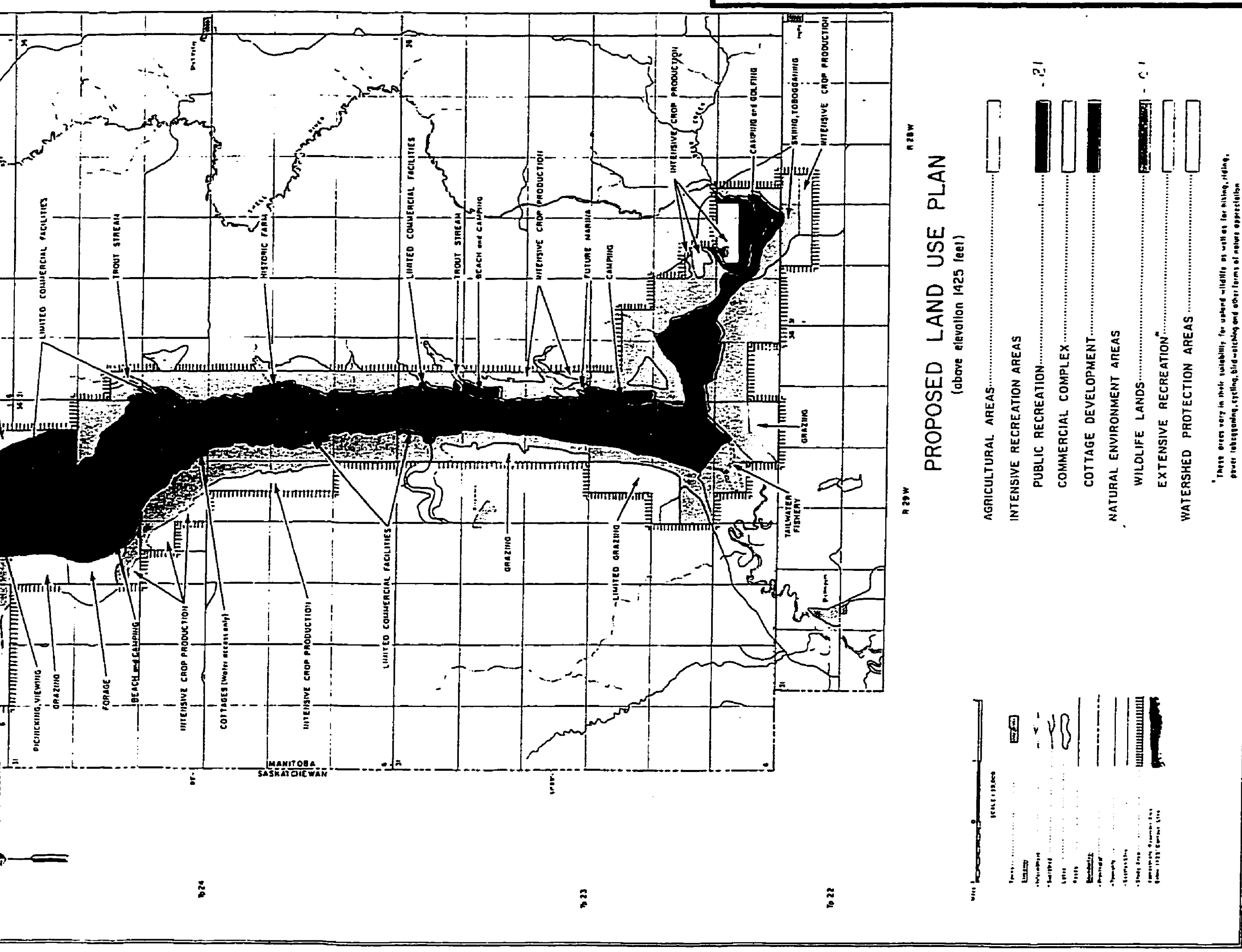


FIGURE 1

Shellmouth Reservoir
Land Use Plan

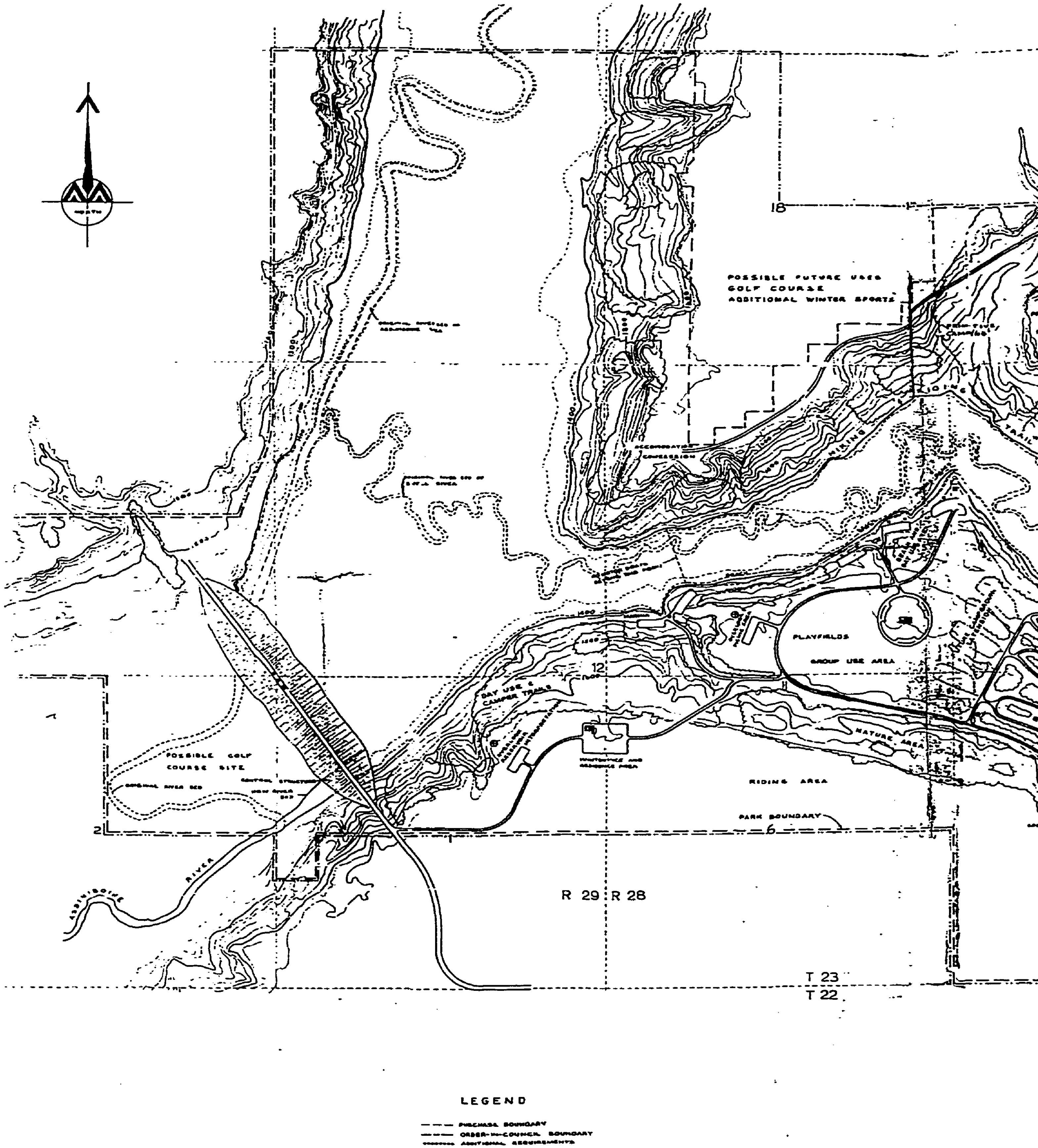
Source: M. McKay, A. Fedoruk, R. Goulden, H. Goulden, J. Hodgson, G. Jenkins, and R. Peiluck. 1969. Shellmouth Designated Reservoir Area Proposed Land Use Plan. Map V. Manitoba Dept. of Mines and Natural Resources. Canada Land Inventory Project, Winnipeg.



Asessippi Park

One of the catalysts to secure recreational use of the reservoir, was the development of Asessippi Park at the south end of the reservoir near the dam site, constructed shortly after the reservoir project (McKay et al 1969). Local stakeholders have argued that the province has not fulfilled its obligations by failing to fully develop the park according to the park plan. Early plans for the park (Figure 2) show trails, campgrounds, a marina, a beach, playing fields, a riding stable, and a concession, all of which were developed. A reconstruction of the historic townsite, a ski chalet and golf course indicated on the preliminary plan never materialized (Parks Branch 1967). Plans after the reservoir's construction were more conservative, eliminating the ski chalet and the golf course, but including an amphitheater in the campground area (Parks Branch 1973). This plan scheduled the restoration and reconstruction of the Asessippi town site for phases 2 and 3 of the development (Figure 3). In the key person interviews, local stakeholders noted that the restoration of the town site that was expected to encourage tourism has yet to occur. Figure 4 details the current Provincial Park Plan.

Local residents have actively pursued provincial funding to finance the ski chalet and ski-hill development near the location of the ski chalet as proposed in the 1967 Parks Branch Preliminary Plan. Development funding was recently secured and the project is expected to be completed in the fall of 1999. Many local stakeholders feel that the development of this project will partially fulfill the government's obligation and compensate the local area for development of the reservoir (key person interviews 1996, 1997).

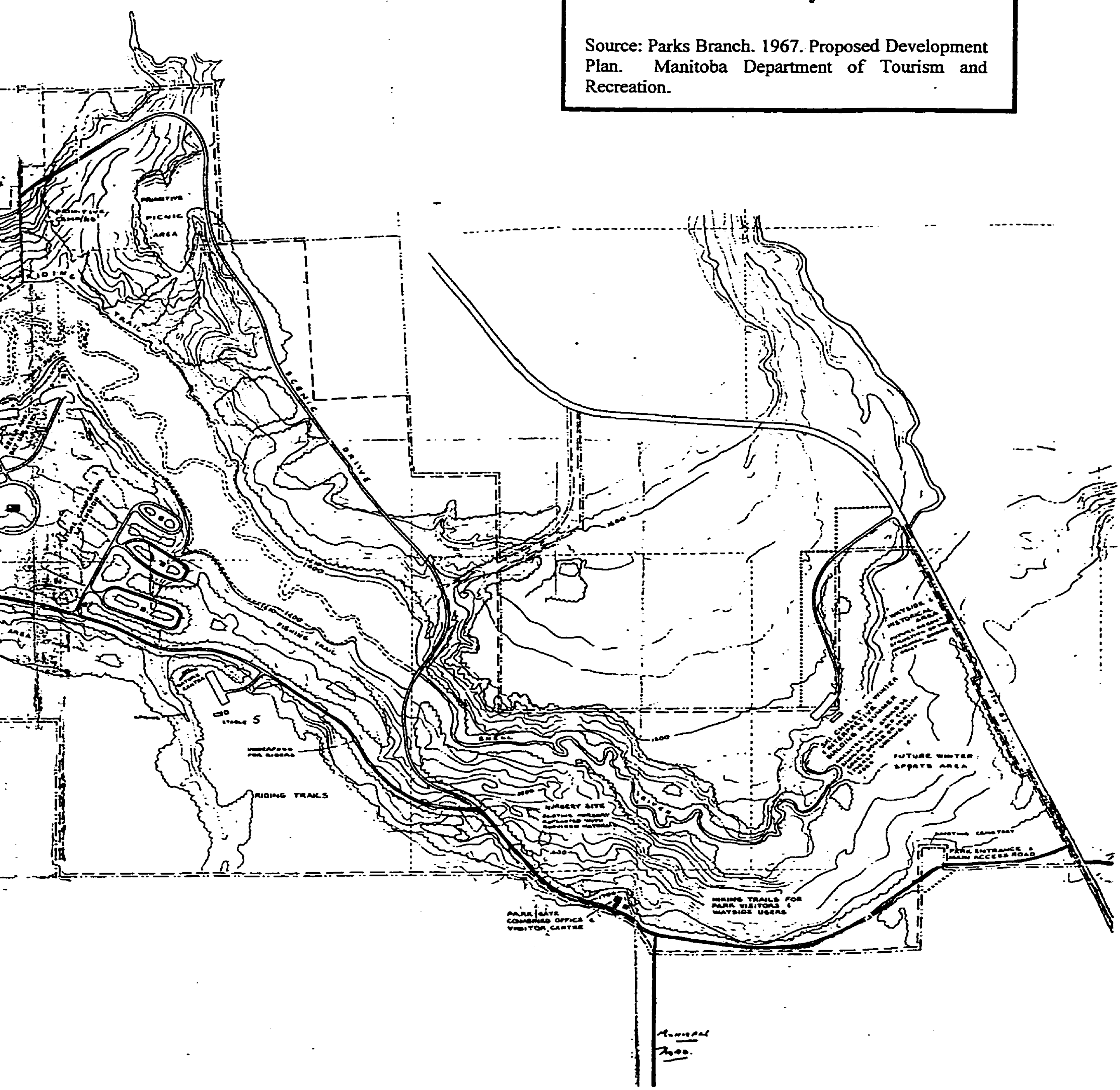


POSSIBLE FUTURE USES
GOLF COURSE
ADDITIONAL WINTER SPORTS
18
PLAYFIELDS
GROUP USE AREA
DAY USE & CAMPER TRAILS
12
NATURE AREA
RIDING AREA
PARK BOUNDARY
6
POSSIBLE GOLF COURSE SITE
2
1
RIVER
R 29 R 28
T 23
T 22
LEGEND
PURCHASE BOUNDARY
ORDER-IN-COUNCIL BOUNDARY
ADDITIONAL REQUIREMENTS

FIGURE 2

Asessippi Provincial Park
Preliminary Plan

Source: Parks Branch. 1967. Proposed Development Plan. Manitoba Department of Tourism and Recreation.



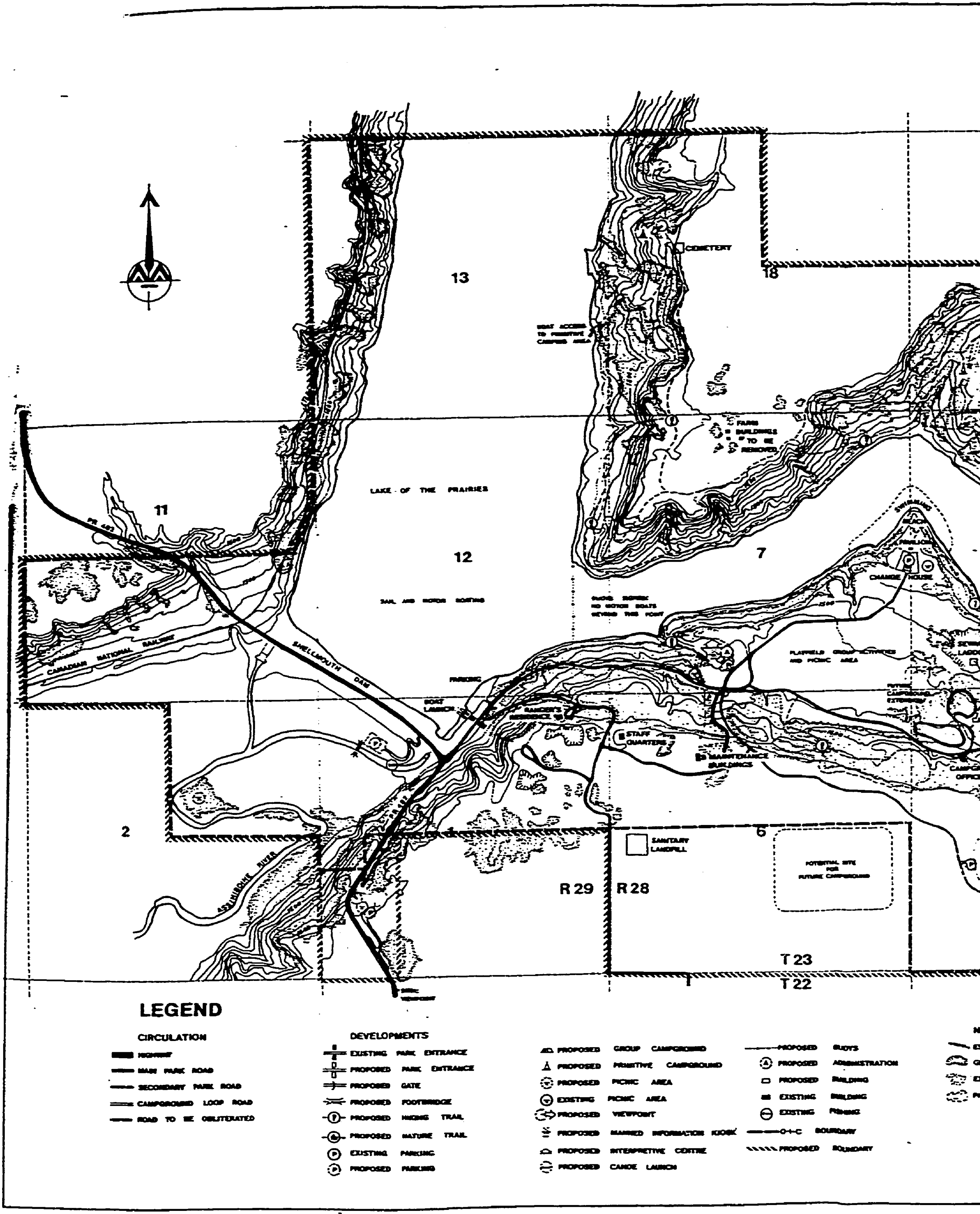

13
CEMETERY
18
BOAT ACCESS TO PRIMITIVE CAMPING AREA
LAKE OF THE PRAIRIES
FARM BUILDINGS TO BE REMOVED
11
PR 482
12
7
SAIL AND MOTOR BOATING
CHANGE HOUSE
CANADIAN NATIONAL RAILWAY
SHELLMOUTH DAM
PLAYFIELD GROUP ACTIVITIES AND PICNIC AREA
PARKING
BOAT LAUNCH
RANGER'S RESIDENCE
STAFF QUARTERS
MAINTENANCE BUILDINGS
2
6
SANITARY LANDFILL
POTENTIAL SITE FOR FUTURE CAMPGROUND
ASSINIBOINE RIVER
R 29
R 28
T 23
T 22
LEGEND
CIRCULATION
HIGHWAY
MAIN PARK ROAD
SECONDARY PARK ROAD
CAMPGROUND LOOP ROAD
ROAD TO BE OBLITERATED
DEVELOPMENTS
EXISTING PARK ENTRANCE
PROPOSED PARK ENTRANCE
PROPOSED GATE
PROPOSED FOOTBRIDGE
PROPOSED HIKING TRAIL
PROPOSED NATURE TRAIL
EXISTING PARKING
PROPOSED PARKING
PROPOSED GROUP CAMPGROUND
PROPOSED PRIMITIVE CAMPGROUND
PROPOSED PICNIC AREA
EXISTING PICNIC AREA
PROPOSED VIEWPOINT
PROPOSED MANNED INFORMATION KIOSK
PROPOSED INTERPRETIVE CENTRE
PROPOSED CANOE LAUNCH
PROPOSED BUOYS
PROPOSED ADMINISTRATION
PROPOSED BUILDING
EXISTING BUILDING
EXISTING FISHING
BOUNDARY
PROPOSED BOUNDARY

FIGURE 3

Asessippi Provincial Park
Proposed Development Plan 7

Source: Parks Branch. 1973. Proposed Development Plan. Manitoba Department of Tourism, Recreation and Cultural Affairs.

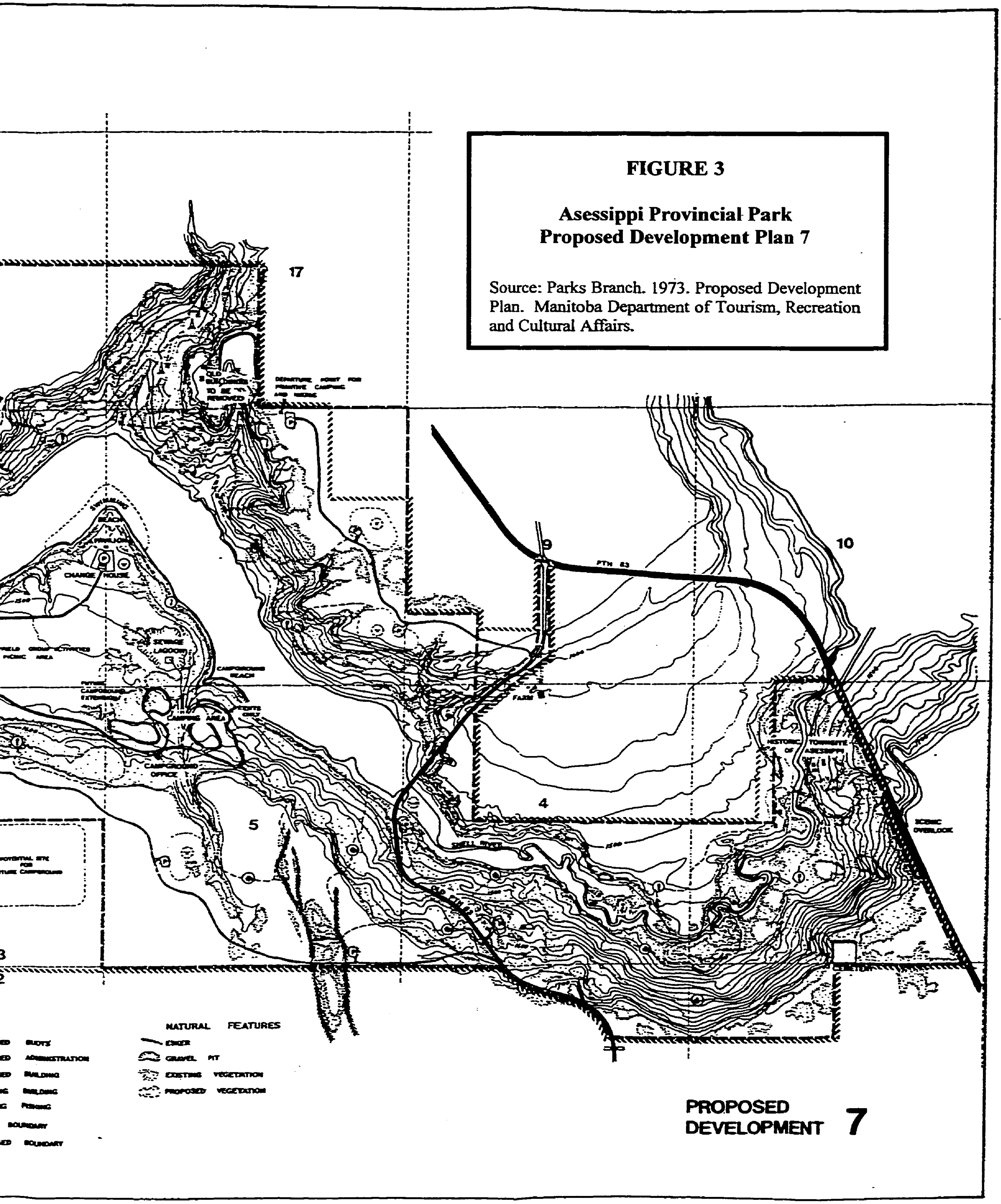
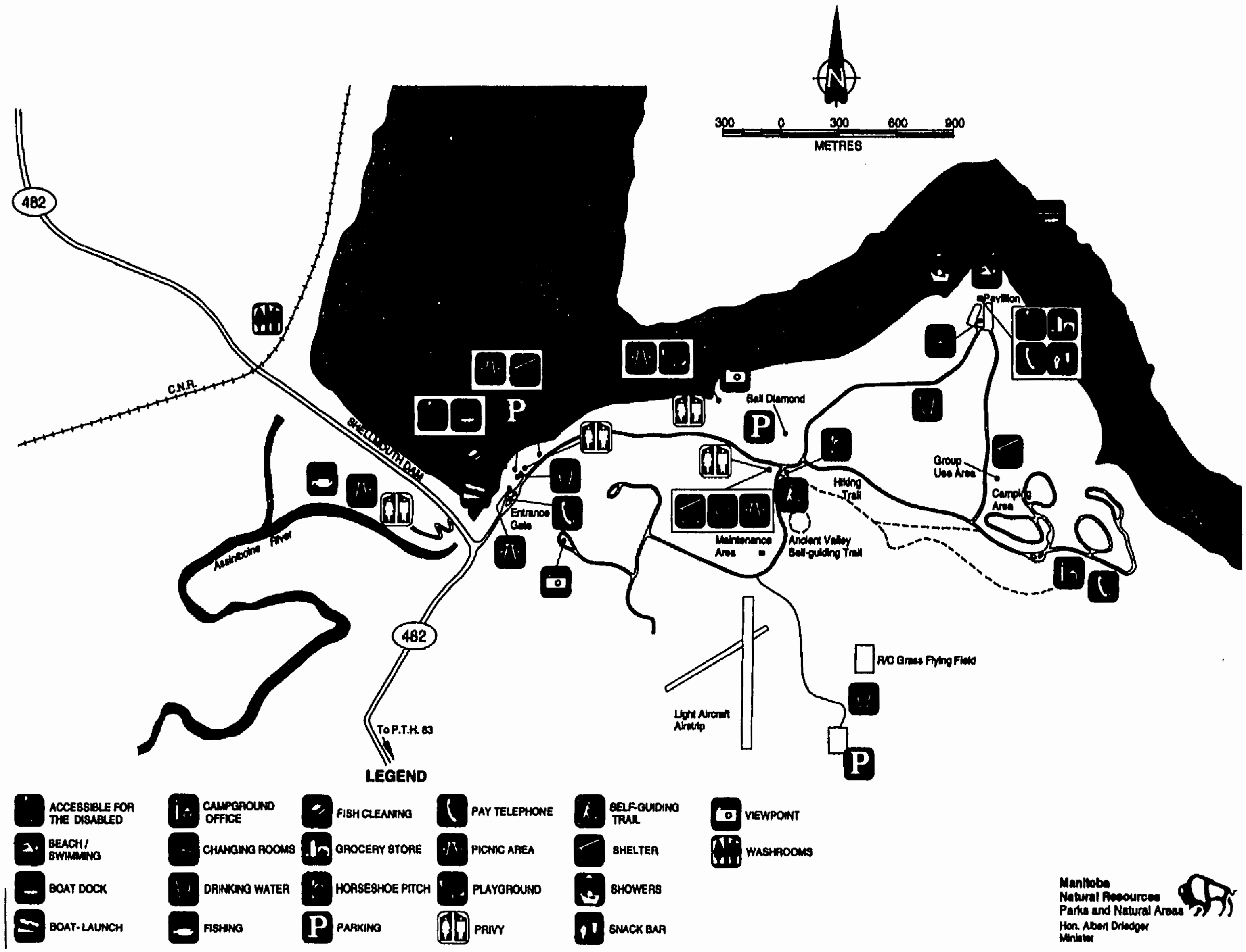


Figure 4

Asessippi Provincial Park – Current Facilities (1995)



6.0 OTHER ISSUES

6.1 Inter-Generational Considerations

The socio-economic impact of the project for future generations is unclear. The impacts will be based on how future generations chose to interact with the reservoir. Regardless, future generations will incur project costs that they would not otherwise face if only the natural river existed. These costs will stem from the need to repair or remove the existing dam. Conversely, improvements to the dam could also be made that would see the reservoir size increase, an option that is already being discussed (PFRA and Water Resources 1992). Regardless of the choice, there will be social, economic and environmental implications for the local area and stakeholders that will result in both benefits and costs.

APPENDIX 5:

ENVIRONMENTAL IMPACTS OF RESERVOIRS WITH REFERENCE TO THE SHELLMOUTH CASE STUDY

1.0 ENVIRONMENTAL IMPACTS OF RESERVOIRS

The following is an overview of the environmental impacts of reservoirs in general, with specific reference to those documented or otherwise noted impacts for the Shellmouth Dam. The geographical site description (Appendix 1) and the general description of reservoirs in Chapter 2, provides context for this discussion. Much of the documentation on the environmental impacts created by Canadian dam sites and reservoirs has been specific to northern hydroelectric projects. There are several possible explanations for this. Hydroelectric projects are closely scrutinized by the federal government because they usually fall within federal jurisdiction: they impede navigable waterways and often have direct consequences for native peoples and their lands. The demand by northern aboriginal residents for compensation and settlement of treaty claims has provided a direct impetus for greater documentation of environmental, as well as socio-economic impacts of northern hydroelectric reservoirs (Rosenberg et al 1987). One other possible reason for the relative lack of documentation on prairie reservoirs impacts, is that changes resulting from northern reservoirs constructed in sensitive northern landscapes are arguably more dramatic than those generally seen with prairie reservoirs.

Regardless of the reason, there is relatively little that focuses on the impacts of reservoirs located in agricultural prairie landscapes. No post-development studies were located that comprehensively reviewed the breadth of the changes imposed by the Shellmouth or Canadian prairie reservoirs over a period of years. While environmental assessments, which generally occur prior to the actual construction of a dam site, anticipate the prominent impacts the reservoir may have on the watershed and surrounding terrestrial landscape, they do not comprehensively document actual resulting impacts. Regardless, no EIA was conducted for the Shellmouth. Available post-development studies tend to focus on a specific issue, such as a methylmercury or oxygen levels, but these individual studies do not constitute a comprehensive post-development assessment of the kind that reviews a wide range of potential environmental impacts and their associated socio-economic effects.

This is also true for the Shellmouth where only a select few impacts have been studied. Furthermore, for most of the monitored impacts, data has only been gathered intermittently, with months, years, or even decades between sampling (Fortin pers. comm. 1997; Kansas pers. comm. 1997). In addition, there is little documented pre-dam data available to compare the observed changes with baseline information. One of the only studies that partially documents baseline conditions is the McKay et al (1969) planning/land use study that outlines some of the known pre-constuction conditions and anticipates select environmental impacts. However, any baseline conditions assessment was inhibited by the fact that the study was started after construction of the reservoir commenced.

The following is an overview of impacts commonly observed in reservoirs located in the plains and boreal forest regions. These provide some insight into the changes created by the Shellmouth Dam. Where possible, studies specific to the Shellmouth Reservoir or impacts otherwise identified are also discussed.

1.1 TYPES OF CHANGES

Impacts created by dams and associated reservoirs vary over time and tend to be dissimilar to the conditions of a natural lake, primarily due to the rapid formation and engineered manipulation of these water bodies (Ackermann et al 1973). Indeed, reservoirs may never arrive at a natural state (similar to a lake) because water levels are continuously subject to manipulation. The impacts may have direct or indirect, positive or negative effects on the local area and watershed, with the magnitude of individual impacts varying over the life-span of the reservoir. Those impacts created at the outset during the construction phase often represent specific short-term changes. Other impacts are cumulative or ongoing and can vary substantially from those during the initial construction phase (Dougherty and Hall 1995). The initial flooding of the reservoir and the ongoing operation generally create longer lasting impacts.

1.1.1 Construction Impacts

General construction impacts on the environment will vary with each project. However, one of the more common impacts results from the general construction of the reservoir and the corresponding development of roads needed to facilitate construction. The economics of constructing dams requires that fill material, such as gravel, is excavated near the site, as was the case for the Shellmouth. If not reclaimed, a gravel pit remains an unproductive property (agricultural or wildlife habitat), and an area for noxious weeds to take hold (Mrena 1999). There was no documentation on gravel pit remmediation for this project, which is not surprising as this would not have been a common practice at the time of the project. No other post-project remediation undertakings were identified for this region.

In order to reduce long-term negative environmental effects and improve recreational use, it is common to remove vegetation, primarily woody vegetation, from the area to be flooded (Ploskey 1985). However, thiscreates short-term erosion conditions because hillsides are exposed to the elements (although bank erosion continues long after the reservoir is fully operational). This erosion may have implications for the reservoir, downstream reaches of the river, and the reservoir area in terms of water quality such as turbidity, nutrient loading, and siltation.

1.1.2 Initial Flooding of the Reservoir

While trees and shrubs may be removed from the areas scheduled to be flooded, meadow grasses often remain. The rational for leaving vegetation varies, but may include providing habitat for benthos and periphyton which are important food sources for fish, creating temporary fish spawning sites and refuge, and reducing the development costs, amongst other benefits. However, while there may be benefits to leaving vegetation, it can also create problems such as trophic upsurge, water quality problems, and loss of wildlife habitat, the nature of which is discussed in greater detail later in this appendix.

Some months before the reservoir was filled, the Shellmouth Reservoir was cleared of woody vegetation (meadow grasses remained) to an elevation of 430.38 m (McKay et al 1969).

1.1.3 Reservoir Operation

The operating regime or rules are developed based on the objectives of the development, but these may change over time as society's needs and objectives shift. For multi-purpose reservoirs, the operating regime represents the prioritization of objectives that are particular to the reservoir itself. Water levels in the reservoir fluctuate according to the operating regime, in a manner that is often dramatically different from naturally occurring lakes and the flow characteristics of the natural river.

The Shellmouth's operating regime is derived from the prioritization of reservoir objectives (see Appendix 1): flood control, domestic downstream water supply, agriculture, industry, and various instream uses (PFRA and Water Resources 1992). The rate that water is discharge from the reservoir is a function of the operating target level, amount of water entering the reservoir, existing stored levels, downstream demand (McKay et al 1969), and estimated future inflows such as meltwater runoff (Warkentin ND). One other constraint on a reservoir operation is the maximum river channel capacity below the reservoir, which dictates the maximum flow that can be discharged without creating downstream flood conditions. The maximum river channel capacity for the Shellmouth is 1600 cfs and anything greater, results in the river overflowing the spillway banks.

In the case of the Shellmouth, the operating regime dictates that the reservoir is drawn down to 423.98 m in the winter, November through March, to accommodate spring melt waters. A summer drawdown also occurs to a target elevation of 427.487 m (Manitoba Natural Resources 1995) to accommodate recreation activities on the reservoir.

1.1.4 Bank Erosion

Bank erosion of reservoir shorelines is dominated by the dramatic toe-of-bluff erosion process, whereby significant amounts of the bluff shore recedes (Figure 1). Over time, as erosion continues, the vertical foreshore erosion dominates the mature shore zone a less significant process in terms of the volume of eroded material (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1993a). The length of time for stable mature shore zones to develop on reservoirs is unknown, but is likely considerable, perhaps several hundred years (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1993a).

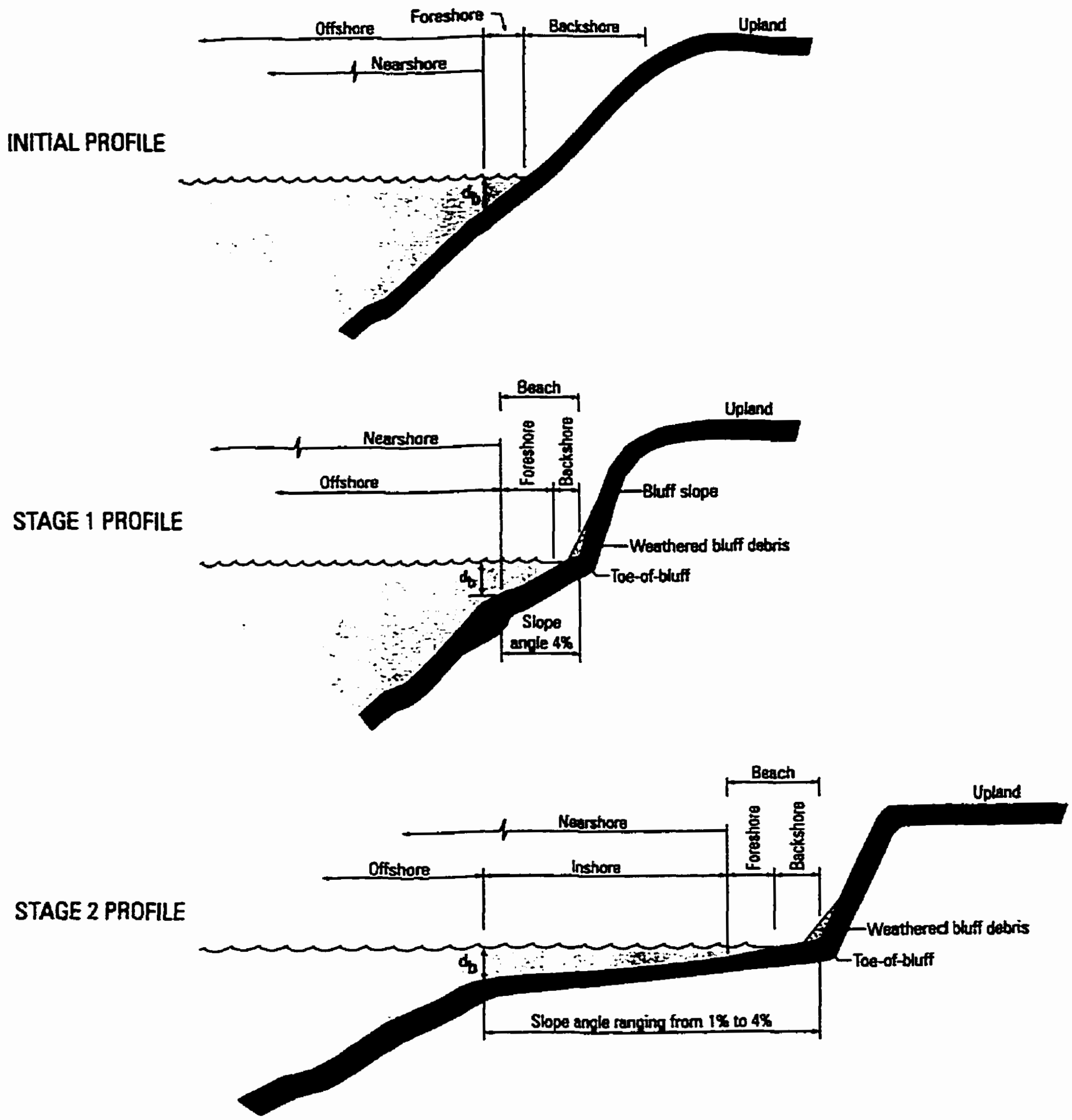
A number of agents actively contribute to bank erosion: waves, reservoir ice, ground water, and fluctuating reservoir levels (Everdingen 1970?). Wave erosion activity is affected by wind influenced wave energy, wave height, and time of erosion activity. Another factor, ice, facilitates erosion processes by helping to destabilize and dislodge bank materials through:

- expansion and contraction of surface ice as a result of temperature variations,
- the ratchet action of water that fills cracks and subsequently expands on freezing, and
- wind energy which pushes ice sheets or flows into the bank.

Erosion processes are further influenced by frequent reservoir fluctuations. Changing the water level during the winter when the reservoir is ice covered, substantially increases erosion damage of the reservoir banks. Ice shelves, created by ice that clings to shorelines after the reservoir levels drop, can dramatically increase rates of erosion and

Figure 1

Shore Zone Profile Evolution



Shore zone profile evolution and related terms (after USCE, 1977). Nearshore and beach slope angles shown are typical for erosion in fine-grained glacial lake sediment around the Great Lakes and Lake Winnipeg.

Source: L.A. Penner and J.D. Mollard and Associates. November 1993. Shoreline Erosion and Slumping on Western Canadian Lakes and Reservoirs – A Photographic Catalogue for Three Western Canadian Prairie Reservoirs. Environment Canada, Water Resources Branch, Regina, Saskatchewan.

expose critical shoreline habitat. When the reservoir is lowered in winter to accommodate spring run-off, the resulting increases in outflow can increase erosion downstream in the spillway as well.

Natural freeze thaw cycles also play a role. Twenty percent of bank recession at Orwell Lake, Minnesota was deemed to be caused by frost action (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1991). Bank material loosened by frost, falls to the toe of the bluff where it is removed by wave action.

Ground water may also influence erosion activity. As the reservoir levels rise, the water table in the surround area also rises. The rate of this rise is dependent on the aquifer material and original slope of the water table. Rapid lowering of the reservoir after a prolonged period at a higher level, particularly when bank material has a low permeability, may prevent an equally rapid adjustment of the water table. The resulting high pressure may lead to bank slides as has been observed with other prairie reservoirs such as Lake Diefenbaker (Everdingen 1970?). The saturation of formerly unsaturated bank material may further contribute to sliding as a result of a decrease in surface tension, swelling of clays, or removal of soluble cement (Everdingen 1970?). Large scale changes in slope may result (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1991).

Another factor influencing erosion rates is the natural geology (erosion potential of shoreline materials) and morphology (shoreline configuration) of the area. In general, courser materials, such as gravel, are less susceptible to erosion forces than are finer materials, such as sand and loams (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1991; Newbury and McCullough 1984). The degree of cohesion between particles, a function of surface tension or cementation will also influence erosion potential; well cemented material is much more resistive than loose course materials. Another factor, the morphology of the valley, plays a role in the rate and magnitude of bank erosion. If shoreline slopes are shallow, then wave energy is dissipated in the shallow water. The result is that bank erosion is less than for sites with steep banks which receive the full force of the wave energy (Everdingen 1970?).

Regardless of the erosion factor, erosion impacts the reservoir in five distinct ways:

1. Sedimentation processes are increased, which decreases the overall storage capacity of the reservoir (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1991). This is discussed in greater detail in the following section. The impact of erosion on reservoir sedimentation is not believed to be significant in the case of the Shellmouth.
2. The shape of the reservoir's cross-section changes, which may impact recreational use. Cross-section changes in the Shellmouth Reservoir are not as dramatic when compared to changes in other reservoirs. However, recreation activities are negatively impacted by cross-section changes that expose boulders in areas where glacial till is eroded. Negative impacts also occur when the width of the beach exposed at low reservoir levels gradually increases, creating problems for boat operators in launching and maneuvering in the shallows (Everdingen 1970?; Petts and Foster 1985).

3. The shore erosion results in increased overall surface area of the reservoir, contributing to increases in total evaporation from the reservoir (Everdingen 1970?). This is not considered to be a significant impact of erosion for the Shellmouth reservoir because of the relatively small changes in total surface area.
4. The habitat in the littoral and riparian zones is regularly disturbed because of the erosion process, which reduces the productivity of these normally highly productive aquatic and terrestrial areas (Petts and Foster 1985). This is believed to be a significant impact of erosion for the Shellmouth reservoir.
5. Water Quality can be negatively influenced by eroded materials (Petts and Foster 1985). Organic and inorganic chemical compounds that influence water quality, can enter the lake via eroded particulate matter. The influx of chemicals associated with erode materials, is usually highest during high inflow periods with high erosion conditions.

L.A. Penner, J.D. Mollard and Assoc. Ltd. (1991, 1993a, 1993b) looked at the rates of erosion experienced by three Canadian prairie reservoirs; Diefenbaker, Avonlea, and Shellmouth and based on this research and other case studies, developed a model to anticipate future erosion. Their findings for the Shellmouth, show horizontal bank recession rates over a 20-year period of between 3.7 m (low wave energy, low beach slope, moderate till, sandy beach) to 40.2 m (high wave energy, steep slope, disturbed till). This translates into an annual volumetric recession rate of between 0.2 m^3 and 1.9 m^3. A summary of field data and sampling locations for the Shellmouth Reservoir is shown in Table 1 and Figure 2. The sediment eroded varied between 0.5m annual

Table 1

Erosion Rates in Relation to Shellmouth Reservoir Bank Conditions

SUMMARY OF FIELD DATA - - ENVIRONMENT CANADA EROSION STUDY

RESERVOIR : LAKE OF THE PRAIRIES

Profile No.	Beach material	Beach slope V:H	Bank material	Bank height (m)	Pre-impoundment valley-side slope V:H	Horizontal bank recession + (m)	Recession rate ++ (m / yr)	Volume of sediment eroded (m^3)	Volumetric erosion rate ++ (m^3 / yr)	Deep water wave energy (t-m/yr)	Effective wave energy (t-m/yr) (1)	Effective wave energy (t-m/yr) (2)
1	Sand	1:24	Till (moderate)	0.3	1:8	3.7	0.2	0.5	0.02	13094	5892	2095
8	Boulders over till	1:10	Till (soft to moderate)	3.5	1:5	21.6	1.0	43.9	2.1	17067	10923	6315
9s	Fine sand to medium gravel	1:16 lower 1:4 upper (stepped profile)	Sand + silt	4.5	1:2	14.3	0.7	31.9	1.5	28987	25798	7247
9A	Sand and boulders	1:45 lower 1:6 upper	Till (disturbed with sand + silt)	4.3	1:7	39.0	1.9	76.0	3.6	21731	10866	1956
9B	Sand - lower Boulder lag - upper	1:9		4.0	1:7	40.2	1.9	76.0	3.6	14921	7461	6118
10-1	Fine sand to medium gravel	1:13 lower 1:10 upper (stepped profile)	Sand and gravel	3.0	1:7	33.5	1.6	62.8	3.0	29626	14813	8888
10-2	Gravel and boulders	1:5	Sand and gravel	6.9 (slope 1:1.6)	1:3	27.4	1.3	57.3	2.7	35793	28276	22908
12A	Sand	1:16	Till	0	1:16	—	—	—	—	38573	6172	6172
12B	Sand	1:7 (stepped profile)	Till (soft to moderate)	4.3	1:6	36.3	1.7	99.0	4.7	38573	22372	19287
13	Sand and gravel over till	1:11 lower 1:3 upper	Till (soft to moderate)	6.4	1:3	28.7	1.4	101.9	4.9	25211	19917	8824

\+ Measured from shoreline elevation 427.0m . Assume vertical bluff slope

++ Lake of the Prairies reached 427.0m elevation in May, 1971 . Rates are calculated based on a 21 year period (1971 to 1992)

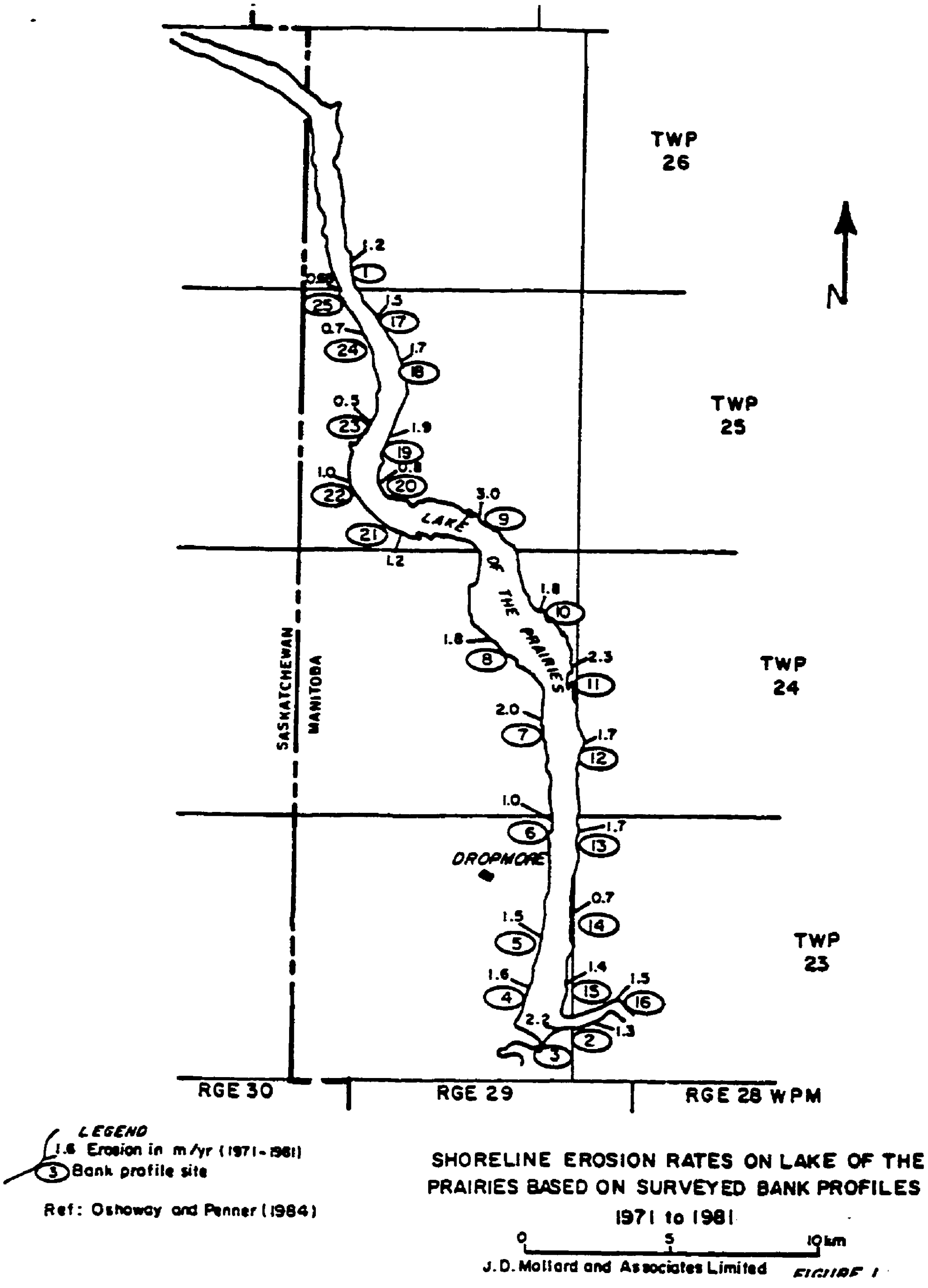
(1) Based on pre-impoundment valley side slope

(2) Based on field measured beach slope (1992)

Source: L.A. Penner and J.D. Mollard and Associates. June 1993. Shoreline and Erosion Slumping on Western Canadian Lakes and Reservoirs. A Methodology for Estimating Future Bank Recession Rates. Phase 6 and 7. Environment Canada, Water Resources Branch, Regina, Saskatchewan.

Figure 2

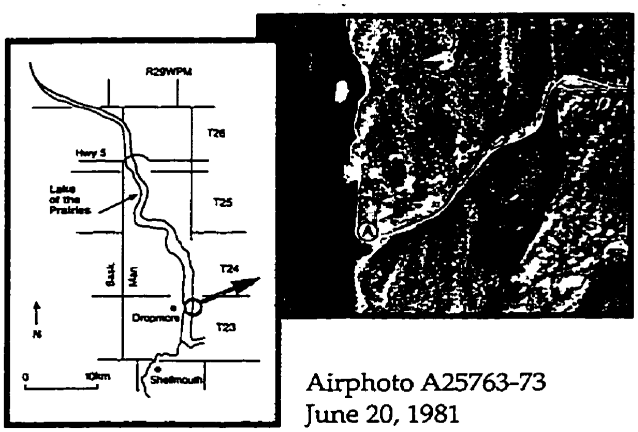
Shoreline Erosion Rates - Shellmouth Reservoir



Source: L.A. Penner and J.D. Mollard and Associates. June 1993. Shoreline and Erosion Slumping on Western Canadian Lakes and Reservoirs. A Methodology for Estimating Future Bank Recession Rates. Phase 6 and 7. Environment Canada, Water Resources Branch, Regina, Saskatchewan.

horizontal recession rate (0.02m^3 annual volumetric erosion) for areas characterized by shallow slopes, moderate till, and sandy beaches to 101.9m annual horizontal recession rate (4.9m^3 volumetric erosion) in areas characterized by steep slopes, high wave energy, and/or easily erodable materials. In some cases, this has created high eroded till banks at the water's edge, and in others, gently sloped beaches have resulted (Figure 3).

For the Shellmouth Reservoir and downstream area, fluctuating winter levels and the resulting erosion, have been highlighted as a concern in public consultations and interviews by cottage owners, downstream landowners, and local representatives. For nine sample sites, the average volume of eroded material was 61m horizontal recession (2.9m^3 volumetric erosion) annually. These findings are similar to those for Diefenbaker and Avonlea (L.A. Penner, J.D. Mollard and Assoc. Ltd. 1991).



Airphoto A25763-73
June 20, 1981

A 6-metre-high till bank with an adjacent sloping slough debris face and bouldery beach.

Figure 3. The various impacts of erosion on the reservoir's shoreline.
L.A. Penner, J.D. Mollard and Assoc. Ltd. 1993. Shoreline Erosion and Slumping on Western Canadian Lakes and Reservoirs- A Photographic Catalogue For Three Western Canadian Prairie Reservoirs p. 23.

Another feature of the Shellmouth Reservoir, is the impact of frequent water level fluctuations on the flora and fauna development of the littoral region (Cole 1983) as well as riparian areas. This area is generally negatively affected by the frequent fluctuations. Aquatic vegetation will not withstand prolonged periods of exposure, while terrestrial vegetation succumbs to protracted submergence (Everdingen 1970?). The loss of a littoral zone along with riparian areas increases susceptibility of the reservoir to bank erosion. Both areas serve to dissipate wave energy before it reaches the shoreline and help bind soils. However, due to frequent fluctuations in water levels, neither of these protective zones are well developed in for the Shellmouth Reservoir.

2.0 GENERAL IMPACTS

A number of other impacts occur, and include increased sedimentation, evaporation, temperature changes, water quality, and ecosystem impacts.

2.1 Sedimentation

As the river flows into the reservoir, the velocity of flow decreases and the suspended solids fall out of solution as the river currents loose their capacity to carry particulate material. The reduction in flow and turbidity means there is less energy to keep sediments suspended. This leads to an increased rate of sedimentation beyond what normally occurs in an unobstructed river. This decreases reservoir storage capacity over time and ultimately shortens the life of the reservoir. The erosion of the reservoir banks discussed earlier also contributes to sediment loading in the reservoir. A study by the United States

Department of Agriculture found the following rates of sedimentation for reservoirs in the United States (Goldsmith and Hildyard 1984):

i. In 1105 reservoirs with a capacity of less than $1.233 * 10^4$ m^3 (10 acre-feet), the rate of sedimentation was about 3.5% per year.
ii. In medium-sized reservoirs comparable to the Shellmouth, with a storage capacity greater than $1.233 * 10^5$ m^3 (100 acre-feet), the median rate of sedimentation was 1.5% per year.
iii. In large $1.233*10^9$+ (1,000,000+ acre-feet) reservoirs, the rate was .16% per year.

The Bassano Dam on the Bow River in Alberta, Canada has seen its storage capacity reduced from 34,000,000 cubic meters to 11,000,000 in approximately 60 years (1911 - 1970) (Baxter and Glaude 1980).

Reservoir sedimentation is complicated by the fact that the frequent water level fluctuations overturn, rework, redeposit and erode marginal sediments, leading to the creation of complex sediment patterns that vary over temporal scales (Petts and Foster 1985). This makes rates of sedimentation difficult to measure.

Sedimentation has some direct environmental consequences for the reservoir and downstream area. Sedimentation can impact aquatic life, such as molusc and insect populations, by decreasing available habitat (Cole 1983), covering fish spawning areas, and suffocating incubating fish eggs (Fisheries and Oceans 1992). This situation has occurred in nearby Dauphin Lake (Government of Manitoba 1989). This has also been studied in the Tennessee River Basin, where roughly half of the mussel fauna has disappeared due to sedimentation (Isom 1969). The study by McKay et al (1969) which characterized the site and potential impacts, anticipated silting problems in certain parts of the reservoir that would interfere with the development of bottom fauna. Unfortunately, no post-development studies were found on the impacts for bottom fauna, such as changes in molusc habitat or populations for the Shellmouth Reservoir site.

Table 2

General Sediment-Related Consequences of Dam Construction

Issue	Impact	
Upstream deposition	Tributary aggregation	
	Increased groundwater levels	• Increased soil moisture in root zone • Back flooding
	Decreased navigational clearance	
	Increased flood frequency	
	Altered geomorphology	
Downstream scouring	Armoring of bed	• Alter habitat in the littoral zone
	Bank instability/erosion	
	Tributary degradation	
	Increased bridge scour	
	Lower groundwater levels	• Agricultural impacts • Loss of riparian vegetation
	Decreased turbidity	• Aquatic habitat changes
	Geomorphic changes	
Reservoir deposition	Reductions in all benefits	
	Reduced useful life	
	Degraded water quality	• Decreased dissolved oxygen • Contamination concentration • Interstitial deposition

Source: adapted from , R. Hotchkiss and F. Bollman. 1997. *Socioeconomic Analysis of Reservoir Sedimentation.* In Holly, F . and A. Alsaffar eds., Energy and Water: Sustainable Development, Proceedings of Theme D, 27th Congress of the International Association for Hydraulic Research San Francisco, CA. August 10-15, 1997. American Society of Civil Engineers, New York, N.Y. pp. 80.

2.2 Evaporation

Increased evaporation losses result from the large surface area created by the reservoir (in comparison to the natural river) which in turn reduces the water available for downstream users. This loss should be calculated into basin management or allocation problems may result. The evaporation may also alter the local microclimate (Petts and Foster 1985) by altering local precipitation levels. For Lake Diefenbaker, which is in a similar climatic zone and latitude, the evaporation rate is estimated by multiplying surface area by net annual evaporation in the order of 50 cm^3 annually (Evendingen 1970?).

2.3 Temperature Changes

Impoundments may also alter water temperatures by increasing winter temperatures and reducing summer temperatures. Temperature changes may also be delayed since more time is required for large volumes of water to respond to changes in air temperature (Fowler ND). The reservoir may also delay the natural seasonal maximums in the reach below the dam. The change in aquatic thermal dynamics impact species that rely on temperature cues for initiating and terminating various life stages. Changes in temperature patterns have been responsible for altering spawning times to the detriment of some fish species (Ackermann et al 1973). This modulation in thermal temperatures is most extreme in the case of deep reservoirs that release water from the sub-surface. No studies were located on the effects of abnormal water temperatures for the Shellmouth Reservoir and the Assiniboine River below the dam.

2.4 Chemical Water Quality

The reservoir develops water quality that is both dependent and independent of its tributaries. Chemical composition of the reservoir will reflect those factors that influence the upstream river quality (upstream activities, climate, geology, and hydrology). The creation of a reservoir also affects water quality through the flooding of organic soils as well as the flooding of vegetation, sedimentation, and erosion process described earlier.

Through these processes, the reservoir acts as a repository of inorganic and organic chemicals. The resulting water quality is complicated by the fact that various conditions may or may not favour the preservation or augmentation of a particular element. Factors that are influential in affecting water quality are:

1. tributary chemical composition and chemical sources at the reservoir site (pesticides, fungicides, flooded vegetation, eroded organic soils, industrial chemicals);
2. ecological dynamics (productivity and nutrient cycles in the reservoir); and
3. chemical reactions between the water column and the reservoir sediment (oxidizing and biological reducing conditions, pH of the water column, sediment/water interface - solubility) (Petts and Foster 1985).

2.4.1 Pollutants

The reservoir can become a catch basin for agrochemical, municipal, and industrial pollutants which are carried from upstream in the water column and deposited in the sedimentation process. Pollutants include pesticides, herbicides, insecticides, heavy metals, and various industrial compounds. Chemicals can create toxic conditions from both the parent compound and, for complex agro-chemicals in particular, from a degraded form of the chemical (Canter 1997).

Agro-chemicals are the primary pollution risk because of the heavy agricultural land use in the upper portion of the Assiniboine Basin, of which the Shellmouth Reservoir is a part (Dillon Consulting Limited 1998). Agro-chemicals can enter the basin, and eventually the Shellmouth Reservoir, via accidental spills, over-drifts, incorrect application, cleaning near a surface water body, or from field run-off from spring melt waters or heavy summer rains. No studies were found that documented the build-up of agro-chemicals in the reservoir. However, upstream studies in 1979 by Gummer did find detectable amounts of farm chemicals. A more recent study by the Prairie Provinces Water Board (PPWB 1995) water sample analysis from the Assiniboine just upstream of the reservoir at Kamsak also found traces of 2,4,5-T and 2,4-D that were below PPWB objectives.

Industrial chemicals and heavy metals are also contaminants with the potential to accumulate in the reservoir's sediments. Sources of industrial chemicals and heavy metals include landfills, municipal effluent, chemical spills, and former industrial sites. While heavy metals and those industrial compounds that are measured are below PPWB objectives (PPWB 1995), there has been no study to determine the impacts of build-up in reservoir sediments and biota. One potential source of industrial pollutants for the reservoir is a contaminated site on the bank of the Assiniboine at Kamsak, which is leaching hydrocarbons and PCBs into the river stretch just upstream of the reservoir (Macibroda Engineering 1994).

2.4.2 Nutrients

Nutrients enter surface water bodies from a variety of sources, including municipal wastewater and septic systems, and runoff containing agricultural fertilizers and livestock manure. Nitrates, which are easily soluble, quickly reach water bodies through field run-off or wastewater. Phosphorus fixes to particulates and enters the watershed through eroded soils (Dougherty and Hall 1995) and deposits in the reservoir as sediment. In water, phosphorus is continually changing due to the process of decomposition and synthesis, modified by various physical, chemical and biological factors. In its dissolved form, phosphorous is of great concern for aquatic systems because it is generally considered to be the limiting factor for the growth of freshwater phytoplankton such as algae (CCME, 1987).

Trophic Surge: Algae Blooms

While algae is an essential component in the food chain, elevated levels of phosphorus, ammonia nitrogen, and nitrate/nitrite in the reservoir can dramatically increase algae growth, which has a number of environmental implications (Fisheries and Oceans 1992).

Habitat

Algae blooms can serve to limit light penetration necessary for submerged aquatic vegetation. This may affect habitat for a variety of vertebrate and invertebrate species that rely on the aquatic vegetation for forage and cover from predators. In response, the invertebrate community may shift to different species and the foraging success of some fish such as salmonids may deteriorate (Tones 1987).

Eutrophication

The decomposition of algae blooms removes critical oxygen from the reservoir through the process of eutrophication. Eutrophication is the process by which water bodies become biologically more productive as a result of an increase in nutrients. Bacteria that decomposes algae, require oxygen. When excessive algae growth has occurred, the bacterial demand for oxygen creates conditions where insufficient dissolved oxygen is available to support fish and invertebrate populations. The result can be widespread fish kills (Moening and Lakatos 1976). Furthermore, when certain varieties of blue-green algae decompose, such as *Aphanizomenum flos-aqua*, compounds are released that can prove highly toxic, causing fish mortality (Gurney and Jones 1997). These toxins contain an alkaloid that affects the nervous system causing suffocation and polypeptides that lead to the rapid degeneration of organs (CCME 1987). These can not only prove harmful to aquatic species, but also to wildlife, livestock, and humans if consumed.

Fish can also be adversely effected in other ways by the over-supply of nutrients. When nutrients decompose anaerobically, gases such as ammonia, hydrogen sulphide and methane are produced. In sufficient quantities, these chemicals are poisonous to aquatic life (Dougherty and Hall 1995; CCME 1987).

For the Shellmouth Reservoir, phosphorous levels are highest in late August and early September. The majority of this phosphorous is in a dissolved form, which is considered to be a significant influence in algae growth.

As algae growth is also a function of light and temperature conditions, excessive algae (*Aphanizomenum flos-aqua*) blooms commonly occur during the summer months from July through September. Wind and wave actions concentrate the algae along the shoreline where it begins to decompose (Gurney and Fortin 1992). These blooms dramatically reduce the aesthetic appeal and recreation value of the reservoir.

Furthermore, these blooms have also been attributed to fish kills, both in the reservoir and in the downstream reaches. An eleven week algae monitoring program in the early 1970s correlated fish kills in 1972 below the dam site to high levels of algae in the reservoir (Moening and Lakatos 1976).

2.4.3 Dissolved Oxygen

During the early stages of life, larval and juveniles are highly sensitive to exposures of low dissolved oxygen (DO) levels, which can increase the negative impact of toxins on aquatic biota. Higher temperatures also increase the adverse effects of low dissolved oxygen levels on fish by increasing metabolisms and hence oxygen demand (CCME 1987). As already indicated, excess nutrient loading may reduce available DO content in water due to the biological oxygen demand of microorganisms digesting organic matter such as algae.

Like their deep naturally occurring counterparts, some reservoirs are characterized by thermal stratification: epilimnion, a layer of oxygen rich warm surface water, rests on top of a mid-column, metalimnion layer, which becomes cooler and heavier with depth (thermocline). The lowest layer of cold water at the bottom of the reservoir or lake, the hypolimnion, has no contact with surface water and thus is usually oxygen deficient. In a reservoir, this deficiency can be compounded by the nutrient rich sediment. Also, the lower strata may have high levels of the by-products of organic decay, such as hydrogen sulfide, that are dangerous to fish (Fowler ND). To further complicate matters, density currents may result, which create differences in suspended and dissolved sediment and temperature between the inflowing tributary and the reservoir. These currents can add an additional layer to the thermal stratification, which has been shown to trap fish in an oxygen deficient environment in the Norris Reservoir in Tennessee (Fowler ND).

Constant flow through the reservoir during winter periods will avoid a reduction in DO in various strata of the reservoir by helping to mix the water column.. When a reservoir is emptied or filled during the winter period, minimum DO levels required to protect fish and other aquatic vertebrates and invertebrates, may not be present. This is believed to be the cause of large scale winter fish (carp) kills in the Shellmouth in 1995 (Kansas pers. comm. 1997).

For the Shellmouth Reservoir, oxygen levels are generally above the CCME guideline of 5.0 mg/L to protect cool water fish (CCME 1987). However, nutrient levels appear to negatively influence DO levels. Measured phosphorous amounts for example, are similar whether observed at the mid-water column or at the surface, but bottom measurements have yielded substantially higher concentrations (Gurney and Fortin 1992, Fortin and Gurney 1997). This nutrient distribution corresponds to lower concentrations of DO observed in the lower water column, particularly in periods of calm weather (Gurney and Fortin 1992) or during the winter months (Kansas pers. comm. 1997). The winter of 1995 saw three tonnes of carp killed as a result of the high level of outflow, with corresponding low inflow rates. Carp that settled in low spots in the reservoir became trapped, and perished due to the low DO levels.

2.4.4 Mercury

It was discovered in the mid-1970s that mercury contamination of aquatic species is often a by-product of reservoir development. Methylmercury is microbially transformed from ambient natural sources: organic material and sediments release methylmercury once prolonged flooding occurs. Greatly enhanced conversion rates of inorganic mercury from sediments have been observed in a large percentage of reservoirs (Rosenberg et al 1995).

Mercury is highly persistent in the environment, accumulating in sediment and food chains at levels of chronic toxicity to aquatic and terrestrial life, including humans (SERM 1997). In the methylmercury form, the chemical is easily absorbed into the aquatic food chain with the highest concentrations observed in predator fish. Bottom feeders that absorb mercury from sediments, also generally have rates higher than those species feeding in the water column (CCME 1987).

Mercury absorption is not confined to aquatic species within reservoirs. Studies have also indicated that aquatic species downstream of reservoirs often show elevated levels of methylmercury in their systems (Rosenberg et al 1995). Mercury is transferred to other non-aquatic species through consumption. Waterfowl that feed on mercury contaminated biota experience impaired reproductive systems and neurological disorders (Scheuhammer 1995).

Fish are one of the most direct routes for human consumption of methymercury. Anglers that regularly consume predator fish from the reservoir would be at the greatest risk, but because of the imposed slot limit, this risk is very low. Mercury, at sufficiently high exposure levels, has been shown to impede growth, development, and behaviour, as well as causing cancer, birth defects, and impaired reproduction (Dumont 1995). What constitutes a risk level will vary with age. For example, the developing nervous system of the fetus appears to be particularly sensitive to the adverse affects of methymercury. Maternal hair levels in the range of 10-20 ppm are associated with neurological effects in their offspring (Bolger 1995).

In the reservoir, unnaturally high mercury levels have been recorded in predator fish (Green and Beck 1995). The current Canadian marketing limit for mercury in fish is 0.5 ug/g (Rosenberg et al 1995). Predatory fish in the Shellmouth Reservoir have been tested with having as much as twice this level or more in their systems (Green and Beck 1995). As a result of these high levels, the province of Manitoba has recommended limiting consumption of fish from the reservoir, and that fish over 50 cm not be consumed (Kansas pers. comm. 1997). Studies have also indicated that downstream fish have shown elevated levels of methylmercury in their tissue (Green and Beck 1995), although no attempt has been made to correlate these elevated levels to the reservoir.

An interesting feature of mercury contamination is the observed trend in northern reservoirs for mercury levels in fish to begin to decline to pre-impoundment levels after twenty to thirty years (Windsor pers. comm. 1998). However, there is no clear evidence that historically high levels of mercury are declining in prairie reservoirs (Harker 1997). The sustained high mercury levels found in predator fish at the Shellmouth Reservoir, appear to confirm this observation (Green and Beck 1995).

2.5 Ecological Impacts

The ecology of a watershed develops in relation to its naturally occurring hydrology cycles. When that hydrology is changed as a result of a water development project such as a dam structure, the existing ecology may not easily adapt to the resulting changes. While the hydrological changes and associated impacts from hydroelectric dams in the boreal forest region have been fairly extensively studied, the impacts of prairie reservoirs are less well understood.

Aquatic Ecosystem

The summer reservoir drawdown characteristic of flood control structures, creates a number of problems in the littoral zone (the nearshore zone from zero depth to the outer edge of rooted plants). This region is critical because it is the most productive area of the aquatic environment and its health influences the overall health of the local aquatic ecosystem (Smith 1992). Frequent water level fluctuations during spring and summer serve to inhibit flora and fauna development of the littoral region (Cole 1983). Relatively stable levels are important for the development of macrophytes (large aquatic plants visible to the naked eye) because exposure or deep submergence reduces survival and productivity (Plosky 1985). The loss of this vegetation represents a loss of habitat for a wide range of aquatic and terrestrial species, particularly waterfowl.

A characteristic of the Shellmouth Reservoir is fluctuating fish populations, which is indicative of an aquatic ecosystem that is less stable than a healthy naturally occurring prairie lake characterized by relatively constant fish populations (Kansas pers. comm. 1997). This may, in part be due to a poorly developed littoral zone, along with temperature, sedimentation, and water quality changes discussed earlier.

The reservoir would have also reduced the availability of waterfowl nesting sites that formerly existed in low-lying areas along the river. Such active nesting sites are common on the Assiniboine above the reservoir (Rozedeba pers. comm. 1997). Today, waterfowl primarily use the Shellmouth as a staging area for migrating waterfowl species (Rozedeba pers. comm. 1997).

The Riparian Zone and Wildlife

The creation of dams usually negatively impact the biologically highly productive riparian areas that exist along side rivers and on valley slopes (Smith 1992). These areas are home to a wide variety of flora that serve to provide habitat in terms of food sources and cover for a number of wildlife species (McKay et al 1969). Particularly in prairie environments dominated by agricultural activities, treed valleys provide valuable winter protection for ungulates, bird species, and other wildlife (Bidlake pers. comm. 1997).

While little research has been undertaken in this region, it is likely that the reservoir has disrupted an important wildlife corridor utilized by predators such as bears, wolves, wild cats, and ungulates (Bidlake pers. comm. 1997) as well as song bird species (Christie pers. comm. 1998).

3.0 RESERVOIR OPERATION: DOWNSTREAM HYDROLOGY

The positive and negative effects of dams on downstream environments are influenced by the reservoir operation (Dougherty and Hall 1995). One of the positive downstream benefits, depending upon dam operation, is the augmentation of flows. This increases the ability of the river to accommodate nutrient and chemical loading such as that from non-point sources or treated municipal sewage, as well as downstream withdrawals for activities such as irrigation or industrial production (ARMAB 1995).

Another obvious downstream benefit is flood control, but the benefits achieved depend upon the flood conditions and dam operation. If floodwaters are released too late and for too long a duration, they can interfere with agricultural planting downstream. If floodwaters are released too early, they can increase downstream erosion rates and cause ice jams. In 1995, landowners downstream of the Shellmouth Reservoir complained that the controlled flows decreased the flood peak, but increased the duration of the flood. This interfered with spring planting and killed perennial vegetation such as meadow grasses that are able to withstand the shorter duration of naturally occurring floods (ARMAB public consultation 1995).

Floodwaters are a necessary component of watersheds that serve to scour the riverbed of sedimentation and contaminants, as well as to control macrophyte growth in the river channel (Chambers et al 1990). Reservoirs inhibit this scouring action by reducing the river's peak flows. In addition, the change in hydrological patterns influences vegetation growth on downstream banks. The higher flow inhibits the draining of bank areas and the development of stabilizing grasses, weeds, and willows. With a more constant year-round release of water from dams, the banks never dry out, leading to greatly increased levels of erosion due to the inability of stabilizing vegetation to take root (Bowles 1995). No studies were identified that reviewed this type of downstream impact being created by the Shellmouth Reservoir. However, interviews with local landowners and comments from public hearings indicated substantial bank erosion just below the dam may be taking place.

Downstream reaches of the river can also be affected by upstream sedimentation. Flood regulations and sediment load obstruction usually creates downstream channel adjustment; reduction in channel width and depth ratio and/or movement in location (Petts and Foster 1985; Ackermann et al 1973). The magnitude of channel changes, decrease with distance from the dam site (Petts and Foster 1985). Water leaving the reservoir is low in suspended sediments and has a tendency to erode the riverbed directly below the dam structure (Dougherty and Hall 1995). This process may reduce the downstream spillway capacity by up to 80%, as in the case of the North Platte River, Nebraska, or conversely the channel may erode and migrate across the valley floor. In the case of the Shellmouth Reservoir, only small changes in riverbed depth due to scouring effects have been observed directly below the dam site (Ashmore 1990).

A seasonal sediment collection program was run from 1969 to 1976, just upstream of the PTH 16 (the Yellowhead) Assiniboine River bridge, which is roughly 20kms below the dam. Samples were taken from April through to October, between 1969 and 1973, and throughout the year for the last three years. Since the construction of the reservoir, flow regime and sediment load has been substantially modified such that sediment concentrations often occur in late April rather than the traditional mid-May discharge peak. Flow regulation also tends to spread the load over a longer time period by eliminating large peak discharges and their large daily loads (Ashmore 1990).

Annual sediment loads at the station below the reservoir are similar to those observed upstream of the reservoir at Kamsack, Saskatchewan, but are lower than would normally be expected at this location (Ashmore 1990). It has been estimated that the reservoir has a trapping efficiency of more than 90% (Oshoway 1984). Sediment loads below the reservoir would be supplied by local channel bank erosion and tributary streams (Ashmore 1990). In some instances, increased water clarity arising from the reduction in sediment loads has been credited as a factor in increased growth of aquatic vegetation (Ackermann et al 1973)

Sediment trapped by the reservoir also represents a loss of fertile silt to downstream flood plains. Over the long term, this leads to a reduction in quality and the quantity of mid-channel bars and islands, which result in fewer places for the river to slow to levels adequate to facilitate sediment deposition. Thus, the necessary habitat for aquatic biota is decreased and the channel becomes more simplified (Bowles 1995). Studies on the South

Saskatchewan River have noted decreased diversity and biomass of insect larvae, which is likely influenced by this phenomenon (Ackermann et al 1973). In the case of the Shellmouth, the reduction in sandbars has been noticed by downstream landowners (Trinder pers. comm. 1997).

4.0 RESERVOIR OPERATION: UPSTREAM IMPACTS

Fluctuating water levels can impact the success of fish spawning activities in the upstream channels and tributaries. Low reservoir levels tend to decrease spawning success for certain species. In the case of the Shellmouth, when the reservoir levels fall below elevation 423.67 m, the impacts are substantial. Low spring time reservoir levels decrease the success of the walleye spawning by inhibiting access to upstream spawning sites (Kansas pers. comm. 1997), or expose eggs or fish fry during drawdown (Ackermann et al 1973).

One impact of the project that was not anticipated was backflooding effects upstream of the reservoir. Backflooding is a rise in the water table upstream of the reservoir. This impact is discussed in detail in Appendix 4 which documents social and economic impacts.

APPENDIX 6:

NET PRESENT VALUE AND BENEFIT- COST RATIO

NET PRESENT VALUE AND COST-BENEFIT RATIO

Definitions

B = future value of a benefit
C = future value of a cost
r = discount rate
t = time period or year
T = final period or year

Present Value of Benefits (PV_B)

$$PV_B = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t}$$

Present Value of Costs (PV_C)

$$PV_C = \sum_{t=0}^{T} \frac{C_t}{(1+r)^t}$$

Net Present Value (NPV)

$$NPV = PV_B - PV_C$$

Benefit-Cost Ratio (B/C)

$$B/C = \frac{PV_B}{PV_C}$$

APPENDIX 7:

COST-BENEFIT ANALYSIS COMPONENTS

1.0 TYPES OF COSTS AND BENEFITS IN CBA

One of the issues in CBA is which costs and benefits to include in the analysis. In general, there are primary and secondary, as well as tangible and intangible costs and benefits. There are also private and external as well as social costs and benefits. In addition, economics has defined a series of non-use benefits that may or may not be included in a CBA.

1.1 Primary and Secondary, Tangible and Intangible

Primary costs and benefits are the positive and negative effects resulting directly from the project being analysed. An example of primary effects would be the goods and services produced by the project, such as electric power from a hydro dam and the construction costs to build the dam. Secondary costs and benefits stem indirectly from the project, and as a general rule are not factored into traditional analysis because they are indirectly generated by the project (Sassone and Schaffer 1978; Sewell et al 1961). For example, an output from a dam project is water for irrigation. That irrigation water is used to produce wheat, which in turn is used to produce flour, and then bread. If the increase in production of wheat, flour and bread is included as benefits in the CBA, the total willingness to pay for irrigation water would be over estimated. In order to avoid the multiple counting of benefits or costs, it is necessary to include only the direct effects of the project (Anderson and Settle 1977).

However, secondary effects should be included in the analysis. The extent to which secondary effects should be included in a CBA will depend upon the individual analysis

(Sewell et al 1961). Generally, when evaluating two or more alternatives that are technically similar and provide comparable services, the secondary effects are likely to be similar. As a result, it would not be necessary to include them in the CBA. However, when projects being compared differ in location or services, consideration of secondary effects may be required. The key that will determine whether secondary effects should be included is whether or not there has been a net gain or loss resulting from the secondary effect. In the majority of cases, secondary effects will cancel themselves out as the benefit becomes a loss elsewhere in the economy. In the case of a reservoir project, expenditures for local services by construction crews, such as beverages and entertainment, are cancelled-out because they represent a net loss of expenditures elsewhere (assuming no net gain in employment and increased expenditures overall).

Evaluation of secondary effects tends to be more important for local and regional CBA where they are more likely to be significant, representing a net benefit or loss. Secondary costs at the national scale can be very difficult to identify and measure (Sewell et al 1961) and are less likely to have a net effect on the total value of output. When secondary costs are included in an economic analysis, they may be treated as additional considerations, separate from and less precisely quantified than primary effects since the quantification of secondary effects is often more difficult than for primary effects.

Primary and secondary benefits and costs can be subdivided into tangible and intangible components (Anderson and Settle 1977). Tangible costs and benefits are usually those with well-defined market values. An example of such costs would include infrastructure and labour costs and benefits like hydroelectric revenues. Intangible costs and benefits are those without a recognized market value or are poorly defined in the market place. These are more difficult to value in money terms and incorporate into an economic analysis of a public investment (Sassone and Schaffer 1978). Examples of intangible effects include the impact of projects on scenery, the effect on wildlife, existing social structure or network, and so on (Perman et al 1996; Sewell et al 1961). Where these intangible effects cannot be measured, a qualitative statement may be prepared and considered along with the cost-benefit ratio (Sewell et al 1961).

1.2 Social Costs and Benefits

Social costs and benefits are the sum of all private and external costs and benefits associated with a particular resource use. (Field and Olewiler 1994; Perman et al 1996).

1.3 Private & External

Private costs and benefits are defined as those that accrue to the owner/user of a resource (Perman et al 1996). Private costs are the inputs used in production including capital, labour and infrastructure costs used in the production of goods and services (Pass, Lowes and Davies 1988). Private benefits are the gains produced by the production of a good or service.

External costs and benefits differ from private ones by the fact they are not incurred by the user of the resource, but by others. Generally, the recipients are external to the decision process and have no choice as to whether or not they incur these costs and benefits (Bojö et al 1990). Environmental pollution produced by a certain segment of the population, but impacting on another sector of society is an example of an external cost. Often externalities take the form of secondary and/or intangible costs and benefits that are without a well-defined market value. These costs and benefits have usually been left out of CBAs, although there is growing interest in including them in economic analyses, particularly where environmental concerns are considered (Bojö et al 1990).

1.4 Opportunity Costs

The opportunity cost is the value foregone by not being able to use the resource for the next highest value activity. It is often described as the real rate of return of capital expenditures (Serageldin 1993). These costs are essentially the maximum value of other projects that could have been achieved if the resources had not been used to produce this project. Opportunity costs are difficult to calculate because there is seldom enough information to measure the value of the next best output that was foregone. As a result, opportunity costs in practice are measured by the inputs used in production (Field and Olewiler 1994).

2.0 SELECTION OF A VALUATION TECHNIQUE

The specific technique to use to determine economic value of costs and benefits is dependent on:

- suitability of the technique to value specific effects,
- theoretical validity of the technique,
- market validity of the technique, and
- requirements and associated availability of specific skills and data.

Where several techniques appear suitable to value a given effect, the preferred method would normally be to choose the method with the higher validity and lower data and skill requirements (Izmir 1993).

2.1 Use and Non-Use Values

The total economic value of environmental amenities is comprised of explicit use values as well as implicit non-use values. Use values are those that accrue from the extraction of services or goods from environmental resources. This may include the extraction of resources such as forestry or the recreational use of wilderness areas. Use values also comprise benefits unaccompanied by market exchanges or explicit activities such as simply experiencing a natural resource without actually participating in any explicit activities.

Non-use values, on the other hand, refer to the benefits individuals may obtain from environmental resources without directly using or visiting them. They are classified into five types (Randall 1987):

1. **Existence value:** the welfare obtained from the knowledge that an environmental or cultural resource exists.
2. **Vicarious value:** the welfare obtained from the indirect consumption of an environmental resource through indirect means such as books and other media.
3. **Option value**: the welfare obtained by retaining the option to use an environmental resource at some future date. It stems from the combination of the individual's uncertainty about future demand for and availability of the resource.

4. **Quasi-option value**: the welfare obtained from delaying a decision until better information is available to avoid irreversible environmental loss. This kind of value may be obtained when future technologies or knowledge enhance the value of a natural resource.

5. **Bequest value**: the welfare that the current generation obtains from preserving the environment for future generations.

Each of these non-use benefits can affect social welfare and consequently may be factored into an analysis. Economic value can therefore be summarized as use plus non-use values.

3.0 MARKET PRICED GOODS AND SERVICES VALUATION TECHNIQUES

The following are brief descriptions of some of the valuation techniques available that can be used to calculate the value of market goods and services.

3.1 Productivity Change Technique

Since productivity can be affected by changes in environmental conditions, the values for a change in the environment can be derived from an associated change in productivity. Increases in output due to changing environmental conditions would indicate an increase in benefit, while a decrease would indicate an increase in cost. This method can cover a loss of income and unemployment prior to the environmental change and from any income generated for reasonably expected future improvements.

Limitations

The difficulties with this method arise in attributing the change in output to a change in environmental conditions and defining natural changes in that output over time. The benefits of this approach are that it is based on observed market prices and output levels.

3.2 Change: in-Income Technique

This technique is usually attributed to changes in health arising out of environmental effect. Losses in income related to changes in health that can be linked to environmental changes are attributed as costs.

Limitations

The difficulty with this method is that the link between environmental changes and health can be hard to establish. This can be due to a variety of reasons such as population mobility, health problems that take years to materialize, and creating causal linkages between health problems that occur in the general population and a specific environmental condition.

3.3 Replacement Cost Technique

The replacement cost technique identifies the expenditures necessary to replace an environmental resource or a man made good, service, or asset as a result of a proposed project. Expenditure on replacement is a measure of the minimum willingness to pay (WTP) as compared to the maximum WTP to continue to receive a particular benefit.

This approach can be used to determine the cost of maintaining a sustainable flow of benefits such as the costs of replacement, and repair of public assets such as roads, rivers, and water storage affected by impacts resulting from a project or activity. What society is prepared to pay in replacement or repair is taken as a measure of the minimum willingness to pay for the use of those assets (Yapp 1989). The replacement cost provides only a minimum estimate of benefit because the cost of replacement exceeds the cost of foregoing the replacement. Otherwise, the replacement cost would not be incurred.

The replacement cost technique can be used to identify the following kinds of benefits:

- The costs of replacing access to houses lost by re-routing a highway can be taken as a measure of the benefits of maintaining access.
- The cost of replacing parkland lost due to construction of a highway is a measure of the benefit from maintaining the flow of parkland amenities (Department of Environment, Sport and Territories, Government of Australia 1996).
- Expenditure to restore strip-mining sites to their original condition can be used to estimate the benefits of maintaining the land environment (Thampapillai 1988).

This technique is valuable because replacement costs can often be estimated relatively simply. Replacement costs are a useful measure of benefit when they are required to meet some socially sanctioned constraint on use of the environment. The cost to restore an environment to meet socially determined standards is a minimum value of the benefits (James 1994). However, it can be difficult to identify replacement goods and services that are good substitutes for the original goods and services. The replacement costs must be limited to those related to restoring benefits lost from a project or environmental affect associated with the project and not benefits lost due to normal wear and tear.

3.4 Preventative-Expenditure Technique

Individuals are sometimes willing to pay to prevent damage to their environment and thereby preserve their existing level of enjoyment from it. Such expenditures will only be made if the individual believes the benefits from the avoided damages exceed the expense to prevent that damage. The willingness to incur these expenses indicates the market value of benefit derived. Examples of common expenditures of this sort include spending to prevent floods, fire, and reductions in water quality. The individual WTP for particular environmental services or improvements to those services, can be aggregated across society as a measure of what society is willing to spend to restore or retain an environmental resource.

Limitations

Unfortunately, this method only provides a minimum measure of the WTP and therefore only the minimum benefit the resource provides. However, the advantages are that it does provide a theoretically correct measure of welfare that can be observed in terms of expenditures in the market place.

3.5 The Relocation-Cost Technique

The relocation-cost method is similar to the preventative-expenditure technique in that activities to maintain a level of enjoyment or output can be related to the WTP for relocation of either the household or the activities occurring at a particular site.

The current cost of living and/or activities are subtracted from the cost of purchase, living and/or activities at the new location. The cost of relocation is an estimate of the benefit from avoiding the damage. The relocation should leave the household, facility or activity operating as closely as possible to the previous one. If a number of possible sites for relocation exist, then the cost of the cheapest one is to be used.

Limitations

This method provides a direct way to incorporate damage costs into the valuation of proposed projects. The relocation costs are a legitimate charge against the project development of an environmental resource if it causes an activity, household or facility to relocate.

3.6 Additional Techniques: Benefits Transfer Approach

In cases where there are limited time and resources, the use of a benefits transfer approach may be applicable. In essence, this approach draws on existing valuation studies. Benefits obtained by other studies conducted on similar projects are transferred directly to the analysis of the project in question. These estimated benefits may be adjusted for biases in the original studies, differences in socio-economic characteristics and nature of the goods and services, and differences in the project (OECD 1994).

4.0 NON-MARKET GOODS AND SERVICES VALUATION TECHNIQUES

The following are brief descriptions of some of the valuation techniques available that can be used to determine the value of non-market goods and services.

4.1 Travel Cost Method

By observing the travel costs of visitors to cultural or recreational areas, economists can deduce shadow prices for the value of an area. The principle is similar to that of hedonic pricing where the value of the resource is inferred from expenditure in another market.

The first step is to identify a number of zones where the travel costs of visitors to a particular destination would be similar. The second is to determine exactly what those costs are. The average cost of travel of visitors from various areas includes all relevant costs. The frequency of visits and travel costs can be interpreted as a demand curve for the recreation area which can then be used to estimate the willingness to pay (WTP) for a recreation area.

The total WTP for all visitors can be determined by multiplying the WTP for each visitor from each zone by the total visitors from that zone. The process would be repeated for each zone and by summing all of the zones, an aggregate of the WTP for the site and hence the value of the site would be determined (Zerbe and Dively 1994).

The WTP for the site could change as a result of variations in environmental quality at the recreation area. If the changes were positive, such as improved water quality, then it would be expected that visitor demand and hence the WTP would increase. If the changes were negative, then the WTP would likely decrease (Department of Environment, Sport and Territories, Government of Australia 1996).

Limitations

The application of the travel cost method is limited to analyzing the WTP for resource based recreational amenities and does not work well in estimating other costs and benefits. In addition, the travel cost method is somewhat simplistic because many factors can influence the decision to visit a given site that may not relate to WTP. Conversely, the frequency of visitation and travel cost may be skewed for a variety of reasons, such as travel to the location being combined with visits to other sites, the individual having other reasons for traveling (i.e; business), or visits differ by lengths of time. Another problem is how to quantify the time costs of travel. The travel time may be viewed as a cost of visitation or as a benefit in itself such as enjoyment of the landscape en route.

Other problems with the travel cost method are more pragmatic, such as the potential for double counting or difficulties in conducting statistical analysis with incomplete data sets. In addition, WTP data is only drawn from those who do visit, and ignores the WTP of those who do not, but are interested in visiting at a future date (Perman et al 1996). It also ignores non-use values of the recreation area.

There is also a problem with using the WTP methodology. It has been strongly criticized as marginalizing benefits accrued to the poor, by not recognizing that one dollar has a different value for the wealthy versus the poor. Attempts to weight values requires both assumptions as to what the correct weighting is, and complex calculations to undertake the value estimate, which in itself results in greater uncertainty with respect to the value estimate (Buss and Yancer 1999).

4.2 Contingent Valuation

Contingent valuation (CV) is another technique used to establish shadow prices for non-market goods. It is widely used since it is one of the few methods capable of estimating use and non-use values (Perman et al 1996). CV involves the use of sample surveys designed to elicit the respondents' WTP for benefits or accept compensation for costs. The approach usually involves purposing a scenario to respondents. In a series of questions formatted in any variety of ways, the individual identifies their own WTP or willingness to accept (WTA) compensation for the good or service in question. Questions can be open ended; " how much would you pay ..." or more structured. In either case, the questionnaire is designed to double check responses to ensure consistent valuation (Perman et al 1996).

Limitations

Problems with this method are related to survey design issues and the generation of biases. There is the potential to bias responses or solicit an incorrect response due to a lack of sufficient context being provided to the respondent to enable them to accurately answer the question. Closely related to this, is the conceptual problem many respondents have with placing a value on WTA (Perman et al 1996). Other problems include biases generated from the selection of the population surveyed (i.e, stakeholder groups) or because the sample set is not actually representative of the chosen population.

4.3 Hedonic Pricing

Another valuation technique is the hedonic or implicit price method that attempts to correlate the non-market item or service to a closely related market item and extrapolate a value (Randall 1987). Statistical techniques such as multiple regression analysis enable the determination of a shadow price for the good or service.

Limitations

There are also many difficulties associated with this method, predominantly because of the difficulty in its application. Advanced statistical techniques required to perform the method decreases its use by general researchers (Sinden and Worrell 1979). In addition, studies that have compared hedonic pricing with CV have found value estimates to be within ±100 percent. This indicates that either one or both methodologies will generate values that may not represent the actual WTP or WTA (Perman et al 1996).

4.4 Dose-Response Valuation Method

The dose-response valuation method is usually used to estimate the value of increases in pollution. This method differs from the previously mentioned approaches in that it does not attempt to measure preferences, but rather the consequences of an activity and/or development. The goal is to estimate the increments of damage created by an activity and/or development, and assign a monetary value for each unit of damage. The method used to assign a monetary value will vary with the specific damage. If the damage is to a marketed good or service, such as agricultural output, then observed prices are used as indicators of value.

Limitations

This technique is not without problems. Errors can be made in estimating the losses arising from the damaging activity or development, particularly where the losses are qualitative rather than quantitative. Furthermore, calculating the value of incremental damages in terms of actual prices can be difficult, and impede the estimation of the true WTP. Placing a value on qualitative changes is typically problematic. The impact of damages may also change over time as individuals respond by substituting activities to mitigate against future losses. Calculating the post-substitution effects requires developing a second model of production and consumption responses (Perman et al 1996).

4.5 Benefit-Transfer Valuation Method

Benefit transfer is the application of monetary values from one particular study to another, often in a different geographic region from the original. The transfer of values is based on expert opinion or meta-analysis. This technique is both a time and money saving mechanism because the analyst is able to avoid using one of the other more involved methods for calculation.

Limitations

The problems inherent in the original non-market items can be magnified if transferred to another study. Assumptions and sources of error are difficult or impossible to identify (Markandya 1998).

5.0 DISCOUNT RATE

5.1 Social Time Preference Rate (STPR)

STPR reflects the social costs of delaying present consumption in order to increase savings for future consumption. A positive rate reflects people's preference for enjoying benefits now, rather than later, known as pure time preference. STPR also reflects an underlying belief that future generations will be better off than today's generation. Therefore, the value of a dollar will be worth less (have less utility) to future generations than it does today, and thus the future should be discounted based on the diminishing marginal utility of consumption (Pearce and Turner 1990). Market interest rates, the government borrowing rate, and the lenders risk (Randall 1987) have all been used as the STPR of discount.

5.2 Social Opportunity Cost Rate (SOCR)

SOCR is based on the marginal productivity of investment, or the real rate of return that the economy's marginal investments yield. This is the value of the least profitable investment project undertaken in the economy (i.e, by the private sector). In addition, the rate at which an individual or society is willing to trade present consumption for future consumption may also be used. The Pigouvian discount rate, whereby society errs on the side of caution and makes provision for future generations, has also been advocated (Sassone and Schaffer 1978).

APPENDIX 8:

SHELLMOUTH DAM COST ESTIMATE

This capital cost estimate was used by Kuiper in his 1961 Shellmouth Dam CBA..

Shellmouth Dam Capital Cost Estimate

Description	Amount	Unit Cost $	Total Cost $
Earth Dam			
Clearing and grubbing	100 acres	100.00	10,000
Stripping	93,000 cu. yds.	0.20	18,600
Embankment	2,050,000 cu. yds.	0.30	615,000
Filter Gravel	10,000 cu. yds.	2.00	20,000
Riprap	17,200 cu. yds.	4.50	77,000
Care and diversion of river			50,000
Earth Dam Capital Cost			790,600
Spillway			
Excavation	130,000 cu. yds	0.25	32,500
Concrete weir	22,800 cu. yds	60.00	1,370,000
Concrete slab and walls	9,500 cu. yds	70.00	666,000
Filter Gravel	3,000 cu. yds	2.00	6,000
Backfill (hand)	7,000 cu. yds	3.00	21,000
Riprap	1,100 cu. yds	4.50	4,900
Sheet piling	15,250 sq. ft.	4.00	61,500
Spillway gates (5)	50,000 lb.	0.40	100,000
Spillway hoists (5)	18,200 lb	0.70	63,500
Conduits gates (5)	69,000 lb.	0.50	276,000
Conduits hoists (5)	14,000 lb.	0.40	45,000
Spillway Bridge Steel	50 tons	400.00	20,000
Spillway Bridge Concrete deck	120 cu. yds.	70.00	8,400
Miscellaneous	10% contingency		274,000
Spillway Capital Cost Total			2,948,800
Reservoir Damages			
Cultivated land	4,900 acres	60.00	295,000
Hay land	19,000 acres	20.00	380,000
Houses, barns and other buildings	one lump sum		450,000
Reservoir clearing	11,800 acres	80.00	944,000
Shell River Bridge	one lump sum		5,000
Dropmore Bridge	one lump sum		10,000
Pyott Bridge	one lump sum		5,000
Man. Highway No. 5 Bridge	one lump sum		213,200
Sask. Highway No. 5 Bridge	one lump sum		242,500
Reservoir Damage Total			$2,544,500
Subtotal			6,284,000
Contingencies 20%			1,261,000
TOTAL CAPITAL COST			**7,545,000**

Source: PFRA. January 1961. Proposed Shellmouth and Holland Reservoirs and Portage Diversion: A Study of the Flood Control and Conservation Benefits of these Projects Alone and in Combination. Winnipeg, Manitoba.