ANALYZING THE EFFECTS OF THE FAIRFORD DAM ON LAKE ST. MARTIN FIRST NATION

By

Myrle J. Traverse

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

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Abstract

Lake St. Martin First Nation is an Anishinaabe community situated northwest of the Narrows at Lake St. Martin in central Manitoba. The land around Lake St. Martin has been affected by flooding since the early 1960's, soon after construction of the Fairford Dam on Lake Manitoba. Traditional activities of the First Nations communities of Lake St. Martin, Little Saskatchewan, and Fairford have been affected downstream by the Fairford Dam, along with the Fairford River, Pineimuta Lake, and Dauphin River. This research explored the historical water situation at Lake St. Martin; examined the First Nations perspective on water level changes over time; and analyzed water resource data for the region. Results indicated that the First Nations perspectives that water levels have increased as a result of the construction and operation of the Fairford Dam were supported by a hydrological analysis of water resource data. Recommendations respecting the situation are provided by collaboration, community consultations, alternative methods for the operation of the control structure, replacement of land base, and construction of permanent dikes.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my advisor - Dr. Rick Baydack, Natural Resources Institute, for his patience, guidance, and encouragement throughout my research, and also to the other members of my thesis committee - Dr. Dave Barber, Geography; Dr. Rick Riewe, Zoology; and a special thanks Dr. Slobodan Simonovic, Natural Resources Institute for his expertise.

Meegwetch neeji Anishinabaag at Lake St. Martin, Little Saskatchewan, and Fairford, for their invaluable knowledge, and for sharing and talking with me. Meegwech Lake St. Martin First Nation Band Council and Narrows Education Authority for supporting me while I was in school.

My sincere thanks to Manitoba Hydro, Water Resources Branch - Department of Natural Resources, and Environment Canada for sharing their data with me.

I would also like to thank my colleagues at the University of Manitoba Natural Resources Institute and Native Studies.

I would also like to thank my 'significant other' - Dennis for his assistance and support, and last but not least, my mother Evangalene for her unconditional love and encouragement.

It was an honour and privilege that I was able to do this research in my own language (Ojibway) without the assistance of translators. I will never be able to repay the elders for their wisdom which they shared with me.

Kichii Meegwech Neeji Anishinabaag

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CHAPTER 1

INTRODUCTION

1.1 Lake St. Martin Study Area

Lake St. Martin First Nation is located in central Manitoba, 255 kilometers north of Winnipeg (Figure 1). It is one of the communities located downstream from the Fairford Dam. Lake St. Martin First Nation is an Ojibway Nation that was signatory to Treaty 2, which was signed in 1871. The First Nation community consists of two parcels of land on each side of the Narrows at Lake St. Martin, with the west section comprising the population center. It is a community consisting of 1,652 registered band members, of which 1,127 live on reserve, and 525 off reserve[1]. The economic base consists of agriculture, trapping and commercial fishing. The community is accessible by an all weather road (Indian and Northern Affairs Canada, 1998). The Fairford Dam was constructed in 1961, and traditional activities of the First Nations have been affected since that time due to increased water levels.

1.2 Objectives

The objectives of this research are: 1) To determine neeji Anishinabaag's[2] perspectives on water level changes at Lake St. Martin; 2) to provide a hydrologic analysis of water levels at Lake St. Martin pre and post construction of the dam;

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[1] Based on Indian and Northern Affairs Canada regional population statistics of December 31, 1996.

[2] Neeji Anishinaabe (singular)/neeji Anishinabaag (plural) - Refers to the Ojibway word meaning my fellow First Nations people in the First Nation communities of Lake St. Martin, Little Saskatchewan, and Fairford.

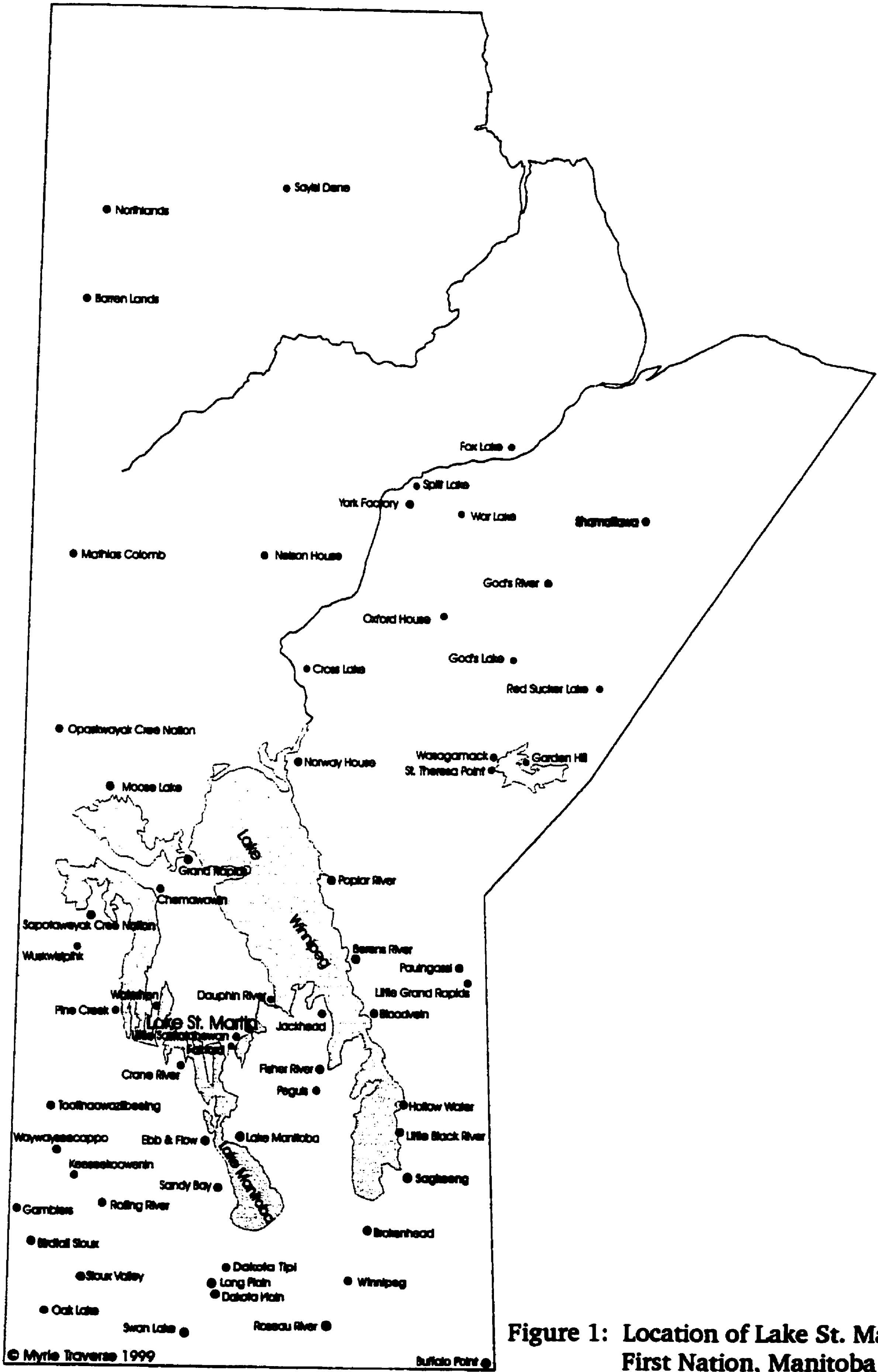


Figure 1: Location of Lake St. Martin First Nation, Manitoba

3) to contrast the perspectives of First Nations people at Lake St. Martin in relation to the hydrological database; and 4) to provide recommendations. The research will demonstrate how a collaborative approach at Lake St. Martin First Nation can be used to remedy the situation. This research will identify the benefits of collaborative research which will include First Nations' perspectives and those of other user groups. The completed thesis will be presented to the Lake St. Martin Chief and Council, and to the Department of Natural Resources for possible future implementation.

1.3 Justification

The Fairford Dam and its effects downstream into Lake St. Martin First Nation have been a contentious issue in central Manitoba since the dam was completed in 1961. The First Nations perspective is that construction of the Fairford Dam has negative impacts on the downstream communities. Proof of this perception has not been clearly demonstrated up to date. Use of a hydrologic analysis should enable an answer to be achieved. The collaboration will assist the community in providing permanent solutions, and to demonstrate how long-term decisions can best be derived.

1.4 Limitations

A limitation which had to be considered was the time/season of the study. The collaboration had to be conducted as spring thaw occurred in order to get a candid response and full cooperation from the First Nations people. The operational rules and controls for the dam were obtained from the Department of Natural Resources, and the historical consequences of the dam were obtained from governmental sources and from oral histories contributed by neeji Anishinabaag. The visiting portion with neeji Anishinabaag was completed during the summer of 1998, with the results presented to the community after May, 1999.

CHAPTER 2

METHODOLOGY

2.1 Introduction

This study consisted of two different methods of data collection and analysis: 1) hydrologic analysis of water resources data, and 2) collaborative research with neeji Anishinabaag. Both techniques required sophisticated data collection and analysis procedures, and these will be described below.

2.2 Rationale for Collaborative Research

Collaborative research was the methodology which I utilized in my visits with neeji Anishinabaag. Collaborative research refers to a process in which university-trained researchers bring their skills and interests to a community. The initial issue is often (though not always) identified by members of the community. Once identified, the issue is negotiated into researchable terms where the community collaborates with the researcher through operationalization of concepts, research design, collection and analysis of data (Schensul *et al.*, 1987; Warry, 1990; Castleden, 1992; Ward, 1996).

Collaboration refers to the principles of consultation, teamwork, and cooperation (Smith & Scott, 1990; Castleden, 1992; Wells Lindfors & Hudelson, 1993; Ward, 1996) and where collaboration is nonheirarchal, nonexploitive, and does not involve opposing activities (Wells Lindfors & Hudelson, 1993). Castleden (1992) and Stull *et al.* (1987) state that the emphasis of collaborative research is on the interrelationship between the researcher and participants.

Castleden (1992) further explains collaborative research that includes the researcher who is external to the group collaborating to conduct the research, and as they work together, each contributes its wisdom to the research (Schensul, 1987; Lapadat & Janzen, 1994; Castleden, 1992). Wells Lindfors & Hudelson (1993) state that collaborative research is continuing and evolving over time, where its life within and dependence upon a relationship among the partners is characterized by mutual trust and respect that is simultaneously affiliative and autonomous.

2.2.1 Collaborative research used by others

Ward (1996) demonstrated the choice of using collaborative research as a methodology which evolved out of working in a collaborative research process with the community participants. A comprehensive account of collaborative community research was undertaken by Castleden (1992) in his doctoral dissertation of the Split Lake First Nation health transfer process. Castleden identified collaborative research as a method for an external researcher to unite with the Aboriginal peoples endeavours for taking control of their own research which is designed to meet their needs. Warry (1990) examined the adherence to the principle of native self-determination in research which produces a fundamental shift from independent to collaborative research. Warry discussed the native peoples involvement in research design and the role of aboriginally defined policy in shaping the parameters of applied research. Lapadat and Janzen (1994) identified the role of collaborative research in northern First Nations communities as originating out of the lack to recognize and influence the roots of frustration and resentment about southern decision-making and its implications for the north. Cruikshank (1990) described how collaborative research is utilized to interpret the past. Cruikshank's collaboration with three women of Athabaskan and Tlingit ancestry motivated her to shift away from oral history committed to documenting changes in social reality and toward an investigation of narrative forms for talking about, remembering, and interpreting everyday life.

Lapadat and Janzen (1994) discuss the variations of collaborative research: intradisciplinary collaboration; interdisciplinary collaboration; interorganizational collaboration; and university-community collaboration. Intradisciplinary collaboration is the situation where two or more researchers in the same discipline or field work together. The subjects may be studied but do not participate in any aspect of the research. Interdisciplinary collaboration is conducted from two or more disciplines equally contributing their expertise to the research. Interorganizational collaboration involves partnerships between universities, government agencies, corporations and other institutions of higher learning.

The final variation of collaboration discussed by Lapadat and Janzen (1994) is university-community collaboration which involves a university researcher working with a local practitioner. It may also involve a broad cross-section of a community or subcommunity using a participatory research model and involves a wide range of community members. This approach differs from the other approaches described in that the participants whose community is under study have a role in deciding the research questions and design, conducting the data collection, interpreting the data, and participating in distributing the findings (Warry, 1990; Lapadat & Janzen, 1994; Ward, 1996). Of all the various collaborative models, this is the one that is most inclusive, involves people farthest away from the university environment and provides the greatest degree of control by local research participants over the research and inception to sharing of results (Lapadat & Janzen, 1994).

2.2.2 Advantages and disadvantages of collaborative research

Collaborative research has a number of advantages. Some of these include: bringing together people of diverse skills and knowledge; it 'demystifies' the research process, allowing those who will utilize the results the opportunity to understand and shape the data collection process (Schensul, 1987; Warry, 1990); it builds a research capability in the community and/or organization that can extend beyond and operate independent of the researcher; it increases the likelihood that the results of the research will be used by nonresearchers; and it improves the quality of the research through access to the community and to key bodies of knowledge (Schensul, 1987).

Lack of knowledge of the community being researched can be a disadvantage for the researcher. However, this factors are not a disadvantage for myself as an Aboriginal researcher in which I will be researching my home community. For example, I have knowledge of the community and the people because I still consider Lake St. Martin First Nation as my home base. When I commenced my research, I knew exactly whom to approach for the type of information I required.

As an Aboriginal researcher and community member, I will always respect my fellow band members and will remain my neeji Anishinabaag, even though my role was that of a researcher. But the respect may not be mutual. The Elders and other community members identify me as one of them, therefore, they may not have taken my role as a researcher seriously. The Elders may have thought of me as a 'little girl' and not as someone trying to establish herself as a credible researcher.

As an Aboriginal researcher I tried to understand the community and my neeji

Anishinabaag whom I collaborated with. I grew up with these people and most of them will be related to me. I had an advantage because I think I *understand*[3] the culture, traditions, politics, social structure, economics, and the activities of everyday life of the people at Lake St. Martin First Nation.

Another advantage I had is understanding and speaking the language of my neeji Anishinabaag. Researchers who do not understand the language of the group they are researching have to rely on translators. A problem with this process is that the translators may translate the words slightly different from what was actually said during the communication between the researcher and the researchees, and neither may be aware of it. Some of the words do not have the same meaning when they are translated, and thus lose their meaning and intent. I had already experienced this problem when doing my own translations where some of the words lost their meaning when they were translated into English.

Another advantage as an Aboriginal researcher is the essence of trust. Membership in the community is the first step in gaining the trust of my neeji Anishinabaag, and more importantly being one them. Trust was one of the factors critical to the success of any collaborative research projects and the necessity to establish a comfortable atmosphere (Wells Lindfors & Hudelson, 1993; Alverman *et al.*,1993; Cameron, 1996).

Warry (1990) argued that adhering to the principle of Native self-determination indicates a fundamental shift from independent to collaborative research. From a Native perspective, applied collaborative research enhances the self-determination process, however, if done from a disciplinary perspective, the researcher is forced to relinquish control over the research process

[3] No one ever truly understands people and their communities.

(Warry, 1990).

However, despite the advantages as an Aboriginal researcher, the question of bias could be an issue. As an Aboriginal researcher studying my home community, and having witnessed the effects of the flooding, it is hard not to be biased. But I am entering the community as a Western researcher, therefore, I have tried to remain focussed, impartial, and not allow myself to be influenced by the stories which were shared with me. It is important to realize that although the First Nations narrations of the flooding will be biased, my role as a credible, unbiased researcher will emerge.

2.3 First Nation Data Collection

The collaboration at Lake St. Martin First Nation required a knowledge and understanding of the Ojibway language and the people. I was in a unique position - I am an Anishinaabe, I speak and understand Ojibway, and I am a member of the community rather than an outsider. The Anishinabaag of Lake St. Martin First Nation with whom I collaborated, are referred to as 'neeji Anishinabaag'. My role was collaborative in which I used both my traditional and western knowledge to collaborate with the community members of Lake St. Martin First Nation.

Traditional knowledge is part of my inherent upbringing as an Anishininaabe and having been raised at, and being a member of Lake St. Martin First Nation. My western knowledge originates from being taught in Western society.

2.3.1 Oral Tradition

Selecting a methodology that reflected and identified the needs of the community was beneficial for my neeji Anishinabaag. Collaborating with my neeji Anishinabaag and belonging to the community contributed toward the success of my collaboration. Understanding the language (Ojibway) and the culture, and knowledge of the community were to my advantage. I conducted my visits in Ojibway and did not rely on translators.

Oral tradition and oral history are invaluable methods of collecting information. As an Aboriginal researcher who collaborated with my neeji Anishinabaag, personal communication vis-a-vis oral tradition stories was one of the methods utilized.

Various studies have been conducted with the Aboriginal people using oral tradition and oral histories as a means of collecting information (Freeman 1981, 1984, 1996; Freeman and Carbyn, 1988; Cruikshank, 1990; Raven & Prince, 1996; Lagrand, 1997). Cruikshank's (1990) study of Athabaskan women demonstrates how oral tradition is a valuable approach for disseminating information. Cruikshank interprets the recollections of the Athabaskan women as culturally and socially constructed and not as a mere regurgitation of facts. Lagrand (1997) shows how Indian oral sources are tilting toward 'oral tradition' and away from 'oral histories'. Lagrand differentiates between oral tradition and oral history by defining oral tradition to describe a type of oral source in which a message considered important by a group of people, but not witnessed first-hand by the narrator, is passed from one generation to another. Oral tradition tends to emphasize the group or community over the individual and the message is passed through a formal, structured and ritualized process of transmission.

Oral history is used to describe a type of oral source in which an individual addresses experiences and feelings experienced first-hand in narrative form. It is an 'eye witness account' as opposed to one 'handed down by word of mouth to later generations' (Freeman & Carbyn, 1988; Cruikshank, 1990; Lagrand, 1997). It is also important to give an account of more than one perspective and to look for links between the stories (Cameron, 1996; Mihesuah, 1996). Aboriginal people rich with information have strong cultural connections to their histories which are transmitted orally and are essential for cultural identity and survival (Cruikshank, 1990; Mihesuah, 1996; Wilson, 1996).

2.3.2 Visiting

Collaborating with my neeji Anishinabaag resulted in a type of interaction/ communication which I refer to as visiting. All the visits took place with Ojibway being spoken. Visiting was the term chosen (for lack of a better word) that reflected the type of interaction I conducted with my neeji Anishinabaag. The term 'interaction' does not describe the activities of collaboration. Visiting was less formal and produced more results than the traditional methods of informal or formal interviews. Visiting produced spontaneous conversation which revealed more information. Visiting produced a friendlier atmosphere than interviewing would have. Visiting also evoked a form of story telling which is collaborative, although not in the traditional sense of questioning and answering, but rather the interviewer and respondent interact to produce meaningful stories (Cruikshank, 1990; Holstein & Gubrium, 1995).

2.3.3 Participant observation

The critical issues of participant observation are the mode of interaction and the quality of relationship the researcher is able to establish (Stocking, 1983; Kinew, 1996). In collaborating with my neeji Anishinabaag, my presence did not interfere with their activities because they knew who I was, therefore, they would not alter their activities due to my presence. The activities of the researcher may be divided into different modes - participation, observation, and interrogation, but the essence is really the interaction (Stocking, 1983; Ellen, 1984).

2.4 Imagery

Maps, air photographs, personal photographs, and aerial photos were used to demonstrate the change in the vegetation at Lake St. Martin prior to and after construction of Fairford Dam. The vegetation at Lake St. Martin First Nation has changed as a result of the effects of the changing water levels. Comparisons of the aerial photographs revealed changes in the vegetation at Lake St. Martin First Nation which will be discussed in Chapter 4.

2.4.1 Mapping

Maps were initially made using a digitizer. Maps were customized to suit each study area using CorelDRAW 8. A scanner was unsuitable for the map making because the editing was too time consuming.

2.4.2 35-mm Photographs and Aerial Photographs

Air photographs which are 35-mm photographs taken from air with a ground 35-mm camera were obtained from North-Man Engineering Inc., 678 Main Street, Winnipeg. Permission had to be obtained from the Chief prior to obtaining the photographs. The photographs were taken May 26, 1996 at a scale of approximately 1:15,000. The researcher's personal photographs using a ground 35-mm camera were also utilized.

Air photographs are different from aerial photographs (which are discussed in the next section) by their camera. Thirty-five mm cameras which take air and personal photographs are light in weight, while aerial cameras are heavy (average weight 8 kilogram). Aerial cameras use long films (250 exposure), while ground cameras use 12, 24, or 36 exposures. Ground cameras require manual operation and have adjustable focus, whereas aerial cameras are motor operated and have infinite focus (Hathout, 1995).

2.4.3 Aerial Photographs

Aerial photographs were bought from the Air Photo Library on 1007 Century Street, Winnipeg. However, the area of study involved a series of photos which were difficult to scan. Scanning required a lot of memory and involved knowledge of scanning programs which involved creating a series of overlapping photographs to create mosaics. Professional scanning was offered as an option at a cost of $3000.00, but was unrealistic. Purchasing a good scanner and printer solved this problem. Two mosaics were constructed from three different time periods depicting the change in vegetation. The mosaics will be discussed in Chapters 4 and 5. The mosaics from the aerial photographs include: 1) 3 overlapping aerial photos from 1958 at a scale of 1:40,000; and 2) 3 overlapping aerial photos from 1986 at a scale of 1:56,000.

A list of available aerial photographs was obtained from Natural Resources Canada, 275

Portage Avenue, Winnipeg. The list was useful in determining the scale and year of the photos which were being used in the research. Suitable aerial photographs which were pre-digitized were unavailable. However, Natural Resources Canada were willing to scan single aerial photographs at a cost.

2.5 Hydrologic Data Analysis

The Fairford Dam is in operation all year. The readings for the water levels are obtained daily by automatic gauges out of the Water Resources Branch in Winnipeg. The water level at the Fairford Dam is adjusted manually by Water Resources Branch (based out of Hodgson, Manitoba) when they receive instructions from Winnipeg. If the readings are too high, a stop log is taken out. There are no set dates when the stop logs are taken out and is mostly dependent on spring runoff. During dry periods, the dam is closed down in the spring, and is reopened in the fall to ensure enough water goes through the system.

Mean monthly water levels were analyzed for four sites which had water gauges for recording water levels. The locations were - Assiniboine River (near Holland), Lake Manitoba (at Steep Rock), Lake St. Martin (at Sandy Bay up to 1965; at Hilbre 1966 to 1998), and Lake Winnipeg (means for all stations were supplied by Manitoba Hydro) (Figure 2).

Data for the Assiniboine River (near Holland) were obtained at cost from Shayne Misener at Environment Canada at 123 Main Street, Winnipeg. Holland was chosen over the other sites because of its proximity and upstream location from Portage Diversion. The data was inconsistent with some days missing and had been recorded as mean daily gauge height in feet. Other dates had only the gauge height recorded and the a.s.l. (above sea level) had to be

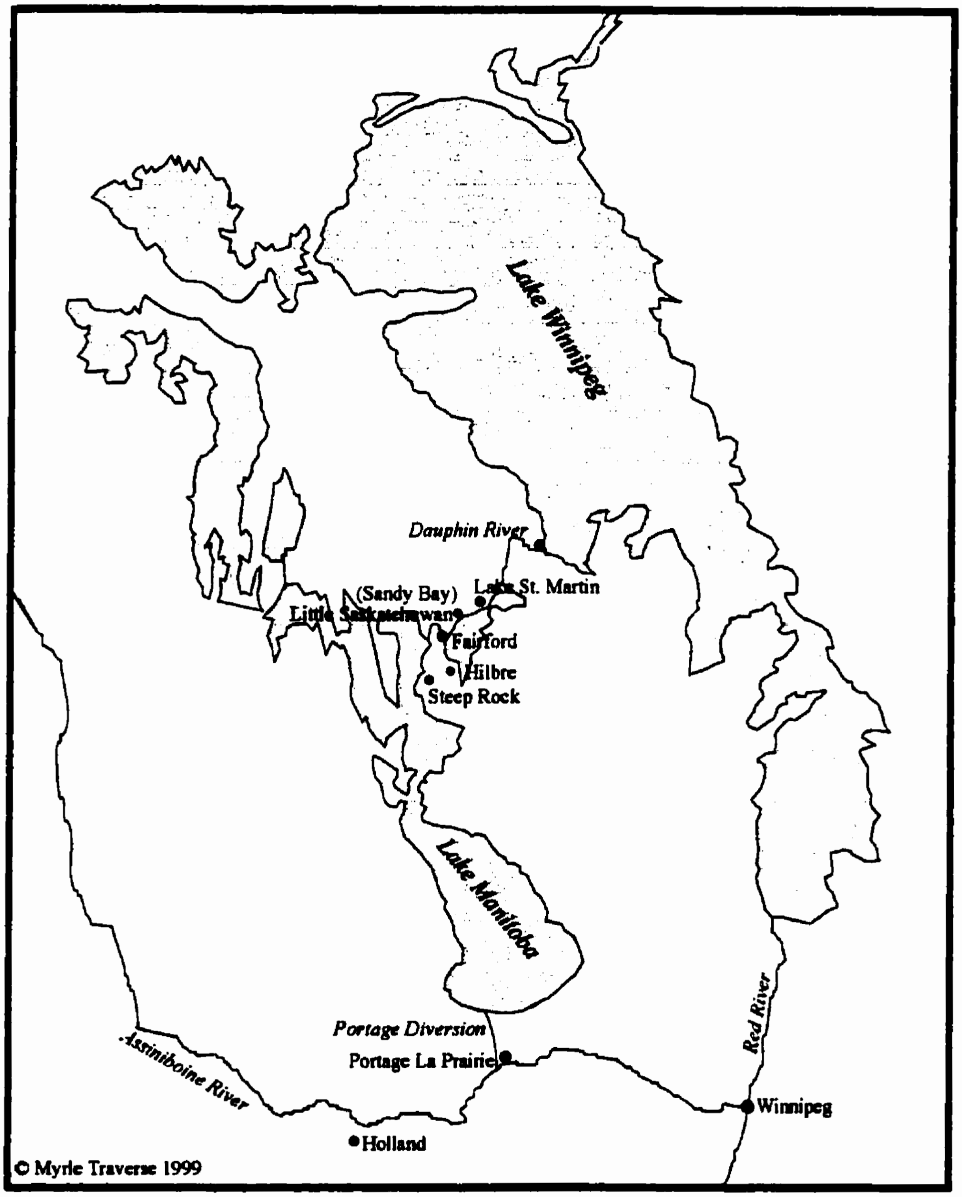


Figure 2: Location of Water Bodies and Water Stations used in the study.

manually added on each monthly mean. The gauge height (in feet) had to be added on to the 960.00 feet to obtain the a.s.l. reading. A sample calculation would be:

6.33 feet + 960.00 feet a.s.l. = 966.33 feet a.s.l.

The average water levels were taken for the available dates to derive a monthly mean and converted in to metres. Appendix A shows a sample of the data.

The data for Lake Manitoba were obtained from Water Resources Branch, Province of Manitoba at 100 Saulteaux Crescent, Winnipeg. Steep Rock was selected due to its close distance to the Fairford Dam. Mean monthly data were obtained in metric units and did not require conversion.

The data for Lake St. Martin were also obtained from Water Resources Branch. Water levels for periods prior to 1955 were unavailable, therefore, only water levels obtained after 1955 were used for analysis. The data was also in metric units and required no conversion. The site at Sandy Bay was used up to 1965 after which Water Resources Branch stopped taking water levels from this site. Sandy Bay is approximately three kilometres from the south western boundary of Lake St. Martin First Nation. After the closure of the Sandy Bay site, data from Hilbre were used.

Data for Lake Winnipeg were obtained from Manitoba Hydro. The data were in feet and had to be converted to metric units. The data represented an average of all the sites on Lake Winnipeg.

2.5.1 Regression

A regression analysis was performed on water levels between: Assiniboine River near Holland and Lake St. Martin; Lake Manitoba and Lake St. Martin; and Lake Winnipeg and Lake St. Martin for both Pre-Portage Diversion and Post-Portage Diversion. The analysis was done to test the hypothesis that the construction of water control structures has had an effect on water levels at Lake St. Martin, and to determine the relationship of the water systems on Lake St. Martin. The objective was to determine the pre- and post-diversion effects on the water levels at Lake St. Martin and to determine the impact of water fluctuations and trends on Lake St. Martin First Nation.

Appendix B and C show data for Pre- and Post-Portage Diversion respectively. The data were entered into a spreadsheet and a regression analysis performed for the entire periods of 1955-1970 for Assiniboine River and Lake St. Martin; Lake Manitoba and Lake St. Martin; and Lake Winnipeg and Lake St. Martin. Regression graphs were obtained for each respective analysis. Sample calculations are also shown in Chapter 4.

2.5.2 Data Analysis

Water levels for the years 1954 to 1997 were obtained for Assiniboine River near Holland, Lake Manitoba, Lake St. Martin, and Lake Winnipeg. The waters levels which were in feet were averaged and converted to obtain metres using the formula:

$a \times .3048 = b$

The following is a sample calculation of the conversions:

963.31 feet x .3048 metres/feet = 293.169 metres.

CHAPTER 3

BACKGROUND INFORMATION ON LAKE ST. MARTIN FIRST NATION AND THE FAIRFORD DAM

3.1 Living off the land

Aboriginal people were the sole occupants of the vast lands now known as North America. Aboriginal people were able to survive in the vast expanse of land by their pursuit of an economy of traditional hunting, trapping, fishing, and gathering which depended on skill and knowledge (Indian Claims Commission, 1995). Their survival depended on a relationship with the environment through knowledge which was passed on through thousands of years of observation and testing (Johnson, 1992; Wolfe *et al.*, 1992; Northern River Basins Study, 1996; Notzke, 1994).

The Earth was viewed by the First Nations people as a living organism where animals, plants, humans, air, water, and land all have a reason for being and together maintain an intricate balance to ensure that continued survival of all life. Any interference with any part of this system will have negative repercussions on other components (Johnson, 1992). In a sense, this depiction is analogous to the ecological perspective of an ecosystem with all parts inter-related and inter-dependant.

Aboriginal people were isolated when they signed treaties and given parcels of land known as 'reserves'. However, this isolation meant that for a while their traditional way of life and ecological knowledge were preserved (Payne and Nepinak, 1996). In some First Nation communities today, however, the traditional way of life that survival once depended upon has been obliterated due to influences from North American settlement by Europeans.

3.2 Traditional ecological knowledge

Traditional environmental knowledge (TEK) is a way of life by a group of people through generations of living in close contact with nature (Freeman & Carbyn, 1988; Johnson, 1992; Wolfe *et al.*, 1992; Berkes, 1993; Notzke, 1994). It includes a system of classification, a set of empirical observations and concepts or understandings about the local environment, and a system of rules or ethics that govern human behaviour and use of resources (Johnson, 1992). The quantity and quality of TEK varies among community members, depending on gender, age, social status, intellectual capability, and profession (hunter/trapper, spiritual leader, healer, etc.).

TEK is being acknowledged and pushed by Aboriginal leaders as a means of returning to traditional values and culture. Payne and Nepinak (1996) describe how TEK began to get lost and cultural extinction began to take hold, only to be replaced by a new culture - one that was deeply rooted in poverty. Aboriginal people are holding on to traditional values, which are based on respect for environmental and natural law, to provide insight and direction into environmental, natural resource and demographic issues. Traditional Aboriginal people are a precious resource for knowledge about how to live on the land in an ecologically and socially sustainable way due to their knowledge of local resource bases, animals, plants, water, rocks, and the soil (Drake-Terry, 1989; Clarkson *et al.*, 1992; Raunet, 1996; Switlo, 1997).

3.3 Background on the Fairford Dam

Assiniboine and Red Rivers flood the City of Winnipeg, therefore Portage Diversion was built as a part of a comprehensive flood control system. The excess water is diverted into Lake Manitoba. Water levels at Lake Manitoba were artificially maintained to improve recreation, which necessitated a need for the Fairford Dam to be built. With the new Fairford Dam, it was possible to maintain Lake Manitoba water levels within the required range (Peterdy, 1961). Lake Winnipeg water levels were artificially altered for Manitoba Hydro requirements. In the middle of this system is Lake St. Martin, which is serving as a 'sink' for water from other areas and has been used to solve problems elsewhere.

Minor channel improvements were undertaken on the Fairford River in 1904 to limit maximum water levels on Lake Manitoba. In 1934, a control structure was built at Fairford to control minimum flows from Lake Manitoba, but nothing was done to reduce the frequency of higher water levels on Lake Manitoba. Studies were conducted on the physical practicability of controlling the water levels on Lakes Winnipeg and Manitoba. The results showed flood control on Lake Winnipeg to be impractical but practical on Lake Manitoba. This provided the groundwork for the construction of a new control structure (Manitoba Water Commission, 1978).

Construction on Fairford Dam commenced in 1960. It was completed and in operation by 1961. Channel improvements were also made in the Fairford River at this time (Peterdy, 1961; Manitoba Water Commission, 1978). This enabled a narrower range of control of flooding for Lake Manitoba. Lake Manitoba is regulated to a target level of 247.55 metres a.s.l., and this effectively maintains the mean monthly lake levels between 247.15 metres and 247.76

metres a.s.l.. With the Fairford Dam in place, it was possible to maintain Lake Manitoba water levels within the required range (Peterdy, 1961).

The regulation of Lake Manitoba reduced the frequency of higher water levels, but the effect was to increase the frequency of higher levels on downstream lakes - Lake St. Martin and Pineimuta Lake. The effect downstream was that when Lake Manitoba is at a low level, the outflow from Lake Manitoba decreases and Lake St. Martin and Pineimuta Lake have lower levels with greater frequency (Manitoba Water Commission, 1978).

The Fairford Dam is a control structure consisting of 11 bays. Bay 1 originates on the northside and progresses to bay 11 on the south side (Figure 3). Each bay has 10 stop logs (made of concrete) which are used for controlling water discharge. Each stop log measures 0.3 metres x 25.4 centimetres x 6.1 metres (Figure 4). A fish ladder was added on bay 9 on the east side in 1982. A flume attracts the fish to go up the ladder (Figures 5). The bays at each end are higher to increase the water concentration in the middle bays.

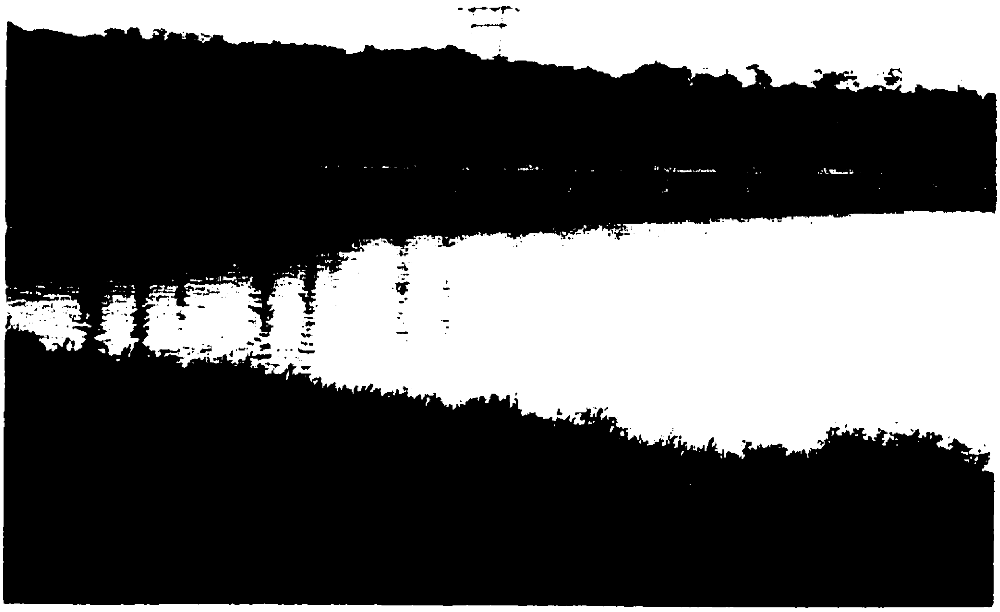


Figure 3: Northwest side of Fairford Dam showing bay 1 starting from left.

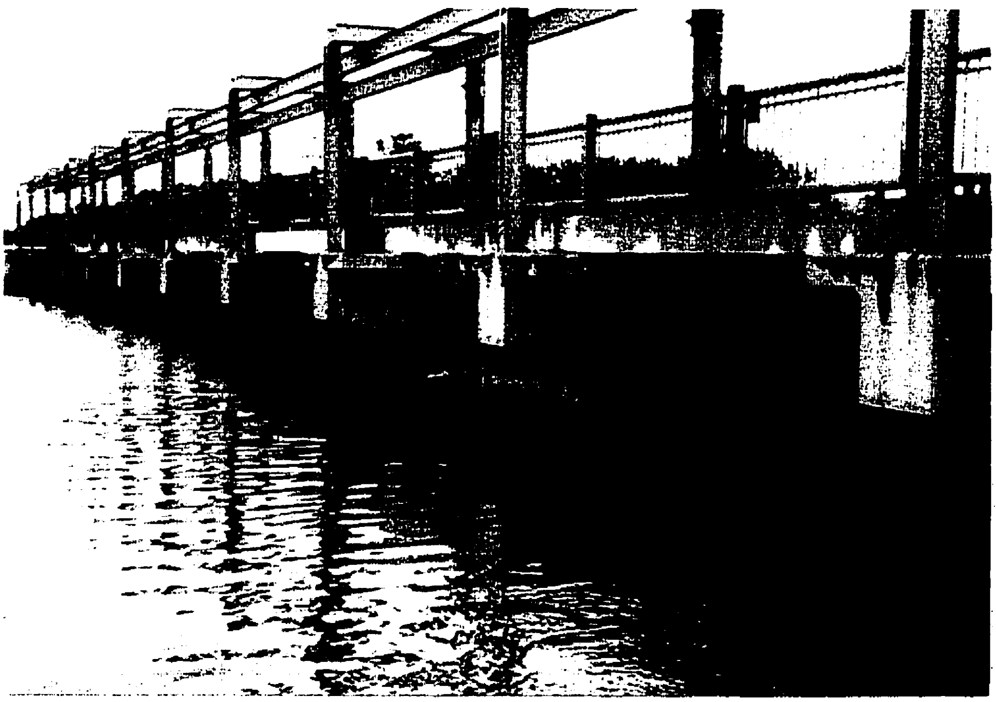


Figure 4: Southwest side of Fairford Dam showing stop logs.

Figure 5: Southeast side of Fairford Dam showing fish flume.

3.4 First Nations communities downstream

There are three First Nations communities situated directly downstream from the Fairford Dam - Lake St. Martin (The Narrows), Little Saskatchewan, and Fairford (Figure 6). The alteration of the natural water regime resulted in the occasional flooding of the land surrounding Lake St. Martin, including First Nations' land. This led to the Government of Manitoba (assisted by the Canada Minister of Indian Affairs and Northern Development) to negotiate a settlement with the First Nations.

Since 1967, the province proceeded with settling compensation for First Nation Bands affected by flooding. In 1977, the Province finalized agreements with each of the First Nations affected, by transferring Crown land to the First Nations equivalent to the land on the reserves being flooded (Weiss, 1977). The transfers did not require that First Nations relinquish ownership to the flooded land - it still belonged to them. These actions absolved the Government of Manitoba from any future claims with respect to the flooding (Weiss, 1977; Manitoba Water Commission, 1978). Non-First Nations land owners were compensated in the form of cash settlements (Manitoba Water Commission, 1978).

3.5 Effects of the Fairford Dam

Various studies have been conducted on the effects of the Fairford Dam downstream (Stone, 1963; Manitoba Water Commission, 1973 & 1978; Ducks Unlimited, 1978; Cook and MacKenzie, 1979; Derksen, 1988; Blais, 1996; Ransom, 1996), however, there are no reports directly documenting its effect on Lake St. Martin First Nation.

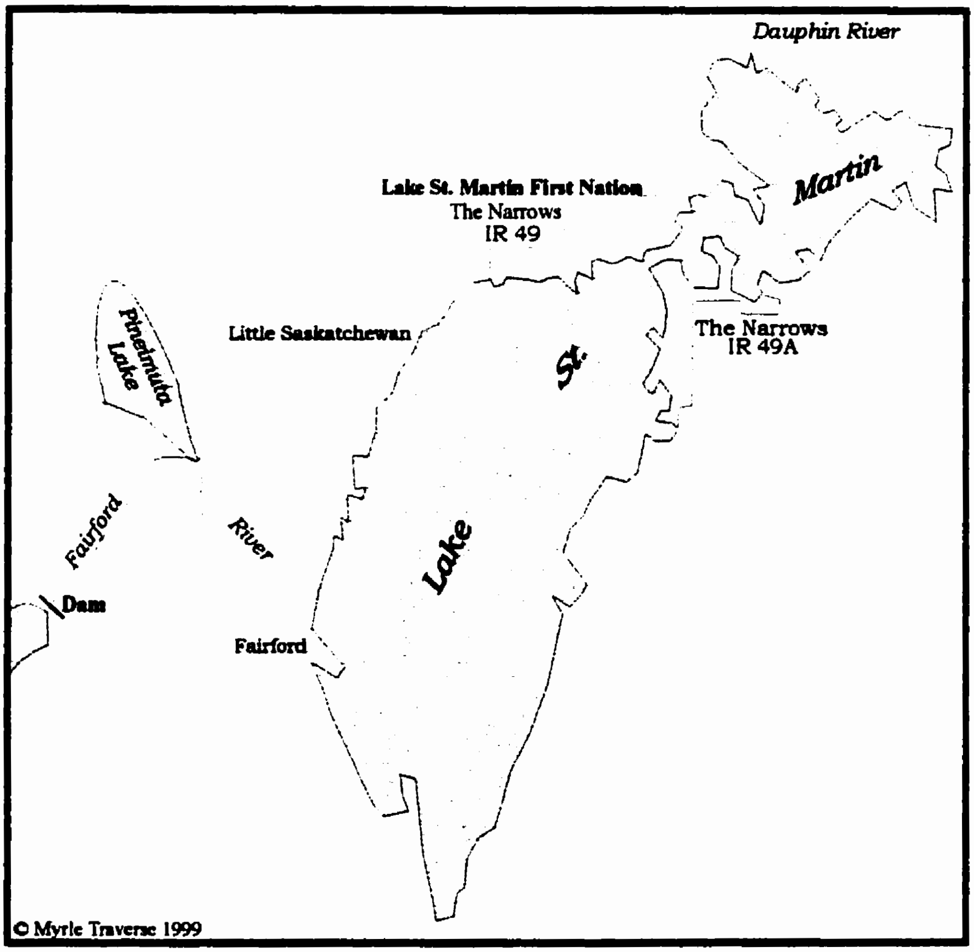


Figure 6: Location of Lake St. Martin First Nation and other First Nation communities downstream from Fairford Dam

3.5.1 Agriculture

After the land around Lake St. Martin and Pineimuta Lake became flooded, the government of Manitoba bought out the affected land and as a result most of it is now Crown land with the exception of First Nations land. The agriculture potential in this area is limited to hay production and grazing. The soils around Pineimuta Lake has some potential for cereal crops if flooding is controlled, however the majority of the area has poor soil and consists of mostly marsh and meadow areas (Manitoba Water Commission, 1978).

3.5.2 Recreation

At the time Manitoba Water Commission (1978) conducted a study, the areas of concern downstream had two provincial wayside facilities, and four campgrounds - two private and two on First Nations land (Manitoba Water Commission, 1978). Low water levels on Lake St. Martin are hazardous to boaters because of exposed and nearly exposed rocks. The great distances from the top of the beach to the water hampers boat launching. Low water levels also promote algae bloom and renders the water unsuitable for swimming (Stone, 1963).

3.5.3 Fishing

Lake St. Martin has been fished commercially since 1922 (Stone, 1963; Manitoba Water Commission, 1978). The species composition of the fish has varied but the change cannot be correlated to the changes in water levels. One impact the Fairford Dam attributed to was the closure of the Dauphin River hatchery, which resulted in the loss of whitefish eggs caused by poor water quality and low dissolved oxygen (Doan, 1977). Oxygen became depleted when flows in the Dauphin River became negligible. There was also considerable wastage of fish in northern Lake St. Martin when nets became frozen under the ice as lake water levels dropped (Doan, 1977).

3.5.4 Wildlife

Pineimuta Lake and its adjacent wetlands are suited to the production of waterfowl with limiting factors being the excessive water level fluctuations which adversely affect the habitat or the nesting success of waterfowl (Ducks Unlimited, 1978). Other wildlife found in the area include mink, coyote, fox, timber wolf, black bear, deer, moose, and other birds beside waterfowl (Ransom, 1996). Muskrat and waterfowl are compatible, therefore, if muskrat numbers decrease, waterfowl numbers also decrease.

The period between 1972-1974 showed waterfowl production to be exceptionally low. Although the area had the capacity to produce 5000 ducks per year, fewer than 200 young were actually being produced (Ducks Unlimited, 1978). The same was true for muskrat numbers. Results of biological investigations revealed that the decreased wildlife production was the result of frequent and severe water level fluctuations during the waterfowl nesting and muskrat reproduction and wintering seasons (Ducks Unlimited, 1978).

As a result of the fluctuation in the water levels, a negative impact on wildlife reproduction in many populations occurs during wet seasons. This has resulted in diminished First Nations traditional methods of supplementing food and income through hunting and trapping (Ransom, 1996).

CHAPTER 4

HYDROLOGIC ANALYSIS OF LAKE ST. MARTIN FLOODING

4.1 Introduction

Lake St. Martin has been repeatedly exposed to flooding since the construction of the Fairford Dam in 1961. The Portage Diversion which came into operation in 1970 has only compounded the situation. Three water bodies are situated downstream from Fairford Dam: Fairford River, Lake St. Martin, and Dauphin River. Lake St. Martin is in between the two larger lakes - Lake Manitoba and Lake Winnipeg. Both Lakes Manitoba and Winnipeg are artificially controlled resulting in the excess water to be diverted into Lake St. Martin.

Construction of the Fairford Dam has contributed to the repeated fluctuating water levels on Lake St. Martin, which has invariably altered the water regime and vegetation at Lake St. Martin First Nation. After Portage Diversion started operation in 1970, a hydrologic analysis has determined that it directly affects the water retention capabilities of Lake St. Martin. Neeji Anishinabaag at Lake St. Martin First Nation have always known that the alteration of the water system has detrimentally affected their livelihood and has created a lifestyle of dependency.

Hydrologic analysis on the effects of Portage Diversion and Fairford Dam on Lake St. Martin First Nation is discussed in this chapter. Various statistical techniques are utilized to determine whether or not Portage Diversion affects the water levels at Lake St. Martin First Nation.

4.2 Physical features of Lake St. Martin First Nation

Lake St. Martin First Nation is situated on the Narrows 49 and 49A at Lake St. Martin. One section of the community - Narrows 49A is unoccupied due to the lack of access/linkage across the Narrows. Lake St. Martin consists of two basins totalling approximately 212 square kilometers with approximately 256 kilometers of shoreline. The land contour is 245.36 metres a.s.l. (Manitoba Water Commission, 1978) around the periphery of the lake and rises to 245.67 metres in its adjacent tributaries.

4.3 Background on Portage Diversion

The Portage Diversion is situated near Portage La Prairie. It is an 28.8 kilometre long channel designed to carry up to 42,482,500 L/m (litres per minute) of flood flow from the Assiniboine River into Lake Manitoba (Galay, 1964; Department of Natural Resources, 1980). The channel has widths varying from 53 metres to 366 metres, with an average width of 183 metres. Three concrete drop structure along the route of the channel keep the water velocities below those which would cause erosion.

Water is diverted into the channel by means of a dam and spillway control structures on the Assiniboine River and a gated control structure at the inlet of the diversion channel. Water flow is regulated into the diversion channel by means of four vertical lift gates, each measuring 4.4 metres by 12 metres (Department of Natural Resources, 1980).

The diversion was constructed to alleviate the flood situation in the Assiniboine and Red River Valleys (Kuiper, 1958; Weiss, 1977). Studies in 1951 and 1952 indicated that the most feasible method of mitigating the threat of flood from the Assiniboine River was to construct a diversion channel from the Assiniboine River near Portage La Prairie north to Lake Manitoba. If water flow had been diverted from the Assiniboine River, flooding would not have been as serious in Winnipeg during the flood of 1948 (Patterson, 1949). Diversion of the Assiniboine River would also increase the value of the Dauphin River power site (Patterson, 1949). The construction of dykes along Assiniboine River were found to be detrimental and expensive to the City of Winnipeg (Weiss,1977).

Portage Diversion was completed and has been in operation since 1970 (Weiss, 1977). No formal operational procedures have been adopted for Portage Diversion. However, a general operational policy is followed yearly depending on the Assiniboine River water levels (Department of Natural Resources, 1980). Operation of the diversion over the winter and spring period are subjected to ice conditions on the Assiniboine River downstream of the control structure. Flow on the river is maintained below 8,496,500 L/m and the remaining flow is diverted into Lake Manitoba to prevent the possibility of ice jams. Once ice had cleared downstream, a flow of less than 16,993,000 L/m are maintained on the river and the rest diverted (Department of Natural Resources, 1980).

4.4 Background on Lake Manitoba

In 1904, minor channel improvements were undertaken in the Fairford River to limit maximum water levels on Lake Manitoba (Kuiper; 1958, Manitoba Water Commission, 1973). During the 1920's and early 1930's the Lake Manitoba water elevation was subject to a natural variation from a maximum mean monthly elevation of 248.1 metres a.s.l. between 1923 and 1925 to a minimum mean monthly elevation of 247.0 metres a.s.l. in 1932 and 1933 (Manitoba

Water Commission, 1973). A control structure was built on the Fairford River in 1934 to minimize the fluctuation of water levels on Lake Manitoba during the preceding years.

A study done between 1956 and 1958 by the Lakes Winnipeg and Manitoba Board evaluated flood damages around Lake Manitoba. The Board recommended the construction of a new control structure at the outlet of Lake Manitoba in the Fairford River (Manitoba Water Commission, 1973). The vast area of Lake Manitoba made available natural facilities for substantial storage during periods of high runoff, and in consequence, the inadequate withdrawal of these excessive amounts gave rise to high water levels during periods of abnormal runoff (Wu, 1955).

The channel enlargement was designed so that the recorded natural Lake Manitoba range of 246.98 - 248.66 metres (Kuiper, 1958) would be reduced to an artificial range of 247.19 - 247.80 metres (Kuiper, 1958; Manitoba Water Commission, 1973). Figure 7 illustrates the natural water levels on Lake Manitoba up to 1960, and the regulated water levels after 1960. The water levels are higher since the Portage Diversion has been in operation (1970), than what was originally projected to be when Fairford Dam was constructed. The regulation of Lake Manitoba consequently affected the water levels at Lake St. Martin. Figure 8 shows that the water levels are much higher since the operation of the Portage Diversion.

Regulation of Lake Manitoba was also meant to create additional benefits by the removal of destructive effects of extreme low water conditions. Shore based industries, farmers, commercial fishermen and recreational users of Lake Manitoba all benefited from regulated water levels (Weiss, 1977; Hobbs & Associates Ltd., 1992). It had been estimated that a positive benefit-to-cost net value of $67 million resulted from Lake Manitoba Regulation Project (Hobbs

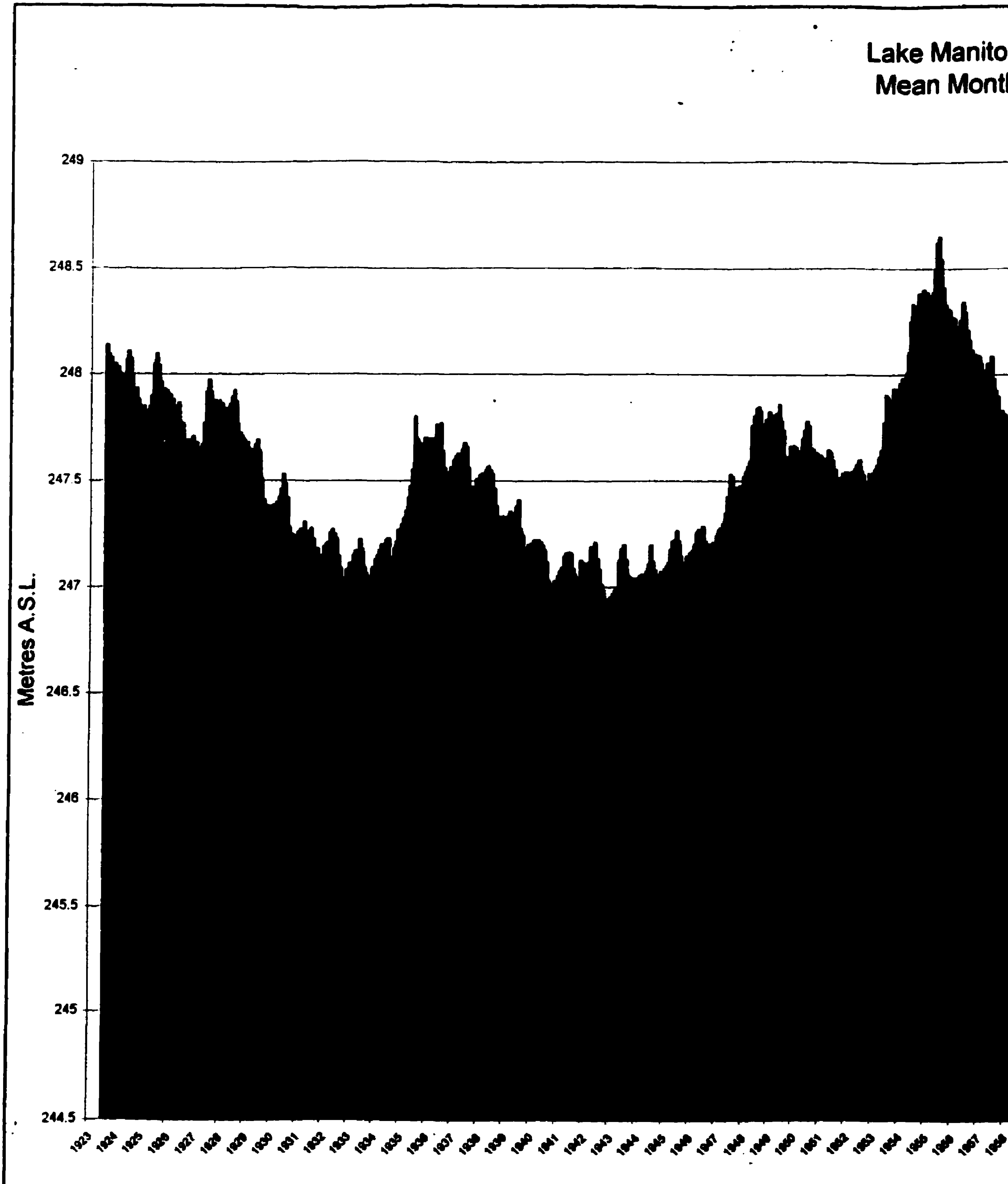
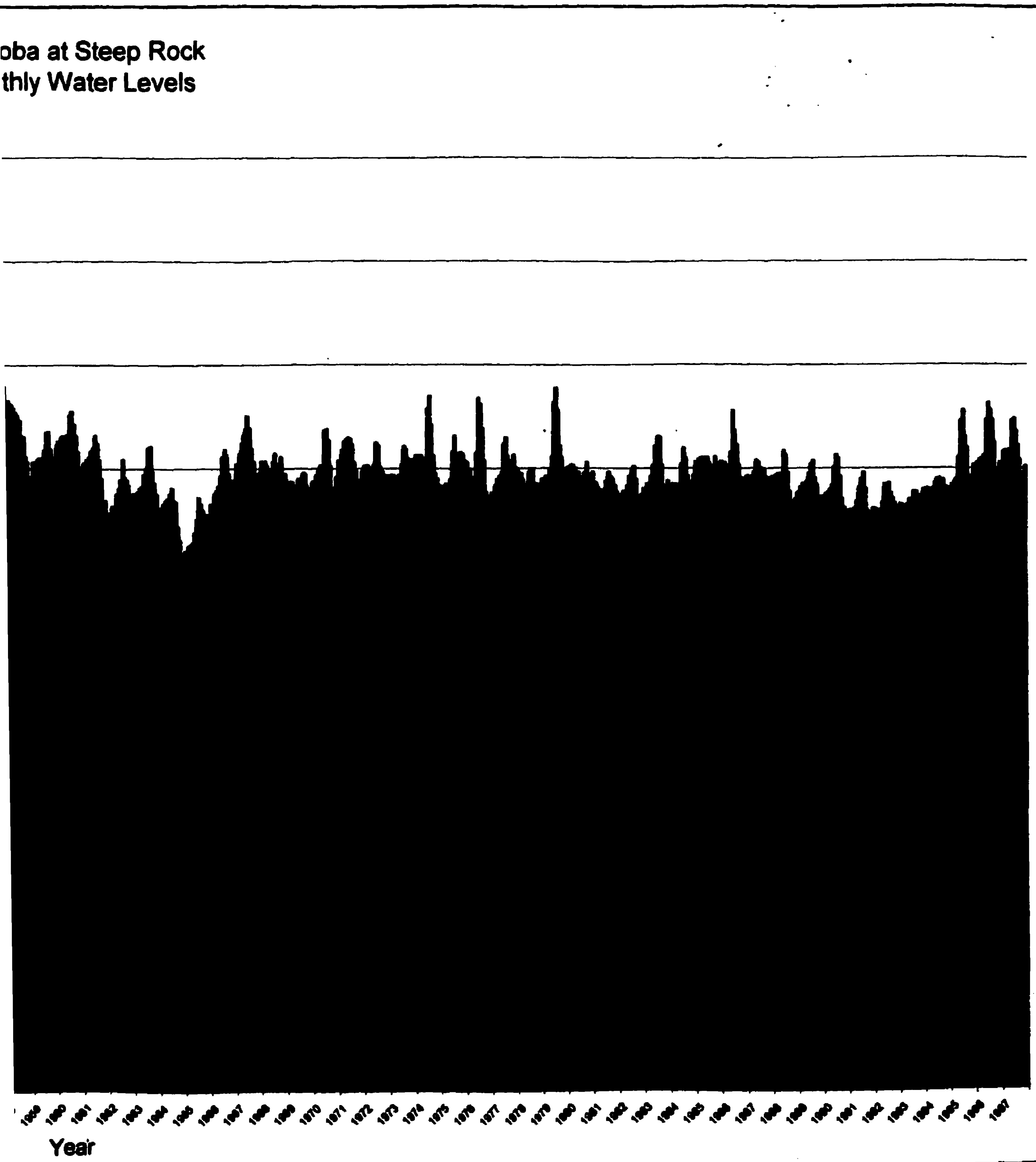


Figure 7: Historical water levels in Lake Manitoba from 1923-1997.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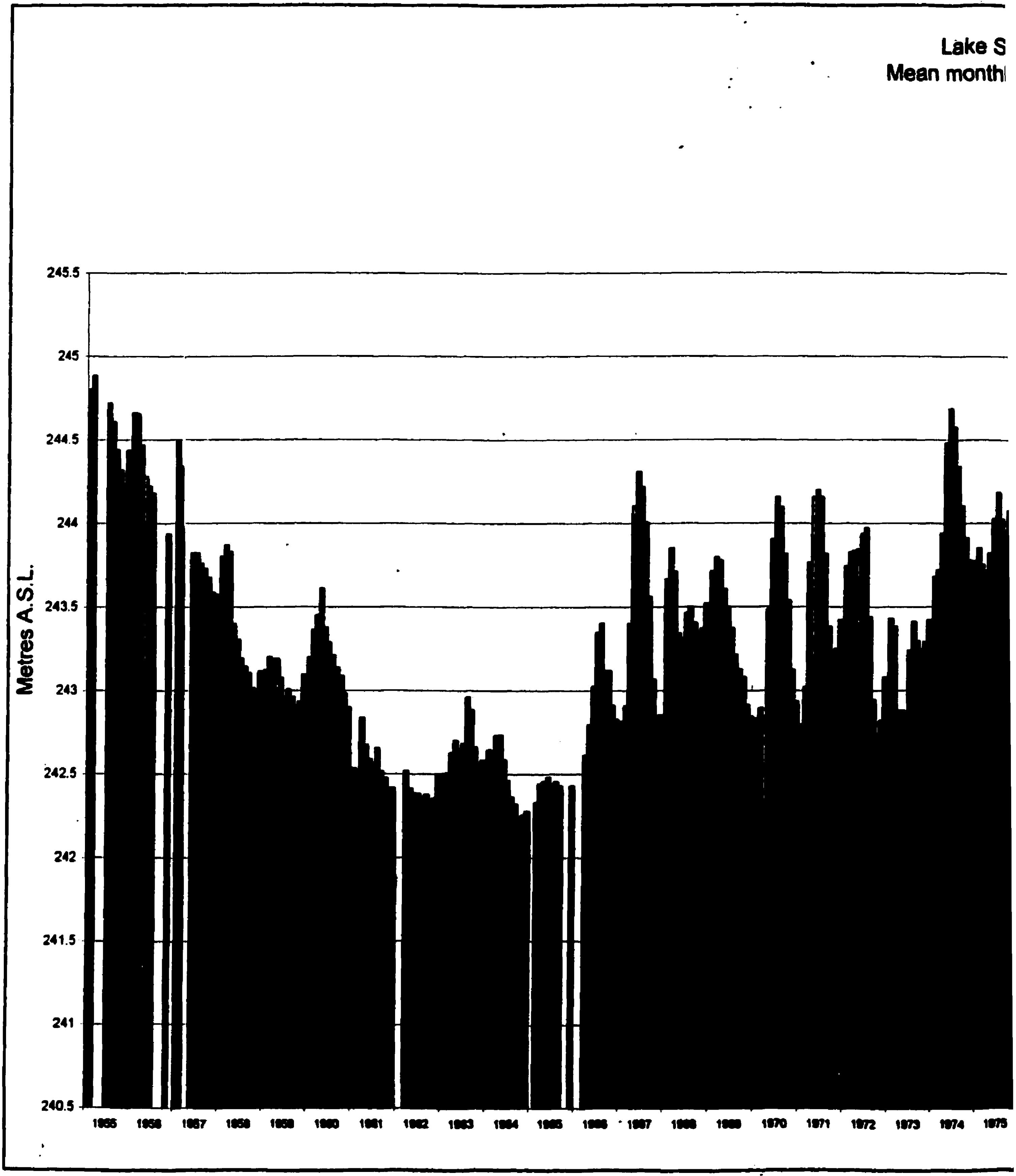
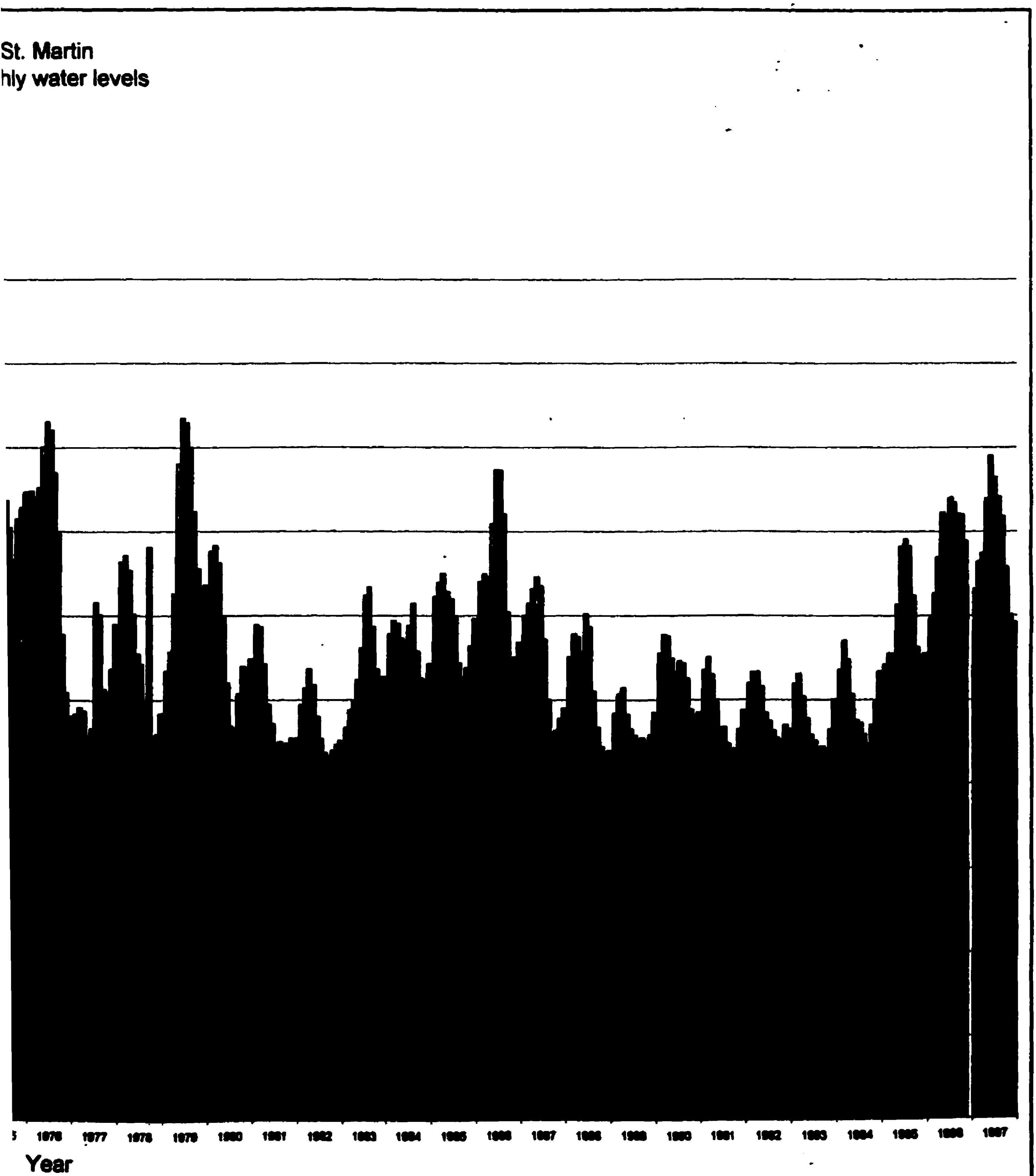


Figure 8: Historical water levels in Lake St. Martin from 1955-1997.


St. Martin
hly water levels
Year

& Associates Ltd., 1992).

Recreational use of beaches was one of the factors which influenced regulation of Lake Manitoba. Cottage owners complained of unattractive beaches when water levels were low on Lake Manitoba. Farmers also complained of dried up marsh lands when water levels were low, since it allowed the growth of weeds which spread onto cultivated fields. Losses in hay production also resulted due to lowering of the water table. When lake levels were too high, vast areas of meadows and pastures were flooded resulting in losses in production (Weiss, 1977). Farmers enjoyed benefits which resulted from the regulation of water levels (Kuiper, 1958).

The mode of regulation, however, did not fully consider the impact on downstream users (Manitoba Water Commission, 1973). Regulation of Lake Manitoba water levels reduced its frequency of high water levels, but increased the frequency of high outflows and high water levels on Lake St. Martin and Pineimuta Lake. The downstream lakes also experienced low water levels when outflows from Lake Manitoba were reduced when they were below target level (Blais, 1996).

4.5 Background on Lake Winnipeg

Lake St. Martin is located upstream from Lake Winnipeg and is connected by Dauphin River. A study conducted by Kuiper (1958), indicated that regulating Lake Manitoba would at times cause a slight increase in the level of Lake Winnipeg. During the preceding 40-year period of the study, water levels at Lake Winnipeg would have increased by 2.54 centimetres in three years. The effect was considered minute that they were not taken into consideration (Kuiper, 1958). Other development projects such as the revised Winnipeg River regulation, the South

Saskatchewan River Project, and the Grand Rapids or Dauphin River power development[4] were being developed so they would have a regulating effect upon the inflows to Lake Winnipeg and reduce its maximum levels by several inches (Kuiper, 1958).

4.6 Analysis

Various experiments were performed using regression analysis to determine whether or not the Portage Diversion had a role in the increased water levels flowing through the Fairford Dam and into Lake St. Martin. These experiments are discussed in detail in sections 4.6.3, 4.6.4, and 4.6.5.

Analysis was done to test the hypothesis that the Lake St. Martin water levels are affected by the construction of water control structures, and to determine the relationship of the water systems on Lake St. Martin. The objectives were to determine the pre- and post-diversion effects on the water levels at Lake St. Martin, and to determine the impact of water fluctuations and trends on Lake St. Martin First Nation.

Historical water levels are also shown in Figures 7 and 8 showing Lake Manitoba and Lake St. Martin. Figure 7 shows that the water levels have increased after the construction of the Fairford Dam. There are also higher water levels after the Portage Diversion came into operation. Figure 8 shows the water levels at Lake St. Martin are much higher after the water control systems were in operation.

Figures 7 and 8 depict variability changes within the two time periods. The water levels

[4] The Fairford River Dam project and Dauphin River Power Development were both considered, but the former prevailed.

are slightly higher after Portage Diversion for Lake Manitoba and Lake St. Martin. The changes in water level are subtle. The subtleties are not significant according to the results revealed in statistical tests, however the changes do impact First Nations perspectives as discussed in Chapter 5.

4.6.1 Regression Analysis

Regression analysis is a statistical tool for evaluating the relationship of one or more independent variables $X_1, X_2, \ldots, X_k$ to a single continuous dependent variable Y. It is most often used when the independent variables are not controllable, as when collected in a sample survey or other observational study. Nevertheless, it is equally applicable to more controlled experimental situations (Kleinbaum & Kupper, 1978:34).

Regression analysis was used to show the character of water level change over time in the different water bodies. Regression analysis defines the relationship between the dependent variable - Lake St. Martin water elevation and the independent variables - Assiniboine River, Lake Manitoba, and Lake Winnipeg water elevations. The water levels for the periods 1955-1997 represented the variables which were used in the calculations. The physical data is available at Native Studies Department, University of Manitoba. Linear regression analysis was performed (Heizer & Render, 1991) using a spreadsheet software.

4.6.2 Data Input

The monthly water level means from each site were entered into a spreadsheet and divided into two groups from 1955-1970 and 1970-1998 to represent Pre-Portage Diversion and Post-Portage Diversion respectively (Appendix B and C).

Regression analysis was performed and summary outputs were obtained as shown in Appendix B and C. Regression analyses were performed on pre-Portage Diversion and post-Portage Diversion to determine whether the dependent variable (Lake St. Martin) was affected by the independent variable (e.g. Assiniboine River). Relationships developed from this experiment are shown in Figures 9, 10, 11, 12, 13, and 14 and are discussed in detail in sections 4.6.3., 4.6.4, and 4.6.5.

Regression analysis was also performed and summary outputs are shown in Figures 15, 16, 17, 18, 19, and 20. Comparative graphs were then generated and shown in Figures 21, 22, and 23. The experiments depicting Figures 21, 22, and 23, were performed to determine whether or not the operation of the Portage Diversion had a role in the flooding on Lake St. Martin.

Mathematical relationships were obtained from each set of regression summary outputs and were combined to obtain comparisons between Pre-Portage Diversion and Post-Portage Diversion relationships. Sample calculations shown in Tables 1, 2, and 3 were used to obtain Figures 21, 22, and 23. A detailed sample calculation of Table 1 is shown in Appendix D.

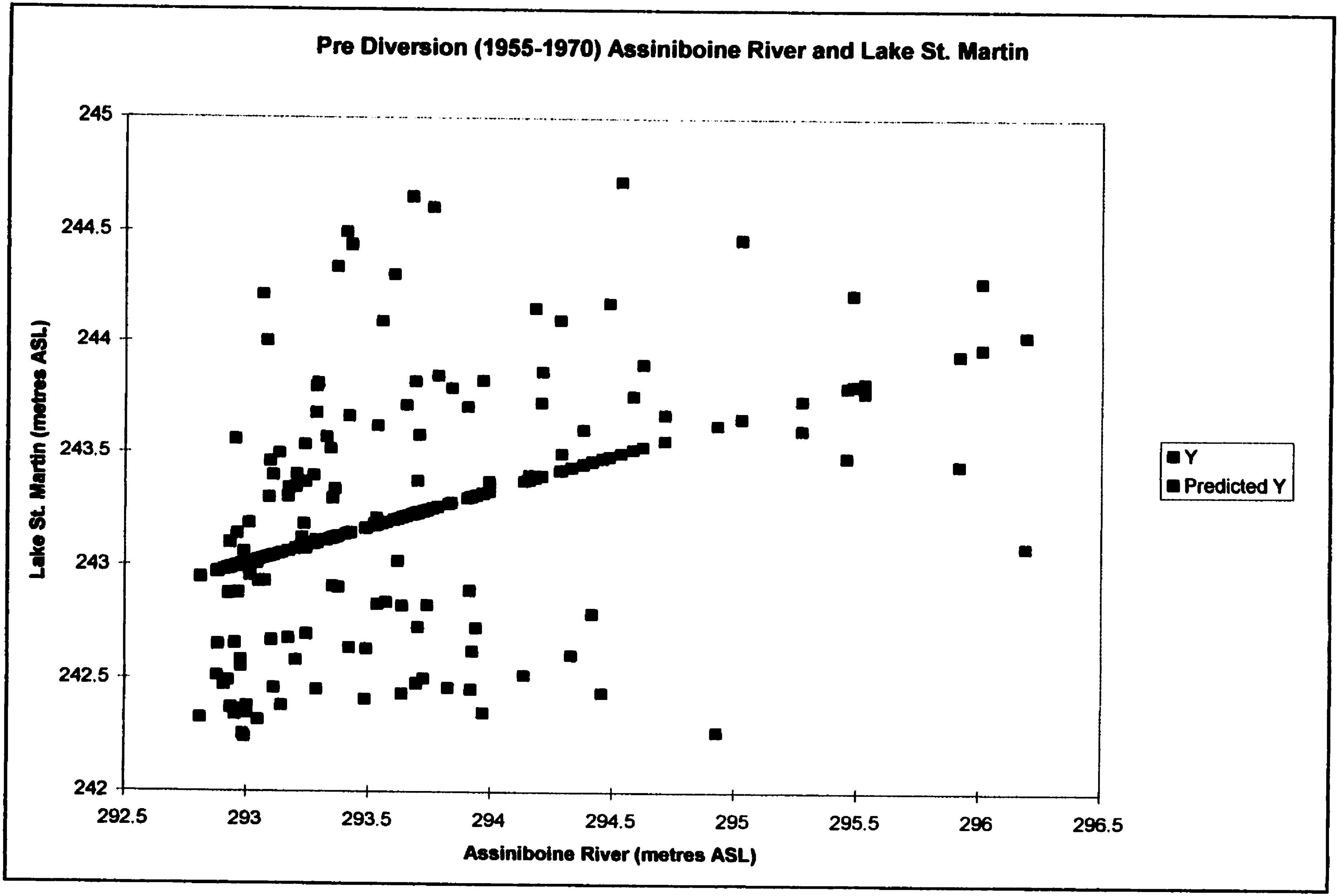


Figure 9: Pre-Diversion - Assiniboine River and Lake St. Martin.

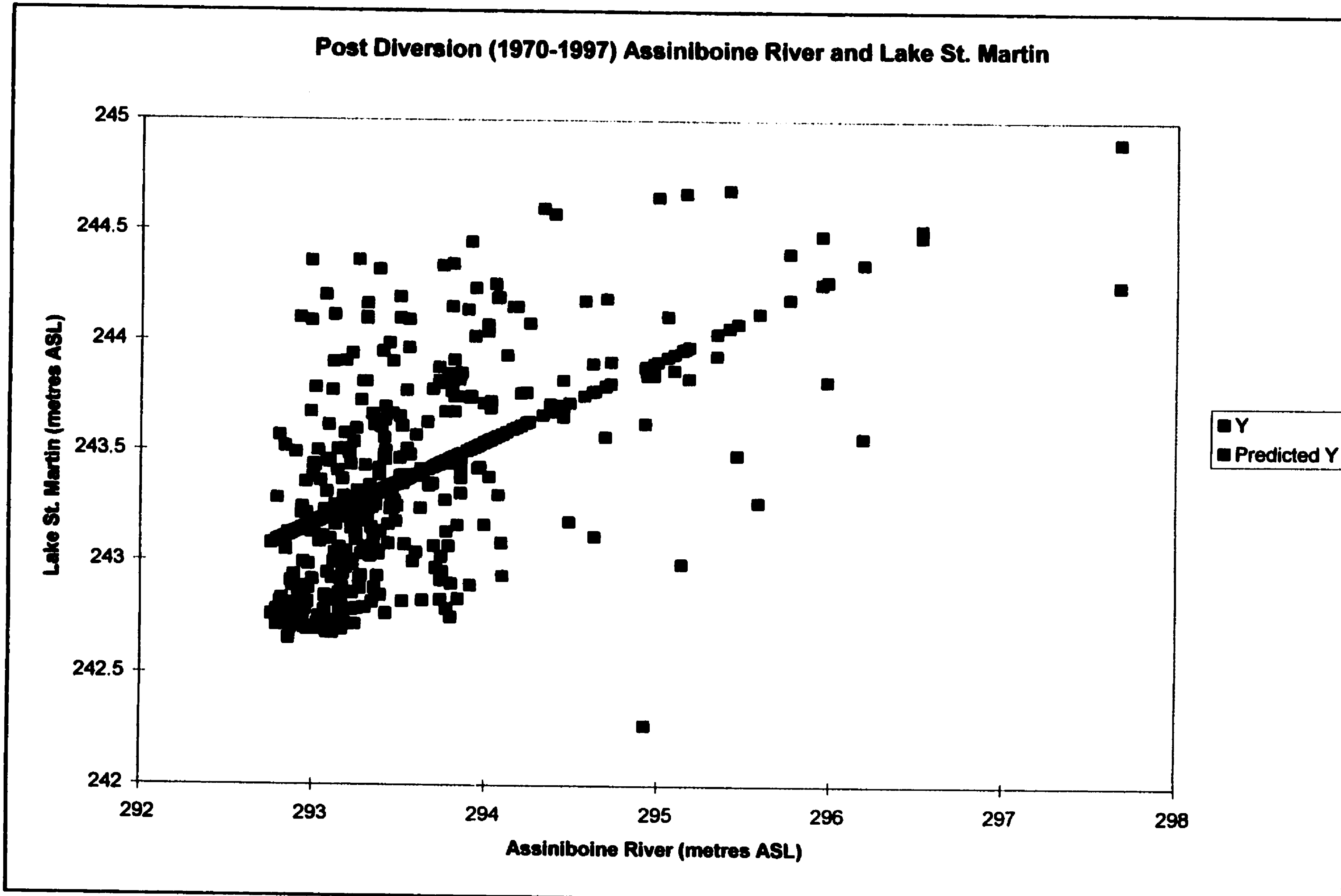


Figure 10: Post-Diversion - Assiniboine River and Lake St. Martin.

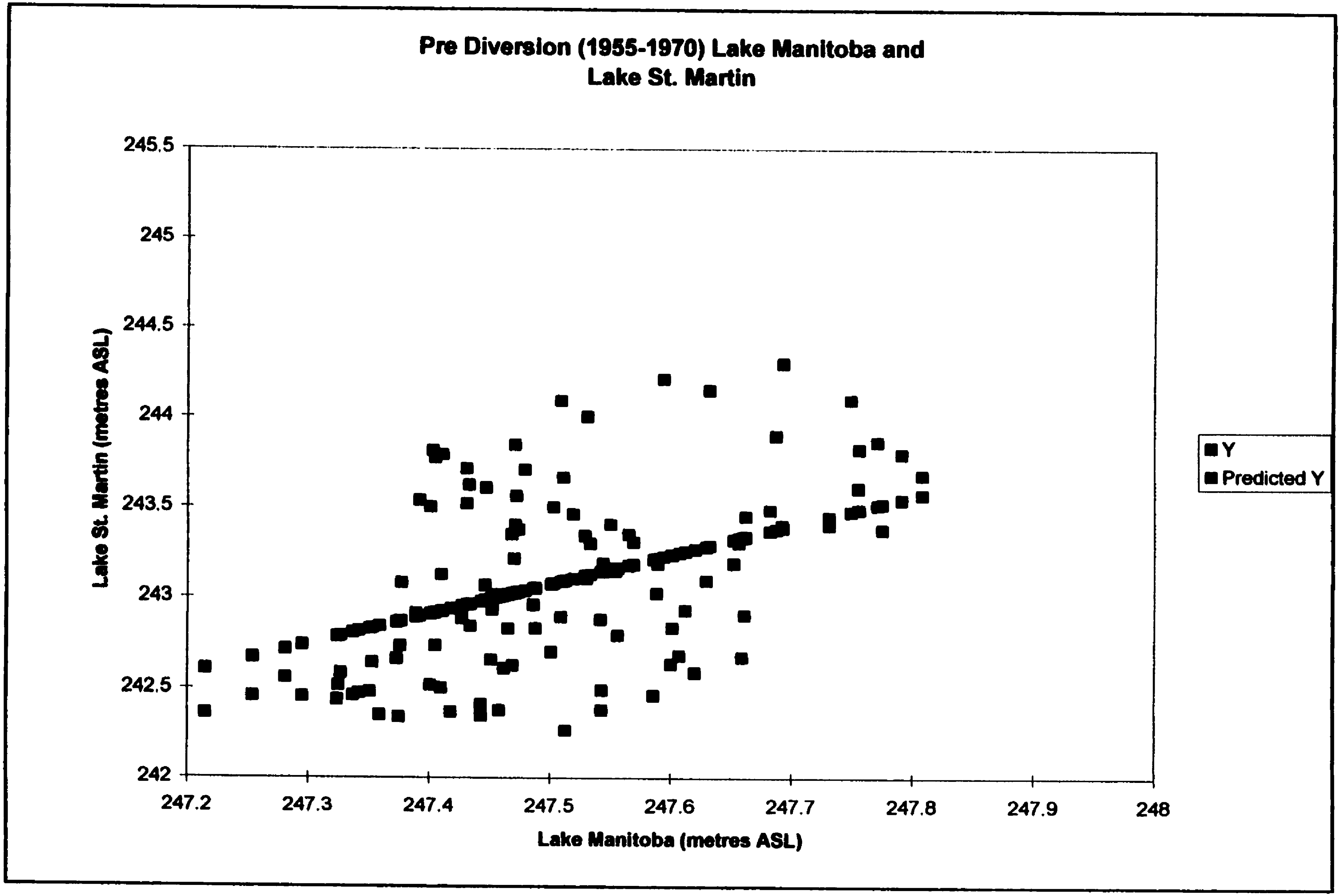


Figure 11: Pre-Diversion - Lake Manitoba and Lake St. Martin.

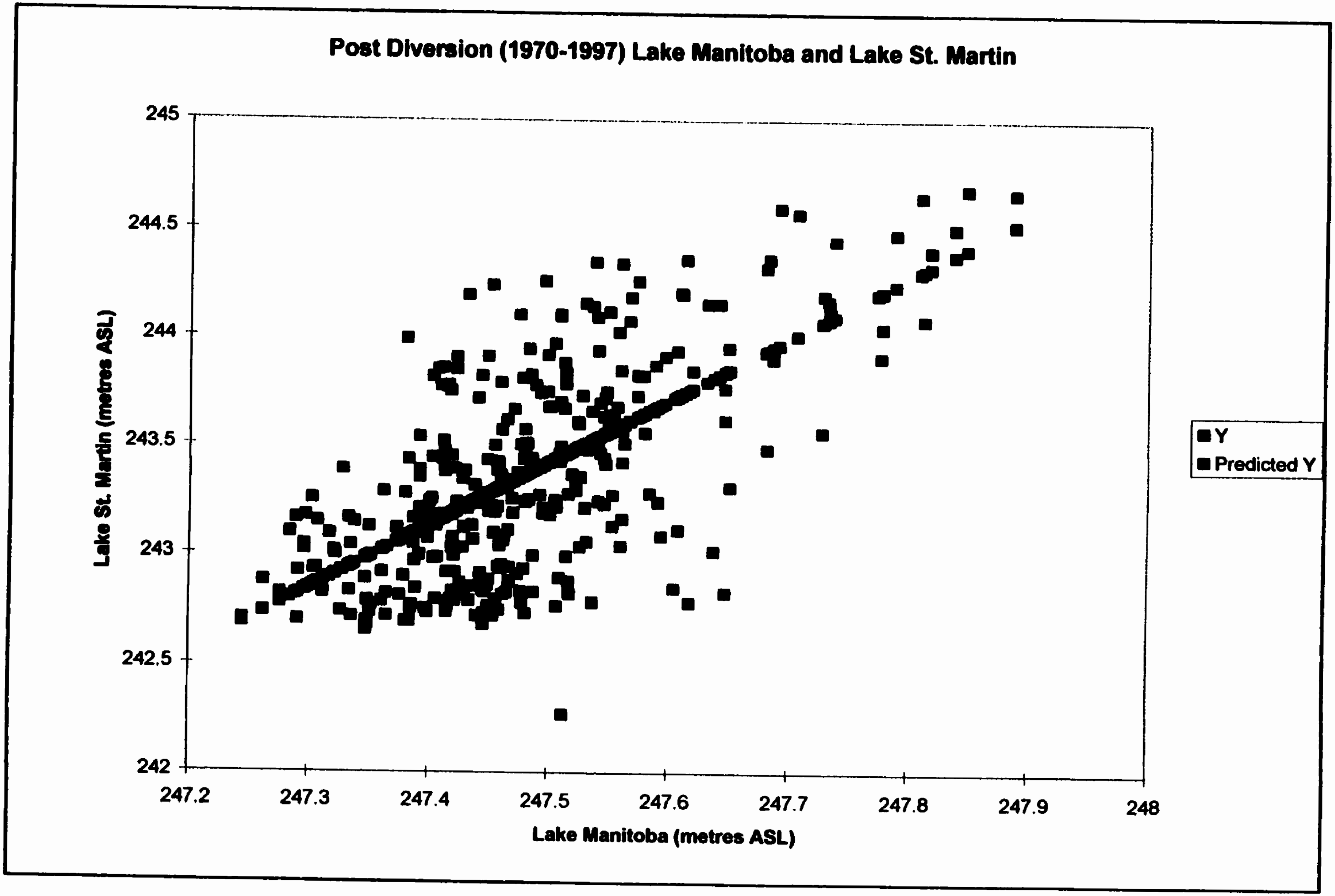


Figure 12: Post-Diversion - Lake Manitoba and Lake St. Martin.

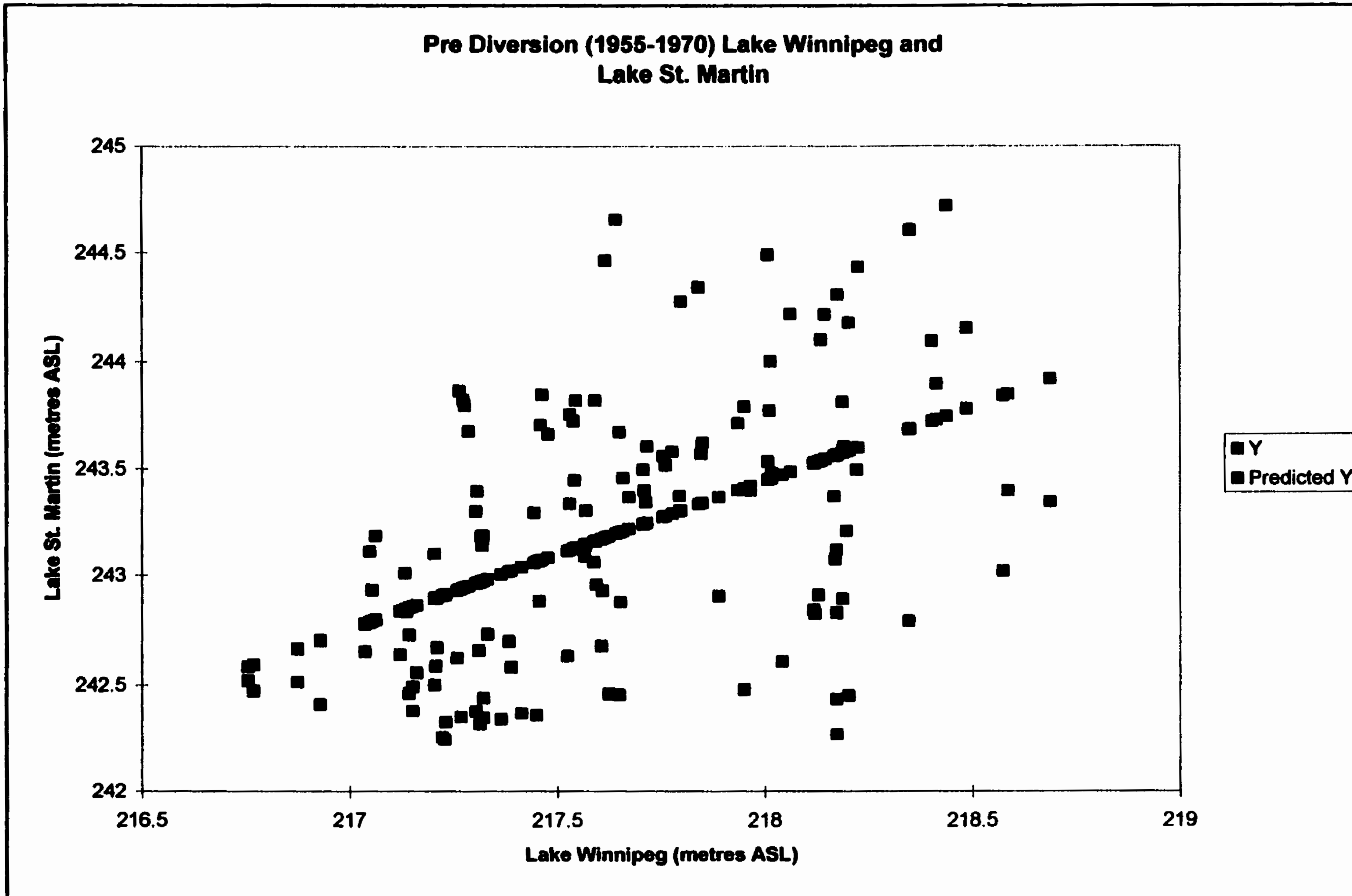


Figure 13: Pre-Diversion - Lake Winnipeg and Lake St. Martin.

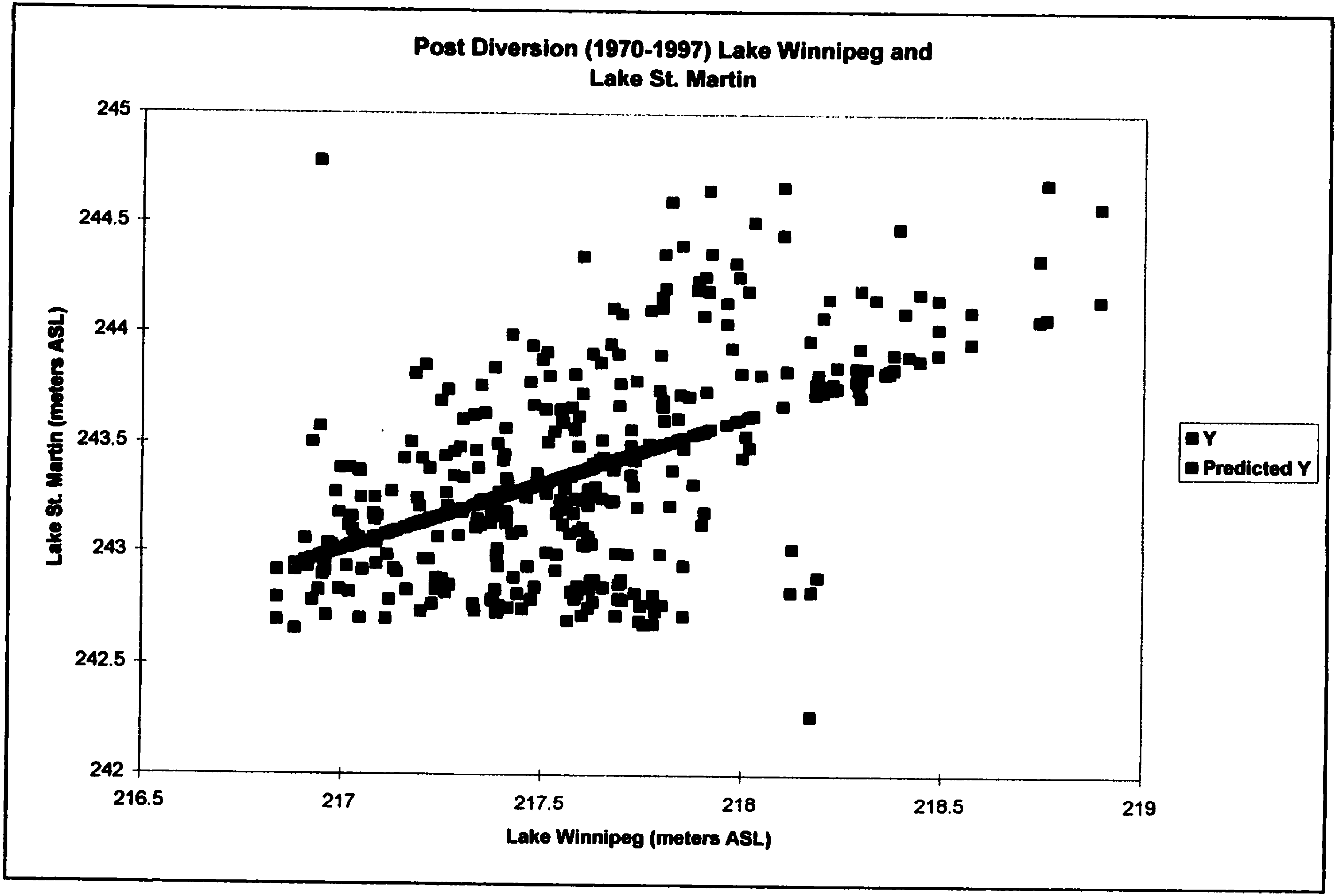


Figure 14: Post-Diversion - Lake Winnipeg and Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.355647
R Square	0.126485
Adjusted R	0.119325
Standard E	0.601281
Observatio	124

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	6.386782	6.386782	17.66553	5.04E-05
Residual	122	44.10778	0.361539		
Total	123	50.49456			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	149.3653	22.32779	6.689661	7.18E-10	105.1652	193.5654	105.1652	193.5654
X Variable	0.319606	0.076042	4.203038	5.04E-05	0.169074	0.470137	0.169074	0.470137

RESIDUAL OUTPUT

ObservatioPredicted Y		*Residuals*
1	243.4991	1.219939
2	243.2526	1.351354
3	243.1456	1.290422
4	243.2255	1.425521
5	243.6569	0.807053
6	243.9718	0.303242
7	243.803	0.414994
8	243.4837	0.69328
9	243.1389	1.353134
10	243.127	1.212959
11	243.2293	0.589686
12	243.2293	0.589686
13	243.5147	0.239278
14	243.3949	0.32913
15	243.5563	0.115729
16	243.2351	0.343933
17	243.1133	0.455702
18	243.1002	0.576806
19	243.1002	0.695806
20	243.3958	0.469171

Figure 15: Summary output for Pre-Portage Diversion - Assiniboine River & Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.518128
R Square	0.268456
Adjusted R	0.266096
Standard E	0.419775
Observatio	312

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	20.04599	20.04599	113.7614	7.85E-23
Residual	310	54.62536	0.176211		
Total	311	74.67136			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	133.627	10.28849	12.988	4.29E-31	113.3828	153.8711	113.3828	153.8711
X Variable	0.373831	0.035049	10.6659	7.85E-23	0.304867	0.442796	0.304867	0.442796

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*
1	243.3973	-0.572333
2	243.4358	-0.607837
3	243.5005	-0.60851
4	243.8803	-1.613323
5	244.0785	-0.596454
6	243.7652	0.132817
7	243.5999	0.554051
8	243.3663	0.726695
9	243.2672	0.545761
10	243.2478	0.2872
11	243.4373	-0.420333
12	243.6089	0.152079
13	243.591	0.563022
14	243.5607	0.636303
15	243.4586	0.695359
16	243.274	0.539032
17	243.1599	0.21705
18	243.2672	-0.036239
19	243.3416	-0.096632
20	243.5166	-0.097585

Figure 16: Summary output for Post-Portage Diversion - Assiniboine River & Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.741234
R Square	0.549428
Adjusted R	0.545735
Standard E	0.431841
Observatio	124

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	27.74314	27.74314	148.7671	7.32E-23
Residual	122	22.75142	0.186487		
Total	123	50.49456			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*lpper 95.0%*
Intercept	-159.8391	33.04489	-4.837028	3.89E-06	-225.2548	-94.42336	-225.2548	-94.42336
X Variable	1.62791	0.133468	12.19701	7.32E-23	1.363697	1.892123	1.363697	1.892123

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	244.9326	-0.213582
2	244.76	-0.156023
3	244.5484	-0.112395
4	244.244	0.407024
5	244.187	0.277001
6	244.2977	-0.022697
7	244.4344	-0.216441
8	244.3596	-0.182558
9	244.1382	0.353838
10	244.0649	0.275094
11	244.0177	-0.198697
12	243.9607	-0.14172
13	243.9021	-0.148115
14	243.9103	-0.186254
15	243.9542	-0.282208
16	243.9656	-0.386603
17	244.0128	-0.443813
18	243.57	0.106979
19	243.5423	0.253653
20	243.5098	0.355211

Figure 17: Summary output for Pre-Portage Diversion - Lake Manitoba & Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.648121
R Square	0.420061
Adjusted R	0.41819
Standard E	0.373755
Observatio	312

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	31.36652	31.36652	224.539	1.47E-38
Residual	310	43.30483	0.139693		
Total	311	74.67136			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-461.736	47.05482	-9.812725	5.7E-20	-554.3232	-369.1487	-554.3232	-369.1487
X Variable	2.849095	0.190135	14.98462	1.47E-38	2.474978	3.223213	2.474978	3.223213

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	243.3154	-0.490445
2	243.381	-0.552974
3	243.4408	-0.548805
4	243.4522	-1.185201
5	243.9337	-0.451699
6	243.9479	-0.049944
7	243.7912	0.362756
8	243.4408	0.652195
9	243.1388	0.674199
10	243.1075	0.427539
11	243.8083	-0.791338
12	243.834	-0.07298
13	243.8197	0.334265
14	243.7314	0.465587
15	243.5006	0.653364
16	243.3724	0.440573
17	243.2157	0.161274
18	243.2442	-0.013217
19	243.3667	-0.121729
20	243.4408	-0.021805

Figure 18: Summary output for Post-Portage Diversion - Lake Manitoba & Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.4733
R Square	0.224013
Adjusted R	0.217652
Standard E	0.566721
Observatio	124

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	11.31143	11.31143	35.21909	2.83E-08
Residual	122	39.18314	0.321173		
Total	123	50.49456			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*.ower 95.0%*	*Jpper 95.0%*
Intercept	92.45788	25.40236	3.639735	0.000401	42.17132	142.7444	42.17132	142.7444
X Variable	0.692599	0.116706	5.934567	2.83E-08	0.461568	0.92363	0.461568	0.92363

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*
1	243.7478	0.971192
2	243.6869	0.917141
3	243.6003	0.835716
4	243.1965	1.454501
5	243.1778	1.286201
6	243.3045	0.970456
7	243.4881	0.729917
8	243.585	0.591953
9	243.45	1.04201
10	243.3343	1.005674
11	243.1612	0.657824
12	243.1293	0.689683
13	243.1189	0.635072
14	243.1252	0.598839
15	243.2013	0.470653
16	243.29	0.289
17	243.3385	0.230518
18	242.9499	0.727066
19	242.9437	0.8523
20	242.9347	0.930304

Figure 19: Summary output for Pre-Portage Diversion - Lake Winnipeg & Lake St. Martin.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.506316
R Square	0.256356
Adjusted R	0.253957
Standard E	0.423232
Observatio	312

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	19.14243	19.14243	106.8659	1.02E-21
Residual	310	55.52893	0.179126		
Total	311	74.67136			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	112.5267	12.65634	8.890936	5.09E-17	87.62353	137.4299	87.62353	137.4299
X Variable	0.601317	0.058168	10.3376	1.02E-21	0.486863	0.715771	0.486863	0.715771

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	243.6867	-0.861658
2	243.7179	-0.889926
3	243.7269	-0.834946
4	243.7179	-1.450926
5	243.6241	-0.142121
6	243.8628	0.035156
7	243.9067	0.24726
8	243.8568	0.236169
9	243.7269	0.086054
10	243.6187	-0.083709
11	243.6885	-0.671462
12	243.7432	0.017818
13	243.8129	0.341066
14	243.7913	0.405713
15	243.7432	0.410818
16	243.641	0.172042
17	243.5087	-0.131668
18	243.4173	-0.186268
19	243.4028	-0.157836
20	243.4521	-0.033144

Figure 20: Summary output for Post-Portage Diversion - Lake Winnipeg & Lake St. Martin.

Table 1: Sample calculation of comparative relationships between water levels at Assiniboine River and Lake St. Martin.

	y1	y2
292	242.690252	242.785652
292.5	242.850055	242.9725675
293	243.009858	243.159483
293.5	243.169661	243.3463985
294	243.329464	243.533314
294.5	243.489267	243.7202295
295	243.64907	243.907145
295.5	243.808873	244.0940605
296	243.968676	244.280976
296.5	244.128479	244.4678915
297	244.288282	244.654807
297.5	244.448085	244.8417225
298	244.607888	245.028638
y1 = 149.3653 + .319606 * a2		
y2 = 133.627 + .373831 * a2		

a2 represents cell number in a spreadsheet

Table 2: Sample calculation of comparative relationships between water levels at Lake Manitoba and Lake St. Martin

	y1	y2
246	240.62676	239.14137
246.5	241.440715	240.56592
247	242.25467	241.99047
247.5	243.068625	243.41501
248	243.88258	244.83956
248.5	244.696535	246.26411
249	245.51049	247.68866
y1 = -159.8391 + 1.62791 * a2		
y2 = 461.736 + 2.849095 * a2		

a2 represents cell number in a spreadsheet

Table 3: Sample calculation of comparative relationships between water levels at Lake Winnipeg and Lake St. Martin

	y1	y2
216	242.05926	242.411172
216.5	242.40556	242.711831
217	242.75186	243.012489
217.5	243.09816	243.313148
218	243.44446	243.613806
218.5	243.79076	243.914465
219	244.13706	244.215123
y1 = 92.45788 + .692599 * a2		
y2 = 112.5267 + .601317 * a2		

a2 represents cell number in a spreadsheet

4.6.3 Relationship between Assiniboine River and Lake St. Martin

Regression analysis was performed on data from Appendix B depicting Pre-Portage Diversion conditions. The same experiment was performed for Post-Portage Diversion conditions (Figure 9 and Figure 10). The experiment was conducted to show if the relationship between Assiniboine River water levels and Lake St. Martin water levels were affected by Portage Diversion.

Comparisons of Figure 9 and Figure 10 indicate that there appears to be a relationship between the water levels at Lake St. Martin and Assiniboine River. Figure 10 shows that Portage Diversion has caused the water level in Lake St. Martin to increase. Figure 9 shows lower water levels at Lake St. Martin for the same water level at Assiniboine River than Figure 10. Comparison of the two relationships shown in Figures 9 and 10, seems to indicate that the Assiniboine River being diverted through the Portage Diversion into Lake Manitoba has an effect on Lake St. Martin water levels. However, statistical tests show no difference between water level change at Lake St. Martin before and after Portage Diversion. Despite the results in Figures 9 and 10, the error rate is too high to bring about a significant relationship.

Figure 21 shows the comparative regression relationships between water levels at Assiniboine River and Lake St. Martin for Pre-Diversion and Post-Diversion conditions. This experiment was conducted to determine whether or not the Portage Diversion had an effect on flooding at Lake St. Martin First Nation.

Results from the experiment would indicate that the Portage Diversion directly affects the relationship between water levels at Lake St. Martin and Assiniboine River. Figure 21 shows that Lake St. Martin water levels are approximately 0.5 metre higher for the same water level at Assiniboine River after the Portage Diversion has been in operation.

Prior to the Portage Diversion, Lake St. Martin received water, however the additional water which resulted after the Portage Diversion was in place has caused Lake St. Martin to become more flooded and accumulate more water. Increased transfer of water from the Assiniboine River has caused the water levels at Lake St. Martin to increase.

The results in Figure 21 indicate that there is a great deal of variation in the data which is typical for this type of large scale water system. The type of change occurring is masked, however, the extreme variability in the data. The degree of change occurring is small and variation in data is large. Even though the results are not significant, the subtle changes which are noted are not surprising, and these will be discussed further in Chapter 5.

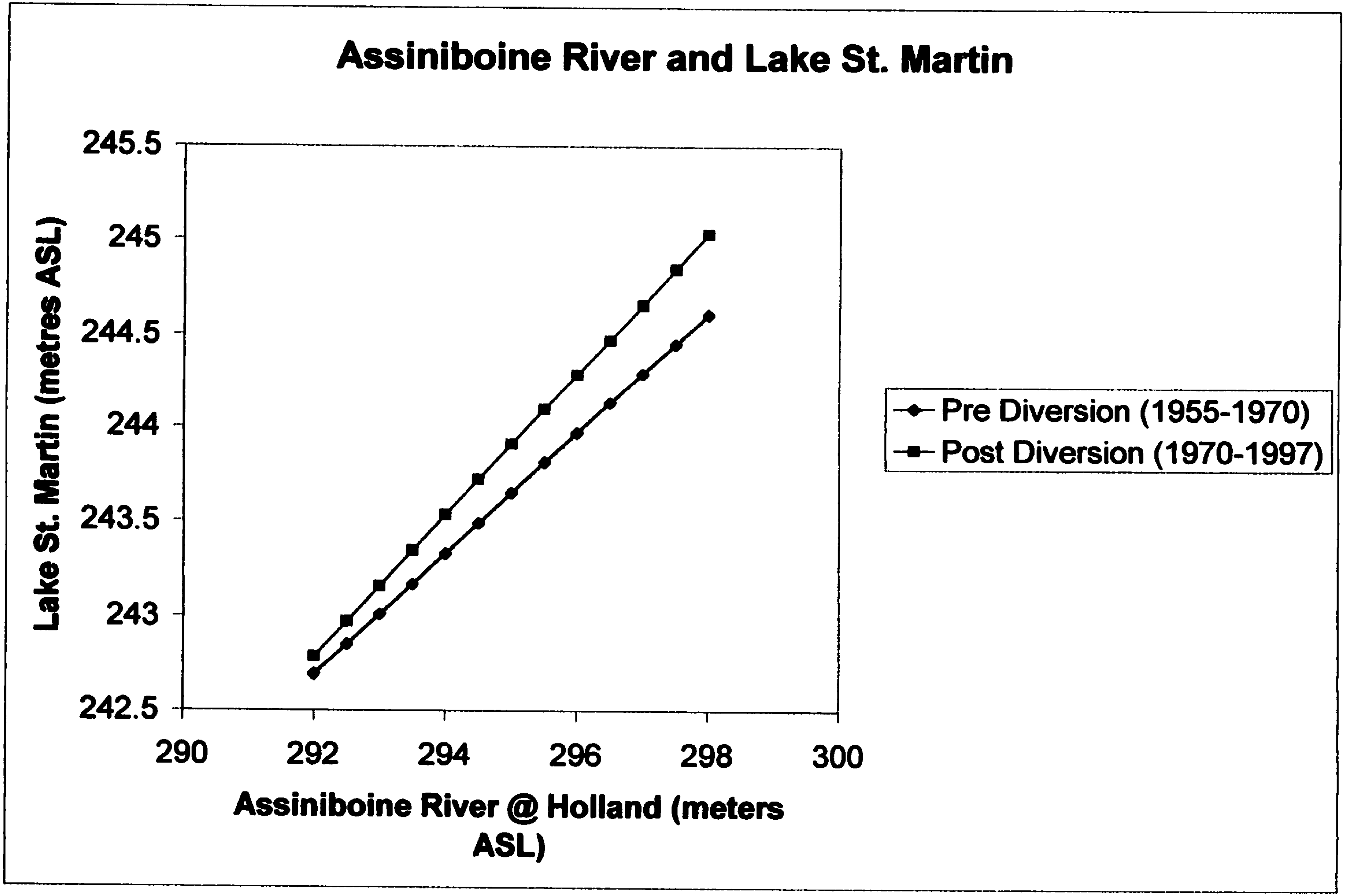


Figure 21: Pre and Post-Diversion - Assiniboine River and Lake St. Martin.

4.6.4 Relationship between Lake Manitoba and Lake St. Martin

Regression analysis was performed on data from Appendix B showing Pre-Portage Diversion water levels (Figure 11). A similar test was conducted for Post Portage Diversion using data from Appendix C for Lake Manitoba and Lake St. Martin (Figure 12). The test was conducted to determine whether the relationship between Lake Manitoba water levels and Lake St. Martin water levels were affected by the Portage Diversion.

Comparison of Figures 11 and 12 show that there is a relationship between Lake St. Martin and Lake Manitoba water levels. Portage Diversion has caused the water levels to increase in Lake St. Martin (Figure 12). Comparison of Figure 11 and 12 shows lower water levels at Lake St. Martin for the same water level on Lake Manitoba before Portage Diversion in Figure 11 than Post-Portage Diversion in Figure 12. Contrasting the two relationships in Figure 11 and 12 show that the water being directed through Portage Diversion and into Lake Manitoba has an effect on Lake St. Martin water levels.

As in the preceding section 4.6.2, the error rate is too high because of data variability for the results in Figures 11 and 12 to be significant. Statistical tests show no difference between water level change at Lake St. Martin before and after Portage Diversion. The experiments show that the slope of the lines could be the same 95% of the time.

Comparative regression relationships are shown in Figure 22 between water levels at Lake Manitoba and Lake St. Martin for Pre-Diversion and Post-Diversion conditions. The experiment was performed to determine whether or not Portage Diversion affected the water levels on Lake St. Martin.

The results from the experiment seem to indicate that after Portage Diversion, water levels have increased on Lake St. Martin. Lake St. Martin water levels shown in Figure 22 are approximately 2.5 metres higher for the same water level at Lake Manitoba after the Portage Diversion has been in operation.

The construction of Portage Diversion created more water to flow through the Fairford Dam from Lake Manitoba causing it to increase water levels on Lake St. Martin. The cross over in the lines indicate that water is being stored up to a certain point on Lake Manitoba. The additional water in the system means additional water in Lake St. Martin. Lake St. Martin is exposed to higher variation in water levels due to control of Lake Manitoba water levels. Lake St. Martin is being sacrificed for the benefit of Lake Manitoba.

There is a relationship between the water levels of Lake Manitoba and Lake St. Martin. The relationship is increased water flowing in from Lake Manitoba through the Fairford Dam into Lake St. Martin which is the result of the Portage Diversion.

The findings for this relationship suggest that there is a great deal of variation in the data, again typical for large scale water systems of this nature. The degree of change in water levels is small and subject to large variations in the data. In this case, the change is subtle and is masked by the extreme variability in data. The results are not significant but the subtle changes are not surprising due to the extensive variations in the data.

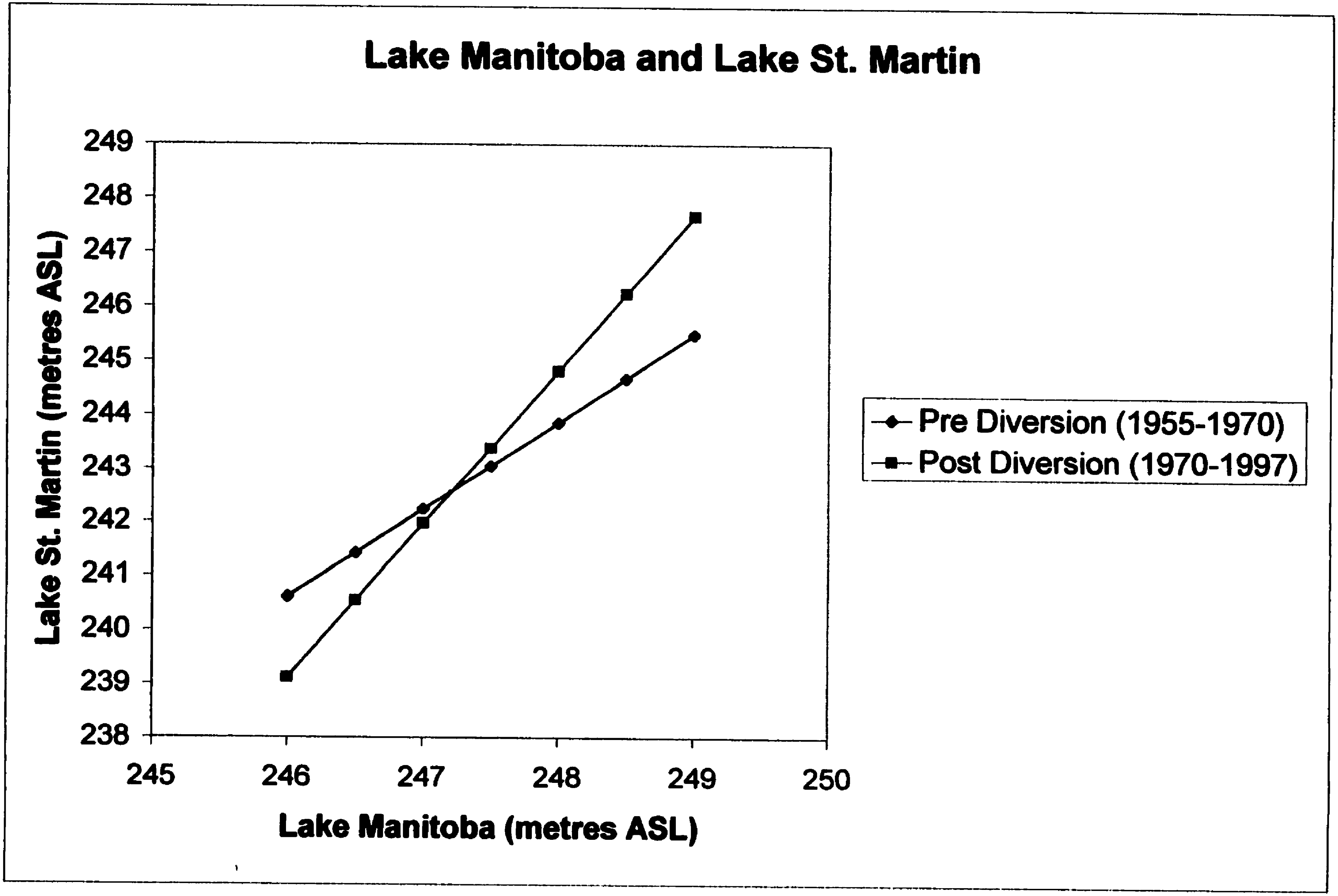


Figure 22: Pre and Post-Diversion - Lake Manitoba and Lake St. Martin.

4.6.5 Relationship between Lake Winnipeg and Lake St. Martin

Regression analyses were performed on data from Appendix B for Lake Winnipeg and Lake St. Martin showing Pre-Portage Diversion conditions. Data from Appendix C was also used for the same experiment depicting Post-Portage Diversion conditions. The experiment was conducted to determine whether or not the relationship between Lake Winnipeg and Lake St. Martin were affected by Portage Diversion.

The results of the tests indicate that there is a slight increase in the water levels in Lake St. Martin resulting from Lake Winnipeg after the construction of Portage Diversion. Figure 13 water levels for Lake St. Martin are much lower at approximately 242.6 metres than in Figure 14 in which the water levels start at approximately 242.9 metres.

The results obtained from this experiment, however, show no difference between water level change at Lake St. Martin before and after Portage Diversion. The results are confounded by the great deal of variation in data for this type of large scale water system.

Figure 13 indicates a slight decrease in the water levels prior to Portage Diversion. Figure 14 shows that the water levels have risen slightly. Comparisons between Figure 13 and Figure 14 indicate that the water level in Lake St. Martin is slightly affected by Lake Winnipeg causing the water levels to increase in Lake St. Martin.

Comparative regression relationships between Lake Winnipeg and Lake St. Martin is shown in Figure 23 for Pre-Portage Diversion and Post-Portage Diversion conditions. The test was initiated to determine whether or not Portage Diversion had an effect on flooding at Lake St. Martin.

Results from the experiment seem to indicate that Portage Diversion affects the relationship between Lake Winnipeg and Lake St. Martin. The results in Figure 23 show that Post Diversion has caused the water levels to increase on Lake St. Martin. However, the results also indicate that despite higher water after Portage Diversion, the levels almost meet. The two lines would eventually cross over indicating at some point the water levels meet and Lake Winnipeg will no longer be able to hold the increased water and Lake St. Martin will be the recipient of the excess water. The additional water that has accumulated in Lake St. Martin from the Assiniboine River has also increased the water level of Lake Winnipeg. Further increase in the water levels on Lake St. Martin will be affected by Lake Winnipeg. Lake St. Martin water levels are affected because it is used as a sink to accommodate the excess water from Lakes Manitoba and Winnipeg.

The types of change occurring in Figure 23 is masked by extreme variability. The degree of change occurring is minimal and variation in data is extensive. Large scale water systems like this one usually have great variations. The results are important because subtle changes for water systems of this nature are able to be observed by local residents even though statistical tests do not show a significant change (see Chapter 5).

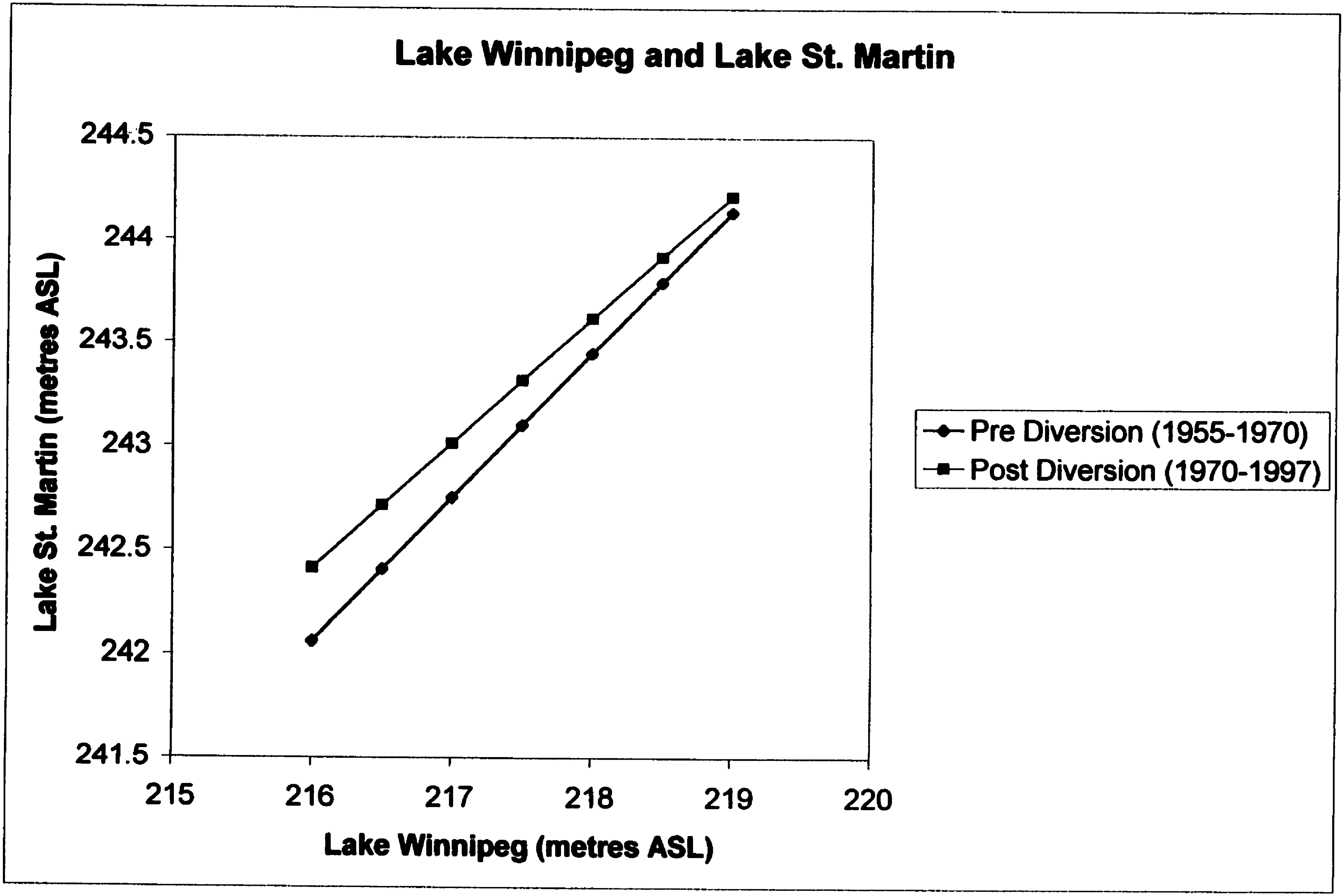


Figure 23: Pre and Post-Diversion - Lake Winnipeg and Lake St. Martin.

4.6.6 Aerial Photo Interpretations

Comparison of the aerial photos taken in 1958 (Figure 24) and 1986 (Figure 25) indicates that water has replaced vegetation in some parts of the shoreline. Comparisons of both photos is made with a red dotted line to focus on the same area in both photos. Figure 25 shows how the middle shore line has decreased. The darkness in Figure 25 shows wetness which indicates water in the area. The area around the Narrows also demonstrates how water has replaced vegetation. What was once a creek has now been engulfed by permanent water. Moving eastward past the Narrows on the North shore shows how much of the land has been saturated with water. The lighter patches along the northern shores of Lake St. Martin in Figure 24 indicate fields. The same sections in Figure 25 are varied in colour indicating a change in vegetation. The land within 0.5 to 0.75 kilometre along the shore line at Lake St. Martin is not very attractive after the repeated flooding, however, the land use has changed with agriculture (mainly hay) being more predominant than in the photo of 1958 (Figure 24).

The aerial photos indicate that Lake St. Martin First Nation have been affected not only by the Fairford Dam and the regulation of Lake Manitoba, but also by the operation of a flood control system, especially the Portage Diversion. The flood control system transfers water from the Assiniboine River through Portage Diversion and into Lake Manitoba. The additional water have added to the variation of water levels in Lake St. Martin. The increase in water levels allows for the saturation of land and also results in changes in vegetation in Lake St. Martin First Nation.

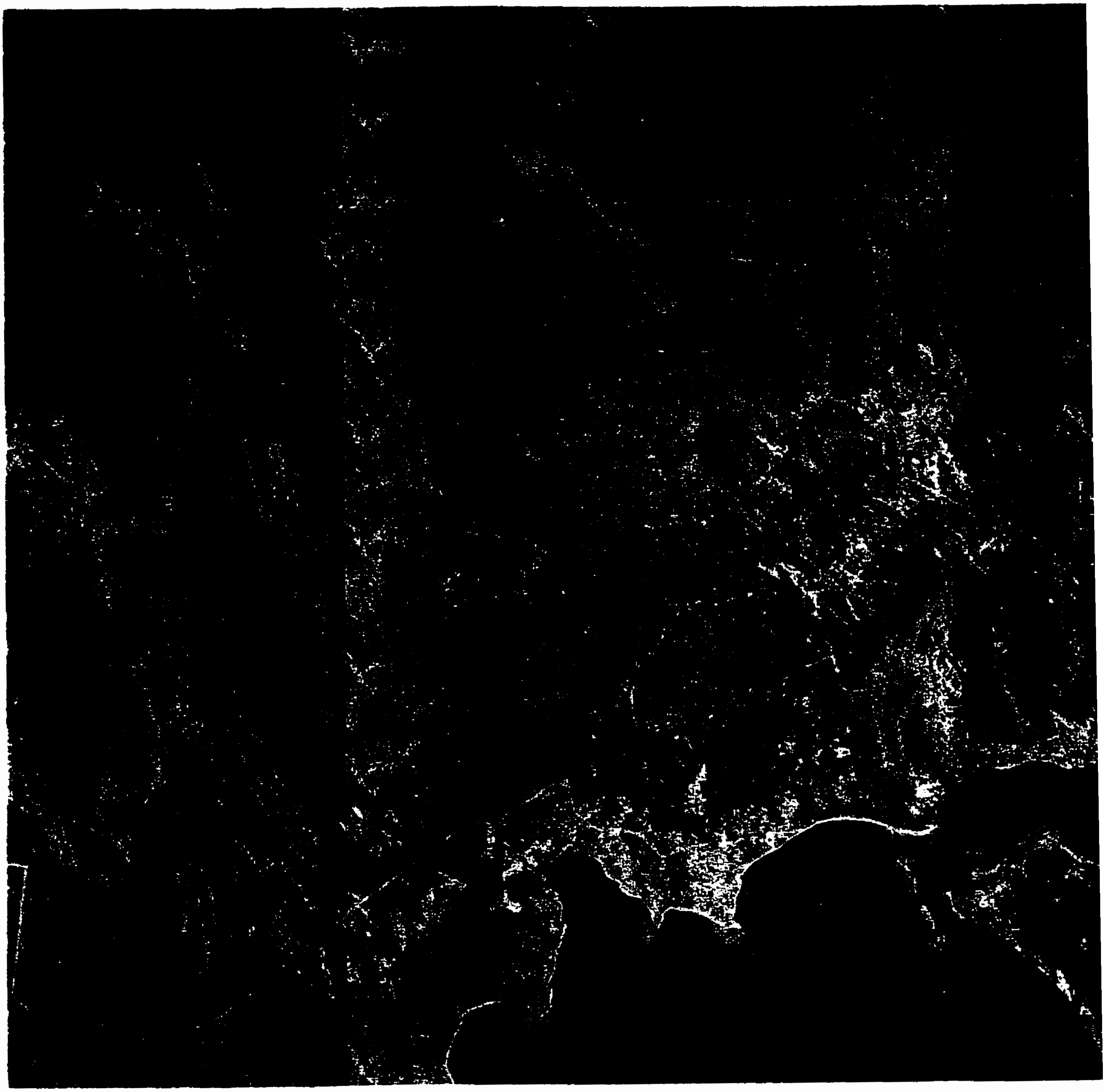
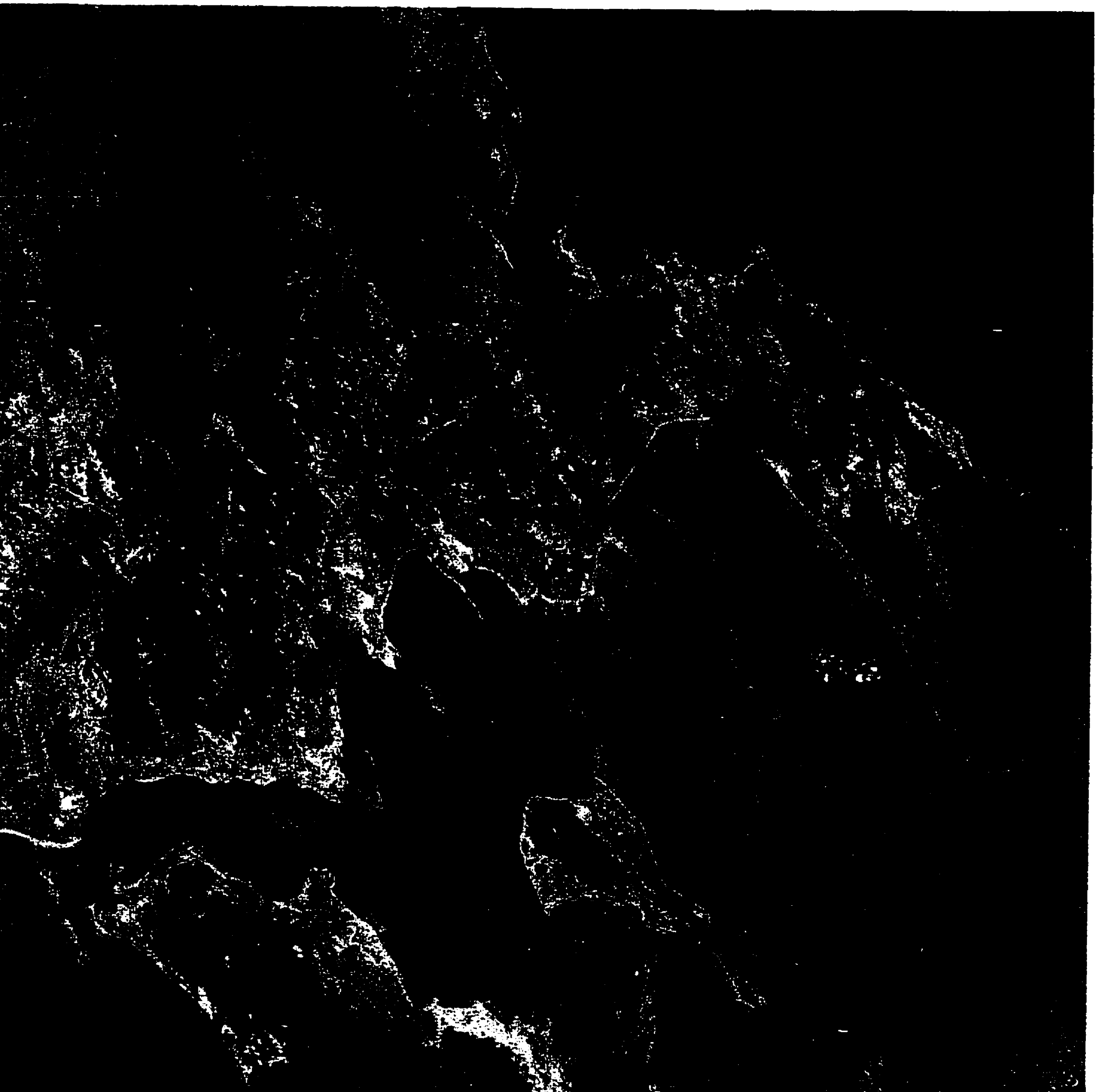


Figure 24: Aerial Photo of Lake St. Martin First Nation taken in 1958 (1:40,000).



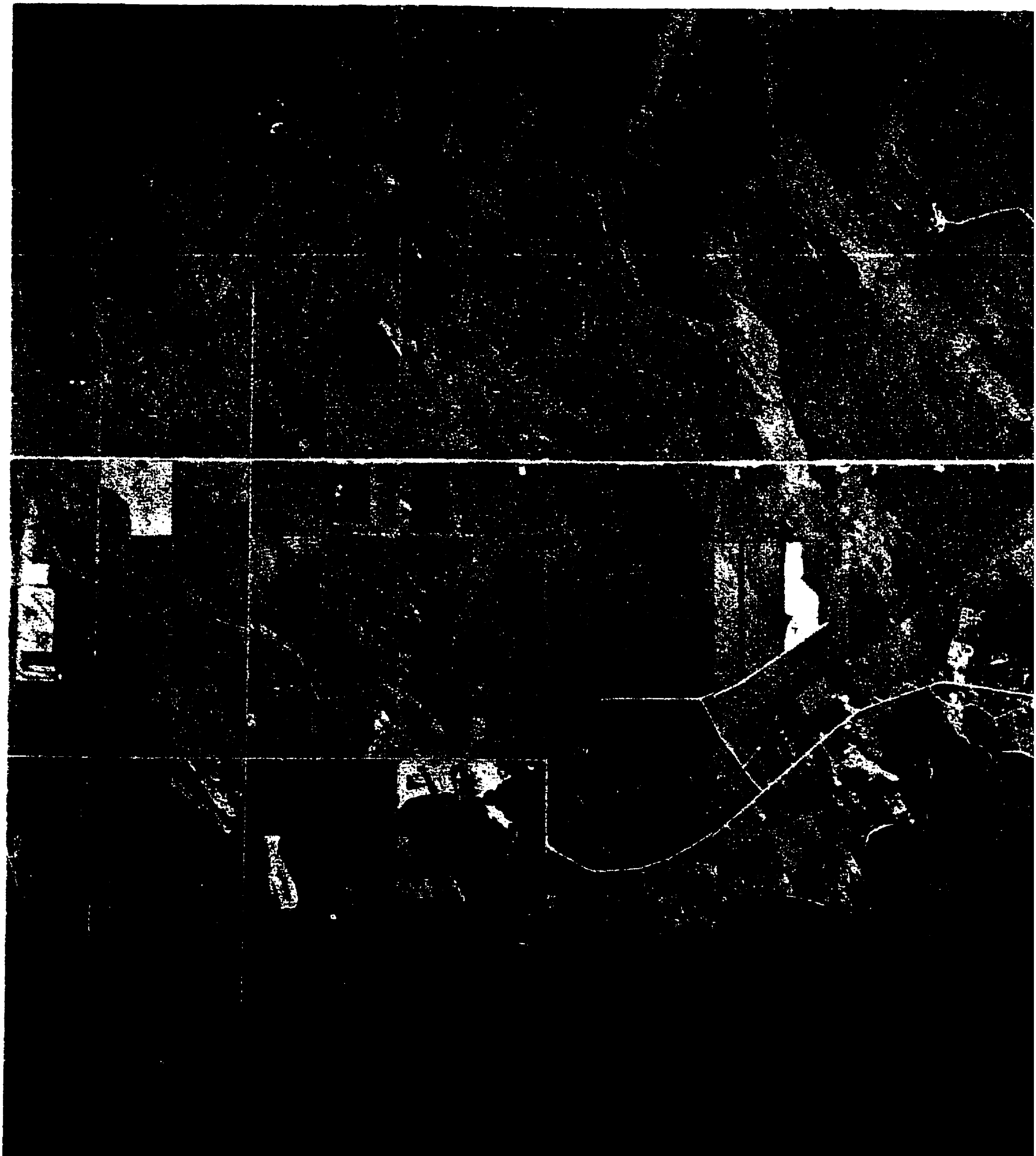
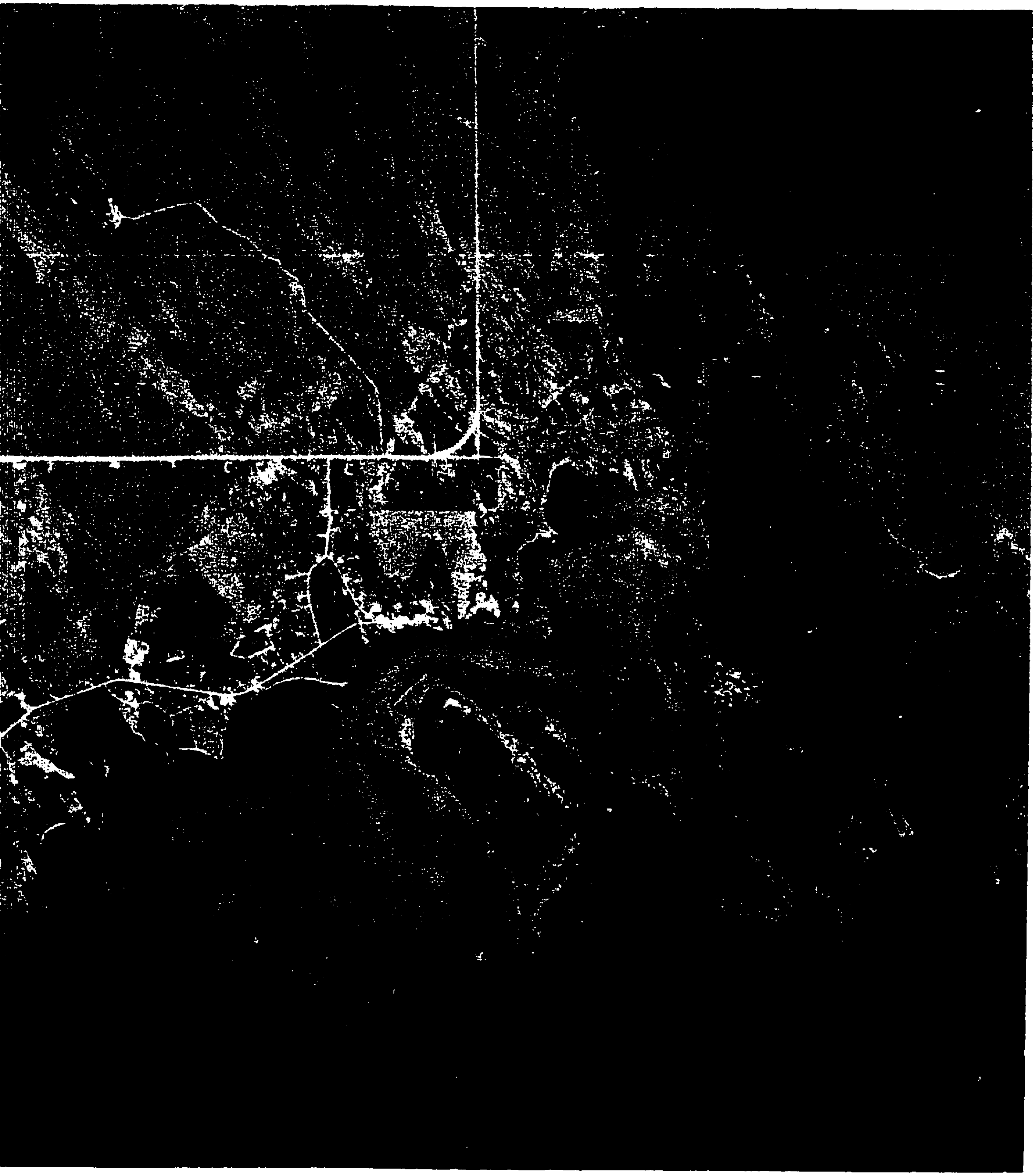


Figure 25: Aerial Photo of Lake St. Martin First Nation taken in 1986 (1:56,000).



4.7 Comparisons - Traditional and Western knowledge systems

Neeji Anishinabaag, like any other Aboriginal peoples, were able to survive in the vast expanse of land by their skills and knowledge. Survival depended on a relationship with the environment through knowledge which has been passed on thousands of years through observation and testing (NWT Culture and Communication, 1991) and experience acquired by direct human contact with the environment (Berkes, 1993).

Neeji Anishinabaag's foundation for self-sufficiency prior to the arrival of the Europeans was based on a traditional economy which emphasized a sustainable use of a natural and renewable resource base - simply put, the collective activities of hunting, fishing, trapping, gathering, some agricultural activity, and some trade. A nomadic existence necessitated the need to seek new resources and to allow for the natural replenishment of those left behind. When the Lake St. Martin First Nation flooded in the late 1800s, the Anishinabaag moved to the south side of the Narrows to allow for the rejuvenation of the environment (F. Traverse, 1998).

The differences between western and traditional knowledge systems are contrasted by the difference in the lifestyle of neeji Anishinabaag prior to the availability of 'conveniences'. An elder from Lake St. Martin First Nation reminisces of her younger days:

> "My dad used to kill moose and we used to tan the hide to make moccasins...They used to smear the moose brain on the hide and it used to soften it. It used to stay on until it was nice and soft. After it softened, they twirled it around with branches. Then it was pulled and dried by the fire. They scraped it further to make it softer and cleaner...They used spruce which was rotten - it's a specific type that looks like ash - powdery. This was also used for diaper rash. They also used muskeg as a powder to prolong the dryness of a diaper. Moose hair was used in the winter as a bed fill. We also used hay as bed fill (Sumner, 1998)."

The differences in the lifestyles between then and now is a reflection of the adaptation of the western lifestyle by the Anishinabaag. Despite the adaptation of the western lifestyle, neeji Anishinabaag are still the holders of traditional knowledge. It was their knowledge of the environment and their ability to adapt that enabled them to survive (M. Traverse, 1998).

The First Nations people at Lake St. Martin - neeji Anishinabaag respect the Earth and the life it sustains. The construction of the Fairford Dam is an alteration of a water system and is in contrast to neeji Anishinabaag beliefs. The Earth was already formed as to how the rivers should flow, and now white man is trying to change them (D. Sinclair, 1998). The Earth is viewed as a living organism where animals, plants, humans, air, water, and land all have a reason for being and together maintain an intricate balance to ensure the continued survival of all life. Any interference with any part of this system will have negative repercussions on the other components. Aboriginal peoples are often reluctant to accept Western knowledge systems because it interferes with nature (Johnson, 1992).

Western scientists are viewed to be constantly tagging and capturing animals or digging holes in the ground (Johnson, 1992). Western science may be able to explain phenomena that traditional knowledge system cannot, however, traditional knowledge systems can explain and identify subtle changes in the environment. If the white man really watches, they can really see something (Marsden, 1998). For example, neeji Anishinabaag have noticed that there are hardly any birds around the Lake St. Martin First Nation area. Some species have not been seen in decades (Marsden, 1998; F. Traverse, 1998; J. Traverse, 1998). Another example is the subtle difference in how wildmeat tastes and the decrease in its abundance. Marsden (1998) and John Traverse (1998) attest that wild meat does not taste the same as it used to, and that it is not as good anymore. Marsden (1998) stated that there are dead rabbits all over, and that there are not as many rabbits now as there once were.[5] Grouse were also in abundance and could be seen all along the roadside and now there are hardly any (Marsden, 1998).

Western science is written, quantitative, objective, concrete, and the researcher is distant from its subject, whereas traditional knowledge systems are orally transmitted, qualitative, subjective, abstract, and is close to its subject. The difference between the two systems is summarized by a First Nation member:

> This is very hard to talk about. If I would have known this was going to happen - that there was going to be this amount of flooding, I would have known what to do and I would have thought about how or what year to keep track. But I didn't know that the flood would have lasted and destroy so much. I thought that it was just going to be a one time thing. If someone asks for something then they start to ask 'when did the flood happen?' Then we don't know because we don't have the dates. We didn't know then because we thought it be just once. It's very hard to keep track especially when you're busy. And now this is very hard for us. They ask - what year, what date, what month, where? But anyway, everyone knows on this side, only if they're from somewhere else then they don't know what's going on. I don't think we should be hiring someone else to work on the flooding. I think that person should come from around here - Anishinaabe. That's what they do. Indian Affairs hires someone that is not from here, someone who doesn't know what's going on and they write and submit a report and Indian Affairs listens to them (Anderson, 1998).

As an Anishinaabe researcher, I cannot approach neeji Anishinabaag and ask them questions about their traditional knowledge systems. Chances are that they will not know what I am talking about, because I am using a western concept on them. However, if I approach neeji Anishinabaag by visiting them, (and it helps that they know me) and asking them to tell me stories about the flood, then I will get more information. Neeji Anishinabaag have not kept records of the water levels, however, they keep a mental track of the changes and the damages that have been incurred by the flood. Results of the hydrological analysis has supported neeji

[5] Marsden is talking about the summer of 1998 and is making reference to the preceding years.

Anishinabaag's perceptions of the flood.

The concept of land ownership was foreign to neeji Anishinabaag. The Earth and its inhabitants were meant for sharing and everything that grows on it has a purpose (Marsden, 1998). This is in contrast to the original decision to construct the Fairford Dam in which land owners on Lake Manitoba would be the beneficiaries. Extremely high levels resulted in flooding which resulted in crop losses of up to $3 million in 1954 and 1955. Low water levels meant inconveniences for marine navigation, beach resorts and wild life interests (University of Manitoba Civil Engineering Department, 1960). Neeji Anishinabaag view the Earth as a gift from the creator, for the collective use and benefit of all living creatures, and not to be altered or destroyed for the benefit of another (M. Traverse, 1998). The environment must be left and preserved so that it will be there for the next year and the future years (Notzke, 1994).

Traditional knowledge systems are useful in that they can provide important human information that if combined with other scientific research will help provide a more complete view of changes and the patterns of changes (Northern River Basins Study, 1996). Western science has a domineering persona and bases its 'theories' and 'facts' on a quantitative approach versus the qualitative approach held by traditional knowledge systems (M. Traverse, 1998). Western scientists who do acknowledge traditional knowledge systems generally apply scientific methods to verify and validate them (Wolfe *et al.*, 1992). Anderson (1998) expressed his frustrations when he was being interviewed by non-Anishinabaag who were doing research on the effects of the flooding for Indian and Northern Affairs Canada. The researchers asked Anderson to show them where the flood was, but when he took them to the spot, there were no visible signs of the flood. The researchers noted on their report that there was no flood, however, Anderson and his neeji Anishinabaag were aware of the changes to the landscape and the destruction that had been left on the land.

Traditional knowledge systems may be able to save western societies from themselves because the components of the knowledge systems have long known that the modern/ technological society is inherently unsustainable. Traditional knowledge systems have chosen to retain the sacred link with the Earth rather than becoming part of a society that will inescapably self-destruct (Clarkson *et al.*, 1992). Marsden (1998) said that his elders told him that the Earth will eventually starve - tuuni pukhutay khamika, and that different things will happen to it.

4.8 Summary

Experiments were conducted to show if the relationships between Assiniboine River and Lake St. Martin, Lake Manitoba and Lake St. Martin, and Lake Winnipeg and Lake St. Martin water levels were affected by Portage Diversion. Results from Figures 9, 10, 11, 12, 13, and 14 seem to indicate that Lake St. Martin water levels have been affected by the construction of Portage Diversion.

Comparisons of Figures 9, 10, 11, 12, 13, and 14 appear to indicate that there is a relationship between the water levels at Assiniboine River and Lake St. Martin, Lake Manitoba and Lake St. Martin, and Lake Winnipeg and lake St. Martin. However the increase in water levels in each experiment are not significant according to statistical tests.

The high error rate for each of the experiments indicates that the lines could be the same 95% of the time. The findings from these statistical tests reveal that there is no difference between water level change at Lake St. Martin before and after Portage Diversion.

Figures 21, 22, and 23 show comparative regressions relationship between water levels for Pre-Portage and Post-Portage Diversion conditions between: Assiniboine River and Lake St. Martin; Lake Manitoba and Lake St. Martin; and Lake Winnipeg and Lake St. Martin. These experiments were conducted to determine whether or not the operation of Portage Diversion had an effect on flooding at Lake St. Martin First Nation. The results from these experiment would seem to indicate that Portage Diversion directly affects the relationship between the water levels between Assiniboine River and Lake St. Martin, Lake Manitoba and Lake St. Martin, and Lake Winnipeg and Lake St. Martin. The results in Figures 21, 22, and 23 depict changes in the water level from a low of 0.1 metres to a high of approximately 2.5 metres.

The results indicate that there is a great deal of variation in data for this type of large scale water system as supported by the variations in the water levels. Any actual differences are therefore concealed by the extreme variability. The degree of the changes occurring are minimal and the variation in data is very large. Tests of this nature rarely show any significant differences because of the high variations.

Aerial photos shown in Figures 24 and 25 reveal findings which statistical analyses were unable to reveal. Aerial photos reveal the subtle changes to the landscape due to the fluctuating and subtle increase of water levels in Lake St. Martin First Nation. The vegetation and landscape have changed due to the flooding.

The results of the statistical tests strengthen the argument that Western Science relies on concrete data and bases its decisions only on these data. However, the First Nation people base their observations and knowledge on subtle changes in the environment, changes that Western Science is unable to capture, as in the case of the preceding experiments. Western Science depicts that there is no significant change in the water levels at Lake St. Martin, yet the First Nations people have been able to identify the subtle changes in their environment which are the result of the repeated water fluctuations that are the results of the altered water systems.

CHAPTER 5

FIRST NATION PERSPECTIVE OF THE LAKE ST. MARTIN FLOODING

5.1 Introduction

The First Nations people - neeji Anishinabaag at Lake St. Martin, Little Saskatchewan, and Fairford were visited for their knowledge on the effects of the Fairford Dam. Neeji Anishinabaag shared with me what they experienced prior to and after construction of the Fairford Dam.

5.2 Before the Construction of the Fairford Dam

Oral histories from the elders indicated that Lake St. Martin First Nation flooded about 100 years ago. The residents went across to the ridge (The Narrows 49A) and lived there where they planted and set up tents and log houses for the winter (F. Traverse 1998).

Neeji Anishinabaag recall another period (1954) when there was a flood prior to the construction of the Fairford Dam (Marsden, 1998; Sumner, 1998). Sumner (1998) recalls:

> I remember when it flooded here the first time - Leslie was about four months. We came by boat - we were working there. Leslie was born in 1954, and Elaine was born that year. The whole field was under water.

Sumner (1998) and E. Traverse (1998) recall how their father went to their barn in April 1954 and found it surrounded by water. Their father's horses had water up to their knees. Marsden (1998) remembers:

> Before this highway, that's when the flood happened. A boat came from over there, and came by this road here and it went up to Axe's house. We gave the children a ride. I pushed them along and told them 'I'm doing this so that you

> will remember in the future'. You'll say 'our dad pushed us in a boat here'. It looked like a lake. Later on when it drained the highway was built.

After the flood, the water simply receded and dried up (Beardy 1998; Sumner 1998).

There was a thriving meeting place at the outskirts of the Lake St. Martin First Nation. Neeji Anishinabaag refer to this place as Brodski's. It had a post office and a general store. Hay used to grow all around the area (Sumner 1998).

Prior to the construction of the Fairford Dam, there were hay fields on both sides of the Narrows (D. Sinclair, 1998; E. Traverse, 1998). D. Sinclair (1998) states that they used to take cattle across (to the other side of the lake) to feed during the summer. The land on both sides of the Narrows was dry prior to the flooding.

5.3 Post Construction of the Fairford Dam

Neeji Anishinabaag agree that the construction of the dam has affected their lives. The dam has left a destruction downstream (D. Sinclair, 1998). The dam was initially built to maintain the water levels on the Lake Manitoba side (University of Manitoba Civil Engineering Department, 1960). However, water levels are maintained on the Lake Manitoba side, but the effect is that water levels are also controlled downstream. The resulting effect is that the dam is opened, then shut, forcing the water levels to go up and down (D. Sinclair, 1998).

Neeji Anishinabaag state that a bridge like the one downstream, should have been built, and not like the kind they did in which Water Resources Branch alter the water flow. The earth was already formed as to how the river should flow, and should not be changed or interfered with (D. Sinclair, 1998). The prevailing perception is that if the dam had not been built, the water levels would have been constant on both Lakes St. Martin and Manitoba (D. Sinclair, 1998). The constant flooding from the fluctuating water levels had caused a lot of damage (Marsden, 1998; F. Traverse, 1998).

> No one comes here when there's a flood. When someone comes here, the water has receded and they don't see the flood. And they make the report. And when it goes to court and we're asked where is the flood - they don't see it. They say (Indian Affairs) 'we sent someone on such and such a date and they didn't see any flood. I told one of them it 'it really flooded on Hay Point' and then he asks me where is Hay Point? And yet we're standing on Hay Point and looking at it. That's how much they don't know what they're doing these people that are sent out here to do studies. We were standing on Hay Point and went to another place to Mouth River. I said Mouth River really flooded, and he asks me where is this Mouth River and these are the people they listen to - the one writing the report. Once it gets to court it gets even harder. They use the reports from these people . And they base their decisions on these reports. Once it gets to the courts, they ask 'is it true this happened' and they say so and so went over there and found this. Then they see the map and he shows them it didn't flood here and it didn't flood there (pointing at map) (Anderson 1998).

5.4 Fishing

Prior to the construction of the dam, fishers caught more fish than they do now (Beardy, 1998). Construction of the Fairford Dam has had a detrimental effect on the fishers at Lake St. Martin. The operation of the dam, in which they shut only to dry off, then re-open but flood, alters the water levels and affects winter fishing (Beardy, 1998; D. Sinclair, 1998).

> While my fish nets are sitting nicely, they close the water, then my nets freeze to the ice. The fish die when the water levels go down. The fish don't arrive in Lake St. Martin because the water levels on each side of the river (Dauphin & Fairford) get too low. (D. Sinclair, 1998).

First Nation people at Lake St. Martin state that Water Resources Branch shut the dam during winter, causing their nets to freeze to the ice and get ruined (Beardy, 1998; Marsden, 1998). It is also during periods when Water Resources Branch shut the dam, that fishers find fish along Dauphin River. When the nets freeze to the ice, the fish perish and the water gets poisoned (Beardy, 1998).

Neeji Anishinabaag contend that fish do not taste the same as they used to (Marsden, 1998; John Traverse 1998). The fish have a 'grassy taste' to them, and the First Nations people believe that this is due to their habitat which has become grassy as a result of the flooding (John Traverse, 1998). The fish taste different due to the repeated flooding and contamination, and will eventually disappear (Thompson, 1998).

The fishers concur that fish are not as abundant since the construction of the Fairford Dam. F. Traverse (1998) states that the fish get stuck coming back through Lake St. Martin. In the fall of 1977, Dauphin River was very shallow and a lot of fish had died because they got stuck trying to make their way back to Lake St. Martin. There were hardly any fish and most of them were found dead along the shores (E. Traverse 1998; F. Traverse 1998). When the water gets too shallow and warm, the fish perish (John Traverse 1998). During periods of low water levels, Marsden (1998) saw the fish getting stranded in the grass after water had receded.

In 1977, nearly 9 million whitefish eggs were killed in late winter, at the Dauphin River hatchery (which takes its water supply form Dauphin River). The loss of eggs was attributed to poor water quality and low dissolved oxygen. The oxygen became depleted when flows in the Dauphin River became negligible, which was attributed to the complete closure of the Fairford Dam. Aside from the loss of eggs, there was a considerable wastage of fish in northern Lake St. Martin when nets became frozen under the ice as lake water levels dropped.[6]

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[6] Inter-departmental memo addressed to the Director, Environmental Control Branch, 1977.

> The dam is destroying the landscape. They keep opening it, then they shut it, when they open it again, they release water and it floods. They shut, then it dries up. The water inhabitants die. The fish get stranded because they go too far inland. The water levels all depend on how the operators maintain the Fairford Dam. When they open it, the water levels go up, when they close it, they go down. Look at Dauphin River now, I've been watching it - it's shallow and when they open it the water will go up. In the fall when they close it, that's when it's destructive - the fish die when there's no water. Even the ice, it kills a lot of fish. In the fall, the fresh snowfall makes a lot of water and it floods. The rapids are six miles long - it's six miles where the water jams and a lot of fish die there. I watch these things. This has been in the working for a long time now, this flood. The water here is also polluted (Marsden, 1998).

5.5 Trapping

Trapping is a livelihood that has also been affected by the Fairford Dam. The muskrats freeze if there is not enough water - when the water levels are low. When the water is restricted it drains the muskrat habitat, and in turn freezes due to lack of water (D. Sinclair, 1998).

> The muskrat freeze when the water is too shallow. When the water is deep it is alright, because there is at least a few muskrat. When the water is shallow, the muskrat are smaller because they do not have enough food - they starve to death. When the water is deeper they're bigger because they eat in the winter and they thrive in deeper water (Beardy, 1998).

The size of muskrat is dependent on water levels. When the water level is really high, the muskrats are bigger, and when the water is shallow, they are smaller (R. Sinclair, 1998). Muskrats are also more abundant when the water levels are higher (Marsden, 1998; R. Sinclair, 1998; John Traverse, 1998).

> I watched the river - they were all over the place - the muskrat. In the fall there was an ice jam in Dauphin River and there was a flood. When the jam was freed the water receded and then the muskrat were destroyed. The ones living in grassy waters were all destroyed. Look at the mouth of river, I saw those huts all over the place in the fall and spring. I asked the trappers 'are there lots?' They said 'no they all froze. They're all on dry land. There's none' (Marsden, 1998).

Beaver is not affected by the water fluctuations, because it controls the water and builds its own dams (R. Sinclair, 1998; Beardy, 1998). The Anishinabaag have noticed other wildlife which do not seem normal. Beardy (1998) has noticed that coyote and fox are stricken with mange and are found frozen in fields.

5.6 Hunting

Hunting has been severely curtailed as a result of the altered water regime. Neeji Anishinabaag have expressed their concerns over the decline and different taste in wildlife species that once thrived around Lake St. Martin First Nation.

5.6.1Waterfowl/Birds

Neeji Anishinabaag state that there are rarely any ducks seen in the area, though geese remain a common sight. Other birds that are no longer seen are wabitheegk - swan, saadaag - pelicans, singibithug - waterhen. It used to be that a person could hear birds singing all over the area, now a song is seldom heard. Meadow larks used to be the most common of the songbirds heard in the area (Marsden, 1998; E. Traverse, 1998; F. Traverse, 1998; John Traverse, 1998).

> It's all quiet now, this river now, all kind of birds used to breed there - yellowheads, red wings. I see crows at least, not as much though. I don't know what's happening to them (Marsden, 1998).

Thompson (1998) states that the ducks lay their eggs in the summer when the water levels are still fairly low, and when the water is released from the Fairford Dam the eggs would all be under water. Despite this , the ducks would still be dying because the water is too dirty (Thompson, 1998).

5.6.2 Wildlife

F. Traverse, (1998) states, "a lot of the little critters have disappeared". Thompson (1998) attributes this to their drinking from the lake which is polluted. Neeji Anishinabaag have also noticed that wildlife such as deer, moose (Marsden, 1998; John Traverse, 1998), rabbit, and grouse do not taste as good as they once did (Marsden, 1998).

> I know these things, things were better before, the wildlife was better, you could keep it for a long time. That's another thing, it's as if things are rotting, it's not like it was. The wildlife is not as good. It's true. The water here is polluted. Everything will get polluted. That's what's happening. Deer - it doesn't taste the same like it used to. Same for moose. Everything tastes different, grouse too taste different, rabbit too. These rabbits, its so strange, I see them all over the road dead. There are no rabbits, for many years now. There's a few but not like they used to be. Ross and I went for a ride, I told him come with me I want to kill chicken. I want to eat it. There used to be grouse sitting all over the roadside. So we went but we didn't see any and we turned around. Then we got stopped by moothuuguma[7] as we were turning. He said 'hello what are you up to' and I said 'we're driving around'. 'You got a gun' he asked me. 'Yes I got a shot gun' I told him. I told him 'I want to eat chicken, or rabbit or anything, that is why I'm carrying a shotgun. I want to shoot them, but there's none' I said. He said 'I think you're right'. So I said 'I think I have to go back and go to chicken delight'. And we both laughed. See, that's what I said - there's no rabbit or grouse. Last fall, the road goes there, and I drove there, and there was no grouse, no rabbit. This is what is strange, the dead rabbits on the road, where do they come from, and there's none in the winter. I was sitting outside and looked toward the little shack, when a rabbit appeared. I looked at it and said, 'you stay there, and I'll eat you in the fall' (laughs). But it will leave. See, all summer the people used to set snares for rabbit, to eat rabbit, snaring right through the summer (Marsden, 1998).

5.7 Farming

The dam has affected and destroyed neeji Anishinabaag's farming. D. Sinclair (1998) used to have more than 100 head of cattle 10 years ago. Now he only has a little more than 50,

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[7] Moothuuguma is the Ojibway word which refers to Department of Natural Resources officers.

and it seems as if they go down by 5-10 heads every year. Another farmer recalls their farm:

> My old man had 500 head of cattle - he did very well before the flood he used to drive on the other side (across the Narrows) with a tractor and to make hay. I used to go with him. There was a lot of hay on the other side - now there's none. Everyone had livestock - now there's only about three families (F. Traverse, 1998).

Fields in which hay once thrived, is now home to bulrushes, reeds, and swamp (Elmer Traverse, 1998).

> The Anishinabaag used to send their cattle across (the Narrows) every summer, now it is no use, because the water is too deep. Even if the cattle went across, it would be useless because the land is under water. The last time the cattle went across, it was very easy. The gate was opened, and away they went. They used to be fine when they were across. After the cattle were sent across, I would consult with the Fairford Dam controllers to tell them that my cattle were across, and to be advised when the water would be released so that the cattle could safely come back in the fall (D. Sinclair, 1998).

There is nowhere for the cows to feed during the summer, since most of the hay land is under water (Marsden, 1998; D. Sinclair, 1998). Much of the land southwest of the Narrows used to be prime hay land, now most of it is under water (Sumner, 1998).

> The flood destroyed the land after the dam was built. The last time we hayed in these fields was about 1963 (Figure 26). We used to plant hay here and my dad used to plant oats, barley, and flax. Now the fields are in no shape for grain. There is a lot of salt (alkaline) surfacing ever since the flood. I don't know why this is happening. When you drive on the road you'll just see it. There's a lot of that probably due to the flood (Beardy, 1998).

Not only have the number of cattle been decreasing since the flood, but the health of the cattle is afffected by the flooding as well. The cattle limp due to foot rot, which occurs when they go into the water or mud too often (Beardy, 1998).

Figure 26: Northwest Lake St. Martin Showing hay land underwater.

Hay fields are scarce, and when the water is high there is not enough feed for cattle (Beardy, 1998). At one time, almost every family had cattle, but now there are only about three families which have cattle. According to F. Traverse (1998), "it seems as if the white man is trying to starve the Anishinabaag" (F. Traverse, 1998).

> There was lots of hay - no one went short. It's only today that the hay is short, but that's due to the flooding. The hay land will never be the same again, it is ruined. The land at the narrows and the mouth of the river is all under water - the hay land is all ruined (John Traverse, 1998).

Upstream from Lake St. Martin is Fairford First Nation. The land situated at the mouth of the Fairford River, emptying into Lake St. Martin was once prime hayland. One of the farmers remembers how discouraged he got when he did not receive assistance from the government or his band:

> My sons, three of them used to work for me to tend to these fields, we used to work hard and we spent a lot of money working on these fields. We also had a lot of cattle before the flood, now we don't have any. We planted alfalfa, four different kinds of grass. There's was no one here from Indian Affairs to see us plant these fields, no one was here from Indian Affairs to see us plant, till, make fences, and pick stones. Then it flooded and our fields got destroyed, even the hay got destroyed. Then we had to sell our cattle. Even when we asked for assistance, the only time someone came out was when there was no flood. When we were to make hay it flooded. And we bugged Indian Affairs that we were being flooded. By the time someone came, the water had already gone away, and it was reported that there was no flood. They listen to the ones that are sent down by Indian Affairs and they don't listen to us. That's what happens despite us telling them what happened. One winter I tried buying hay. There were 18 calves. I bought 68 bales. When I sold those calves, the cost of the hay far exceeded the calves. I didn't get anything in return and all my work was for nothing, looking after the cattle all winter. I didn't get anything from there because I was busy paying off the hay. I was unable to do that in the second year, I was forced to sell all my cattle. All the fields I had, and my machinery and cattle would have been enough now to distribute among my sons, now I don't have anything to give my sons. This flood has destroyed me. (Anderson, 1998).

5.8 Gathering

Neeji Anishinabaag gather various species of edible berries every summer. Species that grow along the shore line such as gooseberries have been decimated (Marsden, 1998). Medicinal plants that grow in the flooded area are directly affected. For example, wikhe (sweet flag) Acorus calamus L. which is chewed for sore throats and to prevent colds is found along river banks. However, the plant can not grow if water levels are too high (F. Traverse, 1998).

5.9 Seneca Root Digging

Seneca root digging provided a means of income for Neeji Anishinabaag during the summer. However, seneca root no longer grows in some areas where it had once thrived and is no longer as abundant in other areas (F. Traverse, 1998). The areas considered the best places to find and gather seneca root are all under water, especially along the shoreline (F. Traverse, 1998). Neeji Anishinabaag used to spend summers along the shores of Lake St. Martin digging for seneca root, but according to First Nations people the plant no longer grows in these regions (Marsden, 1998; Sumner, 1998; John Traverse, 1998).

5.10 Vegetation/Landscape

The vegetation and landscape around Lake St. Martin is visibly affected by the higher water levels, most notably is the lack of trees around some areas along the Lake St. Martin First Nation shoreline. E. Traverse (1998) remembers when she used to go to the shore with her mother in the 1950's to do their laundry in the lake. E. Traverse (1998) states that they used to sit in the shade under the trees, however, the trees have since disappeared (Beardy, 1998; E.

Traverse, 1998).

The vegetation has changed as a result of the fluctuating water levels. Areas in which hayfields once thrived, have been replaced by bulrushes and reeds, and other forms of inhospitable vegetation (Elmer Traverse, 1998). E. Traverse (1998) states that they used to walk to the shore from their house (in the 1950's), but the area is now swamp-like, muddy, and has been replaced by reeds. Most of the shoreline is permanently wet and spans approximately one kilometre inland in some places.

> The land used to be nice but ever since the flood the land is ugly - it is not nice anywhere. Also for someone to settle somewhere to build a house - there is no nice piece of land anywhere for houses to be built. What we have to do is clear the land or get another piece of land. What should be done is build a bridge to get across to the other side because the land on the other side is bigger but you have to paddle to get there. It's hilly on the other side and the land is nicer but no one can get across unless we have a ferry or bridge. However, the land there is also flooded. If someone lives there no one can do anything because of the flood - the tractors would get stuck - even when someone tries to have cattle - they cannot.(F. Traverse, 1998).

After the flood waters had receded, there were no visible signs of the flood, however, neeji Anishinabaag were aware of the changes to their landscape. Land that was once fertile has been destroyed, there is nowhere to make hay, and alien species are growing in what were once hay fields (Anderson, 1998; Beardy, 1998; Marsden, 1998; D. Sinclair 1998; Elmer Traverse, 1998; J. Traverse, 1998; John Traverse, 1998). Land cover has been replaced by different vegetation that are associated with wet conditions (Figure 27).

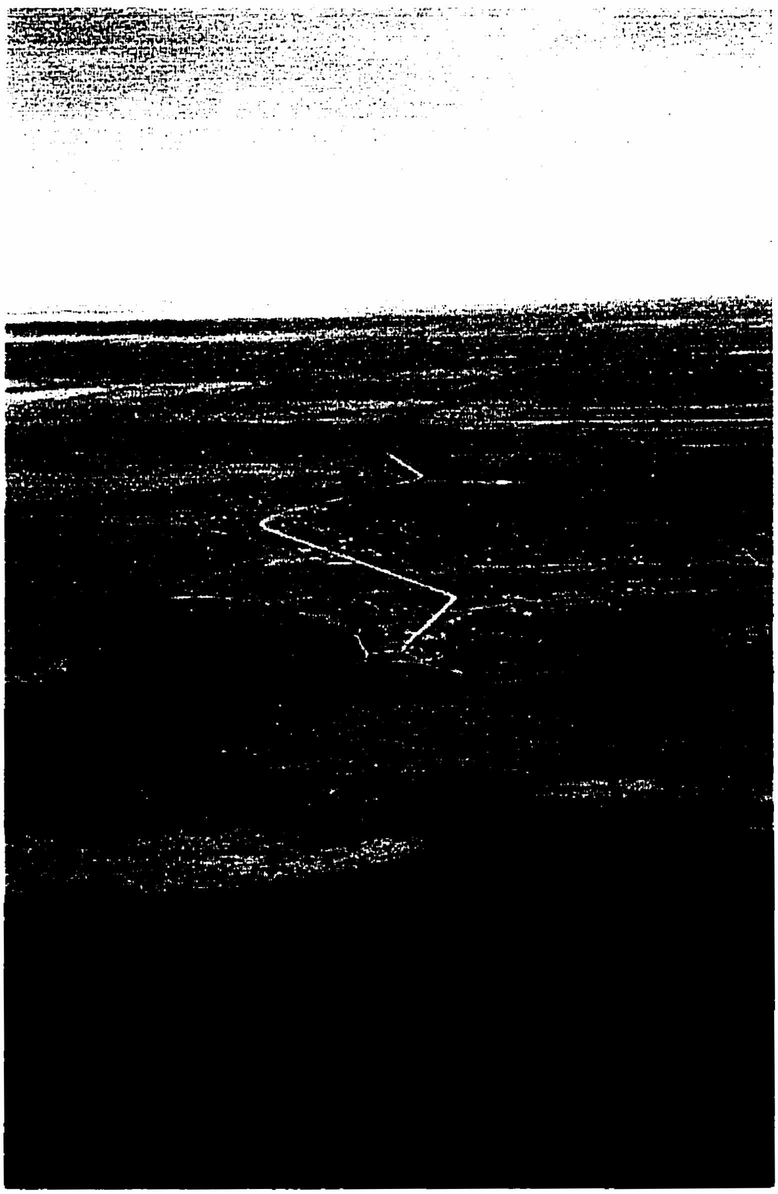

Figure 27: Air photo depicting the extent of flood damage at Lake St. Martin First Nation.

5.11 Recreation

The flood has destroyed a valuable means of recreation neeji Anishinabaag had access to. Three baseball diamonds once existed in the field going toward Stella's Beach. The baseball fields were home to women's and men's fastball teams from Lake St. Martin First Nation, and were able to accommodate spectators and players who came to the regional tournaments (E. Traverse, 1998). The baseball fields are now swamp-like and covered with vegetation that is associated with flooding.

There was a public beach on Lake St. Martin First Nation, however, the beach is not safe for public swimming anymore as it has become over grown with inhospitable vegetation. J. Traverse(1998) spoke of the change houses at Stella's Beach which were completely under water when it flooded. The beach was used by both First Nations and non First Nations, but it too became invaded by vegetation associated with flooding (E. Traverse, 1998; J. Traverse, 1998).

5.12 Destruction of the road

After the Fairford Dam was constructed, the road linking the First Nation communities of Lake St. Martin and Little Saskatchewan was flooded over and has yet to be re-opened (Sumner, 1998; J. Traverse, 1998). Trenches were dug along side of the road to accommodate the excess water. However, the water remained in the trenches, causing the Lake St. Martin - Little Saskatchewan road to be permanently submerged in water (J. Traverse, 1998). Marsden (1998) who was witness to this event states that after the water went into the trenches it remained there, and has not yet disappeared.

5.13 Construction of dikes

Neeji Anishinabaag acknowledged that construction of dikes, though costly, would help control the flooding situation. They also admit that sandbagging is just not good enough, though less expensive than construction of dikes, is only temporary, extremely messy, and leave an undesirable image on the landscape (Marsden, 1998; E. Traverse ,1998). Building a dike would be expensive but more beneficial as a long term solution.

5.14 First Nation Well Being

Neeji Anishinabaag conceded that the flood has altered their lifestyle and well being. Wildlife that was once abundant hardly exists anymore, and even if it were available, it does not taste as good as it once did (Marsden, 1998; John Traverse, 1998). Neeji Anishinabaag get sick from the processed food which was once an alternative, but is now the preference. Sicknesses and diseases that are not in the Ojibway vocabulary are now common - diabetes, cancer, arthritis, etc.

Marsden (1998) tells of his fondness for wildlife as opposed to 'white man's food':

> When we were out seneca rooting, the rabbit was our diet. You get sick of the food we eat today. Jacob gave me moose meat a while back, it's as if it's the first time I ate, it was so good. Somebody gave me fish, and I had half of it for lunch, I thought I should have had all of it, see, that's all I had all day. That's the kind of food I like. I don't like this white man's way of eating. Elsie [his wife] says 'that's the same way my dad is, he only likes wild food'. After a flood dried off, it used to smell, because of lot of things perished.

The lack of accessibility to traditional foods has led to an increase in the consumption of foods that are foreign to neeji Anishinabaag (Sumner, 1998; E. Traverse, 1998).

In the summer of 1997, Lake St. Martin First Nation peoples were warned not to swim in

Lake St. Martin because of the risk of contracting hepatitis (Sumner, 1998, E. Traverse, 1998). Thompson (1998) acknowledged that it is a difficult time for everybody and does not know what is going to happen to people because of the dirty water.

Bottled drinking water was delivered to each home at Lake St. Martin First Nation starting in late spring of 1999 because the local pump house had been contaminated by the increased water levels from spring runoff (E. Traverse, 1999). Residents were warned not to drink their water until such time when it would be safe.

5.15 Water levels

D. Sinclair (1998) stated that the water has come really close to where he lives. His son's house, who lives nearby, was completely surrounded by water. The land around the shoreline had been destroyed and will never be the same again (D. Sinclair, 1998). In 1977, the water came to within six metres of a house that is situated about one kilometre from the lake (Figure 28). Figure 29 is marked by a red line which indicates how far the water went inland and the position of Figure 28 (marked by X). During periods of high water levels, water approached close to some of the houses even though they are not located near the lake. There are only a few houses that are located within 30 metres feet from the lake.

Figure 28: Flood of 1977 at Lake St. Martin First Nation.

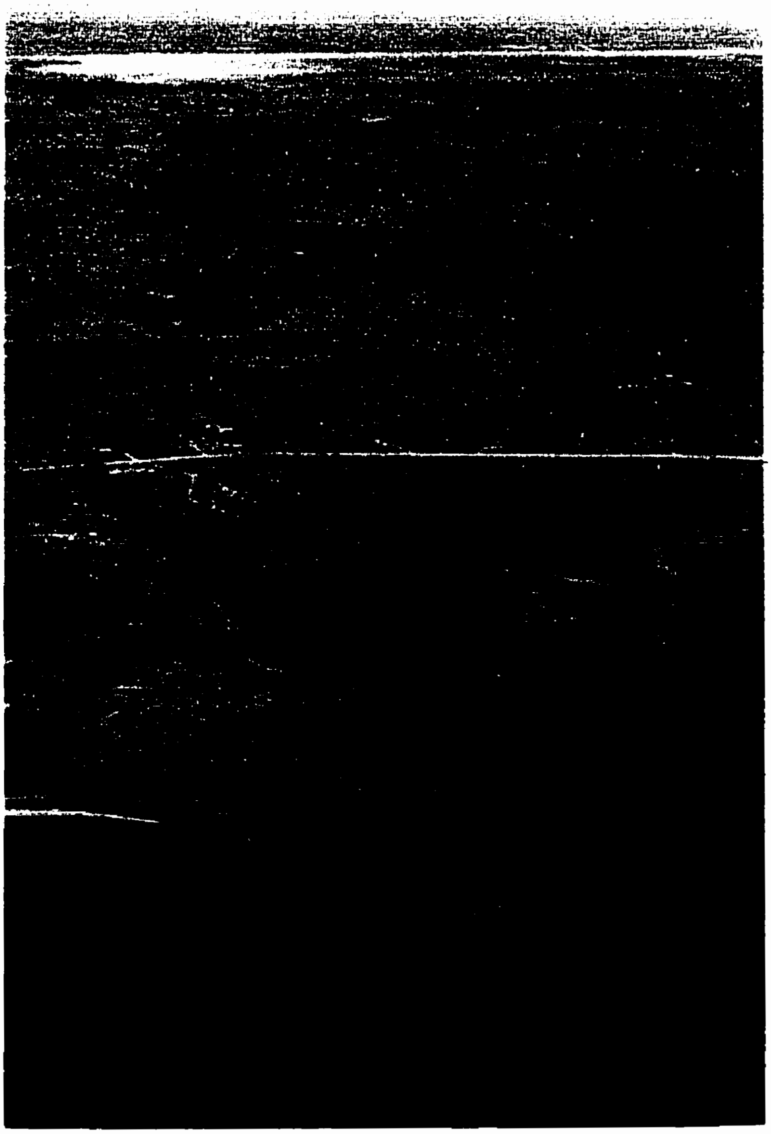

Figure 29: Air photo showing how far flood moved inland with reference to Figure 28.

5.16 Summary of First Nations Perspective

The First Nation traditional knowledge systems refers to a broad scope of indigenous knowledge which encompasses environmental, traditional healing with plants, cultural, social and family values, to name a few (M. Traverse, 1998). The traditional knowledge systems of neeji Anishinabaag offer a view of the world, of past, present, and future, and base observations in relation to past and present phenomena. They are different from those of the white man whose knowledge is based solely on explaining and rationalizing events (Marsden, 1998). Traditional knowledge systems consists of the observations of nature by elders and other Anishinabaag, through an awareness of the subtle and obvious changes in nature (M. Traverse, 1998).

First Nation people at Lake St. Martin First Nation have suffered and lived through the effects of flooding. Their livelihoods have been severely curtailed as a result of the subtleties of damage caused by the construction of the Fairford Dam.

First Nation people agree that there was reasonable economic prosperity before the Dam was constructed (Hobbs & Associates Ltd., 1992; Marsden, 1998; E. Traverse, 1998; F. Traverse, 1998) The people enjoyed all the leisurely activities associated with self-sustained livelihoods. However, these livelihoods of fishing, trapping, hunting, farming, gathering, root digging, and recreation, have been affected by construction of the Fairford Dam which consequently has had an effect on the well-being of First Nation People at Lake St. Martin First Nation.

Cattle ranching was once the main source of income for a majority of Lake St. Martin First Nation people, but now only a couple of families raise cattle. Even then, the number of cattle raised are not at par as what they once were before the land was flooded. Hay fields have been replaced by bulrushes and tall reeds. The land is never completely dry and remains swamp-like.

Fishing has also been affected by the fluctuating water levels that are a consequence of Fairford Dam. Fishing is no longer a viable economic option for the fishers at Lake St. Martin. Fish species that were once abundant have been depleted. The constant fluctuations of water levels has had undesirable effects on the fishery business. If the water levels are too low, the fish are affected due to the lack of oxygen and warm waters during the summer. In the winter the latter condition also prevails along with fishnets being frozen onto the ice due to low water levels.

The flood situation has wrought havoc on the landscape at Lake St. Martin First Nation. Change in vegetation is most prominent both by air and by land. The change in vegetation in turn affects both human and wildlife species that rely on the land for their livelihood. Neeji Anishinabaag have coped with the effects of the floods, but will need alternative strategies once the damage caused by flood conditions exceed the threshold of coping among the First Nations at Lake St. Martin First Nation.

The changes identified by the First Nations are subtle, but these subtleties verify and support the subtleties identified by hydrologic changes which have been revealed by the various experiments. The revelations in the experiments may be minute and not considered significant, but they support what the First Nations people have known and identified all along that the alteration in the water levels brought on by Portage Diversion and Fairford Dam.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Neeji Anishinaabeg believed for years that the Fairford Dam had an adverse effect on the First Nation community of Lake St. Martin but were unable to prove it. The construction of the Fairford Dam has had a negative impact downstream. The First Nations communities have been affected, along with recreation, wildlife, fisheries, and agriculture. The Government of Manitoba has taken steps in compensating for the loss of hayland, but this is not comparable to the destruction the dam has caused from increased the fluctuations of water levels.

The Fairford Band had taken action in taking its claim to court, however, it lost the case. As one First Nation member stated 'they're only doing this to back track the native people and keep them from winning'.[8] However, with input from a First Nation perspective and results obtained by the application of both knowledge systems - western and traditional, both parties - neeji Anishinabaag and the government can collaborate to reach an agreement or understanding of the impacts the water control systems have on downstream users.

Although analysis did not show with statistical significance that the flood control system and its operation are the cause of the flooding at Lake St. Martin, water level changes were evident. This was due to the large variation in the data and which is characteristic of these types of water systems. First Nations perspectives on the situation, however, revealed that subtle changes in the environment resulted from the operation of the water control system. After the

[8] J. Anderson (1998) in his reflections regarding the flood.

Portage Diversion was in operation in 1970, the increase in flooding became even more noticeable. The Assiniboine River which is diverted by the Portage Diversion into Lake Manitoba has an impact on Lake St. Martin waters levels.

6.2 Recommendations

Throughout this study, emphasis has been placed on the importance of collaboration. Collaboration should be the first step in achieving a solution regarding the flooding on Lake St. Martin First Nation which is caused by the development of water control structures. Collaboration involves two or more people or parties working together to reach an agreement or compromise.

Collaboration between the concerned stakeholders - downstream users and representatives of upstream interests have to reach an agreement on how to reduce or eliminate the flooding that has hitherto, destroyed Lake St. Martin. A collaborative approach will alleviate or minimize the fluctuation of water levels at Lake St. Martin First Nation.

In order to minimize the flooding, the Department of Natural Resources should collaborate with First Nations people by holding meetings in First Nation communities and advising them of increased water levels resulting from the water control systems. Natural Resources should ask for permission from First Nations people to release the water.

Results from the analyses support what neeji Anishinabaag knew all along, that the Fairford Dam is contributing to the flooding. There has to be some form of collaboration between the Province of Manitoba and the First Nations people with regard to the operation of Fairford Dam. Since it is First Nation land that is most affected, perhaps the Government should be more willing to study alternative methods for the operation of the Fairford Dam.

There is no doubt that neeji Anishinabaag have suffered losses in both physical, social, and mental nature. Continuous flooding will eventually increase the flooded area. Compensation should be provided in the form of accessing the land across the Narrows by connecting it with the populated side by means of a bridge. Replacement of land that has been flooded is another alternative. The land at Lake St. Martin First Nation has been damaged, therefore, it should be replaced. The land should be near the area as relocation and uprooting the First Nation people to a completely different location would not be feasible. The water remains in the landscape, even though it may not be readily visible to the naked eye.

The construction of permanent dikes should be seriously considered. They would be more beneficial as a long term strategic plan, rather than short term solutions of yearly sandbagging. Sandbagging has been employed as a strategy for controlling flooding within the last five years. This is not a feasible method as the sandbags are not only unattractive, but they do more damage than good. They do not last and eventually rot within a few months. Money is allocated for the removal of sandbags in the fall, but the sandbags are not removed because the money is diverted elsewhere.

If all else fails, collaboration among the affected First Nation communities would be the last resort in achieving a solution. It is very important for Fairford, Little Saskatchewan, Lake St. Martin, and Dauphin River get together and unite as one, in doing so, they would be very powerful (Anderson 1998). Past claims against the various government levels by each of the First Nation have not been successful. In order to demonstrate authority, the First Nation band have to display solidarity. Discussions with both levels of governments - Manitoba and Canada have been futile. However, court action taken by Fairford First Natoin also proved to be unsuccessful.

Monetary compensation should also be awarded for the downward spiral of neeji Anishinabaag well being that is attributed to the gradual depletion of fishing and hunting livelihoods. If a monetary compensation is reached, the money should go to each person and not to the Chief and Council, since it is the people that have been affected by the flood and not limited to Chief and Council. Community infrastructure should also be developed to replace the traditional activities that have been attributed to the flood.

This research was a collaboration effort with neeji Anishinabaag. Neeji Anishinabaag have maintained that the their land is being flooded. The research has provided the concerned parties with a method of reaching a compromise - through collaboration. Collaboration has shown how the western and traditional knowledge systems can validate and support the interests at stake. Collaboration would be more beneficial to all concerned stakeholders.

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APPENDIX A

SAMPLE DATA

ASSINIBOINE RIVER NEAR HOLLAND

DEPARTMENT OF NORTHERN AFFAIRS AND NATIONAL RESOURCES–WATER RESOURCES BRANCH

Daily Gauge Height in feet and Discharge in cubic feet per second for year ending 31 December 1963

Drainage area 61,980 square miles

Station No. 5MH-5

Day	January Gauge Height	January Discharge	February Gauge Height	February Discharge	March Gauge Height	March Discharge	April Gauge Height	April Discharge	May Gauge Height	May Discharge	June Gauge Height	June Discharge
1					1.82	36.0	5.80	2040	2.18	1560	1.96	1040
2					1.82	38.0	5.76	2050	2.39	1460	1.96	1040
3					1.82	40.0	5.65	1990	2.28	1350	1.95	1030
4					1.82	42.0	5.62	2010	2.15	1210	2.02	1090
5					1.82	44.0	5.75	2200	2.17	1230	2.09	1150
6					1.82	46.0	6.36	2480	2.20	1260	2.13	1190
7					1.82	48.0	7.14	2770	2.22	1280	2.18	1240
8					1.82	50.0	8.58	3780	2.04	1110	2.21	1270
9					1.82	52.0	7.22	3240	1.97	1050	2.25	1320
10					1.82	54.0	6.29	3460	2.01	1080	2.32	1390
11					1.82	57.0	5.11	3280	2.02	1090	2.62	1700
12					1.82	60.0	4.02	3180	2.02	1090	3.15	2260
13					2.61	64.0	4.03	3190	2.03	1100	3.51	2630
14					3.32	68.0	4.03	3190	2.04	1110	3.71	2850
15					3.32	73.0	4.03	3190	2.04	1110	4.10	3270
16					3.32	76.0	3.30	2420	2.06	1120	4.22	3390
17					3.32	80.0	3.21	2320	2.08	1140	3.91	3060
18					3.32	85.0	3.23	2340	2.09	1150	3.55	2680
19					3.32	90.0	3.04	2130	2.10	1160	3.46	2580
20					3.32	100	3.13	2230	2.11	1170	3.53	2650
21					4.24	452	2.95	2040	2.12	1180	3.38	2500
22					4.26	468	2.99	2080	2.13	1190	2.98	2070
23					4.82	761	2.94	2030	1.95	1030	3.23	1840
24					5.52	1280	2.82	1900	1.96	1040	3.40	1640
25					6.33	2020	2.81	1890	1.98	1050	2.51	1590
26					7.65	2360	2.80	1880	1.99	1060		1520e
27					7.36	2480	2.79	1870	2.00	1070		1470e
28					7.38	2500	2.78	1860	1.99	1060		1420e
29					6.56	2680	2.76	1840	1.98	1050		1370e
30					5.92	2060	2.60	1680	1.97	1050		1340e
31					5.82	2010			1.96	1040		
total						20274		72560		35650		55630
mean						654		2420		1150		1850
ac-ft						40210		143900		70710		110300
max.						2680		3780		1560		3390
min.						36.0		1680		1030		1030

Adjusted for

Day	July Gauge Height	July Discharge	August Gauge Height	August Discharge	September Gauge Height	September Discharge	October Gauge Height	October Discharge	November Gauge Height	November Discharge	December Gauge Height	December Discharge
1		1320e	1.64	777	1.19	406	1.06	368	1.12			
2		1290e	1.60	745	1.19	406	1.07	378	1.11			
3		1280e	1.63	769	1.20	406	1.07	368	1.10			
4		1280e	1.51	668	1.21	416	1.08	378	1.10			
5	2.22	1280	1.46	629	1.22	425	1.08	368	1.09			
6		1270e	1.43	604	1.23	425	1.08	368	1.09			
7	2.19	1250	1.26	468	1.25	444	1.09	368	1.08			
8	2.21	1270	1.30	500	1.26	454	1.10	378	1.08			
9	2.23	1290	1.32	516	1.27	454	1.11	387	1.08			
10	2.04	1110	1.33	524	1.26	444	1.11	378	1.08			
11	2.06	1010	1.33	524	1.25	434	1.12	387	1.07			
12	2.07	974	1.32	516	1.22	396	1.13	387	1.07			
13	2.08	918	1.31	508	1.21	387	1.13	387	1.07			
14	2.08	868	1.30	500	1.20	378	1.13	378	1.07			
15	2.09	842	1.29	492	1.19	358	1.13	378	1.07			
16	2.10	809	1.28	484	1.18	349	1.14	378	1.07			
17	2.13	785	1.27	476	1.17	340	1.14	378	1.07			
18	1.09	769	1.27	476	1.18	340	1.14	378	1.09			
19	1.18	745	1.28	450	1.19	349	1.15	378	1.92			
20	1.27	736	1.28	434	1.20	358	1.15	378	1.94			
21	1.49	728	1.28	425	1.22	368	1.15	368	1.98			
22	1.57	720	1.28	396	1.05	358	1.15	368				
23	1.57	720	1.28	378	1.07	378	1.15	368				
24	1.58	728	1.29	387	1.08	387	1.15	358				
25	1.58	728	1.30	396	1.09	396	1.15	358				
26	2.00	1070	1.32	416	1.08	387	1.15	349				
27	2.03	1100	1.33	425	1.08	387	1.15	349				
28	1.90	990	1.15	378	1.08	387	1.15	349				
29	1.78	893	1.16	387	1.07	378	1.15	340				
30	1.658	785	1.17	396	1.05	358	1.14	349				
31	1.72	842	1.18	396			1.13	340				
total		30400		15139		11753		11431				
mean		981		488		392		369				
ac-ft		60300		30620		23310		22680				
max.		1320		777		454		387				
min.		720		378		340		340				

Adjusted for

Computed from Table No. 2, dated July 14, 1964 from March 1 to October 31

Ice conditions March 1 to April 11.

e – Estimated

Discharge affected by upstream regulation.

Discharge adjusted to engineer's measurements August 20 to October 31.

Accuracy Records good except for estimated periods which are fair.

Add 980.00 feet to convert gauge height to elevation above mean sea level (U.S. of C. datum)

For the year:

Maximum Daily Gauge Height 8.58 ft on April 8

Minimum Daily Gauge Height 1.05 ft on September 22

Maximum Daily Discharge 3780 cfs at G.H. 8.58 ft on April 8

Minimum Daily Discharge 36.0 cfs at G.H. 1.82 ft on March 1

Annual Summary	
total	253,139
mean	1,030
ac-ft	502,000
max.	3,780
min.	36.0

Adjusted for: mean, cfsm, in., ac-ft

	Ice Period Gauge Height	Ice Period Discharge	Open Water Period Gauge Height	Open Water Period Discharge	Summary
Computed by					
Checked by					
Date					

APPENDIX B

WATER LEVELS SHOWING PRE-PORTAGE DIVERSION FOR 1955-1970

WATER LEVELS FOR PRE-PORTAGE DIVERSION 1955-1970				
Year	Lake St Martin	Assiniboine River	Lake Manitoba	Lake Winnipeg
Jul-55	244.719	294.531	248.645	218.438
Aug-55	244.604	293.76	248.539	218.35
Sep-55	244.436	293.425	248.409	218.225
Mar-56	244.651	293.675	248.222	217.642
Apr-56	244.464	295.025	248.187	217.615
May-56	244.275	296.01	248.255	217.798
Jun-56	244.218	295.482	248.339	218.063
Jul-56	244.177	294.483	248.293	218.203
Sep-56	244.492	293.404	248.157	218.008
Oct-56	244.34	293.367	248.112	217.841
Jan-57	243.819	293.687	248.083	217.591
Feb-57	243.819	293.687	248.048	217.545
Mar-57	243.754	294.58	248.012	217.53
Apr-57	243.724	294.205	248.017	217.539
May-57	243.672	294.71	248.044	217.649
Jun-57	243.579	293.705	248.051	217.777
Jul-57	243.569	293.324	248.08	217.847
Jan-58	243.677	293.283	247.808	217.286
Feb-58	243.796	293.283	247.791	217.277
Mar-58	243.865	294.208	247.771	217.264
Apr-58	243.824	293.964	247.756	217.274
May-58	243.397	293.272	247.731	217.307
Jun-58	243.3	293.09	247.656	217.304
Jul-58	243.187	293.007	247.652	217.322
Aug-58	243.141	292.959	247.554	217.319
Sep-58	243.102	292.931	247.53	217.204
Oct-58	243.009	293.041	247.456	217.133
Nov-58	242.931	293.074	247.452	217.054
Dec-58	243.111	293.283	247.529	217.048
Apr-59	243.185	293.522	247.544	217.063
May-59	243.185	293.233	247.589	217.316
Oct-59	242.878	292.925	247.542	217.652
Nov-59	242.93	293.05	247.612	217.609
Dec-59	243.09	296.192	247.629	217.566
Apr-60	243.447	295.918	247.662	217.542
May-60	243.606	294.376	247.755	217.716
Jun-60	243.373	293.699	247.775	217.795
Mar-61	242.462	293.825	247.586	217.143
Apr-61	242.832	293.535	247.601	217.136
May-61	242.672	293.101	247.659	217.21

Jun-61	242.586	292.975	247.62	217.207
Jul-61	242.492	292.923	247.543	217.152
Aug-61	242.654	292.882	247.451	217.036
Sep-61	242.514	292.877	247.325	216.874
Oct-61	242.473	292.907	247.342	216.768
Apr-62	242.517	294.135	247.401	216.755
May-62	242.41	293.485	247.443	216.929
Jun-62	242.381	293.143	247.543	217.152
Jul-62	242.379	293.002	247.458	217.304
Aug-62	242.348	293.001	247.443	217.322
Sep-62	242.371	292.936	247.418	217.414
Oct-62	242.342	292.953	247.375	217.365
Nov-62	242.352	293.968	247.359	217.268
Mar-63	242.502	293.724	247.41	217.204
Apr-63	242.625	293.924	247.469	217.258
May-63	242.699	293.243	247.501	217.383
Jun-63	242.634	293.49	247.6	217.524
Jul-63	242.68	293.17	247.607	217.606
Aug-63	242.957	293.012	247.486	217.594
Sep-63	242.88	292.965	247.427	217.457
Oct-63	242.659	292.951	247.373	217.31
Nov-63	242.557	292.976	247.281	217.161
Mar-64	242.64	293.419	247.353	217.121
Apr-64	242.729	293.94	247.376	217.143
May-64	242.731	293.701	247.405	217.332
Jun-64	242.583	293.2	247.327	217.389
Jul-64	242.459	293.11	247.337	217.624
Aug-64	242.362	292.984	247.215	217.45
Sep-64	242.318	293.047	247.15	217.313
Oct-64	242.243	292.991	247.085	217.228
Nov-64	242.254	292.985	247.056	217.222
Mar-65	242.328	292.811	247.139	217.231
Apr-65	242.441	294.455	247.187	217.322
May-65	242.455	293.918	247.254	217.649
Jun-65	242.48	293.695	247.351	217.95
Jul-65	242.435	293.635	247.324	218.173
Aug-65	242.453	293.285	247.295	218.203
Apr-66	242.609	294.328	247.462	218.042
May-66	242.792	294.413	247.556	218.347
Jun-66	243.02	293.618	247.588	218.575
Jul-66	243.346	293.2	247.565	218.688
Aug-66	243.398	293.107	247.471	218.587
Mar-67	242.904	293.374	247.661	217.889
Apr-67	243.398	294.154	247.692	217.966
May-67	244.099	294.282	247.749	218.136
Jun-67	244.306	293.6	247.693	218.176
Jul-67	244.215	293.063	247.594	218.145
Aug-67	244.002	293.08	247.531	218.014

Sep-67	243.559	292.952	247.472	217.755
Oct-67	243.063	292.987	247.446	217.588
Jan-68	243.294	293.35	247.533	217.444
Feb-68	243.663	293.418	247.511	217.478
Mar-68	243.846	293.78	247.471	217.463
Apr-68	243.706	293.903	247.479	217.46
May-68	243.337	293.359	247.529	217.53
Jun-68	243.304	293.168	247.569	217.569
Jul-68	243.459	293.095	247.519	217.658
Aug-68	243.496	293.131	247.503	217.706
Sep-68	243.401	293.204	247.55	217.709
Oct-68	243.343	293.171	247.468	217.713
Nov-68	243.367	293.239	247.471	217.673
Dec-68	243.517	293.342	247.431	217.761
Jan-69	243.621	293.535	247.433	217.85
Feb-69	243.712	293.652	247.431	217.935
Mar-69	243.791	293.836	247.411	217.95
Apr-69	243.773	295.529	247.405	218.011
May-69	243.605	295.273	247.447	218.191
Jun-69	243.496	294.288	247.401	218.222
Jul-69	243.371	293.992	247.474	218.167
Aug-69	243.209	293.531	247.47	218.197
Sep-69	243.121	293.225	247.41	218.173
Oct-69	243.075	293.24	247.377	218.17
Nov-69	242.91	293.352	247.389	218.13
Dec-69	242.84	293.57	247.434	218.118
Jan-70	242.825	293.636	247.465	218.121
Feb-70	242.828	293.739	247.488	218.173
Mar-70	242.892	293.912	247.509	218.188
Apr-70	242.267	294.928	247.513	218.173
May-70	243.482	295.458	247.682	218.017
Jun-70	243.898	294.62	247.687	218.414
Jul-70	244.154	294.178	247.632	218.487
Aug-70	244.093	293.553	247.509	218.404
Sep-70	243.813	293.288	247.403	218.188
Oct-70	243.535	293.236	247.392	218.008

APPENDIX C
WATER LEVELS SHOWING POST-PORTAGE DIVERSION FOR 1970-1997

Table 2: Water Levels showing Post-Portage Diversion for 1970-1997

WATER LEVELS FOR POST-PORTAGE DIVERSION 1970-1997				
Year	Lake St Martin	Assiniboine River	Lake Manitoba	Lake Winnipeg
Jan-70	242.825	293.636	247.465	218.121
Feb-70	242.828	293.739	247.488	218.173
Mar-70	242.892	293.912	247.509	218.188
Apr-70	242.267	294.928	247.513	218.173
May-70	243.482	295.458	247.682	218.017
Jun-70	243.898	294.62	247.687	218.414
Jul-70	244.154	294.178	247.632	218.487
Aug-70	244.093	293.553	247.509	218.404
Sep-70	243.813	293.288	247.403	218.188
Oct-70	243.535	293.236	247.392	218.008
Mar-71	243.017	293.743	247.638	218.124
Apr-71	243.761	294.202	247.647	218.215
May-71	244.154	294.154	247.642	218.331
Jun-71	244.197	294.073	247.611	218.295
Jul-71	244.154	293.8	247.53	218.215
Aug-71	243.813	293.306	247.485	218.045
Sep-71	243.377	293.001	247.43	217.825
Oct-71	243.231	293.288	247.44	217.673
Nov-71	243.245	293.487	247.483	217.649
Dec-71	243.419	293.955	247.509	217.731
Feb-72	243.739	293.912	247.493	217.908
Mar-72	243.822	294.446	247.485	217.996
Apr-72	243.831	295.177	247.514	218.109
May-72	243.843	294.973	247.62	218.31
Jun-72	243.935	294.12	247.607	218.292
Jul-72	243.968	293.553	247.505	218.167
Aug-72	243.435	293.218	247.486	217.999
Sep-72	242.941	293.173	247.467	217.853
Oct-72	242.718	293.242	247.454	217.685
Nov-72	242.816	293.342	247.462	217.588
Jan-73	243.298	294.074	247.465	217.633
Feb-73	243.426	293.967	247.449	217.645
Mar-73	243.379	294.022	247.457	217.679
Apr-73	242.877	293.355	247.467	217.697
May-73	242.877	293.272	247.517	217.63
Jun-73	242.846	293.389	247.605	217.588
Jul-73	243.237	293.248	247.591	217.679
Aug-73	243.407	293.144	247.547	217.627
Sep-73	243.291	293.178	247.522	217.557
Oct-73	243.239	293.343	247.541	217.545

Nov-73	243.288	293.455	247.522	217.615
Dec-73	243.416	293.626	247.561	217.682
Jan-74	243.563	294.693	247.561	217.722
Feb-74	243.675	293.818	247.557	217.798
Mar-74	243.715	293.989	247.547	217.865
Apr-74	243.935	295.337	247.541	217.972
May-74	244.477	295.944	247.789	218.389
Jun-74	244.684	295.408	247.848	218.758
Jul-74	244.574	294.393	247.707	218.892
Aug-74	244.337	293.745	247.56	218.74
Sep-74	244.099	293.501	247.475	218.569
Oct-74	243.907	293.461	247.449	218.377
Nov-74	243.773	293.541	247.416	218.225
Dec-74	243.77	293.803	247.41	218.182
Jan-75	243.849	293.788	247.408	218.234
Feb-75	243.846	293.849	247.423	218.283
Mar-75	243.748	293.916	247.418	218.289
Apr-75	243.712	294.374	247.441	218.295
May-75	243.819	295.979	247.579	218.356
Jul-75	244.181	294.571	247.568	218.441
Aug-75	244.02	293.934	247.558	218.487
Sep-75	243.822	293.845	247.574	218.365
Oct-75	244.072	294.01	247.567	218.2
Nov-75	244.139	293.893	247.536	217.959
Jan-76	244.255	294.051	247.496	217.905
Feb-76	244.236	293.936	247.452	217.889
Mar-76	244.191	294.064	247.432	217.914
Apr-76	244.255	297.673	247.574	217.99
May-76	244.505	296.523	247.838	218.026
Jun-76	244.651	294.995	247.81	217.914
Jul-76	244.599	294.33	247.692	217.819
Aug-76	244.346	293.806	247.538	217.6
Sep-76	243.989	293.438	247.381	217.423
Oct-76	243.383	293.604	247.328	217.219
Nov-76	243.041	293.371	247.335	217.082
Dec-76	242.898	293.8	247.379	216.951
Feb-77	242.913	293.742	247.443	216.957
Mar-77	242.95	293.751	247.461	216.957
Apr-77	242.932	293.373	247.479	216.914
May-77	242.782	293.224	247.618	216.926
Jun-77	242.828	293.135	247.648	216.941
Jul-77	243.575	293.184	247.557	216.944
Aug-77	243.502	293.144	247.482	216.926
Sep-77	243.057	293.154	247.532	216.908
Oct-77	243.038	293.192	247.56	216.966
Nov-77	243.178	293.251	247.501	216.993
Feb-78	243.816	293.797	247.444	217.182
Mar-78	243.855	293.858	247.412	217.207

Apr-78	243.764	294.236	247.415	217.347
May-78	243.505	293.544	247.481	217.514
Jun-78	243.267	293.23	247.492	217.624
Jul-78	243.206	293.2	247.495	217.737
Aug-78	242.993	293.123	247.421	217.795
Sep-78	243.904	293.115	247.423	217.795
Oct-78	242.779	293.067	247.416	217.777
Nov-78	242.792	293.3	247.418	217.691
Jan-79	243.038	293.598	247.459	217.624
Apr-79	243.624	294.925	247.554	217.591
May-79	244.398	295.757	247.818	217.847
Jun-79	244.669	295.155	247.888	218.1
Sep-79	244.114	293.12	247.55	217.798
Oct-79	243.773	293.11	247.489	217.694
Nov-79	243.663	293.343	247.471	217.572
Dec-79	243.675	293.767	247.502	217.478
Jan-80	243.779	293.692	247.514	217.469
Feb-80	243.879	293.726	247.513	217.499
Mar-80	243.913	293.814	247.499	217.511
Apr-80	243.807	293.762	247.478	217.517
May-80	243.486	293.209	247.48	217.591
Jun-80	243.096	293.1	247.454	217.591
Jul-80	242.837	293.083	247.445	217.618
Aug-80	242.779	293.165	247.478	217.627
Sep-80	243.032	293.129	247.526	217.603
Oct-80	243.194	293.182	247.45	217.545
Nov-80	243.185	293.291	247.47	217.408
Dec-80	243.237	293.624	247.48	217.353
Jan-81	243.34	293.673	247.428	217.304
Feb-81	243.441	293.812	247.403	217.258
Mar-81	243.429	293.857	247.383	217.2
Apr-81	243.206	293.288	247.392	217.194
May-81	242.968	293.191	247.388	217.204
Jun-81	242.852	293.153	247.437	217.268
Jul-81	242.731	293.106	247.481	217.389
Aug-81	242.746	293.061	247.459	217.45
Sep-81	242.731	293.103	247.446	217.386
Oct-81	242.737	293.174	247.415	217.332
Nov-81	242.767	293.422	247.386	217.225
Feb-82	242.968	293.713	247.388	217.216
Mar-82	243.066	293.701	247.375	217.24
Apr-82	243.179	294.487	247.411	217.301
May-82	243.081	294.092	247.463	217.426
Jul-82	242.764	293.155	247.507	217.746
Aug-82	242.681	293.081	247.446	217.777
Oct-82	242.694	293.166	247.348	217.563
Dec-82	242.752	293.798	247.397	217.414
Jan-83	242.788	293.773	247.422	217.374

Feb-83	242.831	293.839	247.42	217.383
Mar-83	242.934	294.1	247.46	217.463
Apr-83	242.989	295.139	247.515	217.536
May-83	243.112	294.633	247.608	217.603
Jun-83	243.304	293.856	247.651	217.728
Jul-83	243.614	293.356	247.647	217.838
Aug-83	243.666	293.46	247.513	217.801
Sep-83	243.429	293.301	247.411	217.703
Oct-83	243.176	293.256	247.406	217.536
Nov-83	243.13	293.388	247.436	217.411
Dec-83	243.13	293.772	247.406	217.371
Jan-84	243.233	293.449	247.423	217.347
Feb-84	243.386	293.528	247.422	217.341
Mar-84	243.465	293.501	247.413	217.335
Apr-84	243.447	293.094	247.419	217.405
May-84	243.36	293.044	247.519	217.487
Jun-84	243.084	293.04	247.594	217.569
Jul-84	243.435	293.002	247.546	217.652
Aug-84	243.566	292.806	247.461	217.581
Sep-84	243.282	292.794	247.362	217.447
Oct-84	243.121	292.861	247.429	217.347
Nov-84	243.109	293.058	247.466	217.335
Dec-84	243.209	293.294	247.53	217.264
Jan-85	243.459	293.419	247.543	217.28
Feb-85	243.608	293.515	247.55	217.301
Mar-85	243.691	294.028	247.543	217.246
Apr-85	243.743	293.89	247.548	217.264
May-85	243.636	293.416	247.551	217.356
Jun-85	243.596	293.248	247.525	217.551
Jul-85	243.49	292.899	247.51	217.722
Aug-85	243.212	292.935	247.506	217.819
Sep-85	243.127	292.991	247.553	217.898
Oct-85	243.185	293.037	247.495	217.905
Nov-85	243.313	293.257	247.522	217.877
Dec-85	243.477	293.413	247.532	217.853
Jan-86	243.605	293.393	247.524	217.804
Feb-86	243.697	293.418	247.51	217.801
Mar-86	243.743	293.82	247.499	217.792
Apr-86	243.724	294.031	247.574	217.844
May-86	244.041	294.009	247.778	217.959
Jun-86	244.361	293.257	247.683	217.92
Jul-86	244.358	292.984	247.614	217.804
Aug-86	244.102	292.923	247.509	217.77
Sep-86	243.517	292.837	247.412	217.649
Oct-86	243.243	292.939	247.448	217.585
Nov-86	243.249	293.129	247.402	217.46
Dec-86	243.337	293.329	247.461	217.411
Jan-87	243.419	293.381	247.458	217.402

Feb-87	243.496	293.42	247.455	217.389
Mar-87	243.569	293.596	247.48	217.408
Apr-87	243.654	294.45	247.536	217.508
May-87	243.727	293.279	247.528	217.6
Jun-87	243.672	292.987	247.5	217.691
Jul-87	243.355	292.959	247.46	217.722
Aug-87	242.993	292.945	247.487	217.713
Sep-87	242.792	292.916	247.456	217.581
Oct-87	242.813	292.968	247.43	217.438
Nov-87	242.883	292.964	247.45	217.234
Dec-87	242.944	293.085	247.458	217.085
Jan-88	243.06	293.298	247.462	217.042
Feb-88	243.249	293.363	247.469	217.048
Mar-88	243.386	293.384	247.458	217.018
Apr-88	243.368	293.171	247.474	217.045
May-88	243.276	293.308	247.584	217.124
Jun-88	243.505	293.182	247.563	217.173
Jul-88	243.429	293.011	247.479	217.155
Aug-88	243.048	292.845	247.387	217.079
Sep-88	242.831	292.818	247.334	216.993
Oct-88	242.715	292.792	247.336	216.96
Nov-88	242.654	292.859	247.348	216.883
Dec-88	242.694	293.039	247.381	216.838
Jan-89	242.794	293.165	247.406	216.838
Feb-89	242.917	293.269	247.422	216.883
Mar-89	243.029	293.38	247.419	216.975
Apr-89	243.066	293.786	247.437	217.033
May-89	242.907	292.875	247.474	217.136
Jun-89	242.819	292.812	247.518	217.258
Jul-89	242.782	292.791	247.537	217.377
Aug-89	242.761	292.761	247.45	217.393
Sep-89	242.767	292.818	247.416	217.328
Oct-89	242.734	292.827	247.351	217.197
Nov-89	242.785	292.954	247.361	217.118
Dec-89	242.917	293.161	247.361	217.051
Jan-90	243.117	293.248	247.373	217.018
Feb-90	243.273	293.322	247.38	216.984
Mar-90	243.383	293.505	247.392	216.996
Apr-90	243.374	293.856	247.413	217.042
May-90	243.243	293.253	247.505	217.188
Jun-90	243.16	293.131	247.561	217.374
Jul-90	243.227	293.069	247.546	217.56
Aug-90	243.212	292.964	247.457	217.615
Sep-90	243.124	292.857	247.35	217.551
Oct-90	242.935	292.891	247.306	217.389
Nov-90	242.877	292.972	247.262	217.249
Dec-90	242.92	293.112	247.291	217.13
Jan-91	243.041	293.186	247.296	217.085

Feb-91	243.173	293.244	247.297	217.079
Mar-91	243.249	293.307	247.302	217.082
Apr-91	243.145	293.224	247.338	217.082
May-91	242.984	292.974	247.407	217.112
Jun-91	242.828	292.943	247.447	217.161
Jul-91	242.831	293.085	247.477	217.234
Aug-91	242.734	292.941	247.399	217.197
Sep-91	242.7	292.869	247.291	217.109
Oct-91	242.703	292.949	247.245	217.045
Nov-91	242.819	293.16	247.276	217.018
Dec-91	242.932	293.279	247.304	217.012
Jan-92	243.02	293.332	247.296	217.018
Feb-92	243.096	293.352	247.284	217.027
Mar-92	243.16	293.837	247.289	217.024
Apr-92	243.163	293.995	247.333	217.088
May-92	243.075	293.437	247.42	217.292
Jun-92	242.917	292.999	247.415	217.533
Jul-92	242.868	292.917	247.426	217.697
Aug-92	242.81	292.865	247.376	217.777
Sep-92	242.767	292.845	247.352	217.801
Oct-92	242.74	292.91	247.327	217.783
Nov-92	242.843	292.944	247.299	217.652
Dec-92	242.823	293.107	247.312	217.572
Jan-93	242.999	293.212	247.322	217.511
Feb-93	243.093	293.252	247.317	217.447
Mar-93	243.148	293.338	247.307	217.339
Apr-93	243.014	293.131	247.321	217.389
May-93	242.886	292.882	247.347	217.429
Jun-93	242.788	292.836	247.349	217.472
Jul-93	242.752	293.035	247.385	217.615
Aug-93	242.694	292.97	247.384	217.743
Sep-93	242.718	293.024	247.365	217.853
Oct-93	242.679	293.114	247.349	217.755
Nov-93	242.819	293.518	247.365	217.731
Dec-93	242.996	293.581	247.392	217.685
Jan-94	243.072	293.531	247.399	217.615
Feb-94	243.176	293.481	247.396	217.578
Mar-94	243.349	293.692	247.392	217.572
Apr-94	243.237	293.465	247.4	217.594
May-94	243.029	293.282	247.428	217.606
Jun-94	242.874	293.168	247.444	217.621
Jul-94	242.856	293.225	247.449	217.691
Aug-94	242.788	293.254	247.434	217.7
Sep-94	242.718	293.202	247.44	217.6
Oct-94	242.843	293.069	247.389	217.481
Nov-94	242.981	293.228	247.404	217.386
Dec-94	243.163	293.437	247.387	217.399
Jan-95	243.176	293.313	247.419	217.411

Feb-95	243.206	293.317	247.432	217.377
Mar-95	243.273	293.767	247.445	217.393
Apr-95	243.267	295.583	247.553	217.511
May-95	243.56	296.187	247.728	217.581
Jun-95	243.907	294.724	247.777	217.688
Jul-95	243.95	293.401	247.65	217.67
Aug-95	243.907	293.186	247.597	217.624
Sep-95	243.614	293.09	247.465	217.548
Oct-95	243.31	293.08	247.438	217.414
Nov-95	243.191	293.232	247.455	217.283
Dec-95	243.27	293.472	247.516	217.261
Jan-96	243.349	293.521	247.526	217.28
Feb-96	243.48	293.562	247.541	217.295
Mar-96	243.627	293.662	247.546	217.328
Apr-96	243.843	294.935	247.56	217.38
May-96	244.111	295.052	247.734	217.676
Jun-96	244.078	294.251	247.813	217.902
Jul-96	244.197	293.496	247.774	217.886
Aug-96	244.166	293.309	247.733	217.798
Sep-96	244.102	293.309	247.619	217.688
Oct-96	244.096	293.309	247.49	217.545
Nov-96	243.941	293.224	247.483	217.475
Jan-97	243.554	293.413	247.58	217.53
Feb-97	243.654	293.502	247.587	217.545
Mar-97	243.816	293.729	247.576	217.581
Apr-97	243.867	295.09	247.589	217.645
May-97	244.191	294.696	247.729	218.014
Jun-97	244.447	293.91	247.738	218.1
Jul-97	244.319	293.377	247.681	217.981
Aug-97	244.203	293.068	247.61	217.807
Sep-97	244.087	292.987	247.54	217.697
Oct-97	243.785	293.013	247.46	217.734
Nov-97	243.499	293.028	247.477	217.767
Dec-97	243.456	293.082	247.509	217.725

APPENDIX D

SAMPLE CALCULATION USED TO OBTAIN RELATIONSHIPS OF PRE- AND POST-PORTAGE DIVERSION

The coefficent for the intercept of 149.3653 the coefficient for the x-variable of .319606 were obtained from Figure 25. The figures were then entered into the equation:

$$y = a + bx$$

$$242.690250 = 149.3653 + .319606 * 292$$

where

$y = 242.690250$ (dependent variable)

$a = 149.3653$ (intercept)

$b = .319606$ (x-variable)

$x = 292$ (independent variable)