Manitoba
CONSERVATION

INVESTIGATION OF THE MERITS OF MANAGEMENT OF RED RIVER SUMMER WATER LEVELS IN THE CITY OF WINNIPEG

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FINAL REPORT

NOVEMBER 2003

KGS GROUP

KONTZAMANIS ▪ GRAUMANN ▪ SMITH ▪ MACMILLAN INC.
CONSULTING ENGINEERS & PROJECT MANAGERS

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EXECUTIVE SUMMARY

Introduction

In October 2002, KGS Group was authorized to proceed with a feasibility study of the merits of summer water level control in the City of Winnipeg. This study was initiated following the emergency operation of the Red River Floodway during the summer of 2002 and a preliminary assessment of summer water control as a part of KGS Group's November 2001 report, "Flood Protection Studies for Winnipeg" (KGS Group, 2001). The scope of work for this current study was based on a proposal submitted to the Province of Manitoba and to the Project Steering Committee on October 11, 2002.

A number of options for summer water level control were considered as a part of the KGS Group study "Flood Protection Studies for Winnipeg" (KGS Group, 2001). The 2001 study concluded that costs to completely eliminate the effects of summer flooding and not raise upstream water levels above the "state-of-nature" would increase the Floodway Expansion costs by over $100 Million. This was deemed not to be practical. For the purpose of this study, the option of using the existing Floodway configuration and temporarily raising the upstream water levels above the "state-of-nature" is being studied to assess the financial feasibility of the summer water level control.

In addition to the merits and costs of summer water level control, this study considered an assessment of the emergency operation of the Floodway that was authorized on June 28, 2002 when the Red River water level was predicted to exceed el. 14 ft JAPSD (James Avenue Pump Station Datum). This decision was based on the risk of basement flooding due to possible heavy rain over the city in combination with high river levels.

To assist with the study direction and provide input to the study, a Steering Committee was established with representatives from Canada, the Province of Manitoba, the City of Winnipeg, as well as upstream and downstream stakeholders. The Steering Committee Members are as follows:

- Rick Bowering (Manitoba Conservation, Chair)
- Eugene Kozera (Manitoba Conservation)

- Rick Hay (Manitoba Conservation)
- Henry Daniels (Manitoba Conservation)
- Maurice Sydor (Environment Canada)
- Doug McNeil (City of Winnipeg)
- Tony Kettler (PFRA)
- Herm Martens (RM of Morris)
- Bob Stefaniuk (RM of Ritchot)
- Val Rutherford (RM of Ritchot)
- Doug Dobrowolski (RM of MacDonald)
- Bud Oliver (Selkirk and District Planning Area Board)
- Cas Booy (Independent Member)

Assessment of Benefits and Costs

The assessment of benefits and costs was based on the effects of summer operation of the Floodway Inlet Control Structure on:

- Potential basement flood damage and operating costs for flood infrastructure in the City of Winnipeg compared to the existing conditions.
- Recreation activities that occur during the summer navigation season on the Red River, Assiniboine River and other tributaries that are affected by changes in water levels on the Red River, between the Floodway Inlet and Floodway Outlet.
- Flood and disruption damages to market gardeners, cereal crops, and uncultivated riverbank land located upstream of the Floodway Inlet Control Structure. Costs associated with these damages were estimated using compensation and buyout approaches. The first approach was based on compensation for losses following each summer operation event, while the buyout approach considers a one time, “upfront”, purchase of the affected lands. A potential hybrid solution (i.e. part buyout and part compensation) was also considered.
- Costs of summer operation and maintenance of the flood control infrastructure.
- Flood damage and maintenance costs to affected municipal infrastructure upstream of the Floodway Inlet Control Structure such as roads, drains, water intakes, etc.
- Property tax revenue to upstream municipalities due to buyout of flood prone lands by the Province.
- Recreational boaters north of Winnipeg.

In addition to quantitative assessment of benefits and costs, additional items were identified which are positively or negatively affected by the summer operation of the Floodway Inlet Control Structure. These include:

- Bank stability effects of summer operation, upstream and downstream of the Floodway Inlet Control Structure.
- Environmental considerations, including potential fisheries effects and the requirements of the Department of Fisheries and Oceans, as well as potential effects to the area north of the St. Andrews Lock and Dam, including Selkirk.

Results and Sensitivity Analyses

The analysis of benefits and costs indicate that the optimum target water level is el. 8 ft JAPSD, where both the B/C ratio and net benefits tend to peak. This occurs because the upstream damages increase at a higher rate than the benefits as the summer water level control is reduced to el. 8 ft JAPSD. Furthermore, there are negligible additional recreation/tourism benefits for controlled water levels below el. 8 ft JAPSD.

The inputs considered in the analysis were based on assumptions that are difficult to verify, require substantially greater effort to substantiate, or depend on future conditions that cannot be predicted with certainty. The sensitivity of the results of the analyses was, therefore, assessed for reasonable bounds in the variability of these assumptions.

For the sensitivity assessment, the base case used the “hybrid” (i.e. part buyout and part compensation) approach to calculating upstream damages. A total buyout approach was deemed to be not economically feasible and a total compensation approach was considered to be extremely difficult to implement and carry out into the future. The benefit/cost ratios and net benefits for the base case are 2.7 and $670,000, respectively, when recreation / tourism benefits are included in the assessment. When recreation and tourism benefits are excluded, these values reduce to 1.9 and $340,000 respectively.

The sensitivity of these economic indicators was tested for reasonable upper and lower bounds for the assumptions that could potentially have the most significant effect on the results. The results of the analysis are shown on the Table below.

Sensitivity Analysis to Cost / Damage Input

Scenario	Benefit / Cost Ratio: With High Recreation / Tourism Benefits	Benefit / Cost Ratio: With No Recreation / Tourism Benefits	Net benefits: With High Recreation / Tourism Benefits	Net benefits: With No Recreation / Tourism Benefits
Base Case	2.7	1.9	$ 670,000	$ 340,000
+10% Upstream Damages	2.5	1.7	$ 630,000	$ 295,000
-25% Upstream Damages	3.6	2.5	$ 760,000	$ 430,000
+40% Benefits due to Reduced Basement Flood Damages	3.4	2.6	$ 960,000	$ 625,000
-40% Benefits due to Reduced Basement Flood Damages	2.0	1.1	$ 380,000	$ 45,000
Highest Benefit Scenario -25% Upstream Damages & +40% Benefits due to Reduced Basement Flood Damages	4.6	3.5	$ 1,100,000	$ 720,000
Lowest Benefit Scenario +10% Upstream Damages & -40% Benefits due to Reduced Basement Flood Damages	1.8	1.0	$ 340,000	$ 5,000

Alternate Means to Deal with Elevated Summer Water Levels

During meetings with the Steering Committee and other stakeholders, alternatives to summer flood control were discussed. These included increasing the size of and/or adding additional Flood Pump Stations in the city of Winnipeg. Such actions could theoretically alleviate basement flood damages by allowing the drainage districts to be isolated from high river levels and pumping the rainfall runoff to the river when necessary. Based on a cursory assessment of this alternative, it was concluded that the high costs required to upgrade the Flood Pump Stations make this option not a viable alternative to summer water level control.

Another alternative that could be considered, in conjunction with increased capacity of the Flood Pump Stations or separately, would be to increase the elevation of the river walkways and the associated infrastructure. Although this is technically feasible, it would, however, be costly and regressive to replace these works constructed over the past ten to fifteen years. This is not seen as a viable alternative.

If the Floodway is expanded as currently planned, the frequency of summer flooding will not be affected. The upstream effects of summer water level control will, however, be reduced, due to the larger capacity of the Floodway. Consideration of the effects of an expanded floodway were excluded from the scope of this study.

Assessment of 2002 Operation of Floodway

As a part of this study, an assessment of the 2002 operation of the Floodway was undertaken. The scope of this assessment included

- Review and documentation of the planning phases of 2002 summer Floodway operation.
- Review of the operation criteria, including
  - Initiation levels
  - Response to rainfall forecasts
  - River level drawdown rates
- Recommendations for future summer operation

Based on the experiences of 2002 and the analysis of rainfall and river water level response times, it was concluded that it is not practical to operate the Floodway in response to rainfall forecasts. This is due to the short time frame and uncertainty associated with forecasting rainfall and the relatively long response time for water levels to adjust to Floodway gate adjustments. Therefore, if a decision is made to operate the Floodway in the future for summer water level control, it should be done as soon as water levels exceed a predetermined threshold, say el. 9 ft or 10 ft JAPSD. The control level would then be el. 8 ft JAPSD based on the costs and benefits analysis. Given the relative response times of the sewer and the river, implementing the Floodway for summer water level control needs to be viewed as purchasing an insurance policy. That is, the costs associated with upstream damages will need to be paid out and depending on the extent of rainfall, there may or may not be avoided damages. In those years when damages do occur they will, however, be substantial. For example in 1993, the total estimated damages of $140 Million could possibly have been reduced by tens of millions of dollars for a cost of summer operation in the order of $1 million.

If the decision is made to control summer levels when water levels exceed the predetermined threshold, it can then be done in a controlled manner, minimizing the concerns associated with the drawdown rate and associated bank stability considerations.

Environmental Considerations

A number of environmental issues will need to be resolved prior to proceeding with the control of summer river levels in Winnipeg. It is assumed that this will be a project requiring a license for a change in the Floodway operation rules and that the environmental issues will be dealt with as a part of the environmental licensing process. These include:

- Fish passage at the Floodway Inlet Control Structure
- Assessment of the effects on and compensation requirements for the upstream stakeholders
- Concerns of downstream stakeholders associated with changed flow regime.

Bank Stability Considerations

The implications of the summer control operation on riverbank stability are complex. Bank stability is controlled by numerous natural and man-made factors. It is anticipated that the incremental impacts on bank performance from the control of the summer flood levels will be relatively minor both upstream and downstream of the Inlet Control Structure relative to the natural factors. Any negative physical impacts that might be realized upstream of the Inlet will be offset by the positive impacts experienced downstream. Based on a comparison of the values of land impacted, the benefit/cost ratio is anticipated to be greater than 1, considering the higher land values within Winnipeg.

An engineering investigation and geotechnical monitoring program is recommended to obtain base-line information on the bank stability conditions prior to implementation of the summer control program, and to determine the influences directly attributed to control of summer water levels. The estimated cost to complete the investigation and installation of the monitoring instrumentation is anticipated to be in the range of $225,000 to $375,000. An additional allowance for monitoring and data interpretation over a 10 year period should also be included for planning purposes.

Assessment of Results

The results of the benefit cost analysis demonstrate that summer water level control is a viable endeavor from a societal perspective. For the base case conditions, benefit / cost ratios of 2.7 and 1.9 with and without tourism / recreation benefits, respectively, have been calculated. Although these B/C ratios are substantially greater than 1, they are not overwhelmingly in support of the summer control initiative. As described above, the B/C ratios are relatively sensitive to reasonable lower and upper bounds associated with the assumptions made for the analysis. When viewed from a lowest reasonable benefit perspective, the B/C ratios are reduced to 1.8 and 1.0 for conditions with and without tourism / recreation benefits, respectively. On the other hand, based on a highest reasonable benefit assessment of the contributing assumptions to the analysis, B/C ratios as high as 4.6 and 3.5 were calculated for conditions with and without recreation benefits, respectively. This would normally be viewed as an attractive project, and justify investment of public funds.

The economic analysis described in this report is based on traditional methods of estimating the expected annual damages (EAD) associated with the status quo (no use of the Floodway in summer season) and with various alternatives of operating the Floodway to reduce summer levels in Winnipeg. In recent years it has become standard policy by the U.S. Army Corps of Engineers to consider risk and uncertainty in the estimation of the EAD. This methodology almost invariably results in computed benefits that exceed the values that would be estimated by traditional, less rigorous means that ignore the existence of uncertainties in the parameters being analyzed. For example, studies of the Floodway Expansion showed an increase of over 25% in the project benefits with proper recognition of the effects of uncertainty. Similar increases in the benefits could be anticipated for this project.

Benefits due to reduced basement flood damages are less than might have been anticipated based on reported basement flood damages in 1993. Although damages were high that year (reported in the order of $140 Million), large portions of these damages were due to significant rainfall events and not necessarily due to the coincident high river levels. That is, substantial portions of these damages would have occurred even if river water levels had been normal. Damages of this type are, therefore, not included with the benefits of summer water level control.

In addition to the benefits that have been quantified, there are a number of intangible benefits of control of summer water levels that should be considered in the assessment of whether or not to proceed.

- Stress and anxiety levels associated with those Winnipegers living in areas vulnerable to basement flooding will be high during periods of elevated river levels regardless of whether or not significant rainfall occurs. Alleviating this stress to those living in these areas is a benefit that cannot be quantified. Furthermore, damages associated with disruption, personal and business loss during periods of flooding has not been considered in the assessment of benefits. Increased stress and anxiety should also be considered for those living upstream of the Floodway Inlet Control Structure as well.

- The potential good will and further establishment of Winnipeg's reputation as the "River City" could bring substantial undefined benefits to the City as a destination and to the citizens for their own use. Reliable stable levels on the Red and Assiniboine Rivers within the City would enhance the well being of all Winnipegers in a manner that can't be quantified.

Other considerations such as resolving issues associated with fish passage and the concerns of Fisheries and Oceans Canada (DFO) with operation of the Floodway Inlet Control Structure will need to be resolved prior to proceeding. Preliminary discussions with the DFO indicate that this issue can be resolved. Further discussion and analysis is required at the next planning stage.

Study Recommendations

Based on the results of the study, a number of recommendations have been made.

- Based on the B/C ratio, control of summer levels appears to have merit and Manitoba should proceed to the next level of assessment of whether or not to proceed with summer control of river level.

- At the next level of planning, the following issues should be resolved, based on more thorough assessment than was possible in this conceptual study:

    - The overall B/C cost ratio required to proceed with the project, with or without tourism and recreation benefits.

    - The value of the intangible benefits, especially the potential for greater economic, recreational and cultural benefits associated with an integrated and fully developed river system in Winnipeg.

    - The approach to resolving compensation issues for upstream stakeholders. This needs to consider geotechnical issues and crop and land related damages.

  - The approach to deal with the environmental issues should be identified, namely DFO and the downstream stakeholders.

- Further studies should be initiated to refine the estimate of benefits and costs based on the results of this study. Consideration should also be given to using the United States Army Corps of Engineers (USACE) methodology for assessing expected annual damages.

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1.0 INTRODUCTION

1.1 STUDY TERMS OF REFERENCE

In October 2002, KGS Group was authorized to proceed with a feasibility study of the costs and merits of summer water level control in the City of Winnipeg. This study was initiated following the emergency operation of the Red River Floodway during the summer of 2002 and a preliminary assessment of summer water level control as a part of KGS Group's November 2001 report, "Flood Protection Studies for Winnipeg" (KGS Group, 2001).

The scope of work was based on a proposal requested by the Province of Manitoba, Conservation Branch. The proposal was submitted to the Province of Manitoba and to the Project Steering Committee on October 11, 2002 (Appendix A). The scope of work included an assessment of the benefits and costs associated with summer operation of the Floodway including:

- Benefits to the City of Winnipeg based on avoided flood damages due to sewer backup, and reduced flood pump station maintenance and operation costs.
- Recreational benefits based on accepted values for increased recreation / tourism and avoided operational costs.
- Qualitative assessment of the benefits of future tourism / recreation development opportunities.
- Costs associated with increased flooding upstream of the Floodway Inlet Structure, based on use of KGS Group's flood damage model, topography upstream of the Floodway Inlet and information from the Province regarding summer use of this area.

In addition to these considerations, the study scope included an assessment of the effects of summer water level control on fish passage and summer navigation and the onetime operation of the Floodway for summer water level control in 2002.

1.2 BACKGROUND INFORMATION

November 2001 Flood Protection Study

As a part of the KGS Group study "Flood Protection Studies for Winnipeg" (KGS Group, 2001), a number of options were considered for summer water level control.

These were divided into three broad categories as follows:

Option 1 Control using the existing configuration only and increasing upstream levels above the state of nature.

Option 2 Control using the expanded Floodway with increased excavation to reduce the upstream impacts of summer water level control.

Option 3 Significant channel modifications that would allow summer levels to be controlled without exceeding natural levels.

It was concluded in the "Flood Protection Studies for Winnipeg" (KGS Group, 2001) that costs to completely eliminate the effects of summer flooding (Option 3 - Natural Levels) would increase the Floodway expansion costs by over $100 Million. These results were very preliminary and it is possible that other measures to control summer levels could be more attractive. Option 1, control of summer levels using the existing Floodway configuration, is similar to the 2002 operation of the Floodway, which initiated this study. Option 2 considers the control of summer levels with an expanded Floodway. The upstream effects of this option would be representative of condition with an expanded Floodway at some future time.

Emergency Operation Of The Red River Floodway – Summer 2002

During the summer of 2002 the Provincial government approved a one-time deviation from the Floodway operation rules in order to reduce the risk of basement flooding in Winnipeg. Prior to this approval, the issue was discussed by the Red River Floodway Operation Advisory Board. It recognized the merits of summer operation in 2002, and agreed that impacted residents south of the Floodway should be fully compensated for any resulting damages. It also requested that a study of benefits and impacts of summer Floodway operation be carried out.

Emergency operation of the Red River Floodway was authorized on June 28, 2002 when the Red River levels were predicted to exceed el. 14 ft JAPSD (James Avenue Pump Station Datum) until July 9, 2002 and to be above el. 12 ft JAPSD until July 14, 2002. This decision was based on the risk of basement flooding due to possible heavy rain over the City.

Based on the assessment at the time, it was recommended that the Red River Floodway be operated outside the existing Floodway Operation procedures to reduce the risk of serious basement flooding in the event of an additional heavy rainstorm during these conditions. Further, it was recommended that the operation be based on continuous monitoring of official Environment Canada weather forecasts.

These recommendations were prepared on the assumption that compensation would be warranted for damage from "unnatural" upstream flooding, and that such compensation would be based on the incremental damage above that which would have occurred naturally.

As a part of the operation of the Floodway in 2002, the Provincial Government committed to having a feasibility study investigating the benefits and cost of the summer operation of the Floodway. It would look at, among other things, the feasibility of purchasing land south of the Floodway that might be flooded often should summer operations take place in the future.

1.3 PROJECT STEERING COMMITTEE

The Project Steering Committee was established for this project with representatives from Canada, the Province of Manitoba, the City of Winnipeg, as well as upstream and downstream stakeholders. The Project Steering Committee Members are as follows:

- Rick Bowering (Manitoba Conservation, Chair)
- Eugene Kozera (Manitoba Conservation)
- Rick Hay (Manitoba Conservation)
- Henry Daniels (Manitoba Conservation)
- Maurice Sydor (Environment Canada)
- Doug McNeil (City of Winnipeg)
- Tony Kettler (PFRA)
- Herm Martens (RM of Morris)
- Bob Stefaniuk (RM of Ritchot)
- Val Rutherford (RM of Ritchot)
- Doug Dobrowolski (RM of MacDonald)

- Bud Oliver (Selkirk and District Planning Area Board)
- Cas Booy (Independent Member)

The Project Steering Committee met on four separate occasions,

i) October 11, 2002 to review the project plan and to provide input regarding study direction.

ii) January 29, 2003 to review the study findings to date and to provide input regarding the documentation phase of the study.

iii) June 16, 2003 to review and discuss the study findings at the draft report stage and to provide input prior to preparing the final draft report.

iv) October 30, 2003 to review and discuss comments prior to finalizing the report.

1.4 REPORT FORMAT

Background information and hydrologic input associated with the study is given in Sections 2.0 and 3.0 of this report. The overall approach for assessing benefits and costs associated with summer water level control within the City of Winnipeg is described in Section 4.0. The assessment of benefits due to avoided basement flood damages in the City of Winnipeg and for enhanced tourism and recreation are described in Sections 5.0 and 6.0 respectively. The development of costs associated with increased flooding upstream of the Floodway Inlet Control Structure is outlined in Section 7.0. Bank stability considerations related to summer water level control are given in Section 8.0. The basis for and the results of the benefit/cost analysis are described in Section 9.0. A description of the operating experience in 2002 and recommendations for the future are given in Section 10.0. Environmental considerations and the assessment of the study results are described in Section 11.0 and 12.0 respectively. Conclusions and recommendations are given in Sections 13.0.

Two elevation datums have been used in the study and in this report that have been commonly adopted by previous planners/designers. They are:

- Canadian Geodetic Vertical Datum, 1928 (1929 adjustment), with Horizontal North American Datum (NAD), 1983, referenced to June 1990.

- James Avenue Pump Station Datum (JAPSD) (gauge zero, el. 0.0 ft, or El. 727.57 ft Canadian Geodetic Vertical Datum). A common reference system that is used by the City of Winnipeg is based on the JAPSD, but represents water levels at other locations in Winnipeg that would be associated with the stated water level at James Avenue. This essentially represents a line parallel to the slope of the river that passes through the stated water level at James Avenue.

Unless elevations are specifically stated as JAPSD, they refer to Canadian Geodetic Vertical Datum (CGVD).

The Imperial System of measure has been used throughout this report since most of the basic data available for the study is expressed in that system.

2.0 2001 FLOOD PROTECTION STUDY – SUMMER WATER LEVEL CONTROL

2.1 GENERAL

The "Flood Protection Studies for Winnipeg" (KGS Group, 2001) examined the use of the Floodway as a means to limit the flow through Winnipeg to approximately 12,500 cfs, and thereby control the water level to El. 734.0 ft at the Forks. The existing summer water level regime in Winnipeg, the basis for summer water level control options that were examined in the 2001 study, as well as the relevant study results from the 2001 study are described below.

2.2 SUMMER WATER LEVELS REGIME

The water level in Winnipeg is controlled during summer by the operation of the control structure at the St. Andrews Lock and Dam (SALD) at Lockport. Public Works Canada operates the gates in the SALD to maintain the desired water level at James Avenue at El. 734.0 ft (el. 6.5 ft JAPSD). The operation of the SALD typically commences when the water level at James Avenue recedes to El. 734 ft following the spring flood and ends in approximately mid-October, when the gates are opened to allow the gradual lowering of the water levels to natural levels for the oncoming winter season.

During the summer water level control period, as flows increase, the gates are progressively opened in order to achieve the summer control elevation. The water levels in Winnipeg can be controlled until the discharge in the Red River downstream of the Assiniboine River reaches a flow of approximately 12,500 cfs, after which the gates in the SALD are fully opened and the water levels in Winnipeg rise as determined by the capacity of the river. Water levels during the summer period from June 1 to October 15 have been as high as El. 745 ft. and have exceeded the desired control level approximately 17 percent of the time for the period from 1967 to 1998.

2.3 SUMMER WATER LEVEL CONTROL OPTIONS

As described in Section 1.2, a number of options for summer water level control in association with the expanded Floodway were considered. Option 1 and 2 required the use of the Floodway Inlet Control Structure gates to control the water level at or above the "state-of-nature" at the

Floodway Inlet. Option 3 did not require the use of the Floodway gates. It, would however, require substantially more excavation in the Floodway channel to achieve the goal of controlled water levels. Since Option 3 would be so much more costly than the Options that require use of the Floodway gates, they were not addressed in any detail.

2.4 2001 STUDY RESULTS

Incremental costs to provide summer water level control varied between approximately $28 million to $445 million. The resulting increase in water levels above "state-of-nature" at the Floodway Inlet would be significant and the backwater effect would extend upstream to Ste. Agathe. Operation of the Floodway Inlet Control Structure gates would be required during summer floods, thereby causing artificial damages upstream. In the past this would not have been done (except in the summer of 2002).

3.0 RIVER WATER LEVEL REGIMES WITH AND WITHOUT SUMMER REGULATION USING THE FLOODWAY INLET CONTROL STRUCTURE

There are a variety of alternative operation modes and rules that could be adopted to regulate river water levels in Winnipeg. All modes that are being considered in this study are based on the premise of raising the gates at the Floodway Inlet Control Structure during flood events to force excess water into the Floodway. Two major alternative operation modes are:

1. **OPERATION MODE A - Select a control water level in the City**

   The selected control level (i.e. the maximum water level at the James Avenue that would be allowed to occur) could range from as low as el. 7 ft JAPSD, to as high as el. 15 ft JAPSD. The selection will depend on the relative merits of each that will be identified in this study. The water level upstream of the Floodway Inlet would be raised to whatever level is required to achieve the control level in Winnipeg. The maximum water level that would be permitted upstream of the Floodway Inlet to achieve such control would be El. 760 ft. This mode of operation could be amenable to a concept whereby compensation would be pre-arranged in an agreement with upstream residents, and would be paid on an as-needed basis according to the pre-arranged terms.

2. **OPERATION MODE B - Select a maximum water level upstream of the Floodway Inlet and operate up to that level to achieve the maximum water level reduction in Winnipeg that is desirable.**

   The lowest water level that would be desired in Winnipeg would be el. 7 ft JAPSD. If that low limit could be achieved with an upstream water level below the selected maximum water level upstream of the Floodway Inlet, then only the upstream water level needed to achieve el. 7 ft JAPSD would be invoked. This concept of river control would be amenable to a situation in which the land affected up to a control level of El. 760 ft limit would be purchased and owned by the Province.

As discussed in Section 7.0, it was concluded that the superior method for compensating for upstream damages operation is based largely on compensation on an as needed basis. Operation Mode A is, therefore, the preferred mode of operation and so is the mode emphasized in the balance of this report.

The main implications of these modes, and other versions of them (such as changing the upstream maximum to El. 758 ft, for example), include radical changes in water levels in Winnipeg and upstream and downstream of Winnipeg during the summer flood events, compared to what has occurred in the past. One means to demonstrate the potential changes in water level regimes is to consider historical water levels and estimate how they would have been different if the new operation mode(s) had been imposed throughout the recorded period. This examination has been done by KGS Group for both modes of operation (as well as for varying versions of each), and for different periods (for example, the period from 1970 to 2001, or the period from (1970 to 1979). The results are summarized in Tables 1A to 1D and Tables 2A to 2D. Careful examination of these tables can permit comparison of the implications of alternative modes. Note that the anomaly in Tables 2A and 2D in which the number of times the water level reaches the maximum allowable upstream of the Floodway Inlet for the maximum elevations of 758 ft and 760 ft occurs as a result of the flood in 1993 that had two peaks.

Table 1A – Comparison of Optional Hypothetical Control Schemes for Operation Mode A (Period of Record 1970 to 2001)

	Actual Conditions 1970 to 2001 (inclusive) [1,2,3,4]	Control el. 7 ft JAPSD [6]	Control el. 8 ft JAPSD [6]	Control el. 10 ft JAPSD [6]	Control el. 12 ft JAPSD [6]	Control el. 14 ft JAPSD [6]
Number of Events Requiring Control of Water Levels [3]	21	21	13	9	4	4
Number of Times Water Level Exceeds Target el. at James Avenue [3]	21	4	2	0	0	0
Total Duration Water Level Exceeds Target el. at James Avenue (days)	380	27	6	0	0	0
Average Duration that Water Level Exceeds Target el. at James Avenue (days per event)	18	7	3	0	0	0
Maximum Duration that Water Level Exceeds Target el. at James Avenue (days) [3]	113	21	5	0	0	0
Approximate Probability that Water Level Exceeds Target el. at James Avenue (% per year) [5]	66%	13%	6%	0%	0%	0%
Number of Times Water Level Exceeds El. 750 ft at Floodway Inlet	3	21	13	9	4	4
Total Duration Water Level Exceeds El. 750 ft at Floodway Inlet (days)	7	380	275	166	90	42
Average Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days per event)	2	18	21	18	23	11
Maximum Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days)	4	113	90	79	62	31
Number of Times Water Level Exceeds El. 755 ft at Floodway Inlet	0	9	5	4	2	0
Total Duration Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	133	84	46	6	0
Average Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days per event)	0	15	17	12	3	0
Maximum Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	73	48	33	5	0
Number of Times Water Level Reaches El. 760 ft at Floodway Inlet	0	4	2	0	0	0
Total Duration Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	27	6	0	0	0
Average Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days per event)	0	7	3	0	0	0
Maximum Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	21	5	0	0	0

Notes :

1. For Actual Conditions, Control elevation assumed to be el. 7 ft JAPSD
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are included in these statistics as independent events
4. For Actual Conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately el. 6.5 ft JAPSD)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. JAPSD represents James Avenue Pumping Station Datum

Table 1B – Comparison of Optional Hypothetical Control Schemes for Operation Mode A (Period of Record 1970 to 1979)

	Actual Conditions 1970 to 1979 (inclusive) [1,2,3,4]	Control el. 7 ft JAPSD [6]	Control el. 8 ft JAPSD [6]	Control el. 10 ft JAPSD [6]	Control el. 12 ft JAPSD [6]	Control el. 14 ft JAPSD [6]
Number of Events Requiring Control of Water Levels [3]	6	6	3	1	1	1
Number of Times Water Level Exceeds Target el. at James Avenue [3]	6	1	0	0	0	0
Total Duration Water Level Exceeds Target el. at James Avenue (days)	83	9	0	0	0	0
Average Duration that Water Level Exceeds Target el. at James Avenue (days per event)	14	9	0	0	0	0
Maximum Duration that Water Level Exceeds Target el. at James Avenue (days) [3]	47	9	0	0	0	0
Approximate Probability that Water Level Exceeds Target el. at James Avenue (% per year) [5]	60%	10%	0%	0%	0%	0%
Number of Times Water Level Exceeds El. 750 ft at Floodway Inlet	0	6	3	1	1	1
Total Duration Water Level Exceeds El. 750 ft at Floodway Inlet (days)	0	83	54	36	31	17
Average Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days per event)	0	14	18	36	31	17
Maximum Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days)	0	47	43	36	31	17
Number of Times Water Level Exceeds El. 755 ft at Floodway Inlet	0	1	1	1	0	0
Total Duration Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	33	31	19	0	0
Average Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days per event)	0	33	31	19	0	0
Maximum Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	33	31	19	0	0
Number of Times Water Level Reaches El. 760 ft at Floodway Inlet	0	1	0	0	0	0
Total Duration Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	9	0	0	0	0
Average Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days per event)	0	9	0	0	0	0
Maximum Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	9	0	0	0	0

Notes :

1. For Actual Conditions, Control elevation assumed to be el. 7 ft JAPSD
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are included in these statistics as independent events
4. For Actual Conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately el. 6.5 ft JAPSD)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. JAPSD represents James Avenue Pumping Station Datum

Table 1C – Comparison of Optional Hypothetical Control Schemes for Operation Mode A (Period of Record 1980 to 1989)

	Actual Conditions 1980 to 1989 (inclusive) [1,2,3,4]	Control el. 7 ft JAPSD [6]	Control el. 8 ft JAPSD [6]	Control el. 10 ft JAPSD [6]	Control el. 12 ft JAPSD [6]	Control el. 14 ft JAPSD [6]
Number of Events Requiring Control of Water Levels [3]	4	4	1	1	0	0
Number of Times Water Level Exceeds Target el. at James Avenue [3]	4	0	0	0	0	0
Total Duration Water Level Exceeds Target el. at James Avenue (days)	27	0	0	0	0	0
Average Duration that Water Level Exceeds Target el. at James Avenue (days per event)	7	0	0	0	0	0
Maximum Duration that Water Level Exceeds Target el. at James Avenue (days) [3]	14	0	0	0	0	0
Approximate Probability that Water Level Exceeds Target el. at James Avenue (% per year) [5]	40%	0%	0%	0%	0%	0%
Number of Times Water Level Exceeds El. 750 ft at Floodway Inlet	0	4	1	1	0	0
Total Duration Water Level Exceeds El. 750 ft at Floodway Inlet (days)	0	27	12	8	0	0
Average Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days per event)	0	7	12	8	0	0
Maximum Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days)	0	14	12	8	0	0
Number of Times Water Level Exceeds El. 755 ft at Floodway Inlet	0	1	0	0	0	0
Total Duration Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	6	0	0	0	0
Average Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days per event)	0	6	0	0	0	0
Maximum Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	6	0	0	0	0
Number of Times Water Level Reaches El. 760 ft at Floodway Inlet	0	0	0	0	0	0
Total Duration Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	0	0	0	0	0
Average Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days per event)	0	0	0	0	0	0
Maximum Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	0	0	0	0	0

Notes :

1. For Actual Conditions, Control elevation assumed to be el. 7 ft JAPSD
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are included in these statistics as independent events
4. For Actual Conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately el. 6.5 ft JAPSD)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. JAPSD represents James Avenue Pumping Station Datum

Table 1D – Comparison of Optional Hypothetical Control Schemes for Operation Mode A (Period of Record 1990 to 2001)

	Actual Conditions 1990 to 2001 (inclusive) [1,2,3,4]	Control el. 7 ft JAPSD [6]	Control el. 8 ft JAPSD [6]	Control el. 10 ft JAPSD [6]	Control el. 12 ft JAPSD [6]	Control el. 14 ft JAPSD [6]
Number of Events Requiring Control of Water Levels [3]	11	11	9	7	3	3
Number of Times Water Level Exceeds Target el. at James Avenue [3]	11	3	2	0	0	0
Total Duration Water Level Exceeds Target el. at James Avenue (days)	270	18	6	0	0	0
Average Duration that Water Level Exceeds Target el. at James Avenue (days per event)	25	6	3	0	0	0
Maximum Duration that Water Level Exceeds Target el. at James Avenue (days) [3]	52	12	5	0	0	0
Approximate Probability that Water Level Exceeds Target el. at James Avenue (% per year) [5]	92%	25%	17%	0%	0%	0%
Number of Times Water Level Exceeds El. 750 ft at Floodway Inlet	3	11	9	7	3	3
Total Duration Water Level Exceeds El. 750 ft at Floodway Inlet (days)	7	270	209	122	59	25
Average Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days per event)	2	25	23	17	20	8
Maximum Duration that Water Level Exceeds El. 750 ft at Floodway Inlet (days)	4	52	35	35	31	14
Number of Times Water Level Exceeds El. 755 ft at Floodway Inlet	0	7	4	3	2	0
Total Duration Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	94	53	27	6	0
Average Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days per event)	0	13	13	9	3	0
Maximum Duration that Water Level Exceeds El. 755 ft at Floodway Inlet (days)	0	34	17	14	5	0
Number of Times Water Level Reaches El. 760 ft at Floodway Inlet	0	3	2	0	0	0
Total Duration Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	18	6	0	0	0
Average Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days per event)	0	6	3	0	0	0
Maximum Duration that Water Level Controlled at El. 760 ft at Floodway Inlet (days)	0	12	5	0	0	0

Notes :

1. For Actual Conditions, Control elevation assumed to be el. 7 ft JAPSD
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are included in these statistics as independent events
4. For Actual Conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately el. 6.5 ft JAPSD)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. JAPSD represents James Avenue Pumping Station Datum

Table 2A – Comparison of Optional Hypothetical Control Schemes for Operation Mode B (Period of Record 1970 to 2001)

	Actual Conditions 1970 to 2001 (inclusive)[1,2,3]	Max EL. 756 ft Upstream of Floodway Inlet	Max El. 758 ft Upstream of Floodway Inlet	Max El. 760 ft Upstream of Floodway Inlet
Number of Times Water Level Exceeds el. 7 ft at James Avenue[4]	21	6	3	4
Total Duration Water Level Exceeds el. 7 ft at James Avenue (days)	380	106	60	27
Average Duration Water Level Exceeds el. 7 ft at James Avenue (days)	18	18	20	7
Maximum Duration Water Level Exceeds el. 7 ft at James Avenue (days)	113	66	51	21
Probability that Water Level Exceed el. 7 ft at James Avenue (% per year) [5]	66%	19%	9%	13%
Number of Times Water Level Exceeds el. 8 ft at James Avenue[4]	13	4	3	2
Total Duration Water Level Exceeds el. 8 ft at James Avenue (days)	275	81	36	18
Average Duration Water Level Exceeds el. 8 ft at James Avenue (days)	21	20	12	9
Maximum Duration Water Level Exceeds el. 8 ft at James Avenue (days)	90	59	30	12
Approximate Probability that Water Level Exceeds el. 8 ft at James Avenue (% per year) [5]	41%	13%	9%	6%
Number of Times Water Level Exceeds el. 10 ft at James Avenue[4]	9	4	1	0
Total Duration Water Level Exceeds el. 10 ft at James Avenue (days)	166	34	4	0
Average Duration Water Level Exceeds el. 10 ft at James Avenue (days)	18	9	4	0
Maximum Duration Water Level Exceeds el. 10 ft at James Avenue (days)	79	25	4	0
Approximate Probability that Water Level Exceeds el. 10 ft at James Avenue (% per year) [5]	28%	13%	3%	0%
Number of Times Water Level Exceeds el. 12 ft at JamesAvenue[4]	4	1	0	0
Total Duration Water Level Exceeds el. 12 ft at James Avenue (days)	90	3	0	0
Average Duration Water Level Exceeds el. 12 ft at James Avenue (days)	23	3	0	0
Maximum Duration Water Level Exceeds el. 12 ft at James Avenue (days)	62	3	0	0
Approximate Probability that Water Level Exceeds el. 12 ft at James Avenue (% per year) [5]	13%	3%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	21	21	21
Total Duration of Inlet Gate Operation (days)	n/a	380	380	380
Average Duration of Inlet Gate Operation (days per event)	n/a	18	18	18
Maximum Duration of Inlet Gate Operation (days)	n/a	113	113	113
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	66%	66%	66%
Number of Times Water Level Reaches Maximum Allowable U/S of Floodway Inlet[4,6,7]	n/a	6	3	4
Total Duration Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	106	60	27
Average Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days per event)	n/a	18	20	7
Maximum Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	66	51	21
Probability that Water Level Will Reach Maixmum Allowable U/S of Floodway Inlet (% per year) [5]	n/a	19%	9%	13%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are included in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. U/S represents upstream
7. Anomaly for maximum elevations of 758 ft and 760 ft occurs as a result of the flood in 1993 that had two peaks.

Table 2B – Comparison of Optional Hypothetical Control Schemes for Operation Mode B (Period of Record 1970 to 1979)

	Actual Conditions 1970 to 1979 (inclusive)[1,2,3]	Max EL. 756 ft Upstream of Floodway Inlet	Max El. 758 ft Upstream of Floodway Inlet	Max El. 760 ft Upstream of Floodway Inlet
Number of Times Water Level Exceeds el. 7 ft at James Avenue[4]	6	1	1	1
Total Duration Water Level Exceeds el. 7 ft at James Avenue (days)	83	33	23	9
Average Duration Water Level Exceeds el. 7 ft at James Avenue (days)	14	33	23	9
Maximum Duration Water Level Exceeds el. 7 ft at James Avenue (days)	47	33	23	9
Probability that Water Level Exceed el. 7 ft at James Avenue (% per year) [5]	60%	10%	10%	10%
Number of Times Water Level Exceeds el. 8 ft at James Avenue[4]	3	1	1	0
Total Duration Water Level Exceeds el. 8 ft at James Avenue (days)	54	29	16	0
Average Duration Water Level Exceeds el. 8 ft at James Avenue (days)	18	29	16	0
Maximum Duration Water Level Exceeds el. 8 ft at James Avenue (days)	43	29	16	0
Approximate Probability that Water Level Exceeds el. 8 ft at James Avenue (% per year) [5]	30%	10%	10%	0%
Number of Times Water Level Exceeds el. 10 ft at James Avenue[4]	1	1	0	0
Total Duration Water Level Exceeds el. 10 ft at James Avenue (days)	36	12	0	0
Average Duration Water Level Exceeds el. 10 ft at James Avenue (days)	36	12	0	0
Maximum Duration Water Level Exceeds el. 10 ft at James Avenue (days)	36	12	0	0
Approximate Probability that Water Level Exceeds el. 10 ft at James Avenue (% per year) [5]	10%	10%	0%	0%
Number of Times Water Level Exceeds el. 12 ft at JamesAvenue[4]	1	0	0	0
Total Duration Water Level Exceeds el. 12 ft at James Avenue (days)	31	0	0	0
Average Duration Water Level Exceeds el. 12 ft at James Avenue (days)	31	0	0	0
Maximum Duration Water Level Exceeds el. 12 ft at James Avenue (days)	31	0	0	0
Approximate Probability that Water Level Exceeds el. 12 ft at James Avenue (% per year) [5]	10%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	6	6	6
Total Duration of Inlet Gate Operation (days)	n/a	83	83	83
Average Duration of Inlet Gate Operation (days per event)	n/a	14	14	14
Maximum Duration of Inlet Gate Operation (days)	n/a	47	47	47
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	60%	60%	60%
Number of Times Water Level Reaches Maximum Allowable U/S of Floodway Inlet[4,6]	n/a	1	1	1
Total Duration Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	33	23	9
Average Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days per event)	n/a	33	23	9
Maximum Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	33	23	9
Probability that Water Level Will Reach Maixmum Allowable U/S of Floodway Inlet (% per year) [5]	n/a	10%	10%	10%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are included in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. U/S represents upstream

Table 2C – Comparison of Optional Hypothetical Control Schemes for Operation Mode B (Period of Record 1980 to 1989)

	Actual Conditions 1980 to 1989 (inclusive)[1,2,3]	Max EL. 756 ft Upstream of Floodway Inlet	Max El. 758 ft Upstream of Floodway Inlet	Max El. 760 ft Upstream of Floodway Inlet
Number of Times Water Level Exceeds el. 7 ft at James Avenue[4]	4	1	0	0
Total Duration Water Level Exceeds el. 7 ft at James Avenue (days)	27	1	0	0
Average Duration Water Level Exceeds el. 7 ft at James Avenue (days)	7	1	0	0
Maximum Duration Water Level Exceeds el. 7 ft at James Avenue (days)	14	1	0	0
Probability that Water Level Exceed el. 7 ft at James Avenue (% per year) [5]	40%	10%	0%	0%
Number of Times Water Level Exceeds el. 8 ft at James Avenue[4]	1	0	0	0
Total Duration Water Level Exceeds el. 8 ft at James Avenue (days)	12	0	0	0
Average Duration Water Level Exceeds el. 8 ft at James Avenue (days)	12	0	0	0
Maximum Duration Water Level Exceeds el. 8 ft at James Avenue (days)	12	0	0	0
Approximate Probability that Water Level Exceeds el. 8 ft at James Avenue (% per year) [5]	10%	0%	0%	0%
Number of Times Water Level Exceeds el. 10 ft at James Avenue[4]	1	0	0	0
Total Duration Water Level Exceeds el. 10 ft at James Avenue (days)	8	0	0	0
Average Duration Water Level Exceeds el. 10 ft at James Avenue (days)	8	0	0	0
Maximum Duration Water Level Exceeds el. 10 ft at James Avenue (days)	8	0	0	0
Approximate Probability that Water Level Exceeds el. 10 ft at James Avenue (% per year) [5]	10%	0%	0%	0%
Number of Times Water Level Exceeds el. 12 ft at JamesAvenue[4]	0	0	0	0
Total Duration Water Level Exceeds el. 12 ft at James Avenue (days)	0	0	0	0
Average Duration Water Level Exceeds el. 12 ft at James Avenue (days)	0	0	0	0
Maximum Duration Water Level Exceeds el. 12 ft at James Avenue (days)	0	0	0	0
Approximate Probability that Water Level Exceeds el. 12 ft at James Avenue (% per year) [5]	0%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	4	4	4
Total Duration of Inlet Gate Operation (days)	n/a	27	27	27
Average Duration of Inlet Gate Operation (days per event)	n/a	7	7	7
Maximum Duration of Inlet Gate Operation (days)	n/a	14	14	14
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	40%	40%	40%
Number of Times Water Level Reaches Maximum Allowable U/S of Floodway Inlet[4,6]	n/a	1	0	0
Total Duration Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	1	0	0
Average Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days per event)	n/a	1	0	0
Maximum Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	1	0	0
Probability that Water Level Will Reach Maixmum Allowable U/S of Floodway Inlet (% per year) [5]	n/a	10%	0%	0%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are included in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. U/S represents upstream

Table 2D – Comparison of Optional Hypothetical Control Schemes for Operation Mode B (Period of Record 1990 to 2001)

	Actual Conditions 1990 to 2001 (inclusive)[1,2,3]	Max EL. 756 ft Upstream of Floodway Inlet	Max El. 758 ft Upstream of Floodway Inlet	Max El. 760 ft Upstream of Floodway Inlet
Number of Times Water Level Exceeds el. 7 ft at James Avenue[4]	11	4	2	3
Total Duration Water Level Exceeds el. 7 ft at James Avenue (days)	270	72	37	18
Average Duration Water Level Exceeds el. 7 ft at James Avenue (days)	25	18	19	6
Maximum Duration Water Level Exceeds el. 7 ft at James Avenue (days)	52	32	28	12
Probability that Water Level Exceed el. 7 ft at James Avenue (% per year) [5]	92%	33%	17%	25%
Number of Times Water Level Exceeds el. 8 ft at James Avenue[4]	9	3	2	2
Total Duration Water Level Exceeds el. 8 ft at James Avenue (days)	209	52	20	18
Average Duration Water Level Exceeds el. 8 ft at James Avenue (days)	23	17	10	9
Maximum Duration Water Level Exceeds el. 8 ft at James Avenue (days)	35	30	14	12
Approximate Probability that Water Level Exceeds el. 8 ft at James Avenue (% per year) [5]	75%	25%	17%	17%
Number of Times Water Level Exceeds el. 10 ft at James Avenue[4]	7	3	1	0
Total Duration Water Level Exceeds el. 10 ft at James Avenue (days)	122	22	4	0
Average Duration Water Level Exceeds el. 10 ft at James Avenue (days)	17	7	4	0
Maximum Duration Water Level Exceeds el. 10 ft at James Avenue (days)	35	13	4	0
Approximate Probability that Water Level Exceeds el. 10 ft at James Avenue (% per year) [5]	58%	25%	8%	0%
Number of Times Water Level Exceeds el. 12 ft at JamesAvenue[4]	3	1	0	0
Total Duration Water Level Exceeds el. 12 ft at James Avenue (days)	59	3	0	0
Average Duration Water Level Exceeds el. 12 ft at James Avenue (days)	20	3	0	0
Maximum Duration Water Level Exceeds el. 12 ft at James Avenue (days)	31	3	0	0
Approximate Probability that Water Level Exceeds el. 12 ft at James Avenue (% per year) [5]	25%	8%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	11	11	11
Total Duration of Inlet Gate Operation (days)	n/a	270	270	270
Average Duration of Inlet Gate Operation (days per event)	n/a	25	25	25
Maximum Duration of Inlet Gate Operation (days)	n/a	52	52	52
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	92%	92%	92%
Number of Times Water Level Reaches Maximum Allowable U/S of Floodway Inlet[4,6,7]	n/a	4	2	3
Total Duration Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	72	37	18
Average Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days per event)	n/a	18	19	6
Maximum Duration that Water Level Controlled at Maximum Allowable U/S of Floodway Inlet (days)	n/a	32	28	12
Probability that Water Level Will Reach Maixmum Allowable U/S of Floodway Inlet (% per year) [5]	n/a	33%	17%	25%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are included in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).
6. U/S represents upstream
7. Anomaly for maximum elevations of 758 ft and 760 ft occurs as a result of the flood in 1993 that had two peaks.

An alternative method of presenting the results summarized in Tables 1A to 1D and Tables 2A to 2D is to compare duration curves that show the percent of time that the water level upstream of the Floodway Inlet is below a specific elevation. These duration curves are shown on Figures 1 and 2 for Operation Mode A and Operation Mode B, respectively.

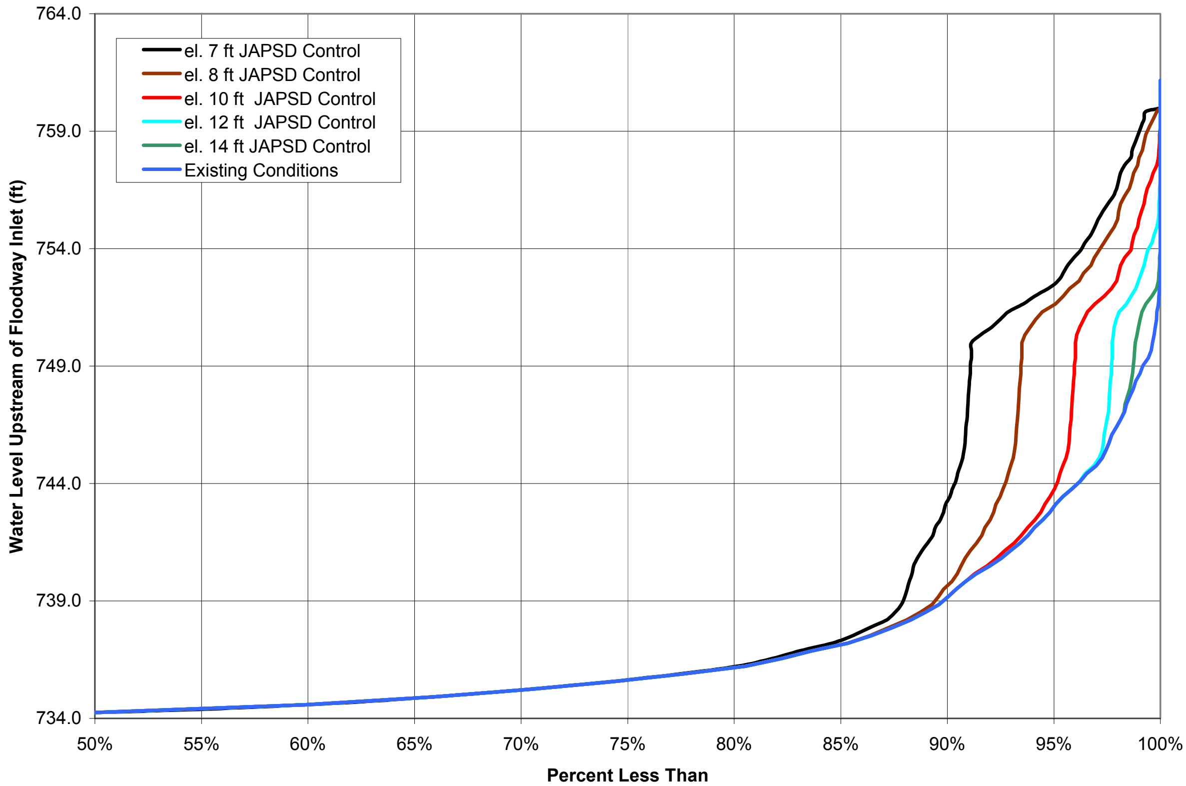

Figure 1 – Duration Curves for Water Levels Upstream of the Floodway Inlet for Operation Mode A for Various Control Water Levels in Winnipeg

Comparing the various control levels at James Avenue for Operation Mode A, as shown in Tables 1A to 1D and Figure 1, it can be seen that for an operation mode that controls to a high James Avenue level, such as el. 12 ft or el. 14 ft JAPSD, water levels upstream of the Floodway Inlet are not frequently increased. However, this also suggests that there are not many occurrences that operation of the Floodway is required during the summer months for such control levels.

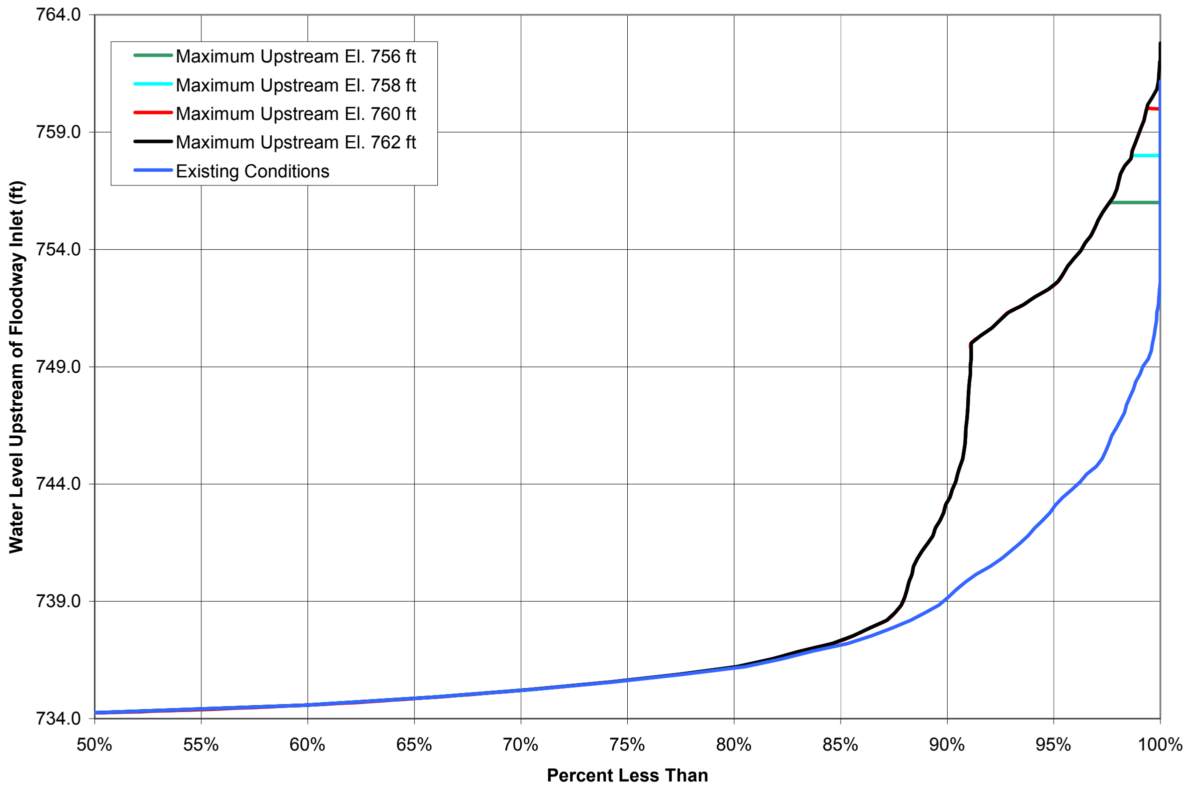

Figure 2 – Duration Curves for Water Levels Upstream of the Floodway Inlet for Operation Mode B for Various Maximum Water Levels Upstream of the Floodway Inlet

The various maximum water levels upstream of the Floodway Inlet for Operation Mode B, are shown in Tables 2A to 2D and Figure 2. It can be seen that there is little difference in the percent of time that water levels are increased above existing conditions "state-of-nature" for the various maximum water levels (i.e. El. 756 ft to 762 ft) upstream of the Floodway Inlet.

As described in Section 2.0, the present operation of SALD is undertaken to control the water level in Winnipeg at a summer water level at James Avenue (el. 6.5 ft JAPSD) by operation of the gates for Red River flows up to approximately 12,500 cfs. For the operation modes A and B it has been assumed that the discharge through the City of Winnipeg would essentially be maintained at this value with excess flows diverted to the Floodway when they exceed this value. At this discharge the gradient through the City is approximately 4 ft. (North Perimeter Bridge to the South Perimeter Bridge).

An alternative method of summer operation of the Floodway could be to maintain a relatively flat water surface profile through Winnipeg (that is similar to what occurs during the summer when river flows are low and all the gates are down in SALD). This would require the operation the Floodway Inlet Control Structure such that flows greater than say 4,000 cfs (0.3 ft gradient from perimeter to perimeter) are passed into the Floodway. This would occur approximately 55% of the time in the summer period, based on the flow records over the past 33 years (1970 – 2002) in comparison to a requirement to divert flow approximately 17% the time when 12,500 cfs is used as the threshold discharge for operation of the Floodway. It is apparent the frequency of artificial flooding would be significantly greater if the mode of operation was based on the “flat” water surface profile through Winnipeg.

Given that the effect in Winnipeg of a “steep” water surface profile is not substantially different from the effect of “flat” profile, the 12,500 cfs threshold for summer operation was selected as the operating mode for the study. Alternate threshold discharges could be investigated in later studies, if warranted.

4.0 ASSESSMENT OF BENEFITS AND COSTS - OVERALL APPROACH

The overall approach associated with the assessment of benefits and costs of summer operation of the Floodway Inlet Control Structure is described in this section. The benefits and costs have been separated into a number of categories and have been converted to average annual values based on their probability distribution. The selection of the optimum scheme is based on the maximum benefit/cost ratio and the maximum net benefits.

The assessment of the average annual benefits due to summer operation of the Floodway Inlet Control Structure has considered:

- Reduction in potential basement flood damage and operating costs for the flood pump stations in the City of Winnipeg compared to the existing conditions.
- Reduction in operation and maintenance costs due to reduced use by the City of Winnipeg's Flood pump stations.
- Increased recreation and tourism.

The methodology for developing average annual benefits and the results of the analyses are described in Sections 5.0 and 6.0.

Average annual costs associated with summer operation of the Floodway have considered the following:

- Flood and disruption damages to market gardeners, cereal crops, and undeveloped land located upstream of the Floodway Inlet Control Structure. Undeveloped land is considered to be the area adjacent to the riverbanks consisting of forest and uncultivated agricultural land that would be inundated due to operation of the Floodway Inlet Control Structure.
- Increased costs of summer operation and maintenance of the flood control infrastructure (i.e. Floodway Inlet Control Structure, Floodway Channel, etc.).
- Flood damage and increased maintenance cost to affected municipal infrastructure upstream of the Floodway Inlet Control Structure such as roads, drains, water intakes, etc.
- Loss of property taxes to upstream municipalities due to provincial buyout of flood prone lands.

- Loss and damages related to recreational boating north of Winnipeg.

The calculation of average annual damages for these components is described in Section 7.0.

In addition to quantitative assessment of benefits and costs for the items considered above, additional items have been identified which will be positively or negatively affected by the summer operation of the Floodway Inlet Control Structure. These include:

- Bank stability effects of summer operation, upstream and downstream of the Floodway Inlet Control Structure. Bank stability considerations associated with the summer water level control and the approach for assessing the affected parties are discussed in Section 8.0.

- Environmental considerations, including potential fisheries effects and the requirements of the Fisheries and Oceans Canada (DFO), as well as potential effects to the area north of the St. Andrews Lock and Dam, including Selkirk. These are described in Section 12.0.

5.0 BENEFITS DUE TO REDUCED BASEMENT FLOODING DAMAGES AND FLOOD PUMP STATION OPERATION

5.1 BACKGROUND INFORMATION

Basement flooding has been recognized as a major problem in Winnipeg for many years. Severe thunderstorms, with usually a short duration but intense rainfall, are recognized as the major cause of basement flooding. The prairie setting with flat terrain provides limited gradient for drainage systems, coupled with sewer systems in the older part of the City designed around 1900, are generally deficient by current standards. The basement flooding problem is aggravated during periods of high river levels as the gravity capacity of the sewer system is reduced. The high river levels occur more often during the spring when rainfall is less intense, but have occurred a number of times during the summer months.

Although it is difficult to separate the effects of high river level and rainfall, significant basement flooding has occurred when river levels are high. This has occurred on at least two occasions in the past. Based on data presented by the City of Winnipeg in 2002, on May 20, 1974 a rainstorm downpour of 1.4 inches (35 mm) in 30 minutes over the central portion of the City with a river level of el. 17.5 ft JAPSD, produced severe basement flooding. On August 8, 1993 a rainfall of 1.6 inches (41 mm) in about 60 minutes occurred with a river level of el. 13.6 ft JAPSD and also produced significant basement flooding. The estimated damages from 1993 event were $140 million.

The most severe flooding occurs in the older portions of the city that are serviced by combined sewers. These combined sewer systems were originally designed to discharge domestic waste as well as surface drainage directly to the rivers. Over time problems related to pollution of the receiving streams and the susceptibility of basement flooding resulted in modifications to the combined sewers and new sewer design. These include:

- Diversion weirs for dry weather flow were installed in the combined sewers, which divert the domestic waste to the sewage treatment plants.
- Combined sewers have been prohibited in new developments for nearly 50 years.
- A sewer relief program was undertaken, the latest (begun in 1977) consisting of upgrading all separate sewer districts to a 10 year level of protection and all combined

sewer districts to a 5 year level of protection, with the potential for future upgrading to a 10 year protection level. Implementation has proceeded successively, beginning with the most historically flood prone districts. The current status of the storm relief program is reflected in the assessment of sewer benefits for this analysis.

A drawing showing the locations of the separate and combined sewer districts, as well as the relieved and unrelieved combined sewer districts is shown on Plate 1.

In the newer areas of the city, land drainage sewers and stormwater retention lakes are generally designed to handle the rainwater runoff. These lakes are designed to rise 4 ft during a 1 in 25 year rainfall event. When rainfall exceeds the design capacity, a greater than normal rise in lake elevations occurs. The lake levels slowly recede as they drain by gravity to the rivers.

During extreme rainfall events, sanitary sewers in the newer districts are at times unable to accommodate the additional runoff which finds its way into the sewer system from house weeping tiles and inflows into manholes from localized surface flooding. This condition can cause sewer back-up into basements that do not have basement flood proofing devices. Where these devices are in place, flooding can also occur as a result of sump pump failures, and overland surface flow into window wells.

When the summer river levels are high, the flood protection system, which consists of dikes, gates on the sewer outfalls, and pumping stations, is put into operation. The system of gated outfalls and dikes generally prevents the Red and Assiniboine Rivers from backing up into the sewer systems. During rainfall events that are coincident with river stages above normal, the gravity capacity of the sewers are significantly reduced. When the river level is high, the flood pumping stations pump the rainfall runoff over the dikes and past the gates directly to the rivers. Although the pumps can assist at these times, the pump capacity is small in comparison to the gravity capacity of the sewers. Therefore, when the gravity capacity of the sewer system is reduced, there is an increased risk of basement flooding.

The risk of basement flooding in Winnipeg can be reduced by lowering the river levels during periods of high rainfall. This can be achieved during the summer, by controlling flows into the City of Winnipeg through the use the Floodway Inlet Control Structure. The effects of controlled summer water levels on the hydraulic grade line and potential flooding in the sewer district are shown schematically on Figure 3. The benefits of summer control were calculated as the reduction in basement flooding damages that could be achieved by reducing the high summer river water levels.

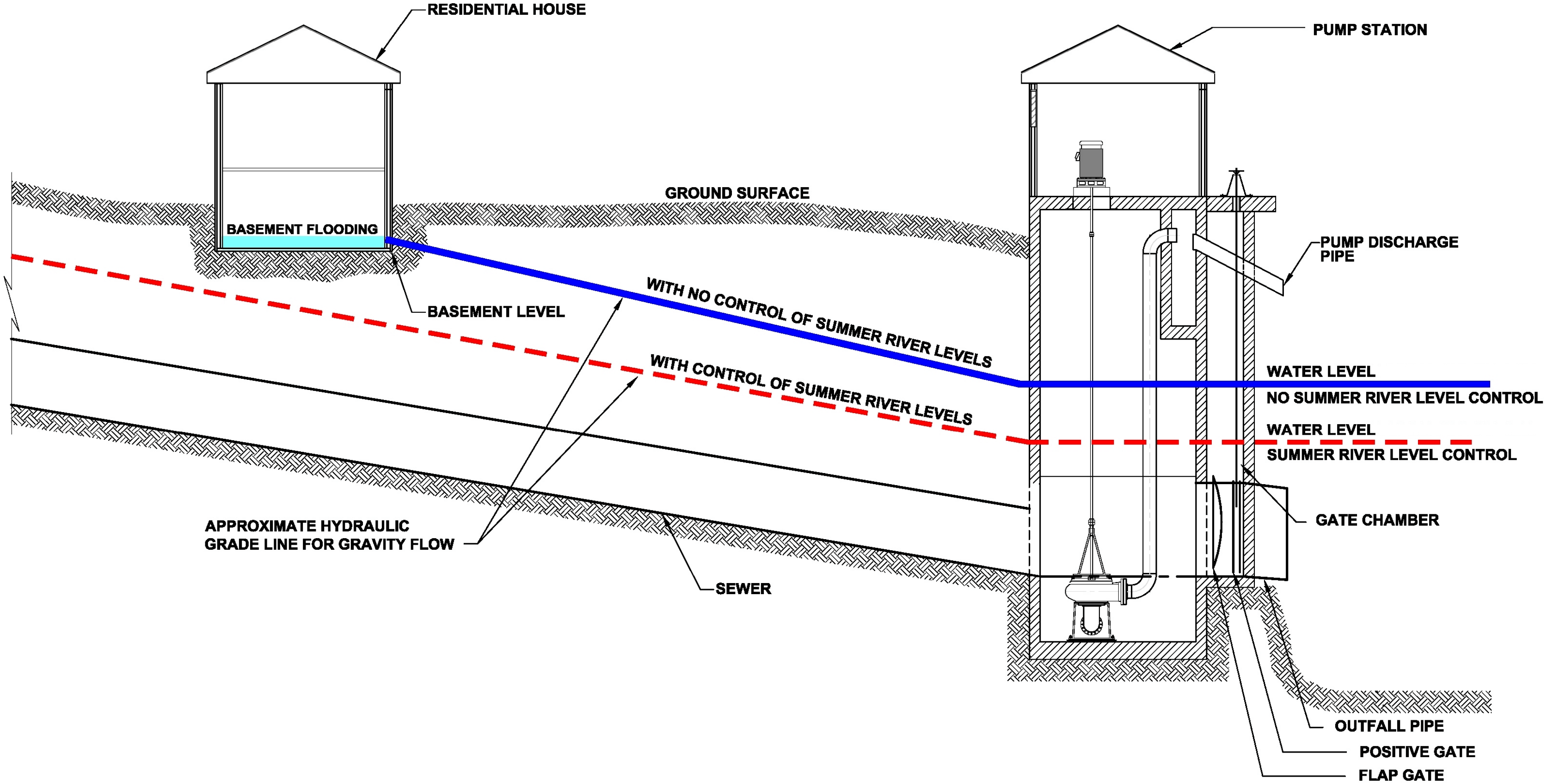

Figure 3 – Effects of Summer Water Level Control on Residential Basement Flooding

The reduction in basement flood damages as a result of summer water level control within the city was estimated using the summer Floodway Operation Mode A, (select a control level in the city), as described in Section 3.0, for two selected control summer water levels in the City:

- Controlled water level within Winnipeg to el. 7 ft JAPSD with a maximum upstream water level at the Floodway Inlet of El. 760 ft.
- Controlled water level within Winnipeg to el. 10 ft JAPSD with a maximum upstream water level at the Floodway Inlet of El. 760 ft.

Basement flood damages were estimated for existing conditions and for controlled summer operating conditions. The benefits of the summer operation were then calculated as the difference between the existing conditions and the modified summer operation. A relationship was then developed to estimate benefits for a range of control elevations.

The approach used to (i) estimate basement flood damages, (ii) calculate the damage probability curves, and (iii) extrapolate the analysis results to the other districts is described in the following subsections.

5.2 BASEMENT FLOOD DAMAGES

5.2.1 General

Estimated basement flood damages due to coincident high river levels and runoff from high rainfall events are based on the total probability method described in the "Flood Control Adequacy Review Study, KGS Group, 2002" (FCARS Report). In this method, the number of basements flooded in any given sewer district was determined from calculations of the storm water level in the sewer system network. The sewer system network of pipes was modelled using a Storm Water Management Model (SWMM) to develop relationships between flooding, river level and rainfall. Many combinations of rainfall events and river levels were simulated. For each combination, a flooded basement area map was prepared. The total damage was then calculated for that combination using a per basement damage value of $4830 in 1994 dollars for residential properties and approximately seven times, on average, that for commercial properties. The estimate of damages was based on a representative averages from surveys conducted by the City of Winnipeg following basement flood events. A relationship of damage and the probability that the damage will occur for various combined events of rainfall and high summer river levels was then developed. Given the substantial level of effort to prepare these relationships, only five sewer districts were assessed in the FCARS study. These same districts have been used for this study and the results extended to other districts as described below.

5.2.2 Calculation of Sewer District Damages

The basis for determining the frequency of basement flooding is shown schematically on Figure 4. Each point on the blue line on the chart represents the sewer outflow at which basement flooding would occur at the lowest basement in the district. The capacity of the sewer for free gravity flow (i.e. normal summer levels) and for river levels up to the controlling basement level within the district are shown on Figure 4. For this sewer district, the gravity discharge capacity of 700 cfs is not affected for river levels up to el. 9 ft JAPSD. When the river level increases above el. 9 ft JAPSD, the discharge capacity of the sewer decreases as shown schematically on Figure 4. At el. 13 ft JAPSD, the discharge where basement flooding occurs, is only 250 cfs. As shown on Figure 4, the gravity discharge capacity is theoretically reduced to zero when the river level reaches el. 17 ft JAPSD.

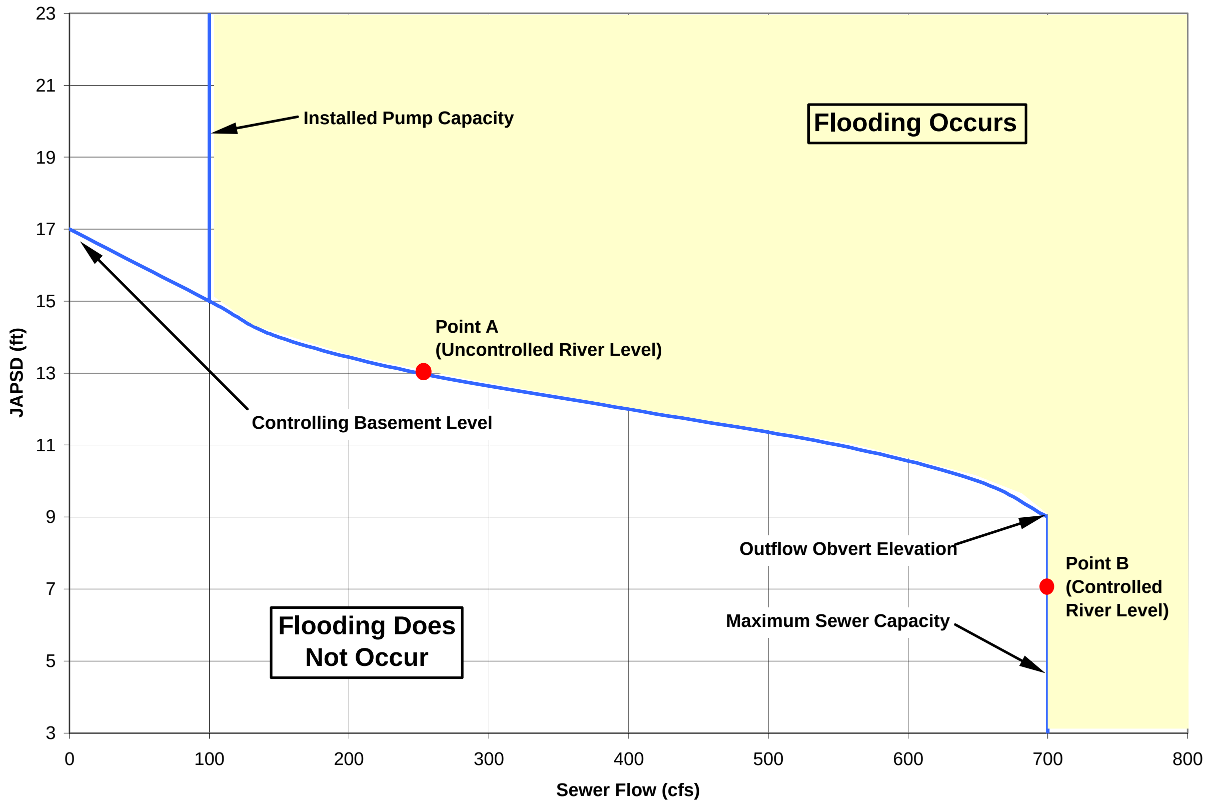

Figure 4 – Performance Curve for Sewer System with and without Summer Water Level Control

The influence of the pump station is also shown on Figure 4. The pump stations were originally designed to carry spring rainfall runoff flows when river levels are high. In this case, the flood pump station capacity is approximately 100 cfs, which is greater than the gravity sewer capacity when river levels exceed el. 15 ft JAPSD.

The benefits of controlling summer water levels are illustrated on Figure 4. Point A represents one of the combinations of rainfall and river level at which basement flooding in the district will occur (i.e. a rainfall event producing a discharge of 250 cfs, when the river level is el. 13 ft JAPSD). When river levels are controlled to el. 7 ft JAPSD (Point B) the gravity discharge capacity is increased to 700 cfs and the probability of flooding is significantly reduced.

Reduction in damages were calculated for the control level of el. 7 ft JAPSD for all five districts and for control level of el. 10 ft JAPSD for just one of the districts (Baltimore) using the methodology developed for the FCARS report and described above. Calculation of the probability of combined runoff from rainfall and high river levels assumes that they are independent events and requires that the probability of each of these events be calculated. The probability of runoff is based on rainfall meteorological records and rainfall/ runoff simulations described above. The probability of summer river levels at the location of the five combined sewer districts and at the James Avenue Pumping Station was based on a partial duration analysis using flow records from 1913 to 2002 for peak flows for the summer months of June, July, August, and September. Stage frequency curves were then developed at these locations using backwater relationships assuming the existing Floodway operation and for the controlled summer operation, assuming a water level control of el. 7 ft JAPSD. A stage frequency relationship was also developed for the modified summer operation for a water level control of el. 10 ft JAPSD at the Baltimore Sewer district.

The stage frequency curves at James Avenue and at each of the 5 sewer districts for the existing conditions, control at el. 7 ft JAPSD and control at el. 10 ft JAPSD (Baltimore flood pump station) are shown on Plate 2.

Flood damages were estimated in the combined sewer districts only for a number of reasons:

- Combined sewer districts are typically associated with the old neighborhoods in the city, which generally have homes with lower basements.
- The combined sewer districts have been studied extensively and analysis and damage data is readily available.
- Flood damages are generally relatively small in the separate sewer districts since the level of protection is high and the land drainage sewers are separated.

Since the majority of the damages occur in the combined sewer districts, a factor of 10% additional damages was applied to account for the contribution to the overall damages from the separate sewer districts. Damages in the separate sewer districts are primarily related to the greater risk of overland flows and increased inflow / infiltration to the sanitary sewers. The 10% factor was based on judgement and discussions with the City of Winnipeg and is considered to be a conservative estimate (i.e. the actual damages are likely higher).

5.2.3 Sewer District Damage Probability Curves

The basement flood damages for the 5 sewer districts were calculated for the el. 7 ft JAPSD control and for the el. 10 ft JAPSD control alternatives using the damage and combined probability data described above. Damage probability curves for each of the 5 sewer districts are shown on Plate 3. The damage curve for the el. 10 ft JAPSD control was developed using data from the Baltimore district.

The estimated average annual damages for the summer period and the benefits associated with the modified summer operation for each of the 5 combined sewer districts are summarized in Table 3.

Table 3 – Average Annual Damages and Benefits

Combined Sewer District	Existing Conditions	Modified Floodway Operation 7 ft JAPSD		Modified Floodway Operation 10 ft JAPSD [1]	
	Average Annual Damages	Average Annual Damages	Average Annual Benefits	Average Annual Damages	Average Annual Benefits
Baltimore	$67,100	$24,000	$43,100	$45,900	$21,200
Mager	$68,600	$34,300	$34,300	NC	NC
Armstrong/Newton	$344,200	$313,900	$30,300	NC	NC
Linden	$4,200	$2,700	$1,500	NC	NC
Colony	$113,100	$95,800	$17,300	NC	NC

Note: (1) NC stands for Not Calculated

The damage values have been adjusted to account for the duration of typical summer floods. The total probability methodology was initially developed in previous studies by KGS Group for spring conditions and is directly applicable to this type of flood that persists during the majority of the spring period when it does occur. That is, the probability that a rainfall event will combine with high river levels to cause flooding is nearly constant since the river levels are high for an extended time during the spring period. However, when this methodology is applied to the longer summer period, it simplistically assumes that the river level is constant throughout the summer season. Consequently, it over-states the potential damages because high river levels typically only persist for a few weeks during the summer. The chance of coincidence of the two events (high river levels ***and*** intense rainstorms) is lower than the methodology indicates, because of the short time that Winnipeg would be exposed to both phenomena in combination. ***An adjustment factor must be applied to recognize this***.

A practical means to quantify the adjustment has been used. It was a simple pro-ration on the basis of the ratio of the usual duration of high river levels during summer flood events (when they occur), to the total time during the summer season.

Review of the summer flood events that have occurred in the past showed that river water levels within 3 ft of the peak for the event persist for an average of about 14 days. The total duration of the summer period from June 1 to October 15 is 137 days. However, by far the highest risk of intense rainstorms is in the June/July/August period. As a compromise, a 100-day period has been used to develop this practical adjustment factor. Based on this rationale, the pro-ration factor would be about 14% (i.e. 14 out of 100 days).

However, a further increase had to be applied to recognize the possibility that there could be more than one summer flood event in any one calendar year. Review of the historical record shows that this is relatively rare, and not more than once in 10 years. As a result, a 10% increase in the adjustment factor was added to accommodate this. The factor adopted was therefore 14% plus (10% x 14%)=15.4%, rounded off to 15%.

As an optimistic measure of the factor (i.e. one that would yield the largest conceivable benefits), a longer duration of each of the high river level events could be adopted. If one were to assume the average total time that the river level would exceed the normal range in Winnipeg when such a flood event does appear, it could be as much as 28 days (4 weeks). This is twice the estimate described above, and forms the extreme upper limit to the adjustment factor.

Further examination of this complex statistical phenomenon was not possible within the time and resources available for the study. Given that many of the other issues have also required an approximate approach, a similar pattern has been adopted for the benefits due to reduced basement flooding damages. The approach has been one of bracketing the range from 15% to 30%, within which the potential benefits would be expected to lie. For the purposes of this study the average value was initially assumed as 22.5%. The sensitivity of the results to this assumption was then assessed for the lower and upper bounds respectively.

Independent analyses (see Appendix B) using other approaches indicated that the correction factor of 22.5% described above might be pessimistically low. This suggests that if more rigorous analysis were to be carried out, the benefits of summer water level control could be slightly larger than described in this report. The difference, however, would not be enough to change any fundamental conclusions described in Section 14.1.

5.2.4 Average Annual Benefits Due to Reduced Basement Flooding for All Districts

Since it was not feasible at this study level to consider all districts, the average annual damages for the remaining combined sewer districts were estimated from relationships derived from the 5 districts described above. The relationships used to estimate the damages for all of the combined sewer districts were based on the following characteristics of the sewer districts:

- The sewer district relief status, relieved or unrelieved
- Drainage basin area
- Relative elevation of low basement within the districts
- Land use
- Ratio of the flood pump capacity to gravity sewer capacity

Using these characteristics the combined sewer district damages for the remaining sewer districts were then estimated as illustrated on Plate 4.

1. The flood damages for each of the 5 known districts were converted into a damage per unit area based on the sewer district drainage area that was used in the "Flood Control Adequacy Review Study" (KGS Group, 2002).
2. The sewer districts were separated into 4 categories of like characteristics (i.e. relieved and unrelieved and commercial and residential).
3. The depth of the low basement in the sewer district relative to a water level equivalent to el. 25.8 ft JAPSD was determined from existing data
4. The damage per unit area for each district was graphed against the depth of the low basement relative to the el. 25.8 ft JAPSD water level as shown on Figure 5.
5. Total average annual damages were calculated for each of the remaining combined sewer districts using the relationships shown on Figure 5 and a factor which incorporates the effects of the pump capacity and reliability into the analysis. The table shown on Plate 4 summarizes the calculations of the average annual damages.

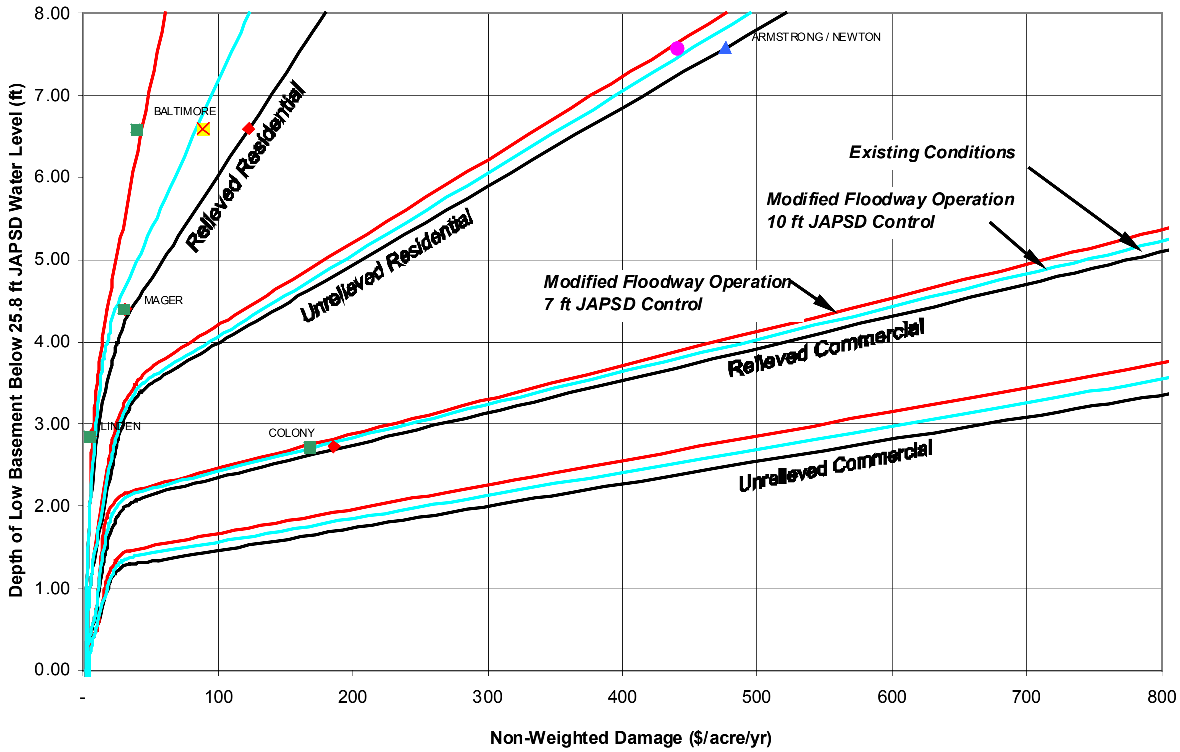

Figure 5 – Relationships for Estimating Damages for Combined Sewer Districts

The average annual benefits due to reduced basement flooding within the City are the differences in the estimated flood damages between the existing conditions and the modified summer Floodway operation. From Plate 4, these are:

- $740,000 for el. 7 ft JAPSD control, and
- $380,000 for el. 10 ft JAPSD control

The average annual benefits for a range of summer water level control elevations were based on the results of the analysis for the el. 7 ft JAPSD and el. 10 ft JAPSD summer control and are shown on Figure 6.

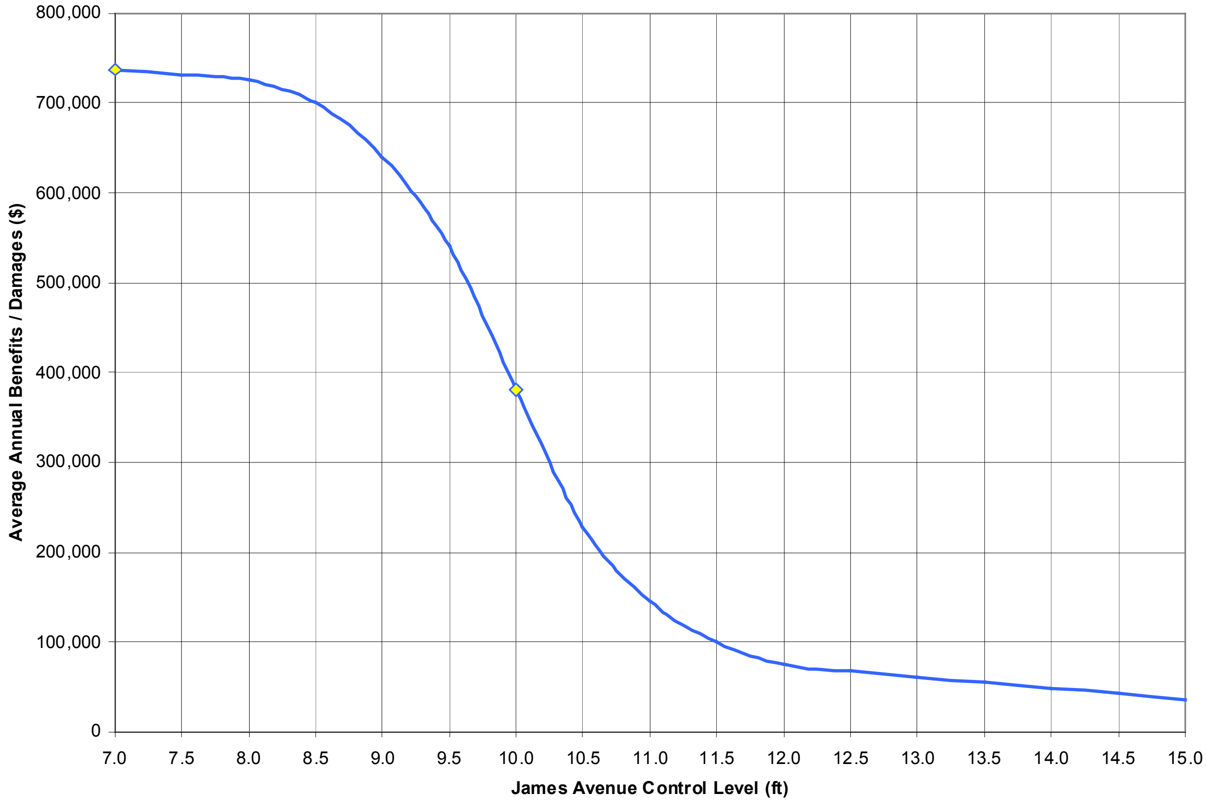

Figure 6 – Average Annual Summer Benefits to Combined Sewer Districts

The relationship shows decreasing average annual benefits from $740,000 for control of summer level at el. 7 ft JAPSD to $380,000 at el. 10 ft JAPSD. The shape of the curve is based on the two points calculated for control at el. 7 ft JAPSD and el. 10 ft JAPSD and engineering judgement. It is apparent that the benefits value will “level out” as the control level approaches el. 7 ft JAPSD. This is due to the reduced or eliminated hydraulic influence of the river on the sewer capacity at levels approaching normal summer levels. Similarly, as river control level increases, the benefits become less and less, and are assumed to reach zero around el. 20 ft JAPSD.

5.3 AVOIDED COSTS ASSOCIATED WITH REDUCED FLOOD PUMP STATION OPERATION

In addition to the benefits due to reduced basement flooding that result from lower water levels on the Red and Assiniboine Rivers, benefits also result from the reduced operation of the flood pump stations. These benefits were based on estimated additional operation costs of $50,000 per event when the water level reaches el. 16 ft JAPSD and $30,000 per event when the water level reaches el. 10 ft JAPSD. These operation costs are over and above operation costs that would occur during periods of "normal" summer levels and were based on discussions with the City of Winnipeg and a cursory assessment of their normal operating costs. They include costs for additional labour and energy. Average annual operation costs, above normal day to day operation, were based on the occurrence of high water levels during the summer months.

6.0 BENEFITS DUE TO INCREASED RECREATION AND TOURISM

6.1 COMMERCIAL AND RECREATIONAL USES OF THE WINNIPEG RIVER SYSTEM

6.1.1 Introduction

The character of the City of Winnipeg is linked to its rivers. The rivers and the green spaces adjacent to the rivers are key attractions both to residents of City of Winnipeg and visitors from outside the City. Accessibility of the river and the adjacent green spaces is a key consideration for many types of commercial and recreational activity.

This section of the report discusses types of recreation activities that occur during the summer navigation season on the Red River, Assiniboine River and other tributaries to the extent they are affected by changes in water levels on the Red River, between the Floodway Inlet and Floodway Outlet. This section discusses activities that may be affected by summer flooding, and includes those that take place on the river system and those that take place adjacent to the river system but that may be impacted by summer flooding. Some of the uses discussed in this section are ‘market’ or commercial activities for which there is a direct cost or charge, and others are ‘non-market’ or recreational for which there is no direct charge. Information for each of the types of activity was provided during key person interviews with people familiar with the activity. Each of the types of use is considered in turn and the following characteristics are noted where possible:

- Estimates of the number of users engaging in the activity each day
- Major access points for the activity
- How the use is impacted by summer flooding

The key person interview program (KPI) included representatives from government, commercial and sport organizations. In total, more than 20 individuals were interviewed using a standardized questionnaire (see Appendix C). A list of the organizations contacted can be found below in Table 4.

Table 4 - Organizations Contacted for the Key Person Interview Program

Organizations contacted for the KPI Program
Government
▪ City of Winnipeg – Planning Division
▪ City of Winnipeg - Parks and Open Spaces Division
▪ Manitoba Conservation – Natural Areas Branch
▪ Rivers West
▪ Manitoba Conservation – Fisheries Branch
▪ Riverbank Management Committee
▪ Destination Winnipeg (City of Winnipeg Tourism)
▪ Parks Canada – The Forks National Historic Site
Commercial
▪ The Forks Market
▪ Paddlewheel River Rouge Tours Ltd.
▪ Splash and Dash Water Taxi Bus Service Rental and Charters
▪ Restaurant Operators
▪ Redboine Boating Club
▪ Royal Manitoba Yacht Club
▪ Fishing Guides
Sport Organizations
▪ Water Ski Manitoba
▪ Manitoba Paddlers Association
▪ Winnipeg Rowing Club

6.1.2 Commercial and Market Uses of the River System

Commercial uses of the river include both those who operate businesses on the river and those whose businesses benefit from being located near the river. Both types of commercial users were consulted during the course of the study.

The Forks Market

The Forks Market is located at the confluence of the Red and the Assiniboine Rivers. There is a public walkway (Assiniboine Riverwalk – Red River Riverwalk) at the river's edge that follows the Assiniboine River from the Legislative buildings to The Forks Market and along the west side of the Red River through The Forks National Historic Site to near the Provencher Bridge. During the summer thousands of people use the walkway on a daily basis. Representatives from The Forks North Portage Partnership (TFNPP) estimate that pedestrian volume on the Riverwalk averages about 20,000 people per week during the summer.

When summer water levels are higher than approximately el. 7.5 ft JAPSD the walkways are flooded. Representatives from TFNPP noted that when the walkways are flooded, sales at the stores in the market are appreciably lower than when the walkways are accessible. Flooding also causes entities responsible for clean-up (The Forks is responsible for clean-up on the Forks site, while the City of Winnipeg is responsible for the Assiniboine Riverwalk from the Legislative Grounds to the CN Rail Bridge) to incur substantial clean-up costs to remove debris and dirt from the walkway.

Paddlewheel and River Rouge

Paddlewheel and River Rouge Tours operates three riverboats, the MS Paddlewheel Queen, MS Paddlewheel Princess and MS River Rouge. The boats operate out of the Alexander docks and are used for public tours and private events including wedding receptions and conventions. These functions are often booked several months in advance. Water levels more than two to three feet above normal require the use of an alternative dock site near the Redwood Bridge. This alternative location is less desirable in terms of accessibility. High water levels reduce revenues and require the operator to incur higher operating expenses. For example, higher operating costs are incurred for providing safe access docking facilities during periods of high river level. The operator noted that he has had considerable problems with high water in the last several years, and commented that the viability of the business would be significantly tested if the conditions experienced in 2002 were repeated.

Water Bus and Water Taxi

Water taxi and water bus service are available from seven locations, one at The Forks, three on the Red River (Taché Promenade, Juba Park, Exchange District) and three on the Assiniboine River (Legislative Buildings, Osborne Street Bridge and Hugo Street). Most of these locations are fixed, rather than floating, docks. Service is available throughout the summer boating season but the peak season is during July and August. The operator of the water taxi also offers boat charters and canoe rentals. Each year an estimated 5,000 customers make use of the water taxi with an additional 20,000 making use of charters and other services.

During an interview the operator of the water taxi noted that elevated water levels are a significant impact to his business. Water higher than a foot or two above normal summer water levels means most of docking sites are inaccessible. He noted consistent problems with summer flooding over the past ten years with the summer of 2002 being especially problematic. Summer flooding results in both lost business revenue and clean-up costs for each flood event. Higher water levels also generate greater amounts of floating debris, which was also noted as a concern. The water taxi operator stated that he experiences damage to his equipment from debris in the river.

Other Commercial Users

In addition to the three commercial operations described above, other commercial activities benefit from having access to the river or being adjacent to the river, including:

- Fishing guides and tour operators
- Fishing and tackle suppliers
- Boating and marine equipment retailers
- Restaurants

Operators of these types of businesses were also consulted during the course of the study. Most of those business operators interviewed noted that their business revenues and volumes suffer somewhat when there is excessive summer flooding (i.e. above the level of the river walkway, approximately el. 8 ft JAPSD). Commercial operators noted that customers tend to use the Assiniboine Riverwalk as a gauge, and when the riverwalk is flooded, river related commercial activity decreases. Most of those interviewed noted that the increased frequency of summer flooding in the City of Winnipeg is more damaging than any specific flood event. Persistent summer flooding causes people to consider river related activities and businesses to be unreliable and unattractive, causing them to find other activities. Commercial operators interviewed all agreed that they felt their business situation would improve if summer water levels were more stable.

6.1.3 Recreational Non-Market Activities

Recreational activities that are affected by changes in elevation of the Red River include those that take place on the water, such as canoeing, rowing and motorized boating, and those that take place adjacent to the river such as trail walking. Two broad types of water-based recreation were not investigated as part of the study. Swimming was not examined, as the Red River is not generally considered an optimal swimming site due to access, water turbidity and the accessibility of other local options for the activity. Water skiing was also not investigated in detail. A representative from Water Ski Manitoba was contacted who indicated that their membership uses the water skiing training facility in Transcona for almost all water skiing activity. The impact of changes in water elevation on other recreational activities are discussed in further detail below.

Canoeing and Paddling

Recreational canoeing and paddling take place throughout the river system from early spring through to late fall. Certain areas such as Churchill Drive, where the Manitoba Paddling Association maintains floating docks, tend to have higher concentrations of canoeing and paddling. A representative from the Manitoba Paddling Association estimated that there would be between 50 and 100 paddlers on the river system on an average day, with several hundred involved during the annual dragon boat races. The Paddling Association also offers instructional seminars and kayak camps.

Canoeing and paddling activities are not affected by high water levels to the same degree as other recreational activities. Avid paddlers will continue to use the river during high water levels. However, during an interview, a representative from the Manitoba Paddling Association noted that high water warnings tend to discourage novice or beginning paddlers who don't believe the river is safe, and reduces the number of program participants, particularly people interested in learning the sport. Continued high water years compound this problem because there is not continuum of development of the sport. Particular problems have been noted the past two to three years and paddling volumes appear to be down over this period. Subscription to the Manitoba Paddling Association's programs has also been down significantly over the past two to three years. This poses a problem because it means fewer people are being attracted to the sport, limiting its potential for growth in the province.

Rowing

The Winnipeg Rowing Club is located on Lyndale Drive near the Main/Norwood Bridge. In 2002, the Rowing Club had between 350 and 400 members. A representative from the club estimated that approximately 150 rowers would use the river on an average day with approximately 50 competitive rowers who would be on the river twice a day. Rowing use of the Red River tends to be concentrated at the launch site at Lyndale Drive and upstream. Rowing activity begins as soon as the river is clear of ice and continues throughout the summer into mid-October.

Generally, moderate changes in water elevation do not impact rowing. The Rowing Club maintains a floating dock that can accommodate changes in River elevation of a few feet with relative ease. The base of the dock can be adjusted to accommodate up to 20 ft of change in elevation but this is considerably more work. Fluctuations in water elevation generally do not affect their more experienced members. However, beginning rowers may be kept off the river due to changes in water elevation. Increased current or debris, which may be influenced to some degree by changes in water level, have a greater impact on both experienced and less experienced rowers.

Trail walking

Trail walking takes place at a variety of locations along the Red River. Trails in view of the river are especially attractive for scenic and aesthetic reasons but many are susceptible to summer flooding. Trails located along the Red River and its tributaries that may be affected by high water levels in the summer include:

- St. Norbert Heritage Park Trail (portions near the LaSalle River more susceptible to flooding than the portion adjacent to the Red River).
- Normand Park trail
- Red River Riverwalk (Forks National Historic Site)
- Assiniboine Riverwalk
- Taché Promenade
- Bunn's Creek pathway
- Seine River pathway

A number of other park facilities, such as King's Park and Maple Grove, have more informal trails which are impacted to varying degrees between el. 10 ft and el. 15 ft JAPSD.

These walkways are low lying and the majority of them are flooded when water levels exceed a foot or two above normal summer water levels. Although some flood at higher levels, the most prominent walkways the Assinibione Riverwalk and the Red River Walkway (Forks site), are flooded at approximately el. 8.5 ft JAPSD. During flooding the trails are inaccessible and flooding causes damage to the trails and incurs clean-up expenses associated with each event. Clean up costs and property damage costs are borne by the City of Winnipeg, the Forks North Portage Partnership and the Forks National Historic Site, depending on which walkways and trails are affected.

Fishing

Fishing takes place both on the river and on the shore adjacent to the river. Use is dispersed throughout the study area, but areas of concentration of activity include the Floodway Inlet, Maple Grove Park, the north perimeter boat launch site and the area near Lockport. Fishing in the study area is carried out primarily as a recreational activity but there is some direct commercial activity related to guiding (i.e. guides providing access and direction to points of best fishing and other interests).

Manitoba Conservation, the City of Winnipeg, Mid-Canada Marine Dealers, Manitoba Wildlife Federation and Fish Futures operate an urban angling partnership that promotes the quality and accessibility of the fishery within the City of Winnipeg. Programs and events run in coordination with the partnership include:

- Learn to fish seminars
- Fishing camps
- Fishing programs for youth at risk
- Media/Corporate Fishing Challenge
- Winnipeg Fish Festival
- Fish Derbies

Although fishing can continue to take place during elevated summer water levels, access to preferred fishing locations is often impaired during periods of high water. Special events, such as the Media/Corporate Fishing Challenge are particularly impacted by elevated summer water levels. The urban angling partnership relies on these events to promote the Red River as a fishery. When boat launches or public docks are not accessible, fishing seems to decline dramatically. During key-person interviews it was noted that the Assiniboine and Red Riverwalk is often used as a gauge by fishers and when the Riverwalk is flooded, fishing declines. Increased current and debris levels were also noted as conditions that can impair fishing.

Motorized Boating

Motorized boating takes place throughout the study area. Access points include the Redboine Boating Club in the City of Winnipeg, the Royal Manitoba Yacht Club north of the City and public boat launches and docks at Maple Grove Park, St. Vital Park, Crescent Park, the Louise Bridge and the North Perimeter Bridge. The Crescent Park boat launch is currently in need of repair and has not been in use recently. Conversations with staff from the City of Winnipeg Parks and Open spaces division indicated that there were no immediate plans to reopen the launch at Crescent Park. Public docks are also located on the Red River at The National Historic Site, Whittier Park and Kildonan Park, on the Assiniboine River at The Forks Historic Port, Navy Way and the Osborne Street Bridge and on the Seine River near Lagimodiere Boulevard. There are also numerous private docks at other locations along the Red River.

Conversations with members of both of the boating clubs indicated that access to docks tends to be constrained when water levels reach more than two or three feet above normal summer water levels. When water elevation exceeds this level, boats and docks must be removed from the river, which is a significant cost and inconvenience to the clubs and members. Damage to docks from debris were noted as a concern by both clubs. Boating activity and membership at the clubs is down in recent years. One of the primary reasons noted for this decline was the repeated summer flooding over the past nine or ten years.

During conversations with staff from the City of Winnipeg Parks and Open Spaces Division it was noted that damage to public docks occurs when water levels exceed two to three feet above normal summer water levels. Damage to docks occurs from debris, when docks float off their moorings during high water or when docks are removed from the river, if there is sufficient advance notice of flooding.

6.1.4 Inventory Of Commercial And Recreational Infrastructure

During the course of the study, an inventory of commercial and recreational infrastructure in the study area was developed. Infrastructure is made up of works located instream and those located adjacent to the river, including:

- Boat Launches
- Boat Docks
- Walkways

Figure 7 illustrates the locations of major commercial and recreation infrastructure. While the inventory is not exhaustive, it does provide an overview of major access points and areas of concentration of recreation infrastructure.

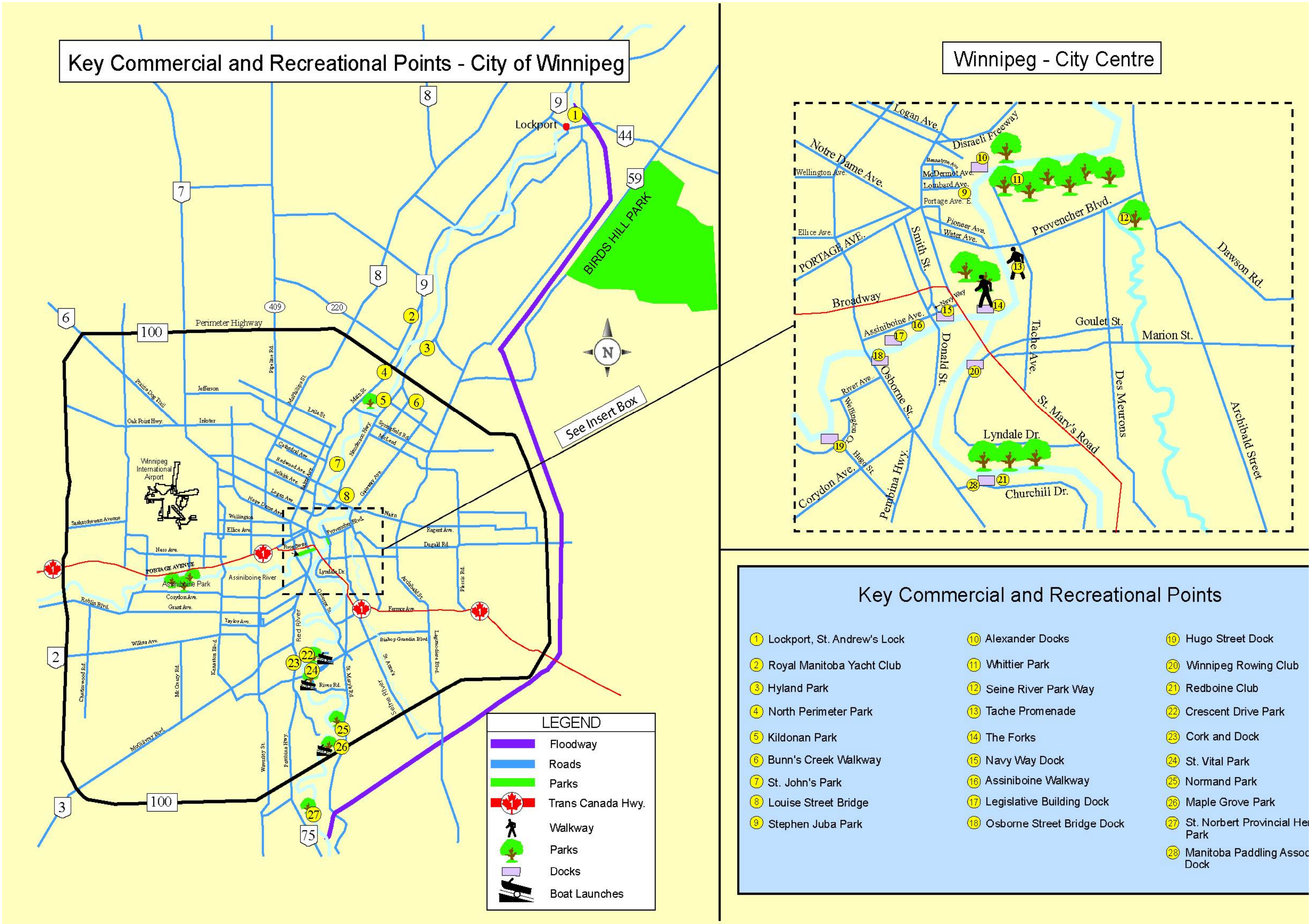

Figure 7 - Recreational and Commercial Infrastructure along Winnipeg's Rivers

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6.2 ESTIMATION OF ECONOMIC DAMAGES ASSOCIATED WITH SUMMER FLOODING OF WINNIPEG'S RIVER SYSTEM

6.2.1 Types of Economic Losses and Estimation Methodology

Summer flooding on the river system in Winnipeg between the Floodway Inlet and Floodway Outlet causes physical damage to property and also affects businesses and recreation that operate on or near the river system. Reducing the incidence or duration of summer flooding would avoid some of these costs and provide benefits to the City of Winnipeg and areas within the Floodway gates (the study area). In order to provide an estimate of the potential benefits of stabilizing summer water levels between the Floodway Inlet and Outlet, it is necessary to understand how commercial and recreational activities are economically impacted by water elevation and duration of summer flooding. During the course of the study, four broad types of economic costs associated with flood damages were identified:

- Property Damage and Clean-up Costs
- Business Interruption Losses
- Recreation Opportunity Losses
- Future Opportunities

Property Damage and Clean-up Costs

Property damage and clean-up costs are direct damages associated with summer flooding events. Types of losses in this category include replacement of damaged docks and operational, maintenance and clean-up costs for boat launches and trails. These types of loss are direct market losses. The potential benefit of stabilizing summer water levels on the Red River is the full avoided cost of these types of damages.

During the course of the study, key-person interviews were conducted with representatives from the City of Winnipeg Parks and Open Spaces Division, business owners, boating clubs and other stakeholders that maintain infrastructure that may be impacted by summer flood events. These representatives were asked to provide estimates of an average range of property damage, clean-up costs and increased operating and maintenance costs that are incurred as a result of summer flooding. Respondents were also asked to estimate at what water elevation these costs begin to be incurred and how the costs are influenced by flood duration.

Business Interruption Losses

Business interruption losses occur when a business is not able to operate or is otherwise impaired by high water levels. In the case of a water taxi, which relies on a fixed dock, the business is not able to operate at all and loses revenue for each day that the dock is not accessible. For businesses located in The Forks Market and Johnston Terminal, the flooding of the Red and Assiniboine riverwalks reduces the pedestrian traffic to the site and has a negative impact on revenue.

During the course of the study, key-person interviews were conducted with representatives from The Forks Market, business owners, boating clubs and other commercial stakeholders whose business revenues may be negatively impacted by higher water elevations. Respondents were asked to provide estimates of business losses or decreased revenues during periods of summer flooding. Participants were also asked to describe how these losses were affected by water elevation and flood duration.

Like property damage costs, business interruption losses are market costs. The impacted businesses bear the full cost of the losses. However, from the perspective of the study area, it is likely that some of the business revenues are not lost entirely, but are rather displaced or redistributed to other locations in the study area. Therefore, including the full cost of the business interruption losses in the estimation of benefits to the study area has the potential to overestimate the true accrued benefit. To account for the fact that some of the business interruption losses are displaced to other locations within the study area, rather than lost entirely, estimates of business interruption losses were adjusted downward based on an estimate of how much of the decreased revenue was lost, rather than displaced.

Recreation Opportunity Losses

There are a variety of recreation activities in the study area that make use of the river system or its banks, including motorized boating, canoeing, paddling, rowing and trail walking. During summer flooding, access to the rivers is impaired which results in the loss of recreation opportunities. For some activities, such as fishing and trail walking, other locations are available within or near the study area to engage in the same activity. For other types of recreation, such as motorized boating and rowing, when summer flooding restricts access to the river there are no other suitable locations for the activity within the study area.

During the course of the study, key-person interviews were conducted with individuals who are familiar with specific types of recreation activities. These interviews included representatives from boating clubs, the City of Winnipeg Parks and Open Spaces Division, Manitoba Paddling Association, Winnipeg Rowing Club and Manitoba Conservation – Fisheries Branch. Respondents were asked to describe how each type of recreation activity is affected by summer flooding and to provide estimates of the number of people who engage in the recreation activity on an average summer day.

Unlike property damage costs or business interruption costs, recreation opportunities generally are not market activities. In order to determine the value of the recreation opportunities, it is necessary to use non-market valuation techniques such as the travel cost method or contingent valuation method. Completing these types of non-market valuation studies is costly and beyond the scope of the present study. However, in order to provide an estimate of the value of recreation opportunities, results from the existing economic literature were used to estimate the value of a recreation day for each type of recreation. Walsh et al (1988) reviewed over 200 studies from 1968 to 1988 that used the Travel Cost Method (TCM) and Contingent Valuation Method (CVM) to provide estimates of the value of different types of recreation activities. The Travel Cost Method uses the costs that an individual incurs to access a recreation site, such as gasoline or transportation costs, as an estimate of the individual's willingness to pay to gain access to a particular recreation site or recreation experience. The Contingent Valuation Method is a tool used to estimate willingness to pay for a particular good or service based on the stated preferences of surveyed consumers. CVM estimates can be used to provide an estimate of the economic value of nontraded good or services, such as environmental effects or recreation benefits, for which there is no direct market information. The authors reported the range, average, median and 95% confidence intervals of the dollar values for 19 types of outdoor recreation activities. A 95% confidence interval is the range of values such that there is a 95% probability that the range includes the true value of the variable. The values reported in the study represent the dollar amount that an individual would be willing to pay over and above their current costs to maintain access and opportunity to use the recreation resource (known as recreation opportunity values).

Recreation opportunity values for each of the types of recreation examined in the study were estimated using the following method:

1. An estimate of the daily average number of recreation users for each recreation type was provided by persons familiar with the particular recreation activity. In most cases, respondents were hesitant to provide exact use estimates, so a range of values was adopted for the study. Respondents were also asked to identify the water elevation at which access to the recreation resource is impaired.

2. The lower 95% confidence bound for each recreation type from the study by Walsh et al was adopted as an estimate of the value of the recreation type. The lower bound was adopted to recognize the fact that most of the studies reviewed by Walsh et. al. were related to rural destination recreation areas while the recreation uses in the City of Winnipeg take place in a more saturated recreation market. The values reported in Walsh et al are stated in third quarter 1987 US dollars. These values were converted into Canadian dollars using the average US dollar per Canadian dollar exchange rate in effect for September 1987 and then inflated into 2002 Canadian dollars using the average of 12 months Consumer Price Index. [Average monthly US Dollar per Canadian Dollar for October 1987 was $0.764 as reported by the Federal Reserve Board. Consumer Price Index for 1987 was 81.5 and in 2002 was 119.0 (average of 12 months, 1992=100. Source: Stat Can CANSIM II table 326-0002)].

3. The estimated daily average number of recreation users were multiplied by the recreation value calculated in step 2 to arrive at an estimate of the recreation value of each recreation type for an average summer day.

4. Some of these recreation types are more replaceable than others. For example, trail walking and fishing can be done at other locations in the study area when water levels on the rivers are high. However, it is more difficult to find suitable replacement sites for motorized boating or rowing when river water levels are elevated. Including the full amount of the recreation values calculated in step 3 would tend to overestimate the

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recreation opportunity losses to the study area due to flooding of the Red River. In order to account for the difference in substitutability, an alternative site factor (y) was estimated for each activity. The alternative site factor was estimated based on the perceived availability of suitable alternative sites for each recreation activity. The alternative site factor also considered the relative quality of the available substitutes. The average daily recreation values calculated in step 3 were then multiplied by (1 - y) to arrive at an estimate of the net loss of recreation opportunity due to summer flooding.

Future Opportunities

In addition to benefits associated with avoided costs of flood damage, summer regulation of the Winnipeg river system may have other potential future benefits, including development opportunities, in the study area. During interviews conducted for the study, respondents were asked to comment on potential future benefits associated with increased summer regulation of the Red River. The results of the comments that were provided have been compiled below.

6.2.2 Results and Discussion

This section of the report presents the results of the analysis. Results are presented separately for each category of commercial and recreation flood damage costs. Results include both quantitative estimates of flood damages and potential avoided costs from water level stabilization and qualitative comments noted during key person interviews. Aggregate results are discussed at the conclusion of the section.

Property Damage and Clean-up Costs

Table 5 summarises the estimated property damage and clean-up costs incurred per flood event and per day of flooding. Results have been aggregated according to uses that take place on the river and those that take place adjacent to the river. Results are also sorted according to the Red River water elevation at which the damage begins to occur (referenced in terms of feet above JAPSD). The types of damage reported during key person interviews in this category include:

- Physical damage and repair or replacement of boat docks and boat launches

- Clean-up costs and debris removal from paths and walkways
- Other increased operating or maintenance costs incurred as a result of flooding

It should be noted that these estimates do not include estimates of damages to private residential docks or land that may also be incurred during summer flooding. This information was excluded from the calculation of property damage and clean-up costs because source information does not exist in a readily available format, collection of the information would have required significant resources, and assessment of private residential docks or land was outside the scope of the study. Inclusion of estimates of damages to private residential docks and land would serve to improve the overall economics of the project.

A review of Table 5 indicates two important points:

- Property damage and clean up costs associated with summer flooding tend to be incurred on a per event basis.
- Approximately two thirds of the property damage and clean-up costs appear to occur when Red River water elevations exceed el. 8 ft JAPSD. This seems to suggest that the greatest benefit in terms of avoiding property damage and clean-up costs associated with summer flooding would be realised if summer water levels could be maintained below el. 8 ft JAPSD.

During key person interviews, respondents noted that the flooding that occurred during the summer of 2002 was among the worst in recent memory. Several of the commercial operators interviewed during the course of the study stated that a repeat of 2002 flood conditions would be extremely detrimental to their business. Several interviewees from commercial, government and recreational stakeholder groups indicated a reluctance to invest in new infrastructure or facilities given their experience with summer flooding over the past ten years. This has led to some infrastructure being removed from service or not being replaced when damaged. For example, representatives from the City of Winnipeg's Parks and Open Spaces Division noted that the boat launch at Crescent Park is currently not in use and would require significant repair to return it to service.

Table 5 - Average Estimated Property Damage and Clean-Up Costs Incurred due to Summer Flooding per Event and per Day.

Type of Use	Water Elevation Trigger (ft above JAPSD)	Average Estimated Cost per Flood Event		Average Estimated Cost per day of Flood Event	
		Low ($)	High ($)	Low ($)	High ($)
On Water	8	19,400	27,500	600	700
Near Water	8	11,500	16,500	-	-
On Water	10	300	800	-	-
Near Water	10	400	600	-	-
On Water	12	500	1500	-	-
Near Water	12	9,500	14,500	-	-
Total Costs @ 8 ft JAPSD		**30,900**	**44,000**	**600**	**700**
Total Costs @ 10 ft JAPSD	(includes damages at 8 ft JAPSD)	**31,600**	**45,400**	**600**	**700**
Total Costs @ 12 ft JAPSD	(includes damages at 10 ft JAPSD)	**41,600**	**61,400**	**600**	**700**

Business Interruption Losses

Table 6 presents the total estimated loss of revenue to businesses per day of flooding. Table 6 also provides an estimate of the net loss to the study area by adjusting the losses to business based on an estimate of the degree to which the revenue was lost or displaced to another location in the study area. The loss factor used to adjust the business losses are also presented in Table 6.

When reviewing the information presented in Table 6 it is important to note the following:

- While the net losses to the study area may be reduced, the businesses impacted by flooding bear the full cost of the lost revenues. This is a significant amount of revenue for many of the businesses involved.
- All of the business owners and operators interviewed during the study noted that business interruption losses begin to be felt when water levels exceed el. 8 ft JAPSD.

Table 6 - Average Estimated Business Interruption Losses Incurred per Day due to Summer Flooding.

Business Use Location	Water Elevation Trigger (ft above JAPSD)	Average estimated losses to business per day of flood event		Loss Factor	Average estimated net losses to business per day of flood event	
		Low ($)	High ($)		Low ($)	High ($)
On Water	8	2,800	4,700	.50	1,400	2,400
Near Water	8	8,800	13,100	.25	2,200	3,300
Costs @ 8 ft JAPSD		**11,600**	**17,800**		**3,600**	**5,700**

During key person interviews, several respondents noted that, in their experience, the public tends to use the Assiniboine Riverwalk as a barometer. When the Riverwalk is flooded, people tend not to frequent businesses associated with the Red and Assiniboine rivers, even if access to that particular business in not yet directly impaired by flooding. It was also noted on several occasions that the persistent summer flooding of the past ten years has tended to make the public view businesses that operate on the river as unreliable or inconvenient. The cumulative effect of several years of summer flooding appears to have a greater impact on the public perception of the reliability of river-based businesses than an isolated summer flood would. Many of the business owners interviewed were optimistic that if summer water levels on the Red River could be stabilised and the incidence of summer flood events reduced, that it could have a positive effect on their business operation.

Recreation Opportunity Losses

Table 7 displays the estimated number of users for an average summer day for recreation activities that may be affected by summer flooding of the Red River. Table 7 also provides an estimate of the net loss of recreation opportunity to the study area. Average recreation values are adjusted using an estimate of the availability of alternate sites within the study area to engage in similar recreation activities. The alternate site factors used to adjust the business losses are also presented in Table 7.

Key observations that may be made from Table 7 include:

- Trail walking and fishing have the highest estimated volume of average daily users.
- Approximately 40 per cent of estimated net recreation opportunity losses are incurred by the time water elevation reaches el. 8 ft JAPSD. Approximately 85 per cent of estimated net recreation opportunity losses are incurred by the time water elevation reaches el. 10 ft JAPSD.

Table 7 - Average Estimated Recreation Opportunity Losses Incurred per Day due to Summer Flooding.

Recreation Activity	Water Elevation Trigger	Average estimated daily number of users		Recreation Value ($)[1]	Alternate Site Factor (*y*)	(1-*y*)	Average estimated net recreation opportunity losses to businesses per day of flood event	
	(ft above JAPSD)	Low	High				Low ($)	High ($)
Trail Walking and Picknicking[2]	8	2,500	7,500	14.16	0.90	0.10	3,500	10,600
Motorized Boating[3]	8	20	50	21.61	0.25	0.75	300	800
Fishing[4]	10	500	1,500	35.98	0.75	0.25	4,500	13,500
Canoeing/Paddling[5]	10	40	60	33.83	0.75	0.25	300	500
Rowing[6]	12	50	100	33.83	0.25	0.75	1,300	2,500
Net Cost @ 8 ft JAPSD							**3,800**	**11,400**
Net Cost @ 10 ft JAPSD (incl 8 ft)							**8,600**	**25,400**
Net Cost @ 12 ft JAPSD (incl 10 ft)							**9,900**	**27,900**

Table Notes:

1. Adjusted from Walsh et al 1988. Adjusted using average US exchange rate of $0.760 for September 1987 per U.S. Federal Reserve Board. Canadian Consumer Price Index for 1987 was 81.5 and 119.0 for 2002 (average of 12 months, 1992=100 Stat Can CANSIM II table 326-0002).
2. Walsh et al 1998 report for Picknicking only.
3. Motorized boating adjusted from Walsh et al.
4. Warm water fishing adjusted from Walsh et al.4.
5. Non-motorized boating adjusted from Walsh et al.
6. Non-motorized boating adjusted from Walsh et al.

It is important to understand that the figures in Table 7 represent estimates of lost recreation opportunity for an **average** day during the period from June 1st to October 31st. Values for July and August and weekends may be appreciably higher. In addition, certain recreation events may be impacted by summer flooding of the Red River, examples of such events include:

- Media/Corporate Fishing Challenge
- Dragon Boat Races at the Forks
- Winnipeg Fish Festival
- Rowing Regattas

When summer flooding impacts recreation events of this nature, the lost recreation opportunity is likely higher than presented in Table 7.

When summer flooding impacts recreation events of this nature, the lost recreation opportunity is likely higher than presented in Table 7. Losses resulting from these summer events were excluded in the assessment of recreational opportunity losses for the following reasons:

- Calculation of recreation opportunity losses (Table 7) were made on the basis of a daily average use rate, whereas summer festival events occur at a specific time and cannot be readily averaged out over the summer period.
- Participation can be influenced by variables unrelated to changes in water level much more so than other recreational activities. Variables would include temperature, precipitation, wind, conflicting events schedules, promotional success, or event pricing.
- Determining a monetary value for these lost opportunities is difficult because the experience cannot be readily replicated or quantified.

Inclusion of related summer recreational events in the estimates of lost recreational opportunity would serve to improve the overall economics of the project.

During key person interviews several respondents noted that the persistent flooding of the past several years has discouraged beginners from taking up certain river related recreation activities including canoeing, paddling, rowing and motorized boating. Representatives from a number of recreation associations predicted that the number of people participating in river related recreation would increase if summer water levels in the study area were more stable.

Future Opportunities

In addition to benefits associated with avoided costs of flood damage, summer regulation of the Red River may have other potential future benefits to the City of Winnipeg. During interviews conducted for the study, respondents were asked to comment on potential future benefits associated with increased summer regulation of the Red River. Potential future benefits cited during interviews included:

- Increased use of existing recreational and commercial facilities
- Development of new commercial and recreational infrastructure
- Enhanced image of Winnipeg as "River City"

The balance of this section discusses each of these points in turn.

Increased Use

During interviews, many respondents noted that persistent summer flooding over the past ten years has affected their commercial or recreational operations. In addition to increased property damage and maintenance costs, several respondents noted that persistent summer flooding has affected their ability to plan future events or activities and to attract new users. These impacts were noted by commercial operators as well as those involved in recreation activities such as canoeing and fishing.

Many of those interviewed commented that more stable water levels would improve the attractiveness of commercial and recreational activities on the river leading to greater use of the river. Respondents also indicated that regulation of summer water levels on the Red River would facilitate the planning of more special events. Particular opportunities noted during interviews included:

- Canoeing and paddling use of the river could increase by ten to twenty per cent. Based on current user estimates and estimated recreation values, this could result in an increase in recreation value related to canoeing or paddling of $30,000 per year.

- Boating clubs could see increases in memberships and use of facilities. If boating club memberships returned to pre-1992 levels it could result in an increase of approximately $50,000 per year in boating club membership revenues. Recreation value associated with motorized boating in the study area could also increase by $40,000 to $50,000 per year.

- Operations of the Splash Dash Water Bus Service Rental and Charters could potentially double or triple from 25,000 customer per year to 50,000 – 75,000 customers. Revenues could increase on a similar scale resulting in approximately $500,000 in additional sales each year.

New Infrastructure

Persistent summer flooding of the Red and Assiniboine rivers inhibits the development of new recreation and commercial infrastructure. Organizations that operate on and along the river are not currently able to justify investing further capital on infrastructure. This would include public and private interests who elect to either not maintain existing facilities or develop new facilities because of the uncertainty of summer water levels.

Improved stabilization of summer water levels could lead to expansion of existing facilities. Development of new infrastructure may also become more feasible. New structures would, of course, be subject to the current legislation, which contains various restrictions and prohibitions on developments within the flood prone areas and within the river. Potential developments noted during key person interviews included:

- Paddlewheel River Rouge Tours Ltd. would consider a multi-million dollar development of a boat terminal. Current plans for such a facility are significantly impeded by investor fears related to summer flooding.

- Parks Canada has considered development of a wooded trail area at the Forks National Historic Site.

- More docks for residential purposes, the water taxi, recreational users and commercial developments.

- In total, potential developments noted during key person interviews could result in more than $5 million in increased capital investments in commercial and recreation related infrastructure.

Enhancing Winnipeg's Image as a "River City"

Winnipeg's rivers and adjacent greenways are one of its most visible summer attractions. Commercial and recreation opportunities related to rivers have tremendous potential in terms of marketing the area to visitors. According to a Statistics Canada visitor survey, nearly a third of all visitors to the area, or approximately 2.8 million tourists, arrive during the June/July/August period, the peak season for river related commercial and recreation activities. A representative from Destination Winnipeg noted that both the river and the green spaces located along its banks are key marketing attractions for the City. There is a reluctance to market the area's river related commercial and recreation opportunities if their accessibility is consistently threatened by flooding during the summer tourism season. If rivers and associated greenspace amenities are not available due to summer flooding, it can produce a significant negative impression on visitors. Summer flooding was repeatedly cited during interviews as one of the primary factors limiting future development and marketing of river related commercial and recreation opportunities in the area.

There are numerous examples of other cities and regions in North America that have taken advantage of their rivers and greenspace with dramatic results. San Antonio, Texas is frequently cited in tourism and recreation literature as a prime example of the development possibilities associated with urban rivers. The City of San Antonio has developed its network of riverwalk and trails to create a thriving commercial and recreation district that is often cited as one of the most visible tourism attractions in San Antonio and the State of Texas (U.S. National Park Services, 1995) *(This report notes that the San Antonio Riverwalk is among the major tourism attractions in the State of Texas and the anchor of the tourism industry in the City of San Antonio. See page 5-6 of the report titled "Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors". 1995.)* and a major contributor to San Antonio's multi-billion dollar a year tourism industry (Lerner and Poole, 1999). *(This reference notes that the San Antonio Riverwalk is a key component of San Antonio's $3.5 billion annual tourism industry. See page 26 of the report titled "Economic Benefits of Parks and Open Spaces" Lerner and Poole 1999.)* The San Antonio Riverwalk is frequently used as a model for urban planning and renewal.

In contrast, the development and marketing of Winnipeg's river system to date has not reached its full potential. The catalyst for much of the development in the last two decades has been The Forks. The impact this initiative has had on the development of the recreational and commercial potential of the Winnipeg River system is significant. The Forks has had enormous benefits to the economy of the City and has also become a significant part of the cultural identity of the area. The magnitude of these benefits could not have been conceived of during the planning stages of the Forks development.

The potential for greater economic, recreational and cultural benefits that could be generated from an integrated and fully developed river system exist in Winnipeg. Although requiring significant investments of time and capital, the benefits could eventually be in the tens of millions of dollars annually. Persistent summer flooding is currently a significant barrier to any such development. Removal of that barrier could open the door to significant economic, recreational and cultural benefits to residents of the area.

Summary and Discussion of Results

During the study, three main types of commercial and recreation losses due to summer flooding of the Red River were identified. Estimating the losses in each category required a slightly different methodology. The results for each type of loss have been presented in the previous sections. This section of the report attempts to combine the losses from each category and discuss the cumulative impact of each of the types of loss.

Figure 8 displays the average estimated property damage and clean-up costs associated with each flood event. As Figure 8 indicates, property damage costs begin to be incurred when water elevation reaches el. 8 ft JAPSD. Estimated commercial and recreation property damage costs per summer flood event range between $30,000 to $45,000 for a flood of el. 8 ft JAPSD to $40,000 to $60,000 for a flood of el. 12 ft JAPSD.

Figure 9 presents the average estimated net property damage, business interruption and recreation losses per day for summer flood events. The values presented in Figure 9 represent damages incurred in addition to the per event property damage figures presented in Figure 8. As Figure 9 indicates, recreation opportunity losses comprise a substantial portion of the net losses per day of flooding. Estimated net costs per day of flooding are between $8,000 and $18,000 per day for a flood elevation of el. 8 ft JAPSD and $15,000 to $35,000 per day for a flood elevation of el. 12 ft JAPSD.

In addition to the damage estimates presented in this section, respondents noted several complicating factors associated with summer flooding, including:

- debris and current
- timing; flooding in July and August and on weekends tends to have greater impacts to business interruption and recreation opportunity losses
- speed of flood onset. If some advance warning of flooding is available it is possible to mitigate some types of property damage costs.

In addition, several respondents noted that persistent summer flooding has had a detrimental effect on public perception of river related commercial and recreational activities. Many respondents felt that more stable summer water levels would improve the situation and result in more river based commercial and recreation activity.

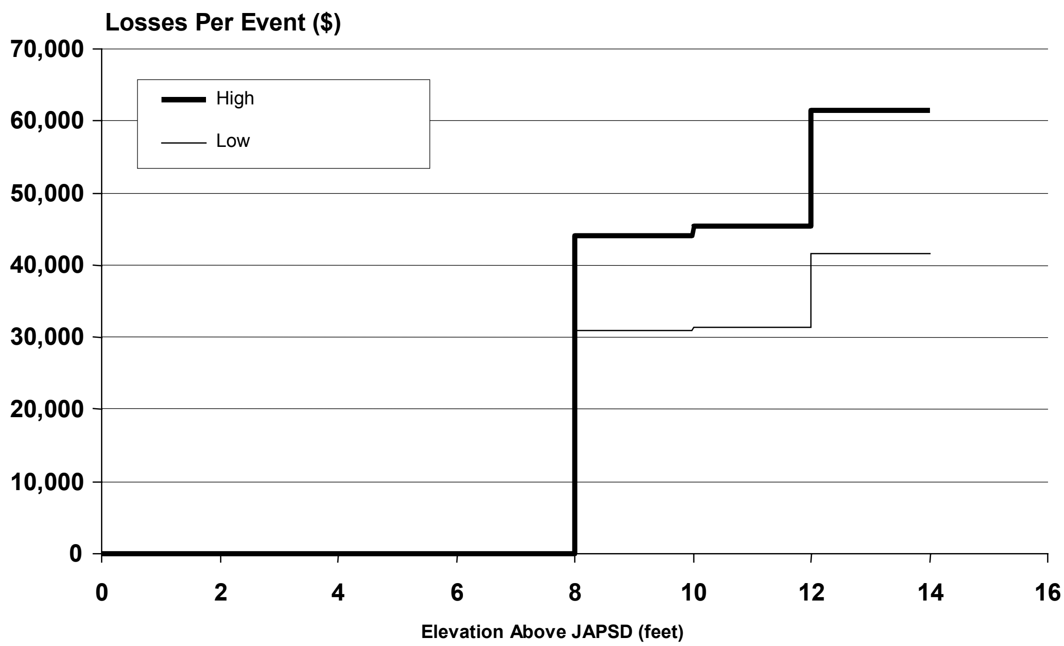

Figure 8 - Per Event Average Property Losses and Clean-Up Costs Due to Summer Flooding of the Red River

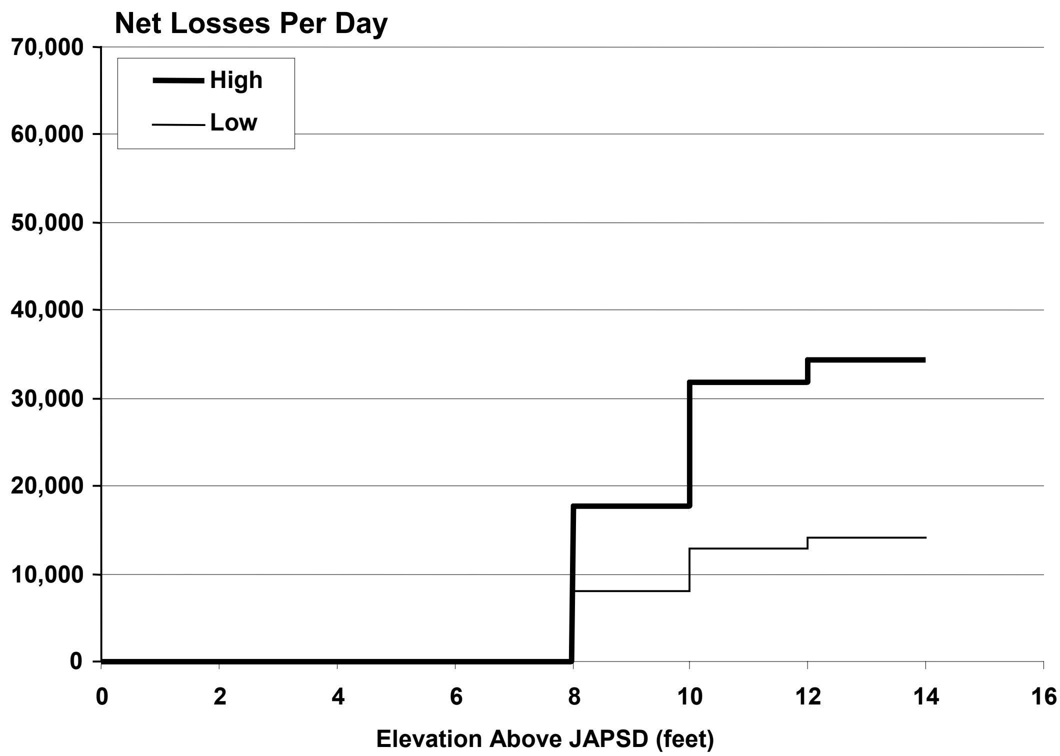

Figure 9 - Per Day Average Net Losses Due to Summer Flooding of the Red River

7.0 FLOOD DAMAGES ASSOCIATED WITH SUMMER OPERATION

7.1 OVERALL APPROACH

As described in Section 4.0, flood damages upstream of the Floodway Inlet Control Structure are incurred by the operation of the Floodway and include flood and disruption losses to market gardeners, cereal crop farms and undeveloped land, increased maintenance and infrastructure damages. In addition to damages upstream of the inlet structure, consideration has been given to potential losses due to boat damage north of Winnipeg as a result of the changed flow regime. Costs associated with crop loss damages were estimated using compensation and buyout approaches. The compensation approach is based on compensation for crop losses following each summer operation event, while the buyout approach considers a one time, “upfront”, purchase of the affected cereal crop and market garden and undeveloped lands. A potential hybrid solution (i.e. part buyout and part compensation) was also considered. Estimates for damages to infrastructure (e.g. roads, drainage works, culverts etc.) were based on the experiences from 2002 and spring flood events. Increased maintenance costs were based on the Province’s current operating and maintenance experience and other spring flood events. Compensation for loss of use and access to undeveloped land adjacent to the river and potential navigation related losses downstream of Winnipeg were also factored into the assessment.

The influence of summer operation on bank stability is complex and the approach associated with incorporating these effects into the overall assessment is described in Section 8.0.

7.2 ASSESSMENT OF DAMAGES UPSTREAM OF THE FLOODWAY INLET CONTROL STRUCTURE

7.2.1 Landowner and Manitoba Land Management Services Input

Landowners

As part of the assessment of upstream damages, input from the market gardeners was solicited. In general, the landowners stated their desire to continue their way of life uninterrupted, and were not supportive of a scheme for compensation or buyout. Most felt that the compensation awarded in 2002 was appropriate for the loss encountered, but that the added inconvenience and uncertainty to their operations is overlooked when considering the true cost of damages.

The market gardeners are especially affected by the summer Floodway operations, as most of their best land is closest to the river and subject to the most frequent flooding. Meetings, questionnaires and interviews have brought forward a general sentiment, which is summarized, in the following quote:

> *"Summer water level control on the Red River for the City of Winnipeg will put much uncertainty in the way of farming business is carried out…. There are many difficulties to overcome in vegetable farming - frost, too dry, too wet, plant diseases, bugs and controlling them, spring flooding,… Adding the uncertainty of implementing a program to control river levels in the City of Winnipeg at the expense of farming lands south of the control gate would make it next to impossible to carry out farming activities in this area. This could result in the loss of customers and future business." (Peter Meyer, Market Gardener)*

Land Management Services

Following the initiation of this study, a meeting was held with Manitoba Land Management Services to solicit their input related to values to use for land purchase and compensation. KGS Group reviewed the approach and the values used in its preliminary analysis. These values were based primarily on KGS Group's previous experience, discussions with landowners (as discussed above), and input from Manitoba Conservation and the Steering Committee. This approach was described to Manitoba Land Management Services (LMS) Branch and suggested values for each of the categories were discussed. Although Manitoba LMS Branch stated its suggested values are highly judgmental and could be studied in much greater detail, these were based on the best available information at this time. The results of the discussion are outlined below:

- A flood zone "Easement" was discussed briefly with potential costs of approximately of 65-75% of market value with the landowner retaining the right and ownership of the land. Although this is possible, it is often quite difficult to execute uniformly, and was not judged to be a good final solution. LMS prefers purchase/expropriation with lease back options because it can be uniformly administered and is the only way to ensure that there are no future claims for flood damage.

- On the subject of a buyout, LMS stated that purchase of an entire property parcel is less expensive, on a per acre basis, than severing a parcel especially if the severance creates a problem with access to the property that remains with the individual owner.

- Considering the purchase of agricultural crop land (i.e. “non-market garden”) the following cost guidelines were established:

  Full Parcel purchase/expropriation

  - Includes fertile cultivated land and non-arable (bush) areas along the river
  - $2000-$2500 per acre
  - Cost includes the purchase price of the land, and all acquisition costs such as legal fees, survey, landowner appraisals, expropriation costs and contingencies

  Severed Parcel purchase/expropriation

  - Includes fertile cultivated land and non-arable (bush) areas along the river
  - up to $4000 per acre
  - Cost includes the purchase price of the land, and all acquisition costs such as legal fees, survey, landowner appraisals, expropriation costs and contingencies
  - Costs are higher due to additional costs for legal survey, and potential costs for severance allowances

- When considering Market Gardeners the LMS staff suggested that a list of land owners and location information be given to them, to determine the assessed value of the property and provide a best estimate of costs for the individual properties. Based on these and subsequent discussions, it was concluded that the value currently used by KGS Group of $6000 per acre is a reasonable estimate. The value of $6000 per acre is higher than assessed value, but is considered reasonable for several reasons as follows:

  - Assessed values are usually somewhat less than current Market Values because they are historically based, and do not reflect current market conditions. For example, the current values for assessment are based on the last assessment year 1999.
  - LMS performs an appraisal of each individual parcel being considered for purchase and offer current market prices as per their legislated mandate.
  - Additional costs for purchase are variable on a case by case basis, and depend on the individual landowner’s willingness to participate in the buyout program. From our discussions, landowners are not supportive of the initiative, and additional appraisal, legal and other costs could be significant.

Although crops are the most directly affected entity due to increased summer levels, other landowners along the river in the area of influence may be impacted by the increased summer level. Since it is very difficult to quantify the direct effect of temporary loss of access and clean-up costs to the affected properties, for the purpose of the study, it was assumed that these properties would be compensated for the “inconvenience” loss. Based on discussions with LMS, a value of approximately 10% (or about $50/acre) of the crop damage compensation value was used to estimate the value for the inconvenience and clean-up losses compensation. This value was highly judgmental and would require further assessment at the next level of study. For the buyout approach, the values of $2,500 per acre for whole parcels and $4,000 per acre for parcels requiring severance were used based on the input from Land Management Services.

7.2.2 Assessment of Upstream Damages – Compensation Approach

The compensation approach was based on the experience from the 2002 summer flood control operations and compensation program and discussions with the affected land owners. In all, 24 landowners claimed for damages as a result of the operation of the Floodway to lower levels in Winnipeg in July of 2002. The classification of damage claims included seven market gardeners and eight farmers growing crops such as wheat, barley, flax and oats. To protect the privacy of the claimants each claim file was given an arbitrary identification number, which appears in the "Claim ID" column of the tables presented.

Compensation to Market Gardeners was based on individual damage claims awarded for the 2002 event where crops were known and flooded. The data is summarized in Table 8.

Table 8 – Compensation to Market Gardeners: Summer 2002 Event and Additional Areas

Claim ID	Compensation per Acre Flooded
11	$ 3,000.00
19	$ 6,500.00
20	$ 7,820.00
20	$ 6,260.00
20	$ 9,200.00
21	$ 31,700.00
22	$ 10,000.00
23	$ 5,000.00
25	$ 3,925.00
Additional Areas*	$ 6,500.00

*Additional areas that are farmed as market gardens and may be flooded at river levels higher than that experienced in 2002 were assessed damages at an average compensation cost of approximately $6,500.00.

Compensation for cereal crops was based on approximate average award values for the 2002 event where crops were known and flooded as presented in Table 9.

Table 9 – Cereal Crop Compensation for Summer 2002 Event

Claim ID	Compensation per Acre Flooded
3	$ 300.00
5	$ 260.00
6	$ 378.00
12	$ 425.00
13	$ 300.00
17	$ 370.00
N/A	$ 415.00
N/A	$ 387.00
Average	**$ 354.38**

The average compensation for flooded cereal crop, was rounded up to $375.00 per acre

Using the compensation values above, a GIS based compensation model was developed using estimated flooded areas derived from calculated water surface profiles and a digital elevation model (DEM) produced from 1998 LiDAR surveys as illustrated on Figure 10 (Note - LiDAR surveys are available south of Winnipeg only as far south as Ste. Agathe). Delineated flooded areas on cultivated areas were calculated using the GIS tool (ArcGIS), and damage estimates were calculated by applying the damage per acre for the **individual market** gardener or the average cereal crop compensation value as appropriate.

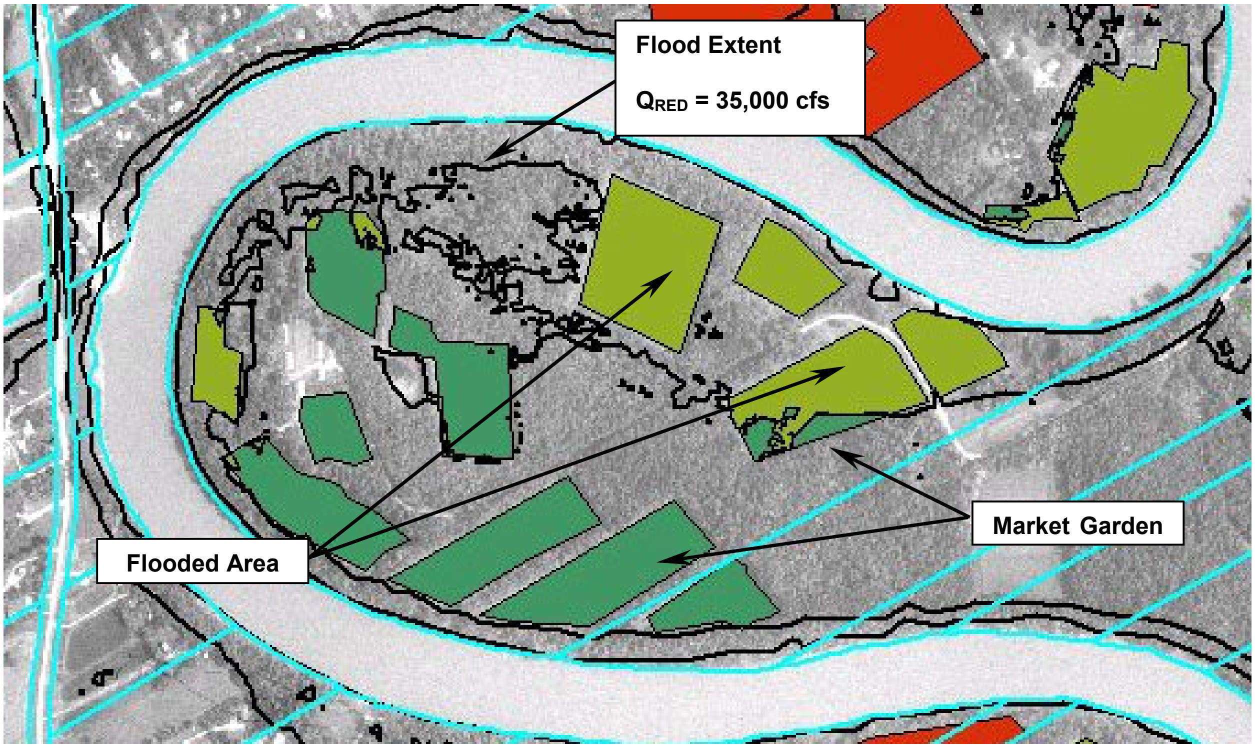

Figure 10 – Sample Compensation Flooded Area Delineation

Based on the flooded areas, and crop compensation values, the estimated damages to market gardeners upstream of the Floodway were calculated. The results are given in Table 10, and shown on Figure 11 for the range of discharges and water levels considered.

Table 10 – Summary of Upstream Damages to Market Gardeners

Red River Discharge (cfs)	Control Level at Floodway Inlet (ft)			
	Natural	755	758	760
12000	$ -	$ 196,200	$ 366,300	$ 532,300
22000	$ -	$ 207,200	$ 373,700	$ 542,000
35000	$ 88,600	$ 235,000	$ 392,300	$ 563,900

The estimated compensation curves are relatively flat because the location of the market gardeners is close to the Floodway Inlet, and within the zone of backwater influence from the control structure. Because of this, increased Red River discharge had only a minor impact on river stages, and results in little additional flooded area.

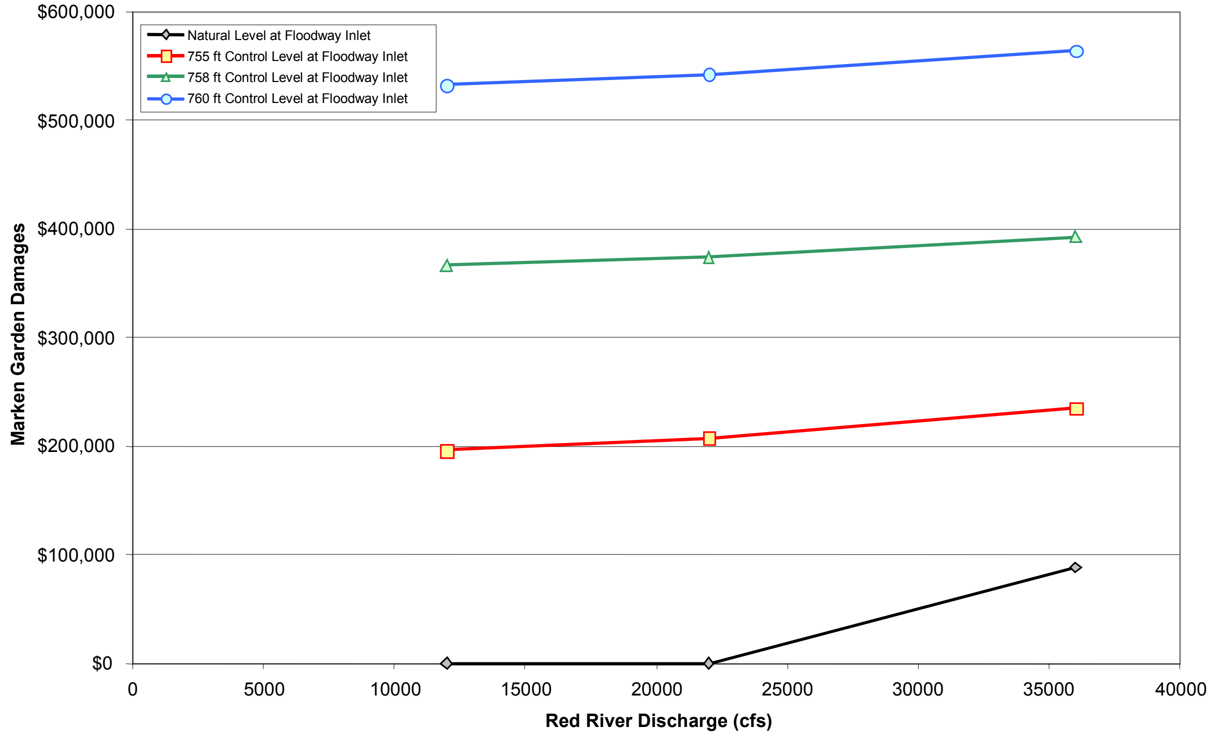

Figure 11 – Estimated Upstream Damages to Market Gardeners

A summary of the estimated compensation for cereal crop damage upstream of the Floodway is given in Table 11, and shown on Figure 12.

Table 11 – Summary of Upstream Damage to Cereal Crops

Red River Discharge (cfs)	Control Level at Floodway Inlet (ft)			
	Natural	755	758	760
12000	$ -	$ 40,000	$ 87,200	$ 133,000
22000	$ 5,800	$ 50,700	$ 99,800	$ 146,100
35000	$ 39,100	$ 77,100	$ 127,000	$ 176,700

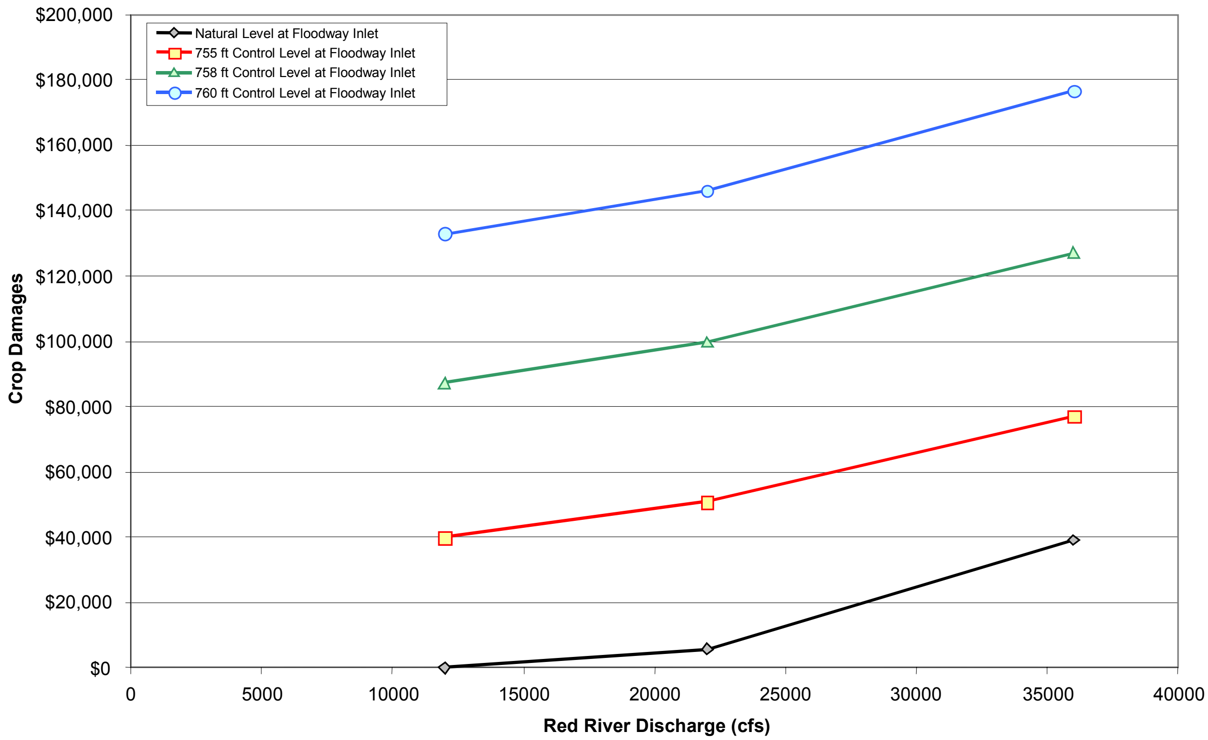

Figure 12 – Estimated Upstream Damages to Cereal Crops

Estimated compensation values for uncultivated land adjacent to the river was based on our discussions with LMS. A compensation value of $50 per acre was used for the study. The results are given in Table 12, and shown on Figure 13 for the range of discharges and water levels considered.

Table 12 – Summary of Upstream Damages for Undeveloped Land

Red River Discharge (cfs)	Control Level at Floodway Inlet (ft)			
	Natural	755	758	760
12000	$ -	$ 41,200	$ 66,700	$ 93,100
22000	$ 4,200	$ 46,000	$ 72,900	$ 99,400
35000	$ 39,000	$ 58,600	$ 86,400	$ 116,400

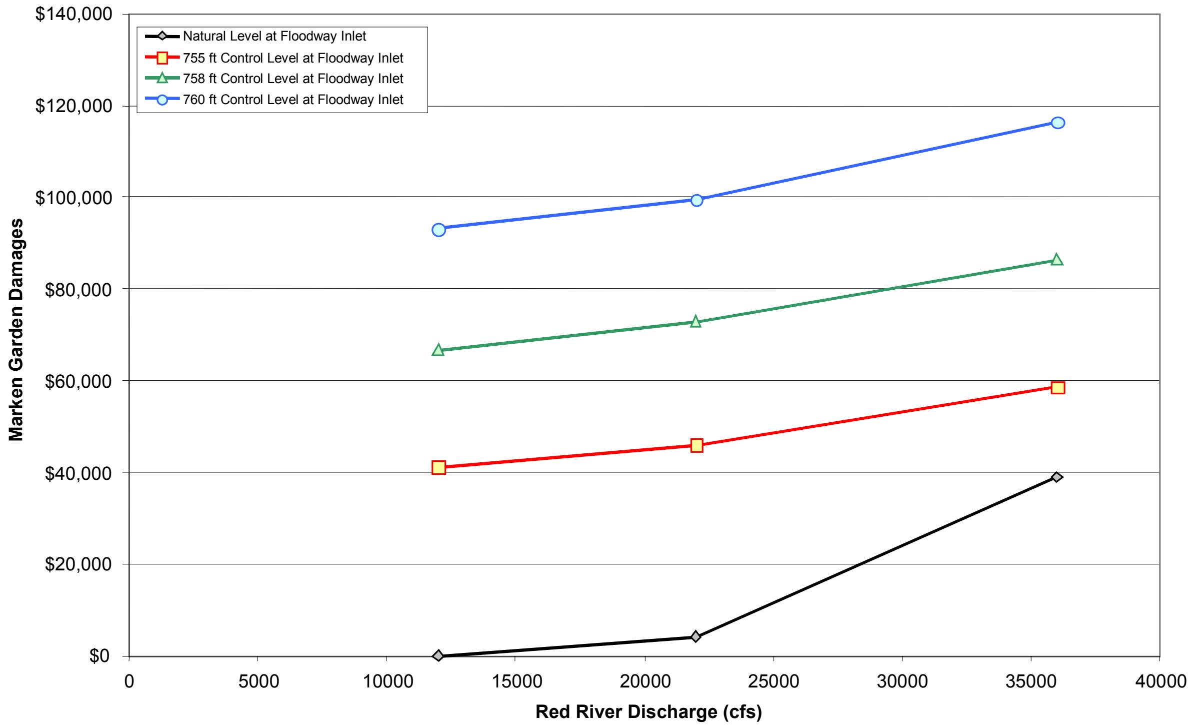

Figure 13 – Estimated Upstream Damages for Undeveloped Land

7.2.3 Assessment of Upstream Damages - Buyout Approach

The estimated cost for the “buyout” of affected properties was based on the establishment of a “flood zone” for a relatively infrequent or large event. Only lands affected by flooding would be purchased. The event chosen was a summer flood on the Red River equal to 35,000 cfs with a simultaneous control at the Floodway Inlet of El. 760 ft. Once the flooded area was delineated, “buyout” costs were calculated by multiplying the number of acres of land to be purchased by the estimated value of the land based on the land use including consideration for land acquisition and legal costs.

Land values were based on discussions with and correspondence received from Manitoba Conservation and Manitoba Land Management Services (Section 7.2.1). It was assumed that the entire property is to be purchased when dealing with the market gardeners. Market garden land values were based on a similar buyout of property for the St. Mary's Road project and supported by discussions with LMS, as follows:

> Value of Land and Buildings per acre = $417,000 / 105.82 acres = $3,940.65 / acre
>
> This value was multiplied by a factor of 1.5 to account for legal and acquisition costs, moving expenses and other overhead associated with the transaction. On this basis, the total "buyout" value per acre of market garden land is estimated to be:
>
> $3,940.65 * 1.5 = $5,910.00 / acre, say $6,000.00 / acre

The costs include all land and buildings on the affected market garden parcel.

Land values for all other areas (mix of agricultural and undeveloped land) were estimated based on a "buyout" value of $2,500.00 per acre for whole parcels of land and $4,000.00 per acre for land where property parcel severance is required. The costs include purchase price of the land and all acquisition costs. The value was based on discussions with LMS as described in Section 7.2.1

Whole land parcels were assumed to include river lots truncated at a reasonable boundary such as St. Mary's Road and Highway 75. This approach for flooded properties considered for a complete buyout is shown on Figure 14.

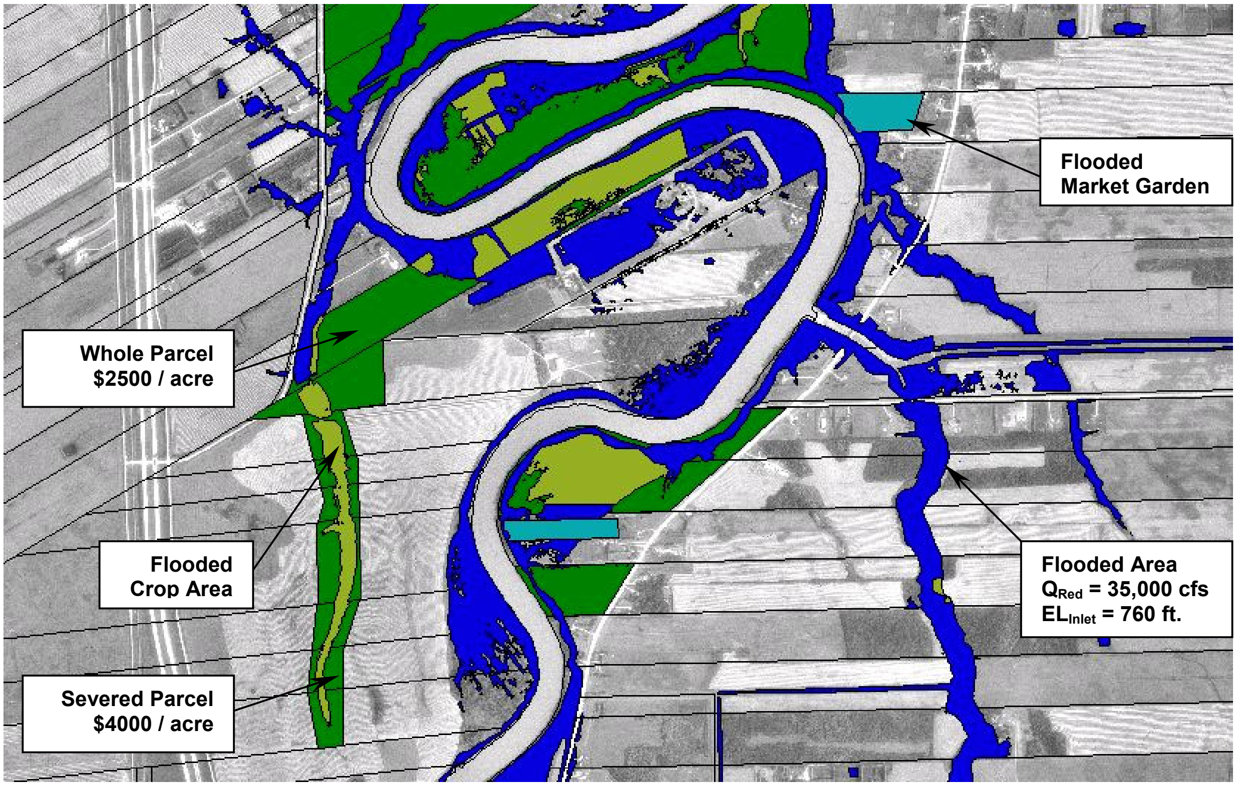

Figure 14 – Sample Area for Buyout Consideration

Using the land values for buyout of Market Gardeners, Cropland and "undeveloped land" discussed above, costs for Total Buyout were estimated as follows:

Market Gardens:

Total Buyout Area is	710 acres	
Buyout cost per acre	$6,000	
Cost for buyout of Market Gardeners		≅ $4,260,000

Cropland:

Area of whole parcel buyout	1120 acres		
Cost per acre	$2,500	≅ $2,800,000	
Area of severed parcel buyout	1440 acres		
Cost per acre	$4,000	≅ $5,760,000	
Cost for buyout of cropland areas			≅ $8,560,000

Undeveloped Land:		
Totally Buyout Area is	2300 acres	
Buyout Cost per Acre	$2,500	
Cost for buyout of Undeveloped Land		≅ $5,750,000
Total Estimated Land Acquisition Costs		$18,570,000

7.2.4 Hybrid (Compensation / Buyout) Approach for Upstream Landowners

Since Market Gardeners will be so significantly affected by summer operations, it may be best to consider a buyout of their property while compensating other crop growers for what may be viewed as a lesser inconvenience. Market garden operations are also highly specialized, and compensation is difficult to assess without significant effort after each event. There is no straightforward mechanism of determining the compensation via a broad-based formula. On the other hand, cereal crop farmers can be compensated for crop losses with a more simple approach, and each claimant can be handled in a similar fashion.

A "Hybrid" approach would reduce the need to purchase large land parcels for cereal crop use, which is the largest portion of the total buyout cost estimates. It would also avoid the difficulty of assessing losses and negotiating more complex per-flood settlements with the market gardeners, which is the largest component of the compensation approach.

7.3 OPERATION & MAINTENANCE COSTS ASSOCIATED WITH SUMMER OPERATION

The estimated increased operation and maintenance (O&M) costs are based on data provided by the Province. The increased O&M costs are based on their operating and maintenance experience for the past several years and considers such items as:

- ***Floodway Channel Maintenance –*** Under current conditions, the Floodway fills with water to varying extents in the spring during the years that require use of the Floodway to protect Winnipeg. This has been invariably during the dormancy stage of the plants that grow on the channel sides and bottom, and does not cause significant damage to them. Flooding in the summer, however, would prevent the access of the plants to oxygen, and has a potential to kill plants that cannot tolerate prolonged submergence. Some plants are more resistant than others are, and varying impacts would occur. In fact, it is speculated that over time, those plants that are naturally more resistant to submergence will flourish and expand their coverage, at the expense of the less resistant varieties. Some damage is known to have occurred during the operation of the Floodway in the summer of 2002, but a systematic assessment was not carried out after the event.

The intermittent summer use of the Floodway would be expected to encourage a reduction in the coverage by vegetation in the channel, notwithstanding the long-term spread of plants that can withstand temporary submergence. The original selection of the design velocity for the Floodway channel of up to 5 ft/s (1.5 m/s) relied on the fact that the bare earth in the channel would be protected from scour effects of the flow, and would be held together by a matted root system. Loss of that vegetative cover, even in only selected locations, would expose the channel to an undesirable increase in risk of erosion. Furthermore, the migration of that erosion is difficult to predict, and may conceivably compromise structures such as bridge abutments, the Aqueduct, transmission lines, and drainage structures along the channel.

If a summer water level control program were put into place that requires use of the Floodway, it would be prudent to establish a parallel program that would monitor and maintain the vegetative cover in the channel. The maintenance should be carried out to the extent that has been proven to provide protection for the channel from the erosive action of the diverted flow through it. Some re-seeding of particularly exposed areas would be desirable. This would likely only be necessary in the short term, probably less than 10 years, until the channel has developed a strong growth of vegetation that is resistant to submergence in the summer growth season. An allowance of $40,000.00 per summer flooding event for this short-term maintenance has been included in the economic assessment. The damage value is based on the cost to re-seed approximately 5 percent of the Floodway base width area (80 acres) at a cost of $500.00 per acre.

- ***Floodway Inlet Control Structure Operation –*** Manitoba Conservation has indicated that operating the Floodway Inlet Control Structure during a summer event would cost the department an extra $700.00 per day. This cost is primarily labour costs for operators to supervise the Control Structure 24 hours a day for the duration of the summer flooding period. This allowance was incorporated into the overall costs to implement a strategy of summer water level control. The per event costs included a 4 week (10 working days before and after) buffer to prepare the structure for summer operation, and to allow for proper shutdown of operations after the summer event is over.

- ***Floodway Inlet Control Structure Increased Maintenance –*** Because the Inlet Control Structure will be used more frequently with summer operations, routine and long term maintenance costs will undoubtedly increase. Historic costs were used as the basis for projecting future costs for maintenance of the structure. Approximately $10,000,000 has been spent maintaining the structure over the past 30 years (or $333,000 per year), and for purposes of this study a 10 percent increase in these annual costs, or $33,000 per year, has been included in the economic analysis for increased use of the structure for summer operations.

  Based on discussions with the Province, it is assumed that additional seasonal or contract staff will be required for the increased maintenance (i.e. existing staff will not be able to manage the additional operation and maintenance).

- ***Other Infrastructure Maintenance Costs –*** Municipal infrastructure upstream of the Floodway Inlet Control Structure will be impacted by summer operations. Steering Committee members originally suggested that these costs were significant during the Summer 2002 event. Closer scrutiny has determined that infrastructure damage was not as significant as originally thought. Still an allowance for potential damages to municipal infrastructure such as ditches, culverts, roads and bridges has been included in the economic analysis. At this level of study, an allowance of 5% of the crop damages for the compensation scheme have been used. This allowance should be reviewed in greater detail at the next level of study.

- ***Other Considerations –*** Although consideration was initially given to potential increases in maintenance of the Floodway Outlet Control Structure, Manitoba Conservation has indicated that this facility would not be significantly affected by increased use. On this basis no allowance was given for this item.

  Consideration was also given to potential increases in administration costs at Manitoba Conservation such as office management costs and costs for compensation negotiations. Manitoba Conservation stated that limited additional resources would likely be acquired to administer a summer operations program, and that existing staff would need to manage the compensation program as it is departmental responsibility. For the purpose of this study, no allowances were given to potential increases in administration costs.

7.4 PROPERTY TAX LOSSES

Property tax losses for the market gardener properties were originally estimated based on a value of be 2% of the land value. However, it has been assumed that the land purchased would be leased back to either the previous landowner or a different landowner and the income from the leased land would be approximately equivalent to the property tax losses. Although lease revenues could exceed property tax losses, it has been assumed that they are equal for the purposes of this analysis. Furthermore, tax losses are generally not included in an assessment of losses for economic studies.

7.5 KEY CONSIDERATIONS FOR DEVELOPING A COMPENSATION PROCESS FOR UPSTREAM FLOODING

Sections 7.1 through 7.4 have discussed types of damage that may occur due to the management of summer water levels on the Red River in the City of Winnipeg. In 2001, KGS Group prepared a report titled "Flood Protection Studies for Winnipeg" (KGS Group, 2001). During the preparation of that report, interviews were conducted with land owners who were impacted by flooding during the 1997 flood. Land owners were asked for their perspectives on their experiences with flood compensation processes and recommendations for improvement with respect to how future compensation processes might be handled. Key findings of the 2001 study included:

- Stress and anxiety of dealing with compensation procedures are often worse than that caused by the actual flood event.
- Existing compensation methods are designed to address direct property damage but do not sufficiently recognize:
  - Impacts on property value
  - Stress and anxiety related to increased flood risk
- There is considerable existing dissatisfaction with the way compensation was handled during the 1997 flood and other recent flooding. It is unlikely that compensation related to future projects can be discussed in a meaningful way without addressing public concerns with respect to past compensation practices.

In the context of the current study, it is likely that issues related to property value impacts (for both landowners and municipalities) and stress and anxiety related to increased flood risk will be significant challenges in the development of compensation mechanisms related to the management of summer water levels on the Red River in the City of Winnipeg. Property value losses may be addressed by considering compensation options that include buy-out and lease back provisions. In the 2001 study, it was noted that developing compensation processes to reflect stress and anxiety impacts due to increased flood risks would increase estimated compensation costs by at least ten to twenty per cent compared to compensation for direct damage costs only. For the present study, this would result in an estimated additional 10% to 20%, which has been included in the estimates used to estimate damages.

Development of a compensation package for project induced flooding that is satisfactory to impacted landowners would require public involvement in the design of compensation guidelines and processes. During interviews conducted for the 2001 study there was broad agreement among landowners that an appropriate compensation mechanism would require:

- Involvement of landowners and municipalities during the development of the compensation process.
- Development of clear compensation guidelines and processes in advance of operation of any future flood protection projects.

A public involvement process to develop a compensation framework for upstream damages as a result of management of summer water levels on the Red River could be undertaken and would increase the probability of landowner satisfaction with the resulting compensation mechanism. Such a public consultation process could involve a series of workshops to establish compensation principles and procedures and a report to government on the findings. The report could then be used by the government to develop the compensation mechanism. Such a process would likely require three to four months to complete at a cost of approximately $20 thousand dollars.

7.6 NAVIGATION LOSSES DOWNSTREAM OF WINNIPEG

Control of water levels during summer floods in Winnipeg will require sustained water levels that are below the normal summer water levels in the river reach between the St. Andrews Lock and Dam (SALD) and approximately the North Perimeter Bridge. Figure 15 shows a typical profile with a controlled water level at approximately el. 7 ft JAPSD at the Forks. Also shown is a higher profile that would occur without diversion of excess floodwater into the Floodway during a severe summer flood event. The reduced water level in the 7 miles upstream of the SALD theoretically could cause adverse impacts on navigation as a result of:

- low water levels at established docks, with difficulties in boat mooring and possibly even boat damage due to insufficient draft at moorages
- high velocities in the river, difficulty in maneuvering boats, and insufficient draft in some shallow locations

While these impacts would occur, they are mitigated by two factors:

- The low profile in Figure 15 would occur in both cases with or without use of the Floodway since the SALD would be operated for both. The difference between the cases is that the lower profile with the summer control scheme implemented would be sustained for a period of time ranging from several days to several weeks, depending on the nature and severity of the summer flood. Consequently, the difficulties at the moorages would occur in both cases, probably requiring the most vulnerable boats to be moved or taken out of the river. This would reduce the potential damages in the case of the summer control scheme, when the low water levels are sustained for longer periods.

- The flood conditions would preclude the use of the lock facilities at the SALD because the existing access canal to the lock is too shallow, whether or not the Floodway would be used during these events. Consequently, movement of boats through the Lock would be essentially unaffected by the use of Floodway in the summer flood events.

Quantification of the economic impacts of the potential impacts on navigation is difficult. However, KGS Group believes that the potential damages would not be insignificant. For example, there could be as many as 100 boats moored in the vulnerable zone between the North Perimeter Bridge and the SALD. However, most of the boats would be protected, or would be moved when the initial low river profile occurs in the early phase of the flood event. If, 10 boats were not moved, and would incur, on average, $2,000 of damage per boat, that would amount to $20,000 per event where the Red River is controlled to a maximum water level of el. 8 ft JAPSD at the Forks. It is assumed that there would be negligible damage to boats if the control level at the Forks was equivalent to el. 15 ft JAPSD. On this basis, the damages were varied linearly between $0 and $20,000 per event for control levels between el. 15 ft and el. 8 ft JAPSD respectively for the economic analysis.

In addition to the direct impacts of reduced water levels downstream of the North Perimeter Highway, there would be a minor recreational impact. This reduced availability of the river in this area was not directly considered in the assessment of recreational benefits. The figures used for damages to boats were deemed adequate to account for lost recreational use as well.

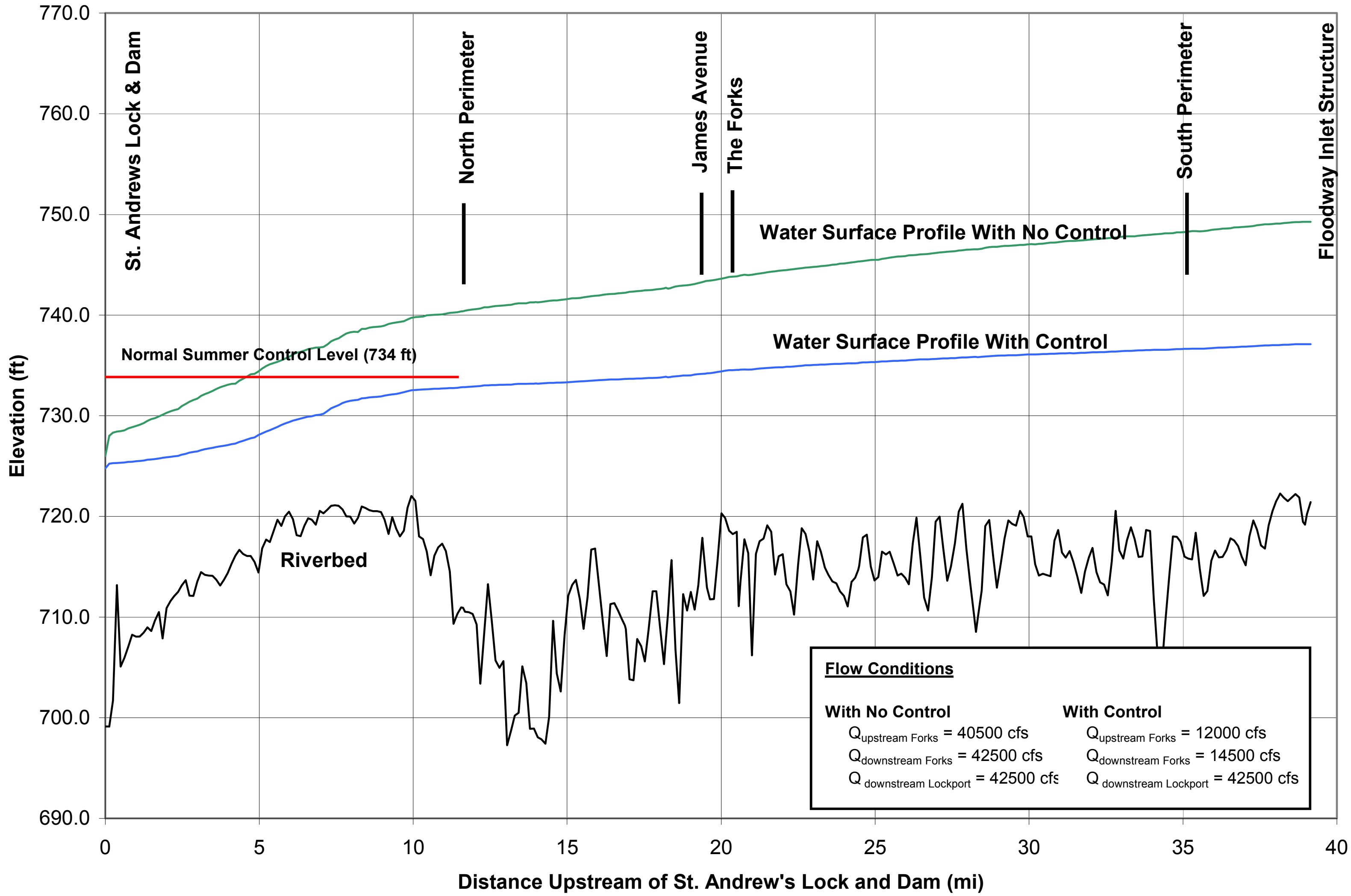

Figure 15 – Red River Profiles Showing Effects of Summer Operations on Navigation Downstream of Winnipeg

7.7 AVERAGE ANNUAL DAMAGES FROM THE MANAGEMENT OF RED RIVER SUMMER WATER LEVELS

Sections 7.1 to 7.6 have described the potential damages from management of Red River summer water levels in the City of Winnipeg. While the majority of the damages identified occur upstream of the Floodway Inlet Control Structure, consideration has been given to costs associated with operation and maintenance of the control structure and channel, as well as potential damages to boats within the reach north of Winnipeg to the St. Andrews Lock and Dam.

The damages caused by summer operations were annualized by determining probability of using the Floodway in the future based on the past 32 years of Floodway operations and summer flood conditions on the Red River. The calculation of average annual damages incorporated the number and duration of the events that the Floodway would have been used for control levels in the City ranging from el. 7 ft to el. 15 ft JAPSD. These events are based on the event durations provided in Tables 1A through 1D. The control levels were related to maximum upstream water levels and potential damages using the established relationships for compensating upstream crop and land damages and damages to market gardeners. Buyout costs were annualized on the basis of a 50 year planning horizon and a discount interest rate of 4%. Property tax losses for the market gardner properties purchased and lease revenues were assumed to offset each other (see Section 7.4).

The damages and benefits that can be attributed to the use of the Floodway to control summer floods will depend on the river flows that occur in the future. These are to a large extent unpredictable. However, it is common practice in analyses of this type to use the historical record of river flow to represent conditions that will occur in the future. In the case of the Red River, it is not known whether the next 50 years will be similar to the relatively wet period of the last 10 to 15 years, or whether they will be similar to the generally drier period represented by the last 90 years that are on the record for Winnipeg. To address this, the sensitivity of the damage estimates was considered in a qualitative manner, using differing assumed periods of river flow record. An extended period, approximately 90 years, and a shorter period, the 12 years from 1990 to 2001 were considered. The extended period of record was found to be statistically similar to the 33 years from 1968 to 2001(i.e. since the Floodway began operation) and so it was concluded that using the 33 year period (instead of the full 90 year period) would, therefore, not skew the damage estimates. The 12 year period covering the 1990s is wetter than the previous 35 years, as can be seen by comparing Tables 1A to 1D (for period 1990 to 2001). The damages would be higher than stated in this report if this recent wet period were used. However, the benefits would also be higher. To some degree, the effects will cancel each other in the computation of the B/C ratio. It is possible that since the benefits exceed the costs, the effect of the shorter period may increase the overall B/C slightly. Since the use of the full length of the flow record is the conventional approach, it was decided to proceed on this basis and recognize that the costs and benefits would be higher if the shorter, wetter period of record were used. Testing the sensitivity of this assumption could be considered at subsequent study stages if warranted.

Table 13, provides a summary of average annual damages calculated in this study. The table lists damages for each category and a total for control water levels ranging from el. 7 ft to el. 15 ft JAPSD. The three schemes – Compensation, Buyout and Hybrid (as described in Sections 7.2.2, 7.2.3 and 7.2.4) - can be directly compared on the table. The compensation and hybrid schemes are similar when considering the control level of el. 7 ft or el. 8 ft JAPSD, but diverge for higher control levels because of the “up front” costs to purchase the market gardener property. The damages and costs of the buyout scheme are more than twice as high (for a control level of el. 7 ft JAPSD) as the other two schemes since it involves the large initial cost for the purchase of significant amounts of market garden land.

The average annual damages for the crop, market gardener, and undeveloped land damages were based on the area between the Floodway Inlet and Ste. Agathe. To account for the area upstream of Ste. Agathe to Morris, a factor of 1.1 has been included in the average annual damages presented in Table 13.

Table 13 - Average Annual Damages Summary

Compensation Scheme

JAPSD Control Level (ft)	Crops	Market Gardeners	Undeveloped Land [1]	Infrastructure[2]	O&M Costs	Property Tax Losses / Lease Back Revenues[3]	Navigation Damages	Total Damages and Costs
7	$ 55,642	$ 191,115	$ 40,437	$ 2,782	$ 175,000	0	$ 13,800	$ 479,000
8	$ 33,234	$ 115,259	$ 24,459	$ 1,662	$ 122,000	0	$ 12,075	$ 309,000
10	$ 16,806	$ 59,625	$ 12,740	$ 840	$ 93,000	0	$ 8,625	$ 192,000
12	$ 9,406	$ 33,764	$ 7,239	$ 470	$ 61,000	0	$ 5,175	$ 117,000
14	$ 3,162	$ 12,650	$ 2,793	$ 158	$ 49,000	0	$ 1,725	$ 69,000
15	$ 2,510	$ 10,256	$ 2,277	$ 125	$ 40,000	0	$ -	$ 55,000

Buyout Scheme

JAPSD Control Level (ft)	Crops	Market Gardeners	Undeveloped Land	Infrastructure[2]	O&M Costs	Property Tax Losses / Lease Back Revenues[3]	Navigation Damages	Total Damages and Costs
7	$ 437,800	$ 198,000	$ 294,800	$ 2,782	$ 175,000	0	$ 13,800	$ 1,122,000
8	$ 437,800	$ 198,000	$ 294,800	$ 1,662	$ 122,000	0	$ 12,075	$ 1,066,000
10	$ 437,800	$ 198,000	$ 294,800	$ 840	$ 93,000	0	$ 8,625	$ 1,033,000
12	$ 437,800	$ 198,000	$ 294,800	$ 470	$ 61,000	0	$ 5,175	$ 997,000
14	$ 437,800	$ 198,000	$ 294,800	$ 158	$ 49,000	0	$ 1,725	$ 981,000
15	$ 437,800	$ 198,000	$ 294,800	$ 125	$ 40,000	0	$ -	$ 971,000

Hybrid Scheme

JAPSD Control Level (ft)	Crops	Market Gardeners	Undeveloped Land [1]	Infrastructure[2]	O&M Costs	Property Tax Losses / Lease Back Revenues[3]	Navigation Damages	Total Damages and Costs
7	$ 55,642	$ 198,000	$ 40,437	$ 2,782	$ 175,000	0	$ 13,800	$ 486,000
8	$ 33,234	$ 198,000	$ 24,459	$ 1,662	$ 122,000	0	$ 12,075	$ 391,000
10	$ 16,806	$ 198,000	$ 12,740	$ 840	$ 93,000	0	$ 8,625	$ 330,000
12	$ 9,406	$ 198,000	$ 7,239	$ 470	$ 61,000	0	$ 5,175	$ 281,000
14	$ 3,162	$ 198,000	$ 2,793	$ 158	$ 49,000	0	$ 1,725	$ 255,000
15	$ 2,510	$ 198,000	$ 2,277	$ 125	$ 40,000	0	$ -	$ 243,000

Notes

1 Undeveloped Land compensation damages were equal to $50 / acre.

2 Infrastructure Damages estimated as 5% of crop damages.

3 Property tax losses for market gardener properties purchased and lease revenues were assumed to offset each other.

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8.0 GEOTECHNICAL CONSIDERATIONS

8.1 GENERAL

The potential impacts that controlled summer water levels will have on the riverbank stability conditions both upstream and downstream of the Floodway Inlet Control Structure are complex. A qualitative evaluation has been performed to define the possible effects to the banks. The most difficult challenge of the assessment is to separate the incremental effects imposed by the summer flooding control from the natural influences and river morphology that contribute to the bank stability conditions.

The assessment was based on the following existing information:

- Topographic maps
- Stereo aerial photography
- Visual observations of the bank conditions during the boat trip taken upstream of the Floodway Inlet Control Structure on October 28, 2002 by representatives of Manitoba Conservation and KGS Group.
- Discussions with Manitoba Conservation personnel and private land owners familiar with issues that have been identified at particular properties within the affected area.
- Review of existing geotechnical reports relevant for the affected area.
- KGS Group familiarity and experience with riverbank conditions in southern Manitoba.

The riverbank lengths that would be affected by summer water level control are shown below. The impacted riverbank lengths extending upstream and downstream from the inlet are roughly the same. The effects gradually diminish as the distance from the Inlet Structure increases in both the upstream and downstream directions.

- Upstream of the Floodway Inlet to Morris

– Morris to Ste. Agathe		21.4 mi
– Ste. Agathe to Floodway Inlet		20.2 mi
	Total	***41.6 mi***

  – This excludes the Rat River and tributaries

- Downstream from the Floodway Inlet to the Outlet Structure

– Inlet to the North Perimeter (Red River)		27.0 mi
– St. James Bridge to Red River (Assiniboine River)		4.3 mi
– North Perimeter to Outlet (Red River)		11.2 mi
	Total	***42.5 mi***

  - This excludes the LaSalle River, Seine River, Bunns Creek and tributaries.

8.2 RIVER MORPHOLOGY

The Red River is a dynamic system whose characteristics and conditions are determined by numerous natural and man-made factors that occur within its drainage basin. The following information is a general representation of the typical river morphology that affects the ongoing formation of the Red River. It is intended to provide an understanding of the processes to which the river is subject and how they impact its state. While the information presented is generally representative of the conditions encountered, it is not intended to provide a detailed account of the environment along specific sections of the river. *The river morphology processes are influenced to varying degrees by a number of factors, and exceptions from the typical conditions will occur.*

Flow Regime –The seasonal and annual flow conditions in the Red River are primarily dictated by precipitation (snow and rainfall) and runoff characteristics (e.g. overland drainage, contributing tributaries, temporary storage, etc.) within its drainage basin. Flow volumes are lowest in the winter, when snow precipitation does not add to runoff and contribute to the river flow. The highest levels are generally observed in the spring during snowmelt, although elevated flows do occur in the summer during high rainfall events. Groundwater contributions to the flow in the Red River are small to negligible, as the riverbank soils are generally low permeability clay and silt materials.

The actual flow in the river at any given time can be highly variable both seasonally and annually. This is a direct result of natural fluctuations in precipitation. A contributing factor to the flow volume is the impact of man-made influences to control and divert natural drainage courses and speed up overland drainage to the river (e.g. ditching to drain farm fields, Seine River Diversion, etc.).

Erosion / Sedimentation – The river geometry and location are influenced primarily by its flow characteristics, and the interaction with the riverbank soil and vegetation conditions. The river is subjected to a continuous and dynamic process of erosion and sedimentation, with an overall mass transport of soil material from the banks and streambed in a downstream direction. In general, flow velocities in the river are the highest along outside bends, which typically results in higher shoreline erosion rates than observed along the inside bends where the velocities are lower. Deposition of fine grained silt can occur along the lower bank areas and flatter flood plains of inside bends. This can be a temporary situation, particularly along the lower bank areas, where high flows and velocities during flood events can remove this fine grained, highly erodable silt. On flat flood plains where velocities are low and vegetation helps to promote sedimentation, the deposited silt can build up in layers over time. Partial erosion of this material and transport into the river may occur from surface water runoff. Very little to no deposition occurs on very steeply sloping sections of the riverbank.

The outside river bends are typically exposed to more erosion, although the rate and location of that erosion on a particular bank will be variable throughout the season and from year to year. Some factors that affect the erosion conditions are as follows:

- Flow velocities and water levels
- Material type (lacustrine clay, till, alluvial sands, silts and clays)
- Slope geometry, with flatter slopes generally being less susceptible to erosion
- Vegetation conditions, with intact vegetation (grass, shrubs, trees, roots, etc.) reducing scour
- Ice conditions, which can contribute to severe erosion during spring flood events
- Wave action. Boat induced waves can cause erosion on riverbank slopes that have exposed soil faces, affecting both inside and outside bends of the river.

Although outside bends are usually more susceptible to erosion, significant scour can still occur on inside bends, particularly on very steep inside bends with exposed soils that are submerged during flood events.

Bank Stability – The process of erosion and sedimentation contribute to the overall conditions of riverbank stability. The most severe impact is from erosion, where loss of material at the lower portion of a slope can cause oversteepening and subsequent bank failures. The failures can be deep seated large movements, or more shallow undercutting and sloughing failures. The type of bank movement that occurs on unstable reaches is related to a number of factors, including bank geometry, foundation soil conditions, groundwater piezometric pressures, vegetation conditions, and river level. Riverbank instability is a natural part of the river morphology, and can be influenced (both positively and negatively) by man-made conditions such as site development (e.g. construction at the top edge of bank), slope grading work, clearing or planting of vegetation, and changes in the flow regime.

8.3 RIVERBANK CHARACTERIZATION

A general characterization of the riverbank conditions was performed between the Floodway Inlet Control Structure and Ste. Agathe. This area would be subjected to the highest increased water levels and the greatest potential impacts from summer flooding control. The approximate river length through this reach is 20.2 mi, for a total bank length (both sides of river) of 40.4 mi.

The characterization was performed using topographic mapping, stereo aerial photographs, and the visual inspection from the boat tour in October 2002. The bank conditions were separated into three general categories – Existing Unstable Banks, Steep Banks Susceptible to Erosion, and Banks with Reasonably Stable Performance, as identified below.

Existing Unstable Banks

This category of banks are those that exhibit active movements and failures which have affected the overall riverbank slopes. The banks are typically at a slope of 5H:1V or flatter, and the majority of the unstable banks are located along outside bends in the river. The failure surfaces are generally deep seated, and are located within low strength lacustrine clays. Numerous open tension cracks occur at ground surface along the entire length of the slope. These tension cracks are caused by the bank movements, and are a direct extension of the deep failure planes to ground surface. The banks are generally vegetated with trees, brush, and grass, except near the shoreline and along the open tension cracks. Active erosion typically occurs along the lower bank area. Bank conditions within this category were observed over an approximate length of 14.3 mi, which is 35%± of the total bank length from Ste. Agathe to the Floodway Inlet.

Bank movements through this type of section are significant and affect large areas of the riverbank. Failures can occur annually, and typically move in the fall or spring periods in combination with changes in the groundwater conditions and river level. Individual movements may not seem catastrophic in nature, as the banks are relatively flat and movement occurs along pre-existing failure planes. However, the failures can cause significant damage to structures or developments within the zone of movement.

Steep Banks Susceptible to Erosion

This category of banks is at a typical slope of 1H:1V or steeper, and has little to no intact vegetation on the steep bank face. The banks are typically high (10 to 25 ft), and a number of these areas occur along inside bends in the river. The foundation soils within the banks are usually higher strength alluvial sands, silts, and clays. The steepness of the bank is attributed to the higher strength soils and improved drainage conditions within the bank. The silts and sands promote groundwater drainage within the bank. This drainage lowers the piezometric levels and improves the stability conditions. This type of bank is generally considered more stable than the flatter lacustrine banks, and makes up approximately 25% (9.9 mi) of the total bank length between the Inlet and Ste. Agathe.

The type of movement that is usually observed along these steep exposed banks is directly related to erosion and undercutting of the soil face, and subsequent sloughing. The characteristic silt and fine sandy soils are more erodable than cohesive clays. The movements are usually associated with elevated river levels, as the majority of the exposed soil face is above the normal summer river level. Movements do not typically occur every year. When this type of slope does move, the failures can appear very significant or catastrophic, particularly for higher banks (greater than 15 ft). The sharp top edge of bank is directly affected. The failures can extend several meters into the bank's top edge, and affect long reaches. Movements are observed to occur almost instantaneously, with little or no warning as perceived from the top of the bank. Significant damage can occur to structures if they are located within the zone of movement.

Reasonably Stable Performance

Riverbank reaches that have performed well recently and historically, and have been subjected to little movement have been categorized as reasonably stable. The banks typically have minor erosion occurring along the shoreline, but no deep seated overall slope failures have been observed. The vegetation is typically intact down to the shoreline. The slope angles are variable, and depend on the foundation soils and groundwater level conditions. This type of bank makes up approximately 40% of the total bank length (16 mi±).

The lengths of these three categories of bank types have been estimated along the Red River between Ste. Agathe and the Floodway Inlet Control Structure. It is anticipated that similar relative lengths will be applicable for the other study reaches (Morris to Ste. Agathe and downstream of the Floodway Inlet). Within Winnipeg, a larger portion of the riverbanks has been upgraded through riverbank stability improvements. These improvements include riprap erosion protection along the shoreline as a minimum, and may have more significant works associated with deep seated slope failures (e.g. shear key installation). The length of riverbanks upgraded within the Winnipeg is approximately 10% of the total length (4.4 mi), versus only 1%± of improved banks upstream of the Floodway Inlet Control Structure.

8.4 PHYSICAL IMPACTS TO RIVERBANK FROM SUMMER WATER LEVEL CONTROL

The physical impacts that may occur to a riverbank and the subsequent stability performance related specifically to summer flooding control are difficult to separate from the normal river morphology processes that affect the bank. However, the general types of impacts and their potential influences on bank stability have been identified below for the affected zones upstream and downstream from the Floodway Inlet Control Structure.

8.4.1 Upstream of Floodway Inlet

During operation of the inlet gates to control summer levels within Winnipeg, the water levels upstream of the Floodway Inlet will be higher than the natural conditions. The water volume entering the system remains unchanged, resulting in flow velocities that are lower than natural. The increased levels and decreased velocities can directly affect the erosion conditions and

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groundwater levels within the bank. Although the banks will experience these impacts under natural conditions (e.g. during spring floods), the summer flood control will increase the frequency of occurrence.

Erosion Impacts

It is anticipated that the lower velocities will slightly decrease erosion rates on intact banks, particularly along outside bends in the river. The higher levels should also act as a buffer to decrease the velocity of flows entering the Red River channel from tributaries. These would result in a slight positive benefit to the erosion conditions. The higher water levels will submerge a larger zone of the bank than would normally occur. This may be detrimental to the steep banks that have exposed alluvial soils along their face, whose fine grained silt and sand materials can be highly erodable.

Groundwater Level Impacts

The influences that summer flooding control will have on the groundwater levels within the bank are directly related to the level and duration of submergence, the rate of drop in the water level during flood recession, and the types of foundation soils. Alluvial banks (interlayed silt and sand materials) that are relatively pervious tend to experience an increase in the groundwater levels (GWL's) adjacent to the bank closely matching that of the flooding river. Similarly, during flood recession, the GWL's are observed to decrease. This results in no overall significant change to the GWL conditions within an alluvial bank, and no great impact on the riverbank stability or performance.

For intact clay banks, the piezometric levels at depth are typically influenced within the zone of water level increase, in response to increased loading. As the flood water recedes, the GWL's also tend to drop, although there may be some minor time lag and increased residual pressures after flood recession. Like the alluvial bank, the impacts to groundwater levels within intact clay banks from summer flooding control are anticipated to be relatively minor.

The type of bank that may be most impacted by submergence and possible GWL increases are the unstable lacustrine clay slopes that have open tension cracks at ground surface. Once a tension crack is submerged, the piezometric pressure along the failure surface at depth can be directly increased to the river level. During recession of the flood, water could remain trapped in the tension cracks, maintaining the elevated piezometric pressure along the failure surface. A higher pressure in combination with a decreasing river level would result in a reduction in the effective strength and the stability, causing a net decrease in the stability conditions. This could contribute to additional movement along pre-existing failure planes. The incremental impact from summer flooding control will be related to the slope of the bank, the number of tension cracks, the increase in water level above normal, and the overall sensitivity to stability.

Temporary Stability Increase

During flood periods, the increased water level results in a temporary improvement to the stability, as the higher water level acts as a counter balance to downslope failures. This is only a temporary condition, as the stability decreases as the water level drops. A critical influence to the stability during flood recession is the rate of drop in the water level. Very fast reductions in the water level can result in a rapid drawdown scenario, where residual increased piezometric pressures in the foundation soils combined with a rapid loss of water at the lower slope area can significantly reduce stability. The rate of reduction in water can be a critical component to the stability conditions, and slower rates of water level decline are preferable to mitigate impacts.

8.4.2 Downstream of the Floodway Inlet

The summer water level control operation will reduce the frequency of elevated river levels within Winnipeg. This will have opposite impacts of similar magnitude to the erosion and GWL conditions that will be experienced upstream of the Floodway Inlet.

Erosion Conditions

The steep alluvial banks within Winnipeg will be submerged less frequently, and reductions in erosion and sloughing will likely be realized. For outside bends actively eroding, there may also be minor benefits with the reduced flooding. A lower vertical portion of the bank will be exposed to flow, and the velocities will remain at summer values, as opposed to increased velocities associated with flood conditions.

Groundwater Level Conditions

For unstable banks with open tension cracks, submergence will occur less often than natural, and the associated reductions in stability will be less frequent. This will be a positive benefit to the stability conditions. For the stable or alluvial banks that are less affected by GWL surcharging, the impacts will remain neutral.

8.4.3 Incremental Impacts of Summer Water Level Control

The primary factors that influence bank stability are the river levels, the foundation soil conditions, and the GWL's within the bank. In general, the incremental impacts on bank stability that are associated directly with summer water level control are anticipated to have a minor influence on these factors both upstream and downstream of the Floodway Inlet.

Spring floods can typically have a much greater influence on the bank stability. The river levels are higher and extend over a longer duration than the usual conditions associated with the summer floods. Also, increased flow velocities are typically realized during spring flood events. All of these factors can have a much greater impact on bank stability than summer control.

The foundation soils within a bank are one of the main factors that influence bank stability. The types of soil conditions do not depend on the flood conditions, although differing soils will be impacted differently during submergence as discussed earlier. Also, natural fluctuations in GWL's and potential influences from artesian conditions in the underlying bedrock aquifer can have a much more severe impact than relatively minor short term incremental changes in river level during summer control.

While the incremental impacts are anticipated to be relatively minor, a net positive benefit to the bank stability will likely be experienced downstream of the inlet within Winnipeg. Upstream of the inlet, it is anticipated that there will be areas that will experience both net positive and negative impacts from summer flood control. Quantifying the actual impacts is a difficult and site specific exercise.

8.4.4 Lockport Class Action Lawsuit

It is worthwhile to identify a recent class action lawsuit that was brought forward by a group of Winnipeg residents who own riverbank property along the Red River. The lawsuit was against the Federal Government, and was related to summer water level control within Winnipeg from the St. Andrews Lock and Dam (SALD). The lawsuit alleged that the SALD control to regulate the summer river water levels increased boat traffic use, which resulted in more wave action on the riverbanks causing increased erosion rates and bank failures. The group that initiated the action was claiming the increased bank damage and loss was a direct result of the Lockport control, and compensation was due. The lawsuit was initiated in the mid to late 1980's and was discontinued in the fall of 2002.

In response to the lawsuit, Public Works Canada engaged the services of a local geotechnical engineering firm to assess the potential impacts. An investigation and evaluation was performed over a 15 year period to evaluate whether or not increased bank failures were observed within Winnipeg, as opposed to riverbank slopes upstream of the influence of the Lockport control. While ultimately Pubic Works Canada was not found to be liable, the case demonstrates the complexity of the issues involved, and the level of effort that may be required in defense.

8.4.5 Engineering Investigation and Monitoring

A detailed engineering investigation, evaluation and monitoring program is recommended. The primary objective of the engineering assessment would be to establish the original base-line conditions prior to initiating summer flood control and monitor the bank performance during natural and controlled summer flood events. This will provide quantitative results that may be used to separate the influence of the summer control on bank stability performance. The Lockport Class Action suit supports the benefits of the proposed investigation and monitoring program.

All investigations would be site specific, and would involve the following general scope components:

- Visual site assessment;

- Topographic survey of the riverbank and bed conditions;
- Subsurface drilling investigation to determine the foundation soil conditions;
- Laboratory and field testing program to determine the relevant engineering properties of the foundation soils;
- Installation geotechnical instrumentation, including piezometers to measure groundwater levels and inclinometers to measure slope movement. The instrumentation must be monitored over an extended period (at least 10 years) to determine the bank performance as related to precipitation and river flow conditions;
- An engineering assessment of the stability conditions, and determination of the relevant factors attributed to summer water level control that influence the performance.

A number of evaluations (likely between 10 and 20 sites) would be necessary to define representative reaches of the river that have unique conditions. Estimated budget cost for the engineering investigation work are provided in Section 8.5.

8.5 ASSESSMENT OF BENEFITS AND COSTS

A qualitative assessment has been prepared to assess the potential benefits and detriments that may be realized from the control of water levels to reduce summer flooding within Winnipeg. Based on physical impacts, we anticipate that any potential negative influences that may occur will be offset by the positive benefits realized. Also, any impacts (positive or negative) will have a relatively minor influence on the natural factors that affect bank stability. Downstream of the Inlet Structure, any impacts observed from summer control are anticipated to be positive, resulting in minor improvements to the bank stability performance. Upstream of the Inlet, there will likely be both minor positive (e.g. reduced flow velocity and erosion) and minor negative (e.g. tension crack submergence) impacts to bank stability.

It is anticipated that the Benefit/Cost ratio with respect to the bank stability considerations will be greater than 1. This is largely due to the relative value of the affected properties. The value of the property downstream of the Inlet Control Structure where improved bank stability performance is anticipated will be greater than that of property upstream of the Inlet structure that may be subjected to negative bank stability effects. Although quantifying the actual value of benefits realized or costs incurred is not feasible with the data available, it can be concluded that the benefits downstream of the inlet control structure will exceed the disbenefits upstream.

Project Costs

An estimate of the costs that may be incurred to implement the engineering investigation and geotechnical monitoring program has been made for budget purposes. This excludes any construction costs for possible mitigation works that may be required at individual properties where minor negative influences may occur as a result of summer flooding control.

A minimum of 15 sites have been assumed for investigation and monitoring, assuming at least 5 sites downstream of the Inlet and 10 sites upstream. Initial costs for site identification, visual inspection, site investigation, installation of appropriate instrumentation and engineering assessment will likely be in the order of $15,000 to $25,000 for each site. For an assumed 15 sites, the total estimated cost is approximately $225,000 to 375,000. The actual costs for investigation will be site specific, depending on the existing slope geometry, soil stratigraphy, and existing bank stability.

The annual monitoring and data interpretation costs will be additional, and estimated at between $15,000 and $30,000 per year for all 15 sites. A minimum of 2 to 4 monitored readings would be required annually to assess the possible relationship between bank performance, and both natural and Inlet control influences. The annual monitoring costs increase as the complexity and number of sites increase, as well as the frequency of reading.

8.6 CONCLUSION OF IMPACTS ON BANK STABILITY

The implications of the summer water level control operation on riverbank stability are complex. Bank stability is controlled by numerous natural and man-made factors. It is anticipated that the incremental impacts on bank performance from the summer water level control will be relatively minor both upstream and downstream of the Floodway Inlet Control Structure in relation to the natural factors. Any negative physical impacts that may be realized upstream of the Inlet will be offset by the positive impacts experienced both upstream and downstream. Based on a comparison of the values of land impacted, the benefit/cost ratio is anticipated to be greater than 1, considering the higher land value within Winnipeg.

An engineering investigation and geotechnical monitoring program is recommended to obtain base-line information on the bank stability conditions prior to implementation of the summer control program, and allow possible separation of the influences directly attributed to control of summer water levels. The estimated cost to complete the investigation and installation of the monitoring instrumentation and anticipated to be in the range of $225,000 to $375,000, assuming 15 sites (assumed 5 sites downstream of Inlet and 10 sites upstream). An additional cost of $150,000 to $300,000 was estimated for monitoring and data interpretation over a 10 year period. The costs would increase for a greater number of sites and for an extended monitoring period. No cost allowance for construction measures to mitigate possible negative influences on bank stability from summer water level control has been made.

9.0 ASSESSMENT OF BENEFITS AND COSTS

9.1 GENERAL

The benefits used in the economic analyses consist of:

- Benefits due to reduced basement flooding and reduced use of flood pump stations, as discussed in Section 5.0, and
- Benefits due to increased recreation and tourism, as discussed in Section 6.0.

To allow the benefits to be assessed separately, the analysis considered benefits with and without recreation / tourism benefits. The two components were separated to allow a comparison of the physical damages (i.e. basement flooding) only to be made to damages upstream. Recreation/tourism benefits are more subjective and were separated to allow this comparison to be made independently.

The three approaches for assessing the costs due to upstream crop and uncultivated land damages were used in the benefit / cost analysis, and include:

- Compensation approach (discussed in Section 7.2.2)
- Buyout approach (discussed in Section 7.2.3)
- Hybrid approach (discussed in Section 7.2.4)

For comparison, both the benefit/cost ratio and net benefits were calculated as part of the economic analysis. Both are indicators used to rationalize the economic justification of a project. The net benefits are included, since it is a better indicator of the optimum Red River summer water level control in the City of Winnipeg.

The B/C ratio and the net benefits were calculated at various control levels ranging from el. 7 ft to el. 15 ft JAPSD. These control levels represent the full range where benefits to the City sewer system and reduced basement flood damages are realized. As well, recreational benefits increase significantly as control levels are lowered, reflecting the increased use of the rivers and the riverwalk at elevations approaching normal summer levels.

Since the benefits associated with increased recreation and tourism are extremely variable, as described in Section 6.2 using high and low opportunity costs, the benefit / cost analysis was performed using a range of recreation and tourism benefits.

9.2 BENEFIT / COST ASSESSMENT

Using the results of the analyses of benefits from Sections 5.0 and Section 6.0, total benefits have been compiled using the upper and lower ranges of potential recreation and tourism benefits. The methodology used to derive the annual benefits incorporates the probability of the benefits based on the use of the Floodway and the duration of the flood events as described in Section 7.6. Damages due to summer operation of the Floodway have been compiled, as described in Section 7.6 and combined with the benefits for reduced flood damages and tourism / recreation benefits. These values are summarized in Table 14.

The B/C ratios and net benefits for the range of control water levels in Winnipeg considering all three damage calculation schemes: Compensation, Buyout and Hybrid approaches are shown in Table 14.

Table 14 – Summary of Benefits and Costs

JAPSD Control Level	*Damages Upstream*	*Benefits due to Reduced Basement Flood Damages*	*Reduction in Flood Pump Station Operation Costs*	*Upper End Recreation Benefits*	*Lower End Recreation Benefits*	*Upper End Total Benefits*	*Lower End Total Benefits*	*Total Costs*	*B/C Ratio with Upper End Recreation Benefits*	*B/C Ratio with NO Recreation Benefits*	*Net Benefits with Upper End Recreation Benefits*	*Net Benefits with NO Recreation Benefits*
COMPENSATION SCHEME												
7.0	$ 479,000	$ 737,600	$ 14,000	$ 317,566	$ 137,191	$ 1,069,166	$ 888,791	$ 479,000	2.23	1.54	$ 590,166	$ 258,600
7.5	$ 394,000	$ 732,000	$ 14,000	$ 317,566	$ 137,191	$ 1,063,566	$ 883,191	$ 394,000	2.70	1.86	$ 669,566	$ 338,000
8.0	$ 309,000	$ 725,000	$ 14,000	$ 317,566	$ 137,191	$ 1,056,566	$ 876,191	$ 309,000	3.42	2.35	$ 747,566	$ 416,000
8.0	$ 309,000	$ 725,000	$ 14,000	$ 88,425	$ 33,891	$ 827,425	$ 772,891	$ 309,000	2.68	2.35	$ 518,425	$ 416,000
8.5	$ 279,750	$ 700,000	$ 13,250	$ 88,425	$ 33,891	$ 801,675	$ 747,141	$ 279,750	2.87	2.50	$ 521,925	$ 420,250
9.0	$ 250,500	$ 640,000	$ 12,500	$ 88,425	$ 33,891	$ 740,925	$ 686,391	$ 250,500	2.96	2.55	$ 490,425	$ 389,500
9.5	$ 221,250	$ 540,000	$ 11,750	$ 88,425	$ 33,891	$ 640,175	$ 585,641	$ 221,250	2.89	2.44	$ 418,925	$ 318,750
10.0	$ 192,000	$ 380,500	$ 11,000	$ 88,425	$ 33,891	$ 479,925	$ 425,391	$ 192,000	2.50	1.98	$ 287,925	$ 188,500
10.5	$ 173,250	$ 228,000	$ 9,750	$ 68,616	$ 26,665	$ 306,366	$ 264,415	$ 173,250	1.77	1.32	$ 133,116	$ 54,750
11.0	$ 154,500	$ 145,000	$ 8,500	$ 48,806	$ 19,439	$ 202,306	$ 172,939	$ 154,500	1.31	0.94	$ 47,806	$ (9,500)
11.5	$ 135,750	$ 100,000	$ 7,250	$ 28,997	$ 12,213	$ 136,247	$ 119,463	$ 135,750	1.00	0.74	$ 497	$ (35,750)
12.0	$ 117,000	$ 75,000	$ 6,000	$ 9,188	$ 4,988	$ 90,188	$ 85,988	$ 117,000	0.77	0.64	$ (26,813)	$ (42,000)
12.5	$ 105,000	$ 67,500	$ 5,750	$ 6,891	$ 3,741	$ 80,141	$ 76,991	$ 105,000	0.76	0.64	$ (24,859)	$ (37,500)
13.0	$ 93,000	$ 61,000	$ 5,500	$ 4,594	$ 2,494	$ 71,094	$ 68,994	$ 93,000	0.76	0.66	$ (21,906)	$ (32,000)
13.5	$ 81,000	$ 55,300	$ 5,250	$ 2,297	$ 1,247	$ 62,847	$ 61,797	$ 81,000	0.78	0.68	$ (18,153)	$ (25,700)
14.0	$ 69,000	$ 48,900	$ 5,000	$ -	$ -	$ 53,900	$ 53,900	$ 69,000	0.78	0.71	$ (15,100)	$ (20,100)
14.5	$ 62,000	$ 43,100	$ 2,500	$ -	$ -	$ 45,600	$ 45,600	$ 62,000	0.74	0.70	$ (16,400)	$ (18,900)
15.0	$ 55,000	$ 36,600	$ -	$ -	$ -	$ 36,600	$ 36,600	$ 55,000	0.67	0.67	$ (18,400)	$ (18,400)
BUYOUT SCHEME												
7.0	$ 1,122,000	$ 737,600	$ 14,000	$ 317,566	$ 137,191	$ 1,069,166	$ 888,791	$ 1,122,000	0.95	0.66	$ (52,834)	$ (384,400)
7.5	$ 1,094,000	$ 732,000	$ 14,000	$ 317,566	$ 137,191	$ 1,063,566	$ 883,191	$ 1,094,000	0.97	0.67	$ (30,434)	$ (362,000)
8.0	$ 1,066,000	$ 725,000	$ 14,000	$ 317,566	$ 137,191	$ 1,056,566	$ 876,191	$ 1,066,000	0.99	0.68	$ (9,434)	$ (341,000)
8.0	$ 1,066,000	$ 725,000	$ 14,000	$ 88,425	$ 33,891	$ 827,425	$ 772,891	$ 1,066,000	0.78	0.68	$ (238,575)	$ (341,000)
8.5	$ 1,057,750	$ 700,000	$ 13,250	$ 88,425	$ 33,891	$ 801,675	$ 747,141	$ 1,057,750	0.76	0.66	$ (256,075)	$ (357,750)
9.0	$ 1,049,500	$ 640,000	$ 12,500	$ 88,425	$ 33,891	$ 740,925	$ 686,391	$ 1,049,500	0.71	0.61	$ (308,575)	$ (409,500)
9.5	$ 1,041,250	$ 540,000	$ 11,750	$ 88,425	$ 33,891	$ 640,175	$ 585,641	$ 1,041,250	0.61	0.52	$ (401,075)	$ (501,250)
10.0	$ 1,033,000	$ 380,500	$ 11,000	$ 88,425	$ 33,891	$ 479,925	$ 425,391	$ 1,033,000	0.46	0.37	$ (553,075)	$ (652,500)
10.5	$ 1,024,000	$ 228,000	$ 9,750	$ 68,616	$ 26,665	$ 306,366	$ 264,415	$ 1,024,000	0.30	0.22	$ (717,634)	$ (796,000)
11.0	$ 1,015,000	$ 145,000	$ 8,500	$ 48,806	$ 19,439	$ 202,306	$ 172,939	$ 1,015,000	0.20	0.14	$ (812,694)	$ (870,000)
11.5	$ 1,006,000	$ 100,000	$ 7,250	$ 28,997	$ 12,213	$ 136,247	$ 119,463	$ 1,006,000	0.14	0.10	$ (869,753)	$ (906,000)
12.0	$ 997,000	$ 75,000	$ 6,000	$ 9,188	$ 4,988	$ 90,188	$ 85,988	$ 997,000	0.09	0.08	$ (906,813)	$ (922,000)
12.5	$ 993,000	$ 67,500	$ 5,750	$ 6,891	$ 3,741	$ 80,141	$ 76,991	$ 993,000	0.08	0.07	$ (912,859)	$ (925,500)
13.0	$ 989,000	$ 61,000	$ 5,500	$ 4,594	$ 2,494	$ 71,094	$ 68,994	$ 989,000	0.07	0.06	$ (917,906)	$ (928,000)
13.5	$ 985,000	$ 55,300	$ 5,250	$ 2,297	$ 1,247	$ 62,847	$ 61,797	$ 985,000	0.06	0.06	$ (922,153)	$ (929,700)
14.0	$ 981,000	$ 48,900	$ 5,000	$ -	$ -	$ 53,900	$ 53,900	$ 981,000	0.05	0.05	$ (927,100)	$ (932,100)
14.5	$ 976,000	$ 43,100	$ 2,500	$ -	$ -	$ 45,600	$ 45,600	$ 976,000	0.05	0.04	$ (930,400)	$ (932,900)
15.0	$ 971,000	$ 36,600	$ -	$ -	$ -	$ 36,600	$ 36,600	$ 971,000	0.04	0.04	$ (934,400)	$ (934,400)
HYBRID SCHEME												
7.0	$ 486,000	$ 737,600	$ 14,000	$ 317,566	$ 137,191	$ 1,069,166	$ 888,791	$ 486,000	2.20	1.52	$ 583,166	$ 251,600
7.5	$ 438,500	$ 732,000	$ 14,000	$ 317,566	$ 137,191	$ 1,063,566	$ 883,191	$ 438,500	2.43	1.67	$ 625,066	$ 293,500
8.0	$ 391,000	$ 725,000	$ 14,000	$ 317,566	$ 137,191	$ 1,056,566	$ 876,191	$ 391,000	2.70	1.85	$ 665,566	$ 334,000
8.0	$ 391,000	$ 725,000	$ 14,000	$ 88,425	$ 33,891	$ 827,425	$ 772,891	$ 391,000	2.12	1.85	$ 436,425	$ 334,000
8.5	$ 375,750	$ 700,000	$ 13,250	$ 88,425	$ 33,891	$ 801,675	$ 747,141	$ 375,750	2.13	1.86	$ 425,925	$ 324,250
9.0	$ 360,500	$ 640,000	$ 12,500	$ 88,425	$ 33,891	$ 740,925	$ 686,391	$ 360,500	2.06	1.78	$ 380,425	$ 279,500
9.5	$ 345,250	$ 540,000	$ 11,750	$ 88,425	$ 33,891	$ 640,175	$ 585,641	$ 345,250	1.85	1.56	$ 294,925	$ 194,750
10.0	$ 330,000	$ 380,500	$ 11,000	$ 88,425	$ 33,891	$ 479,925	$ 425,391	$ 330,000	1.45	1.15	$ 149,925	$ 50,500
10.5	$ 317,750	$ 228,000	$ 9,750	$ 68,616	$ 26,665	$ 306,366	$ 264,415	$ 317,750	0.96	0.72	$ (11,384)	$ (89,750)
11.0	$ 305,500	$ 145,000	$ 8,500	$ 48,806	$ 19,439	$ 202,306	$ 172,939	$ 305,500	0.66	0.47	$ (103,194)	$ (160,500)
11.5	$ 293,250	$ 100,000	$ 7,250	$ 28,997	$ 12,213	$ 136,247	$ 119,463	$ 293,250	0.46	0.34	$ (157,003)	$ (193,250)
12.0	$ 281,000	$ 75,000	$ 6,000	$ 9,188	$ 4,988	$ 90,188	$ 85,988	$ 281,000	0.32	0.27	$ (190,813)	$ (206,000)
12.5	$ 274,500	$ 67,500	$ 5,750	$ 6,891	$ 3,741	$ 80,141	$ 76,991	$ 274,500	0.29	0.25	$ (194,359)	$ (207,000)
13.0	$ 268,000	$ 61,000	$ 5,500	$ 4,594	$ 2,494	$ 71,094	$ 68,994	$ 268,000	0.27	0.23	$ (196,906)	$ (207,000)
13.5	$ 261,500	$ 55,300	$ 5,250	$ 2,297	$ 1,247	$ 62,847	$ 61,797	$ 261,500	0.24	0.21	$ (198,653)	$ (206,200)
14.0	$ 255,000	$ 48,900	$ 5,000	$ -	$ -	$ 53,900	$ 53,900	$ 255,000	0.21	0.19	$ (201,100)	$ (206,100)
14.5	$ 249,000	$ 43,100	$ 2,500	$ -	$ -	$ 45,600	$ 45,600	$ 249,000	0.18	0.17	$ (203,400)	$ (205,900)
15.0	$ 243,000	$ 36,600	$ -	$ -	$ -	$ 36,600	$ 36,600	$ 243,000	0.15	0.15	$ (206,400)	$ (206,400)

9.2.1 Compensation Approach

Figure 16 shows the average annual benefits and costs for the Compensation approach. Both benefits and costs increase as control water levels in the City decrease. Average annual benefits from reductions in basement flooding range from $35,000 to $740,000 for control levels of el. 15 ft JAPSD and el. 7 ft JAPSD respectively. The benefits for improved recreation and tourism are estimated to be a minimum of $135,000 and a maximum of $315,000 when considering a City control water level of el. 7 ft JAPSD. No recreation benefits are realized for control levels greater than el. 14 ft JAPSD.

Total costs due to summer operation of the floodway range from $480,000 annually at el. 7 ft JAPSD to $55,000 annually for control levels at el. 15 ft JAPSD.

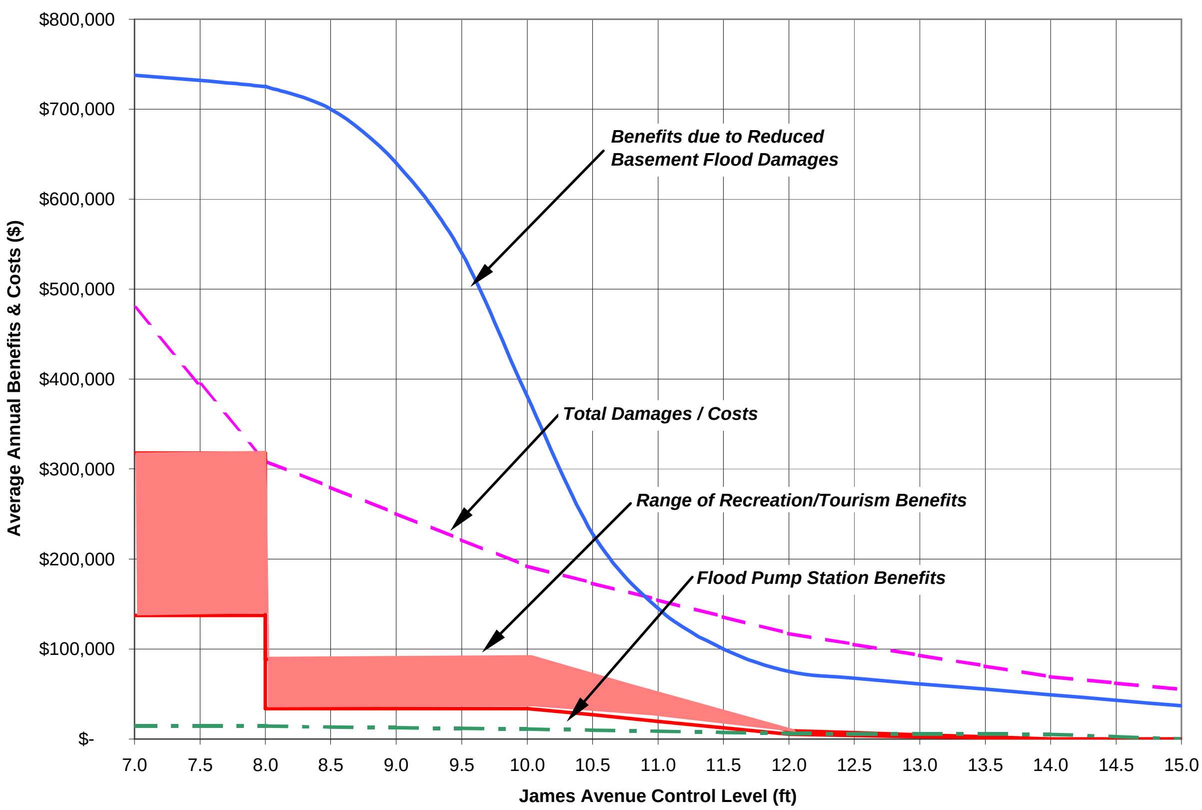


Figure 16 – Summary of Average Annual Benefits & Costs for the Compensation Approach

9.2.2 Buyout Approach

The average annual benefits and costs for the Buyout Scheme are summarized on Figure 17. The benefits in the City do not change with the differing upstream damage assessment approaches, but it can be seen on the figure that the initial costs to purchase land drive the total average annual costs above any benefits that were calculated for reduced basement flood damages and/or recreation/tourism. Only when considering the lowest control level of el. 7 ft JAPSD and the highest potential recreation/tourism benefits do the total benefits approach the total costs. Based on the high initial purchase costs, the buyout approach is not considered to be a likely compensation method for proceeding with project implementation.

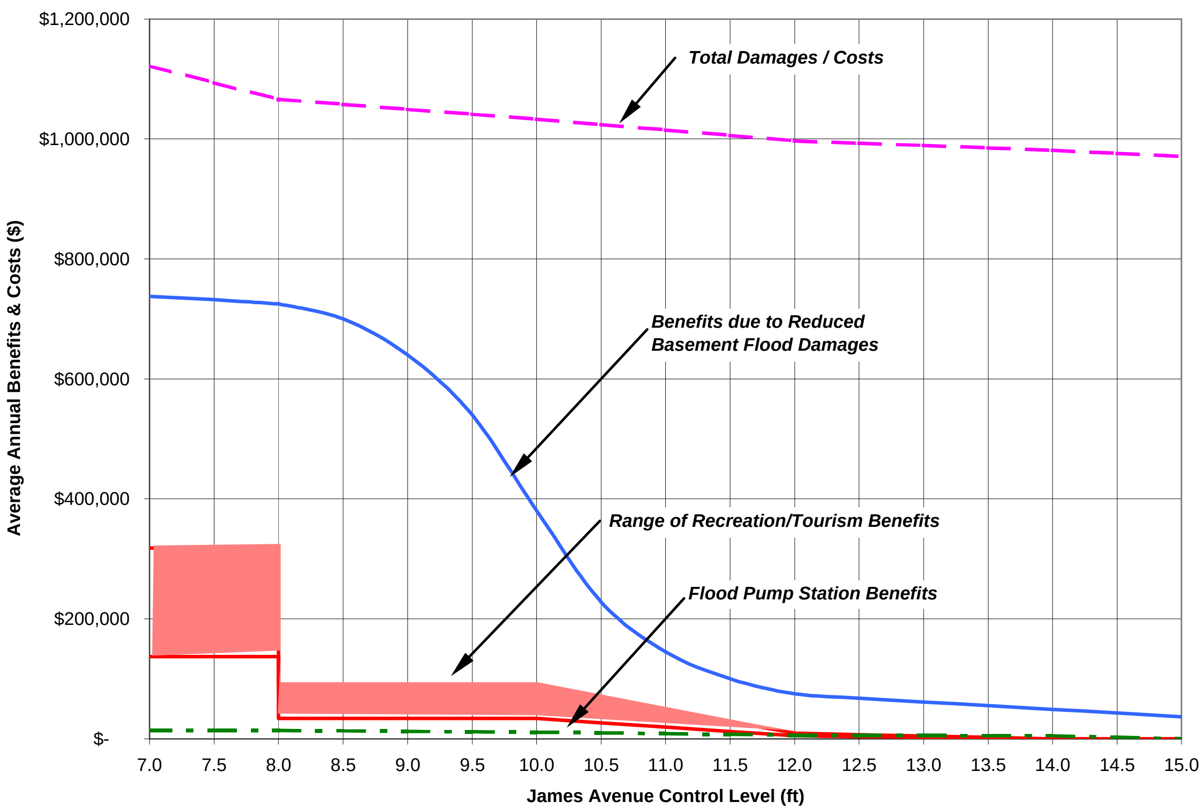


Figure 17 – Summary of Average Annual Benefits & Costs for the Buyout Scheme

9.2.3 Hybrid Approach

The "hybrid" approach for compensating upstream land owners, buying out the market gardeners and compensation for the other land owners, significantly reduces the initial costs of land purchase. The average annual benefits and costs for the "hybrid" scheme are shown on Figure 18. As is evident on the figure, at higher control levels, the costs are higher than the projected benefits, but for control levels of el. 10 ft JAPSD and less, the benefits begin to surpass the costs. At the el. 7 ft JAPSD control level, the benefits and costs calculated for the hybrid approach are very similar to those calculated for the compensation approach. Since the Provincial administration requirements to implement the "hybrid" approach will likely be significantly less, the "hybrid" approach is viewed as the most favourable alternative. Furthermore, compensation to market gardeners on a per-event basis in the long term may not be viable. Market gardeners have stated that, if they are periodically flooded and so unable to supply produce to their regular customers in those flood years, at some point in the future they may loose their customers due to being "labeled" as unreliable suppliers.

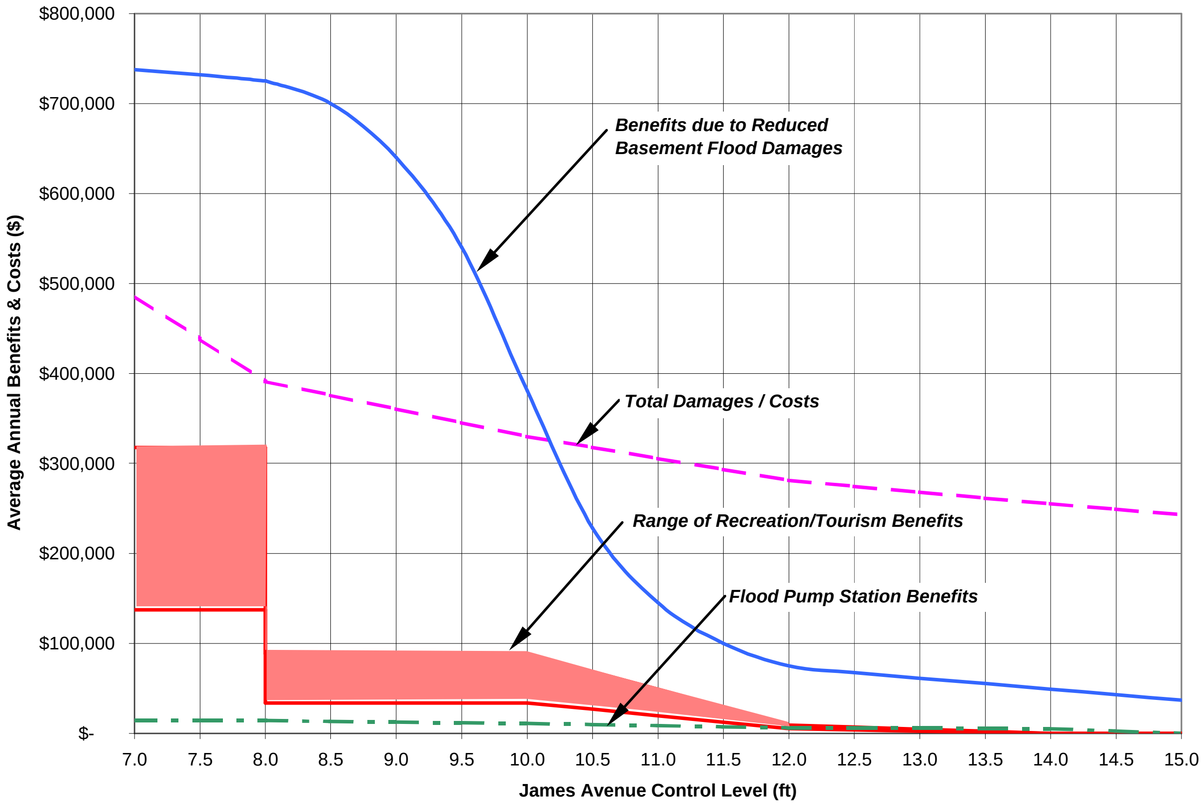


Figure 18 – Summary of Average Annual Benefits & Costs for the Hybrid Approach

9.3 ASSESSMENT

To allow a direct comparison of the three compensation approaches considered, the benefits/cost ratios and net benefits were calculated. Net benefits are viewed as a better indicator of overall project viability than a comparison of the B/C ratios since the calculation of net benefits allows one to determine the control level at which incremental benefits exceed incremental costs, and the point where overall benefits to society are maximum. Benefit/costs ratios for each scheme are shown in Figure 19, and the net benefits for each scheme are shown in Figure 20.

Each figure displays the economic indicators over the range of JAPSD control water levels with the upper and lower brackets for recreational and tourism benefits. The figures indicate increased B/C and net benefit estimates as the control levels decrease towards el. 8 ft JAPSD.

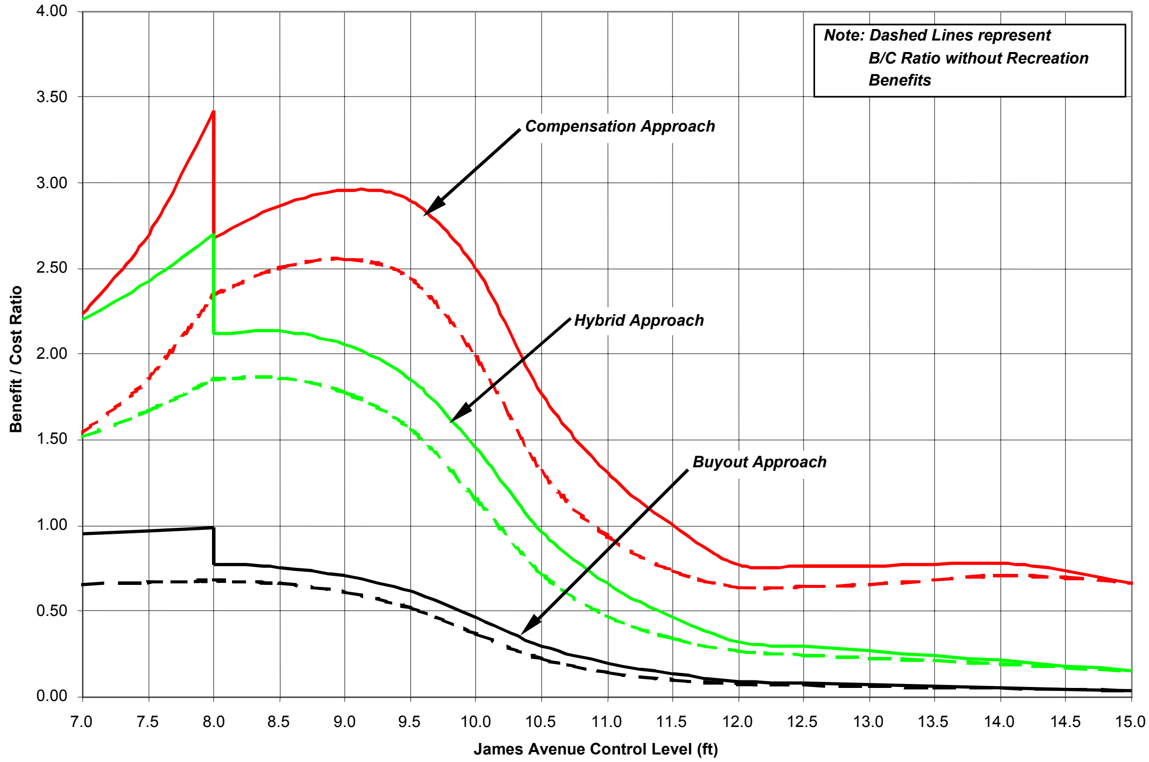


Figure 19 – Benefit / Cost Ratios for Various James Avenue Control Levels

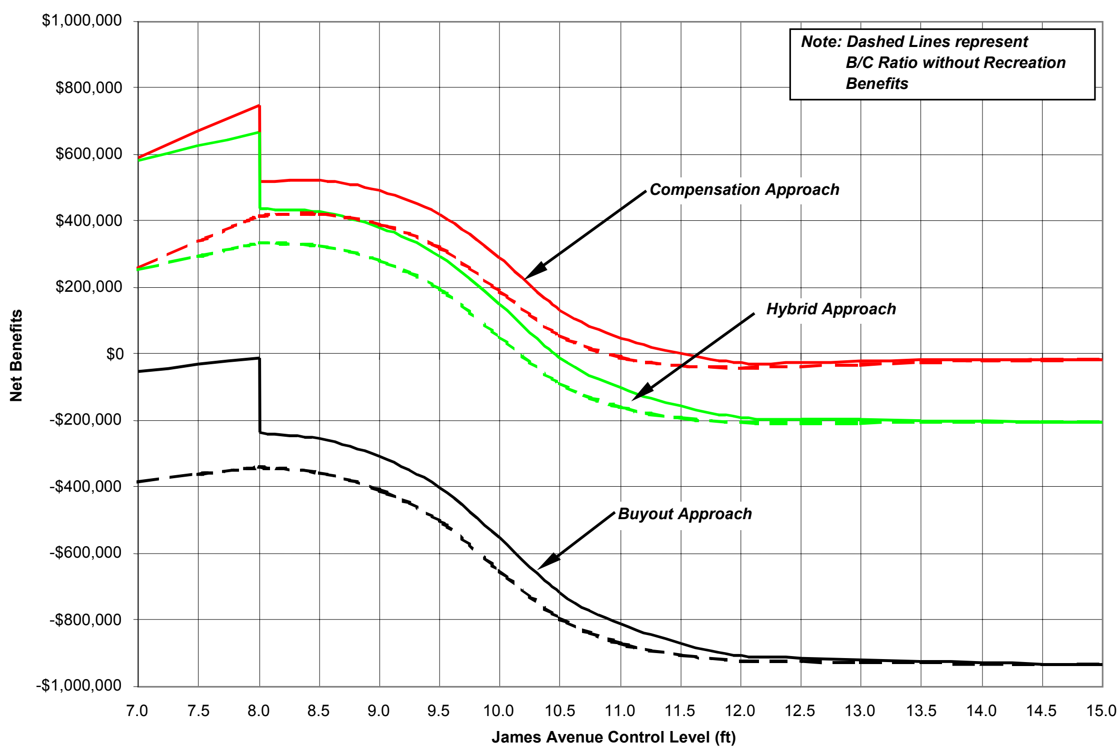


Figure 20 – Net Benefits for Various James Avenue Control Levels

9.4 OPTIMUM CONTROL LEVEL

The analysis of benefits and costs indicate that the optimum control water level is el. 8 ft JAPSD, where both the B/C ratio and net benefits tend to peak. This occurs because the upstream damages increase at a higher rate than the benefits as the summer water level control is reduced to el. 8 ft JAPSD. Furthermore, there are negligible incremental recreation/tourism benefits for controlled water levels below el. 8 ft JAPSD.

9.5 SENSITIVITY ANALYSIS

A number of the inputs considered in the analysis were based on assumptions that are difficult to verify, require substantially greater effort to substantiate, or depend on future conditions that cannot be predicted with certainty. The sensitivity of the results of the analyses has, therefore, been assessed for reasonable bounds in the variability of these assumptions.

For the purpose of this sensitivity assessment, the base case has been based on the results of the "hybrid" approach for upstream damages and costs. This is based on the conclusion that a total buyout approach is not economically feasible and that a total compensation approach will be difficult to implement and maintain into the future. As shown on Figures 19 and 20, the benefit/cost ratios and net benefits for the base case are 2.7 and $670,000 when recreation / tourism benefits are included. When recreation and tourism benefits are not considered, these values reduce to 1.9 and $340,000 respectively.

The sensitivity of these values was tested for reasonable upper and lower bounds for the assumptions that could potentially have the most significant effect on the results. The analysis results are shown on Table 15. The parameters considered in the sensitivity analysis and the rationale for their selection are described below.

Table 15 - Sensitivity Analysis for the "Hybrid" Approach

Scenario	Benefit / Cost Ratio: With High Recreation / Tourism Benefits	Benefit / Cost Ratio: With No Recreation / Tourism Benefits	Net benefits: With High Recreation / Tourism Benefits	Net benefits: With No Recreation / Tourism Benefits
Base Case	2.7	1.9	$ 670,000	$ 340,000
+10% Upstream Damages	2.5	1.7	$ 630,000	$ 295,000
-25% Upstream Damages	3.6	2.5	$ 760,000	$ 430,000
+40% Benefits due to Reduced Basement Flood Damages	3.4	2.6	$ 960,000	$ 625,000
-40% Benefits due to Reduced Basement Flood Damages	2.0	1.1	$ 380,000	$ 45,000
-25% Upstream Damages & +40% Benefits due to Reduced Basement Flood Damages	4.6	3.5	$ 1,100,000	$ 72,000
+10% Upstream Damages & -40% Benefits due to Reduced Basement Flood Damages	1.8	1.0	$ 340,000	$ 5,000

Upstream Damages – The evaluation of upstream damages and other costs were based on conservatively high estimates of the potential damages and costs. This was believed to be appropriate for the base case analysis given the concerns of upstream stakeholders to the results of the analysis. For the sensitivity analysis it was assumed that these aggregate costs could possibly be reduced by as much at 25%, while a reasonable upper limit was judged to be +10%.

Benefits due to Reduced Basement Flood Damages – The assessment of the basement flood damage was approximate, using the methodology developed for the assessment of individual districts in the FCARS Report (KGS Group, 2002). Given that it was not practical to conduct additional district analyses, the results from the 5 districts assessed in this study were extended to the remaining 37 districts. The extrapolation of these results is approximate and so one could anticipate results to range by 25%, up or down. Another assumption, the summer duration factor as described in Section 5.0, has expected bounds of ± 30% for the estimate used in the base case. For the purpose of this analysis, the combined effect of these two assumptions, the summer duration factor and the extrapolation of the analysis, has been taken as ± 40%. The bounds have been taken as less than the sum of uncertainties described above (i.e. (30 + 25)) to account for the low probability that the extreme upper or lower bounds would occur together.

Recreation and Tourism Benefits – The bounds for the recreation and tourism are reflected in the analysis of the base case conditions, with and without recreation and tourism benefits. The lower bound of these benefits (as described in Section 6.0) will be between these limits.

Other Parameters – The sensitivity analysis could be conducted on a number of other analysis parameters, such as, economic life of the project (50 yrs), discount rate (4%), period of flow record used in the analysis (33 yrs), and operation costs upstream and downstream. The effects of the variance in these parameters was judged to be relatively minor in comparison to the parameters considered in Table 15 and described above.

***Highest Reasonable Benefit* / Lowest Reasonable Benefit** – In addition to the assessment of the individual parameters, highest and lowest benefit scenarios were considered. The B/C ratio exceeds 4.6 for the highest reasonable benefit scenario, which considers 10% decreased costs, 40% increased benefits with recreation and tourism benefits. The lowest reasonable benefit scenario was based on 10% increased costs, 40% decreased benefits and no recreation and tourism benefits. For these extreme conditions, the B/C ratio is reduced to 1.0.

As shown on Table 15, the base case benefit cost ratio is 2.7 and 1.9 with and without recreation and tourism benefits respectively.

10.0 ALTERNATIVE MEANS TO DEAL WITH ELEVATED SUMMER WATER LEVELS

10.1 GENERAL

During meetings with the Steering Committee and other stakeholders, alternatives to summer flood control were discussed. Alternatives included increasing the size of and/or adding additional Flood Pump Stations in the City of Winnipeg. Such actions could theoretically alleviate basement flood damages by allowing the drainage districts to be isolated from high river levels and pumping the rainfall runoff to the river when necessary. The other alternative that could be considered in conjunction with increased capacity of the Flood Pump Stations or separately, would be to increase the elevation of the river walkways and the associated infrastructure.

The feasibility of these alternatives is discussed below.

10.2 INCREASE FLOOD PUMP STATION CAPACITY

The viability of increasing the capacity of the Flood Pump Stations was assessed as a part of the Flood Adequacy Review Study (KGS Group, 2002). The existing flood pump stations were constructed in the 1950's for use during spring periods when river levels are typically high and spring rainfall discharges are moderate (i.e. in comparison to summer rainfall discharges). The economic viability of increasing the Flood Pump Stations' capacities was found to be unattractive for the following reasons.

- Increasing the capacity of a Flood Pump Station is very expensive. Based on data from other jurisdictions and City of Winnipeg experience, adding 25 to 30% additional capacity to existing stations would cost approximately $2 to $5 Million per station for some of the larger stations. The City has 36 Flood Pump Stations. Although, some of these could possibly be eliminated from the need to be upgraded based on the frequency of use, the majority would likely need to be upgraded to provide comparable benefits to the benefits provided by summer water level control. Total costs for increasing the capacity of the stations would, therefore, be in the order of $50 to $75 Million.

- The majority of the Flood Pump Stations are constructed in developed areas along the riverbank. Expanding or constructing new Flood Pump Stations is very difficult in these areas due to the lack of available land and due to the presence of existing infrastructure. This is complicated by the need to deal with unstable river banks in a number of these areas.

- The results of the assessment for the FCARS (KGS Group, 2002) were based primarily on upgrading for spring use. The required discharge capacity to upgrade for summer use would be significantly higher making the necessary upgrades even more costly and less attractive. For example, upgrading the Baltimore Flood Pump Station to accommodate a 2 yr and 5 yr summer storm would require increasing the Flood Pump Station capacity from 92 cfs to 360 cfs and 750 cfs respectively.

Based on this cursory assessment it can be concluded that, from a cost perspective, upgrading the Flood Pump Stations is not a viable alternative to summer water level control.

10.3 INCREASE RIVERWALK ELEVATION

Increasing the elevation of the river walkways and supporting infrastructure is technically feasible. The river walkways could then be kept open during high water periods to a new threshold level. For example, if the river walkways elevations were increased from el. 8.5 ft JAPSD to el. 10.5 ft or el. 11 ft JAPSD, the incidence of summer flooding affecting the use of the walkway would decrease from 6% of time to about 3% of the time. Concerns with such an approach, as an alternative to summer water level control, are outlined below.

- Increasing the elevation of the recreation infrastructure provides no relief to the basement flood damages, which are the most significant components of the potential benefits to summer water level control.

- Increasing the elevation of the Forks and Assiniboine River walkways is difficult and costly due to hydraulic and geotechnical considerations. The lower riverbanks are relatively unstable along significant portions of the walkway length. Increasing the walkway elevation would, therefore, require substantial additional fill into the river or possibly shear keys to increase or maintain the bank stability. Since the walkways extend over approximately 1.2 mi this work would be extensive. Raising the height would also necessitate removal and replacing the back stone seating walls, river edge curb and lights.

- Increasing the elevation of the river walkways would require an increase in the lateral extent of the walkways, which would have a detrimental effect on the hydraulic capacity of the rivers. Although this could likely be accommodated on the Red River, the Assiniboine River is relatively narrow and further restriction of the river section would likely not be acceptable from a hydraulic perspective. Velocities would increase potentially threatening the unprotected south bank along this section. Head losses would also increase, potentially violating the flood protection guidelines for projects constructed within the river channel.

- Increasing the walkway elevation would necessitate adjusting the elevation of the associated infrastructure that ties into the walkways. Although this is technically feasible, the majority of these works are concrete structures and would be costly to accommodate the changes. Affected infrastructure would, at a minimum, include

  - Norwood Bridge and Main Street Bridge underpasses
  - Legislature Grounds Dock and Plaza
  - Kennedy Street Riverwalk Access
  - Donald Street Riverwalk Access and Dock
  - Bonnycastle Park Riverwalk Access and Amphitheater
  - Forks Dock and Plaza (Assiniboine River)
  - Forks Dock and Plazas (2 on the Red River)
  - St. Boniface Basilica Dock and Plaza on the Red River across from the Forks
  - Alexander Dock
  - CAR*RAC boat taxi docks (3 locations)

- Increasing the elevation of the walkways would eliminate or significantly reduce the experience associated with being adjacent to the water. Although this is difficult to place a value on, it was a part of the original architectural design criteria and contributes to overall value of the walkway attraction (i.e. providing an experience close to the water).

In summary, it is technically feasible to increase the elevation of the infrastructure. It would, however, be costly and regressive to replace the infrastructure constructed over the past ten to fifteen years. The cost of elevating the infrastructure would likely increase exponentially above el. 10 ft JAPSD. Although this is not a particularly attractive alternative, raising the walkways and supporting infrastructure could possibly be justified based on the benefits described in Section 6.0. Confirmation of the costs and viability associated with proceeding with this work would, however, require additional study.

11.0 OPERATION OF THE RED RIVER FLOODWAY - SUMMER OF 2002

11.1 GENERAL

As a part of this study, an assessment of the 2002 operation was undertaken. The scope of this work included:

- Review and documentation of the planning phases of 2002 summer Floodway operation.
- Review of the operation criteria, including
  - Initiation levels
  - Response to rainfall forecasts
  - River level drawdown rates
- Recommendations for future summer operation

Background information leading to the decision to operate the Floodway during the 2002 summer period, the 2002 operating criteria, the conditions which occurred in 2002, and our assessment are described below.

11.2 BACKGROUND CONDITION LEADING TO THE FLOODWAY OPERATION

Record rainstorms across southeastern Manitoba and in some U.S. portions of the Red River during June and July, 2002 resulted in record high summer flows and levels on the Red River and some of it's tributaries. Levels of the Red River in the City of Winnipeg rose to el. 17.3 ft JAPSD on June 14 and then declined very slowly. In late June levels were still near el. 15 ft JAPSD and indications were that levels would be much above average for several more weeks at least. This raised concerns about the possibility of heavy rainstorms over the City which could result in storm sewer backup and basement flooding and operation of the Red River Floodway to reduce river levels in the Winnipeg area was reviewed. Since such an operation would produce artificially increased water levels upstream of the Control Structure to St. Adolphe, the intent was to avoid such an operation unless weather conditions indicated a strong possibility of significant rainfall over the City of Winnipeg.

Background information associated with the risk of basement flood damages and the sewer system hydraulics are described in Section 5.0.

During the summer of 2002 the Provincial government approved a one-time deviation from the Floodway operation rules in order to reduce the risk of basement flooding in Winnipeg. Prior to this approval, the issue was discussed by the Red River Floodway Operation Advisory Board. It recognized the merits of summer operation in 2002, and agreed that impacted residents south of the Floodway should be fully compensated for any resulting damages. It also requested that a study of benefits and impacts of summer Floodway operation be carried out.

This Board's membership includes representatives from the City of Winnipeg, the federal and provincial governments and the rural municipalities immediately upstream (south) and downstream (north) of the Floodway. Following meetings of the Floodway Operation Advisory Board, a news release was issued around June 28, 2002. Operation criteria and drawdown limits were established for the emergency operation. These are described below.

11.3 OPERATION CRITERIA

Precipitation Forecast

A decision was made by the Floodway Operation Advisory Board that Floodway operation would be conditional on a certain risk criteria for damaging rainfall. This would be linked to the official weather forecast for the City to be obtained from Environment Canada.

Floodway operation would be initiated when levels of the Red River at James Avenue are in excess of el. 12 ft JAPSD and when the weather forecast indicates a 30 percent or more risk of a heavy thundershower over the City. The operational objective was to reduce the level at James Avenue to el. 12 ft JAPSD whenever the weather forecast indicated a 30 percent chance (or greater) of a heavy thundershower over the City within 72 hours. This would be done as slowly as possible to reduce the risk of river bank failures. A further reduction of 1.5 ft in the level at James Avenue to el. 10.5 ft JAPSD would be effected if the weather forecast indicated at least a 30 percent chance of a heavy thundershower within the next 24 hours. A 'heavy' thundershower was defined as one which could produce at least 1.4 inches (35 mm) of rain in an hour, or at least 0.8 inches (20 mm) in 30 minutes.

Drawdown Rate

A maximum drawdown rate of 1.5 ft per day was recommended by the Board. This was based on the historical regulated drawdown that has occurred in late October of approximately 1 ft per day. Conditions associated with the natural recession of historical floods, have exceeded that rate, with some rates as much as 1.3 ft per day. An aggressive rate of regulated lowering would be 1.5 ft per day, but may carry with it an additional risk of riverbank failures in some areas. Under the conditions in which it would be desirable to lower the river level, the riverbanks are generally saturated, and there is a risk of riverbank sloughing even in the absence of recession of river levels.

11.4 2002 CONDITIONS AND OPERATIONS

Floodway operation did not occur for a considerable period following the announced intention to possibly operate, since the threat of heavy rain did not exceed 30 percent. Constant communication between the Winnipeg Weather Office and Water Branch was maintained with discussions scheduled several times per day when the threat of thunderstorms existed.

The Floodway was put into operation late on July 4, 2002 in response to heavy thundershowers in the Winnipeg area. Earlier in the day there was a forecast of thundershowers, but the risk of a heavy thundershower was expected to be less than 30 percent. Heavy thundershowers did, however, develop late in the evening, producing up to 2.8 inches (70 mm) of rain in southern portions of the City within a few hours and up to 1.0 inch (25 mm) in 30 minutes. Fortunately the rainfall was much less in most other parts of Winnipeg and particularly in the older downtown portions where the combined sewers exist. The separate storm sewers in the newer southern portions of the City were able to convey the rainfall runoff without a significant difficulty. Some flooding of basements occurred, but was reportedly relatively minor and orders of magnitude less than the flooding of 1993 and 1974.

The water level of the Red River late on July 4 at the start of the storm was el. 14 ft JAPSD. The water level rose to el. 15 ft JAPSD by 11:40 p.m. due to local City runoff from the thunderstorms. The effect of the Floodway operation reached the downtown area at about 2:00 a.m., July 5, by which time the storm had passed and the rainfall runoff had begun to subside. The water level at James Ave. had declined to el. 14.4 ft JAPSD by 2:00 a.m. and continued to decline to el. 13.5 ft JAPSD by 10:00 a.m. and to el. 11.6 ft JAPSD by midnight, after which it began to rise again. Water levels were controlled to near el. 12 ft JAPSD by Floodway operation until July 26 when Red River flows subsided. River water levels in the City were back to near normal by early August.

Red River water levels at James Avenue and precipitation events during the period from May 1 to August 30 are shown on Figure 21.

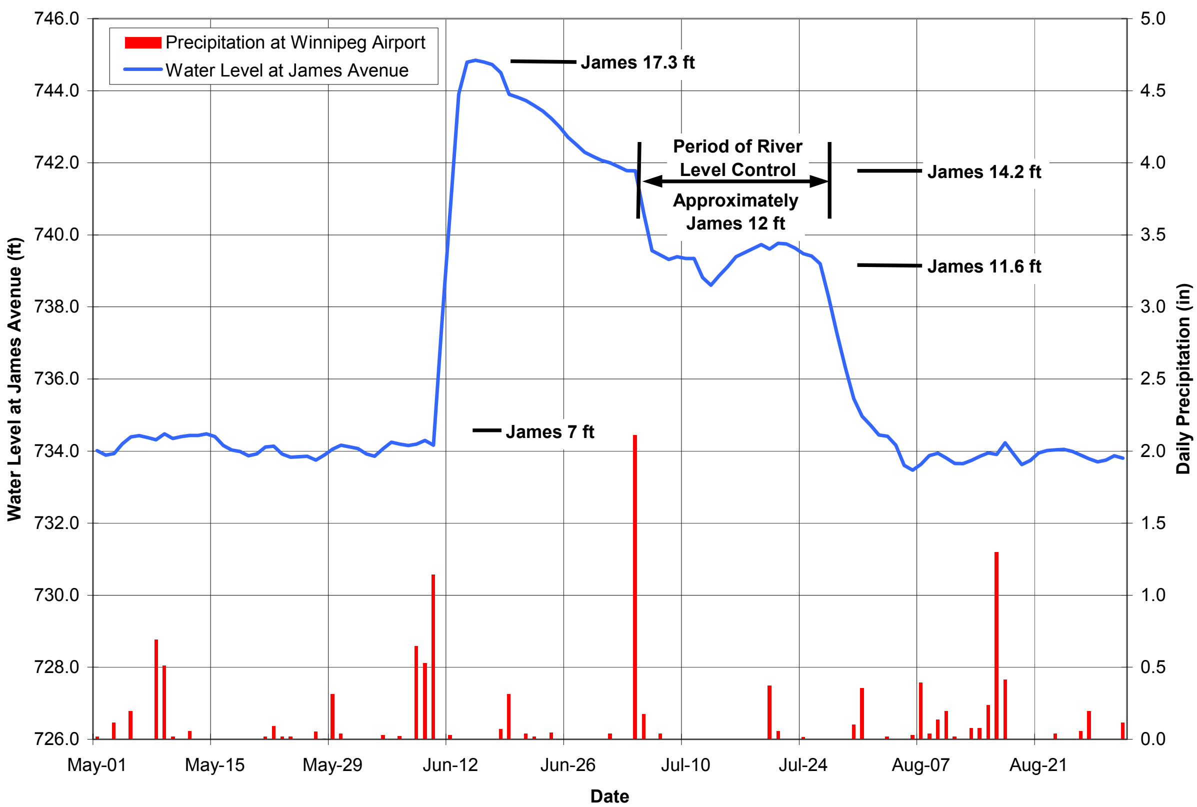


Figure 21 - Red River Water Levels at James Avenue and Winnipeg Precipitation for Summer of 2002

11.5 ASSESSMENT OF 2002 OPERATION

The rainfall forecasting required to adequately permit drawdown of water levels in Winnipeg would require an accurate rainfall forecast to be made at least 24 to 36 hours (assuming maximum drawdown rates of 1.5 ft/day) before heavy thunderstorms occurred. This was discussed with Mr. A. Warkentin and in his opinion, this would be difficult to forecast for 6 to 12 hours, since the occurrences of the large storms are usually quite localized. While it is possible to forecast that the conditions are favorable for the occurrence of extreme storms, it is difficult to forecast with any degree of precision where the storms will occur.

Since, the time for the development of the storms is also not long, this precludes the longer planning horizon required for the successful operation of the Floodway to reduce water levels.

Rainfall Predictions

The short-term operation of the Floodway control gates to reduce water levels in Winnipeg to prevent damages caused by a specific rainstorm was reviewed as part of the “Flood Control Adequacy Review Study” (KGS Group, 2002) conducted for the City of Winnipeg. The operation was rejected on the basis that substantial benefits to lower water levels at James Avenue (central part of City where combined sewers are concentrated) would not occur until well after flooding from rainstorms had already occurred. The following is taken from the “Flood Control Adequacy Review Study” (KGS Group, 2002) with appropriate references changed for this report.

> *In the assessment of the operation rule changes, it was assumed that the gates would be operated to achieve a 5 ft rise in the water level above the Floodway Inlet Control Structure. This operation, however, is required only if a rainstorm were to occur in coincidence with high river levels in Winnipeg. Since rainstorms do not always occur when the river stage is high, the operation of the gates could theoretically be delayed until the rainfall had occurred or was judged to be imminent based on weather forecasts. This operation, however, would involve added risks in that the river level may not be reduced to the extent possible in the time for the maximum rainfall to occur. The feasibility of this procedure therefore depends on the rate that the water level can be lowered following gate changes at the Floodway Inlet Control Structure.*
>
> *Response times for the changes in water level along the Red River were investigated using the Environment Canada 1D Hydrodynamic Model. The following conditions were assumed:*
>
> - *fifteen minute duration for Floodway gate setting changes*
> - *initial water levels assumed at natural levels for flood return periods ranging from 2 years to 25 years in the spring and from 20 years to 500 years in the summer.*
>
> *The response of the river system for these assumed conditions is shown on Figure 22. The full change in water level is shown to take approximately 24 hours. For high flows on the Red River, the change could be as much as 6 ft in one day. Approximately 50 percent of the change will occur in 6 hours and 10 percent of the change (6 ft) would*

occur in the first 2 hours. (Note – approximate upstream water levels before and after implementing the control are shown on the Figure as well).

The response times are considered to be too slow to be effective in increasing the capacity of the combined sewers. The estimated time to peak for most sewer systems following the start of severe rainstorms is approximately 1 hour. Maximum flooding on the district will therefore have occurred before any benefit of reduced water levels would have occurred. While the response times are shown to be too slow for providing additional protection against flooding on the combined sewer district, the response times are considered to be extremely rapid with respect to the stability of the river banks.

A daily drawdown rate of 2 ft/day for the river banks in a saturated state is considered to be the maximum rate which would be required to minimize river bank failures. This operating procedure would therefore likely be unacceptable from bank stability considerations.

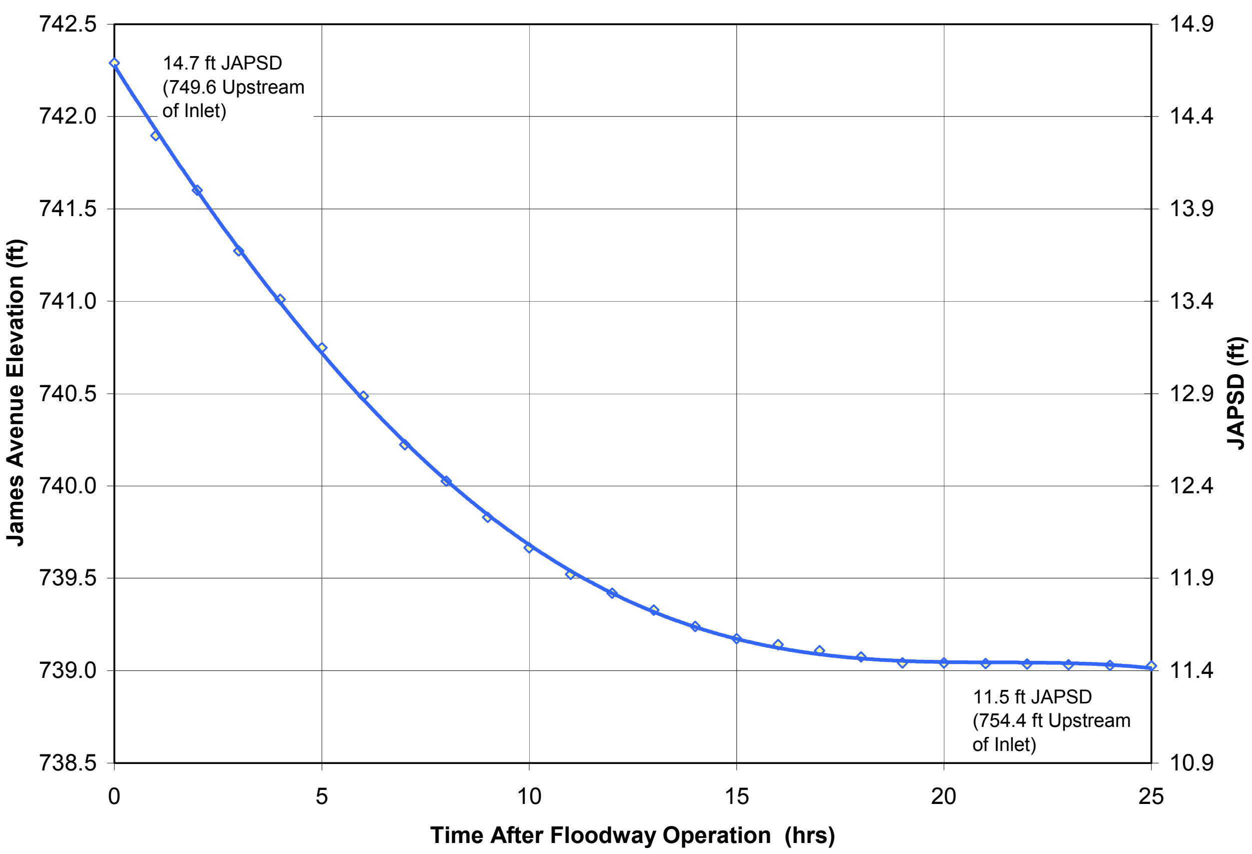


Figure 22 - Estimated Water Level Drawdown at James Avenue

It is very difficult to predict precipitation amounts reliably in advance to meet the intent of the criteria developed for the 2002 Summer Floodway Operation. This was recognized by meteorologists during the planning stages of the summer Floodway operations in June 2002. Only short term forecasts of approximately 2 to 3 hours have any degree of reliability in terms of rainfall amounts at a specific location such as the City of Winnipeg. This, however, does not leave enough time to reduce river levels in the City to prevent possible sewer backup. The event of July 4, 2002 underlines this difficulty.

11.6 RECOMMENDATIONS FOR FUTURE OPERATION

Based on the experiences of 2002 and the analysis of rainfall and river water level response times, it was concluded that it is not practical to operate the Floodway in response to rainfall predictions. This is due to the short time frame and uncertainty associated with forecasting rainfall and the relatively long response time for water levels to adjust to floodway gate adjustments. Therefore, if a decision is made to operate the Floodway in the future for summer water level control, it should be done as soon as water levels exceed a predetermined threshold, say greater than el. 9 ft to 10 ft JAPSD. The control level would then be el. 8 ft JAPSD based on the benefits analysis. Given the relative response times of the sewer system and the river, using the Floodway for summer water level control needs to be viewed as purchasing an insurance policy. That is, the costs associated with upstream damages will need to be paid out and depending on the extent of rainfall, there may or may not be avoided basement flooding damages. In those years when basement flooding damages do occur they will, however, be substantial. For example in 1993, damages could possibly have been reduced by tens of millions of dollars for a cost of summer operation in the order of $1 Million.

If the decision is made to control summer levels when water levels exceed the predetermined threshold, it can then be done in a controlled manner, minimizing the concerns associated with the drawdown rate and associated bank stability considerations.

12.0 ENVIRONMENTAL CONSIDERATIONS

12.1 GENERAL

A number of environmental issues will need to be resolved prior to proceeding with summer water level control in Winnipeg. It is assumed that this will be a project requiring a licence for a change in the operation of the Floodway and that the issues will be dealt with as a part of the Environmental licensing process. These include:

- Fish passage at the Floodway Inlet Control Structure
- Assessment of the effects and compensation requirements for the upstream stakeholders
- Concerns of downstream stakeholders associated with changed flow regime.

A description of the approach to resolving those issues is described below.

12.2 FISH PASSAGE OF THE FLOODWAYS INLET STRUCTURE

KGS Group conducted a cursory assessment of the fish passage limitations at the Floodway Inlet Control Structure for the existing and summer level control conditions. The results and assumptions are appended to this report (Appendix D) and conclude that there would not be a significant difference between the existing conditions and summer water level control conditions. Under conditions of high flow through the Floodway Structure, the structure now essentially acts as a barrier to fish passage due to the high velocities. Although conditions are worse when the gates are raised for summer water level control, they are not significantly worse.

KGS Group forwarded a copy of its assessment to DFO and met with them in November of 2002. They were receptive to the approach but made no commitment. It was agreed that in the absence of any further comment that this would best be addressed in a subsequent study.

12.3 UPSTREAM STAKEHOLDERS

The effects on upstream stakeholders would have to be defined (as described in Sections 7.0 and 8.0) and mitigation measures proposed as a part of the Environmental review process. Mitigation would be primarily related to satisfactory compensation.

12.4 DOWNSTREAM STAKEHOLDERS

The effects on downstream stakeholders (i.e. the area downstream of the Floodway Outlet Structure and the Selkirk area) with respect to changed flow conditions and the physical impacts to the riverbanks, are anticipated to be negligible. This would need to be defined and defended as a part of the Environmental process. Furthermore, the damages downstream of the outlet structure will be studied as part of the on going Project Definition and Environmental Assessment (PDEA) studies for the Floodway expansion.

13.0 ASSESSMENT OF RESULTS

The results of the benefit cost analysis demonstrate that summer water level control is a viable endeavor from a societal perspective. For the base case conditions, benefit / cost ratios of 2.7 and 1.9 with and without tourism / recreation benefits, respectively, have been calculated. Although these B / C ratios are substantially greater than 1, they are not overwhelmingly in support of the summer control initiative. As well, there are a number of uncertainties associated with the analysis, which both positively and negatively impact the benefit cost assessment. As described above, the B / C ratios are relatively sensitive to reasonable lower and upper bounds associated with the assumptions made for the analysis. When viewed from a lowest reasonable benefit perspective, the B/C ratios are reduced to 1.8 and 1.0 for conditions with and without tourism / recreation benefits, respectively. Projects of this type, which have a relatively high level of uncertainty in the benefits and costs, could be viewed as a requiring a B/C ratio that exceeds 1.0 by a large margin. In this regard, it may be difficult to support a project of this type strictly on the basis of benefits and costs. On the other hand, based on highest reasonable benefit assessment of the contributing assumptions to the analysis, B/C ratios as high as 4.6 and 3.5 were calculated for conditions with and without recreation benefits, respectively. This would normally be viewed as an attractive project, and justify investment of public funds.

The economic analysis described in this report is based on traditional methods of estimating the expected annual damages (EAD) associated with the status quo (no use of the Floodway in summer season) and with various alternatives of operating the Floodway to mitigate summer flood damages in Winnipeg. In recent years, it has become standard policy of the U.S. Army Corps of Engineers (USACE) to consider the influence of risk and uncertainty in the estimation of the EAD. Uncertainties abound in the estimation of damages/benefits and the estimations of hydrologic and meteorological events. The risk due to summer flooding are highly probabilistic. The USACE methodology incorporates the risk and uncertainty into the benefit analysis and gives due recognition of the possible range of precision in the estimation of the EAD. This methodology almost invariably results in computed benefits that exceed the values that would be estimated by traditional, less rigorous means that ignore the existence of uncertainties in the parameters being analyzed. For example, studies of the Floodway Expansion showed an increase of over 25% in the project benefits with proper recognition of the effects of uncertainty. Unfortunately, the work required in defining the effect of uncertainty in the case of the summer water level control concept, would be extensive, and beyond the scope of this study. However, it is worth noting that undertaking an analysis using the USACE methodology would likely increase substantially the benefits stated in this report.

Benefits due to reduced basement flood damages are less than might have been anticipated based on reported basement flood damages in 1993. Although damages were high that year (reported in the order of $140 Million), large portions of these damages were due to significant rainfall events and not necessarily due to the coincident high river levels. That is, substantial portions of these damages would have occurred even if river levels had been normal. Damages of this type are, therefore not considered as benefits of summer water level control.

The implications of the summer water level control operations on riverbank stability are complex. It is anticipated that the incremental impacts on bank performance from the summer water level control will be relatively minor both upstream and downstream of the Floodway Inlet Control Structure in relation to the natural factors. Any negative physical impacts that may be realized upstream of the Inlet will be offset by the positive impacts experienced both upstream and downstream. An engineering investigation and geotechnical monitoring program is recommended to obtain base-line information on the bank stability conditions prior to implementation of the summer control program, and allow possible separation of the influences directly attributed to control of summer water levels.

Annual costs associated with upstream damages are estimated to be approximately $400,000 to $500,000. Although there are substantial benefits due to reduced basement flood damages and enhanced recreation / tourism, the costs will be paid out annually or on a per-event basis, with no recoverable benefits in the form of taxes or other revenue. This study has defined a framework for compensation to upstream stakeholders, but there will be substantial effort required to develop a mutually agreeable compensation arrangement. Three approaches for upstream compensation were explored. The total buyout approach is clearly too expensive to consider and would force the Government to purchase significant portions of land unaffected by the artificial flooding. The total compensation approach is potentially the least costly of the approaches considered. This alternative would likely result in unpredictable annual payouts and would potentially "tie-up" Government negotiators dealing with each unique market garden claim in the future. The "hybrid" approach seeks to define a practical method of compensation by purchasing the market gardeners property and compensating the cereal crop and others on a per-event basis.

In addition to the benefits that have been quantified, there are intangible benefits to summer water level control that need to be considered in the assessment of whether or not to proceed.

- Stress and anxiety levels associated with those Winnipegers living in areas vulnerable to basement flooding will be high during periods of elevated river levels regardless of whether or not significant rainfall occurs. Alleviating this stress to those living in these areas is a benefit that can not be quantified. Furthermore, basement flooding damages associated with disruption, personal and business loss during periods of flooding has not been considered in the assessment of benefits. Upstream stakeholders will also be subject to similar stresses, even if they are fairly compensated.
- The potential good will and further establishment of Winnipeg's reputation as the "River City" could bring substantial undefined benefits to the City as a destination and to the citizens for their own use. Reliable stable levels on the Red and Assiniboine Rivers within the City would enhance the well being of all Winnipegers in a manner that can't be quantified.

Other considerations such as resolving issues associated with fish passage and the Fisheries and Oceans Canada (DFO) concerns with operation of the Floodway Inlet Control Structure will need to be resolved prior to proceeding. Preliminary discussions with the DFO indicate that this issue can be resolved. Further discussion and analysis is required at the next planning study stage.

14.0 CONCLUSIONS AND RECOMMENDATIONS

14.1 CONCLUSIONS

Based on the results of the study the following conclusions are presented.

- Annual benefits due to reduced basement flood damages vary depending on the control level selected for summer control. Estimated annual benefits range from $740,000 to $1,070,000. Estimated benefits that could be achieved by summer water level control for a single extreme event are in the tens of millions of dollars.

- The benefit due to reduced basement flood damages was calculated using approximate methods and could vary substantially (± 40%). The level of effort to refine these estimates is considerable and not practical at this level of study.

- In recent years, it has become standard policy of the U.S. Army Corps of Engineers (USACE) to consider the influence of risk and uncertainty in the estimation of the estimated annual damage. The work required to conduct such an analysis is extensive, and beyond the scope of this study, however, using the USACE methodology would likely increase substantially the benefits stated in this report.

- Annual recreation / tourism benefits vary depending on the control level selected for summer water level control. They have been estimated to be between $140,000 and $320,000 depending on whether low or high estimates are taken.

- The potential for greater economic, recreational and cultural benefits that could be generated from an integrated and fully developed river system exist in Winnipeg. Although requiring significant investments of time and capital, the benefits could eventually be in the tens of millions of dollars annually. Persistent summer flooding is currently a significant barrier to any such development. Removal of that barrier could open the door to significant economic, recreational and cultural benefits to residents of the area.

- Three alternates approaches were investigated to assess the magnitude of project costs related to upstream damages. The "hybrid" approach, a combination of purchasing market gardeners property and compensating cereal crop and other landowners was selected as the most appropriate method. It was selected partly because it accounts for the fact that periodic flooding of market gardeners could ruin their businesses even if per-event compensation was provided.

- Estimated upstream and other damages vary depending on the control level selected for summer water level control. Total estimated average annual damages, including increased operation and other factors, are approximately $500,000.

- Benefit/cost (B/C) ratios for proceeding with summer water level control were calculated using the "hybrid approach", based on the best estimate of the benefits and cost. B/C ratios of 2.7 and 1.9 with and without tourism/recreation benefits, respectively, were calculated.

- The B/C ratios are sensitive to a number of assumptions used in the analysis. Depending on the highest and lowest benefit scenarios considered, the B/C ratios varied from 4.6 to 1.0. Similarly, net benefits ranged from $1,000,000 to $5,000.

- Bank stability issues upstream of the floodway are complex and a monitoring program is recommended to obtain baseline information. From a societal perspective, the value of bank stability benefits downstream of the Floodway Inlet Control Structures will exceed the damages upstream.

- Two alternatives to summer water level control were considered;

  i) increasing the capacity of the Flood Pump Stations, and

  ii) increasing the elevation of the river walkway elevations.

  These are not considered viable alternatives to summer level control.

- A number of environmental issues will need to be resolved should the summer water level control proceed. These include:

  - Department of Fisheries and Oceans' concerns with fish passage at the Floodway Inlet Control Structure during periods of summer water level control
  - Compensation issues associated with upstream stakeholders affected by artificial flood levels.
  - Concerns that residents downstream of the Floodway Outlet will have with the changed flow regime.

  With further study and consultation it is believed that these environmental issues can be resolved.

14.2 RECOMMENDATIONS

Based on the results of the study, a number of recommendations have been made.

- Based on the B/C ratio, summer water level control appears to have merit and Manitoba should proceed to the next level of assessment of the decision to proceed with summer water level control.

- At the next level of planning, the following issues should be resolved, based on more thorough assessment than was possible in this conceptual study:

- The overall B/C cost ratio required to proceed with the project, with or without tourism and recreation benefits.

- The value of the intangible benefits, especially the potential for greater economic, recreational and cultural benefits associated with an integrated and fully developed river system in Winnipeg.

- The approach to resolving compensation issues for upstream stakeholders. This needs to consider geotechnical issues and crop and other land related damages.

- The approach to deal with the environmental issues should be identified, namely DFO and the downstream stakeholders.

- An engineering investigation and monitoring program to obtain baseline information should be initiated prior to implementing summer water level control.

- Further studies should be initiated to refine the estimate of benefits and costs based on the results of this study. Consideration should also be given to using the USACE methodology for assessing expected annual damages.

15.0 REFERENCES

1. KGS Group, 2001, "Flood Protection Studies for Winnipeg".

2. KGS Group, 2002, "Flood Control Adequacy Review Study – Draft Report".

3. Lerner and Poole, 1999, "Trust for Public Lands".

4. U.S. National Park Service, 1995, "A report produced by the U.S. National Park Service".

5. Walsh, Richard G. Donn M. Johnson and John R. McKean, 1988, "Review of Outdoor Recreation Economic Demand Studies with Non-market Benefit Estimates, 1968-1988". Colorado Water Resources Research Institute. Colorado State University, Fort Collins, CO.

PLATES

COMBINED SEWER

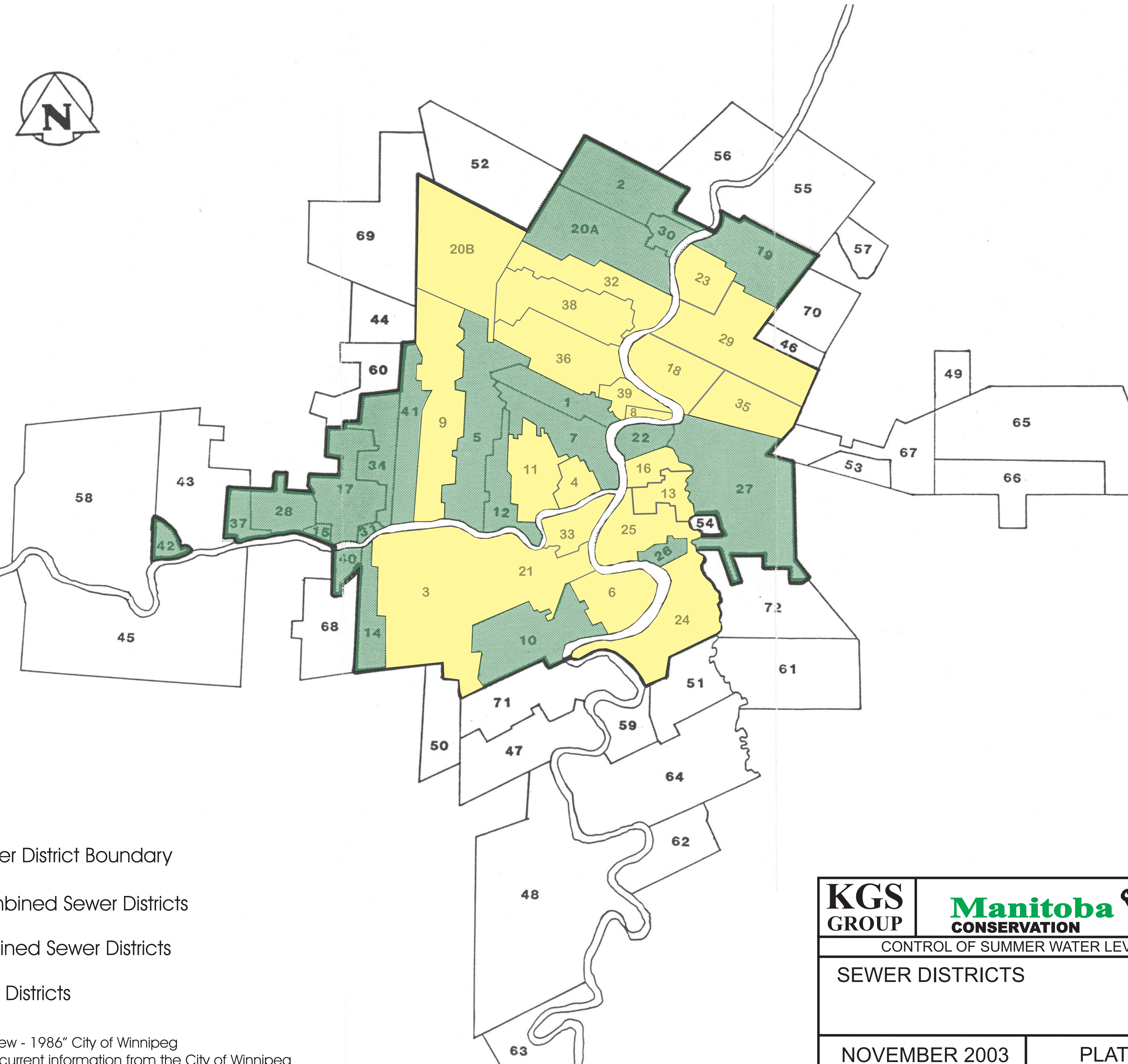
DISTRICTS

1 ALEXANDER
2 ARMSTRONG
3 ASH
4 ASSINIBOINE
5 AUBREY
6 BALTIMORE
7 BANNATYNE
8 BOYLE
9 CLIFTON
10 COCKBURN/CALROSSIE
11 COLONY
12 CORNISH
13 DESPINS
14 DONCASTER
15 DOUGLAS PARK
16 DUMOULIN
17 FERRY ROAD
18 HART
19 HAWTHORNE
20a JEFFERSON EAST
20b JEFFERSON WEST
21 JESSIE
22 LAVERENDRYE
23 LINDEN
24 MAGER
25 MARION
26 METCALFE
27 MISSION
28 MOORGATE
29 MUNROE
30 NEWTON
31 PARKSIDE
32 POLSON
33 RIVER
34 RIVERBEND
35 ROLAND
36 SELKIRK
37 STRATHMILLAN
38 ST. JOHN'S
39 SYNDICATE
40 TUXEDO
41 TYLEHURST
42 WOODHAVEN

SEPARATE SEWER

DISTRICTS

43 AINSLIE
44 BROOKLANDS
45 CHARLESWOOD
46 CHELSEA
47 CRANE
48 FORT GARRY
49 LAKESIDE MEADOWS
50 LINDEN WOODS
51 MAGER SEPARATE
52 MAPLES
53 MISSION GARDENS
54 MISSION SEPARATE
55 NORTH KILDONAN
56 NORTH MAIN
57 OAKLEIGH
58 PARKDALE
59 PULBERRY
60 RIVERBEND SANITARY
61 SOUTHDALE
62 SOUTH ST. VITAL
63 ST. NORBERT
64 ST. VITAL
65 TRANSCONA
66 TRANSCONA CNR
67 TRANSCONA WEST
68 TUXEDO
69 TYNDALL PARK
70 VALLEY GARDENS
71 WILLOW
72 WINDSOR PARK



LEGEND

Combined Sewer District Boundary

Unrelieved Combined Sewer Districts

Relieved Combined Sewer Districts

Separate Sewer Districts

Source: "Basement Flooding Relief Program Review - 1986" City of Winnipeg
Relieved Sewer Districts based on most current information from the City of Winnipeg

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CONTROL OF SUMMER WATER LEVELS

SEWER DISTRICTS

NOVEMBER 2003 | PLATE 1

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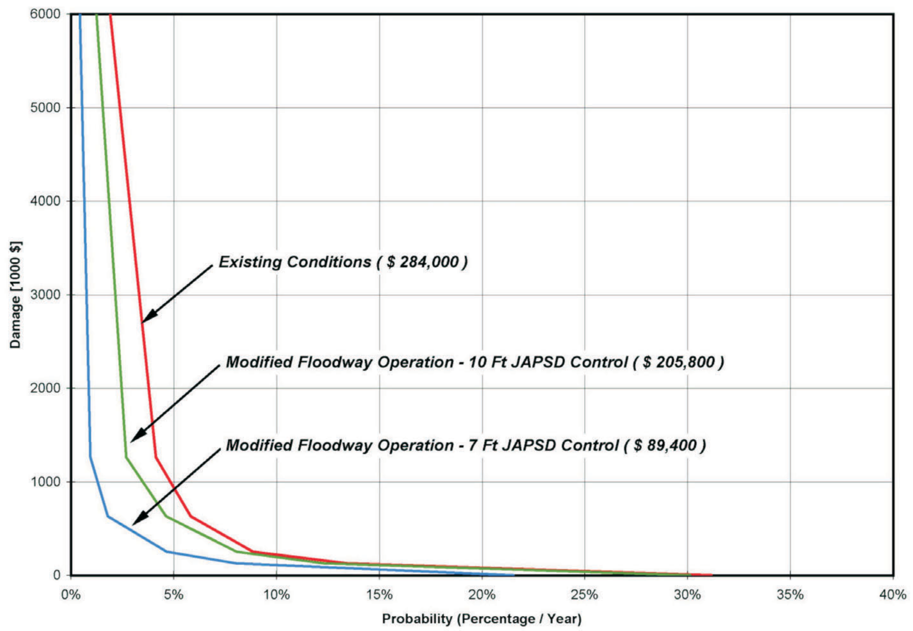
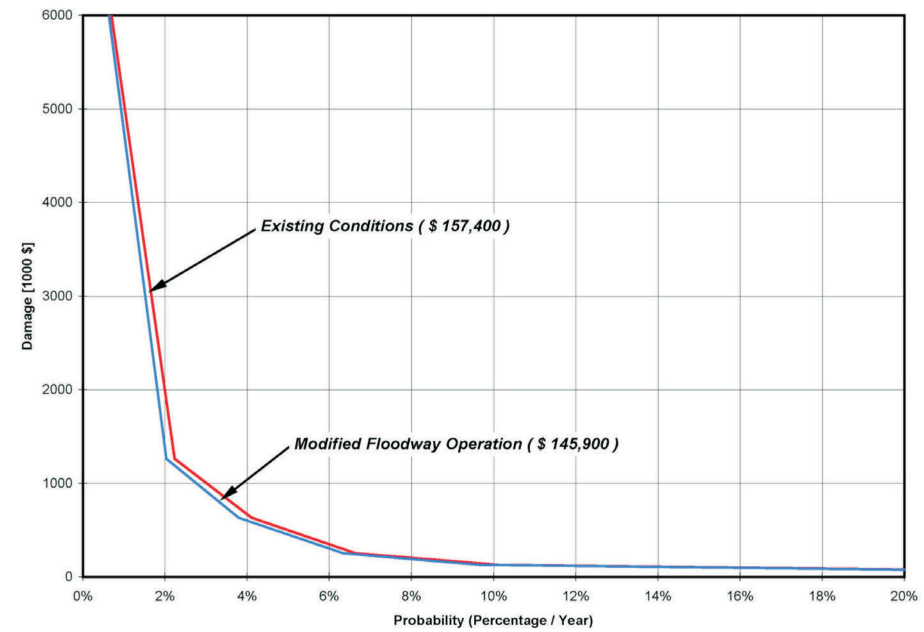
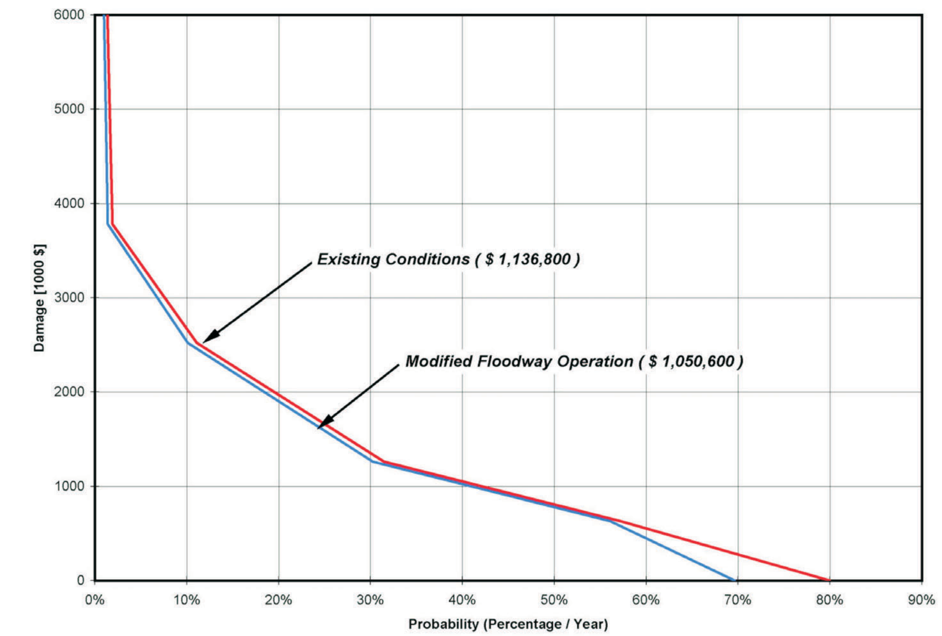


BALTIMORE SEWER DISTRICT



ARMSTRONG/NEWTON SEWER DISTRICT



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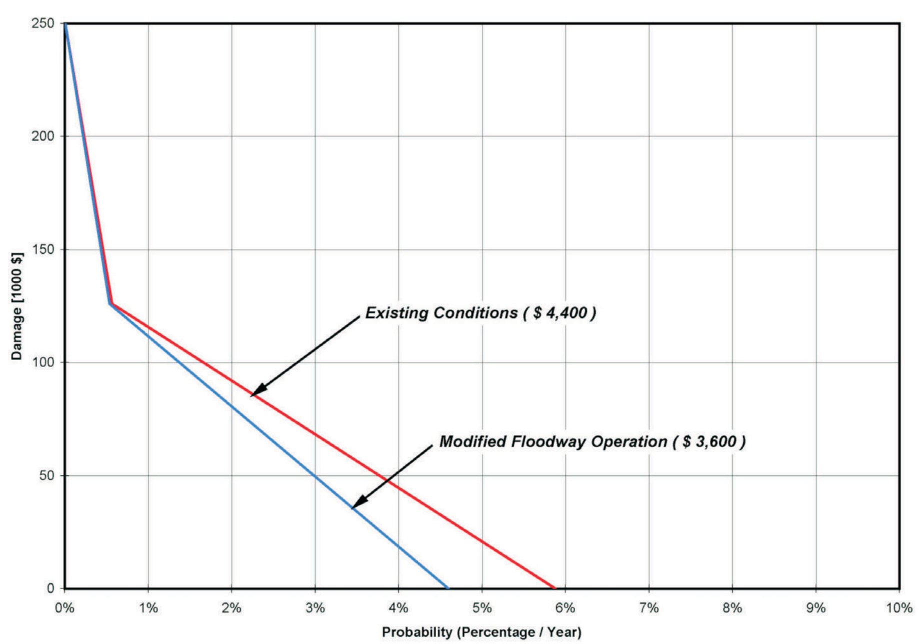
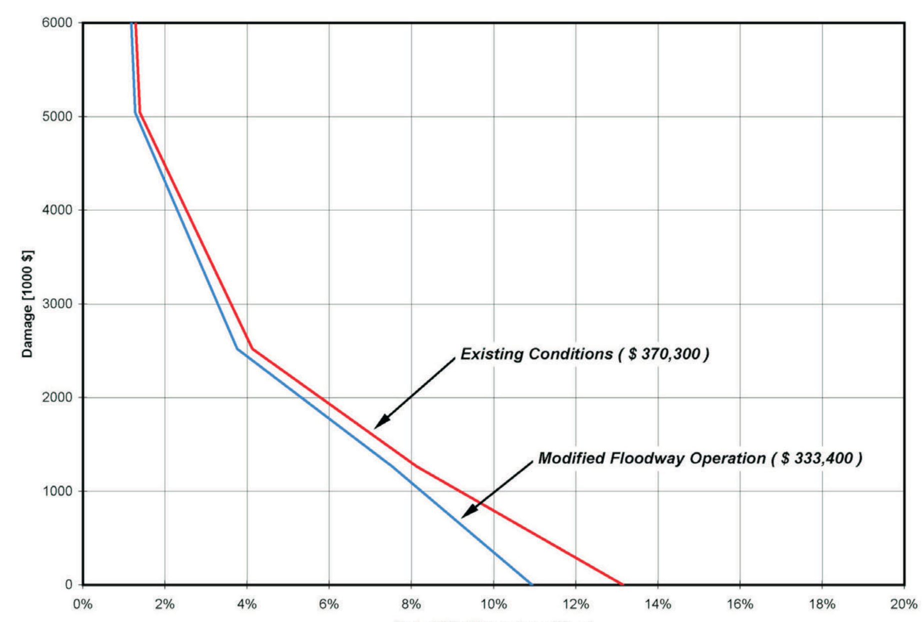


MAGER SEWER DISTRICT



LINDEN SEWER DISTRICT

NOTE : VALUES IN BRACKETS ARE AVERAGE ANNUAL DAMAGES.

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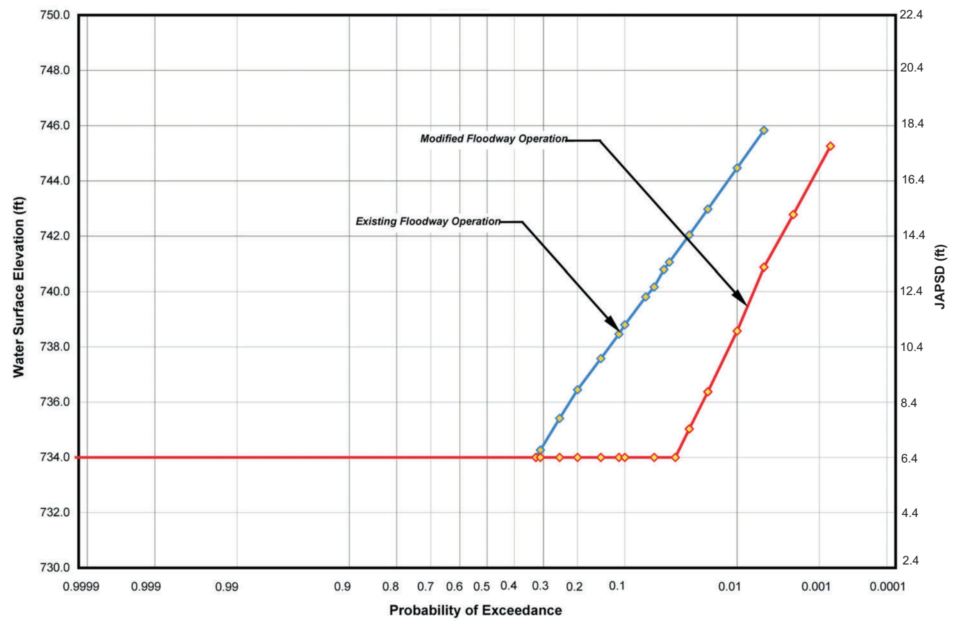
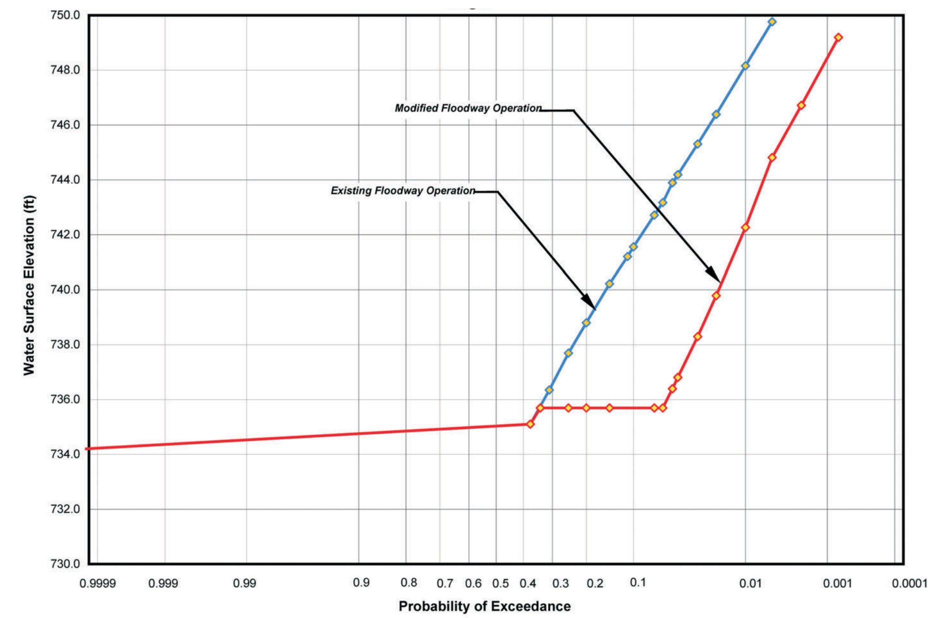
CONTROL OF SUMMER WATER LEVELS

SUMMER DAMAGE - PROBABILITY CURVES

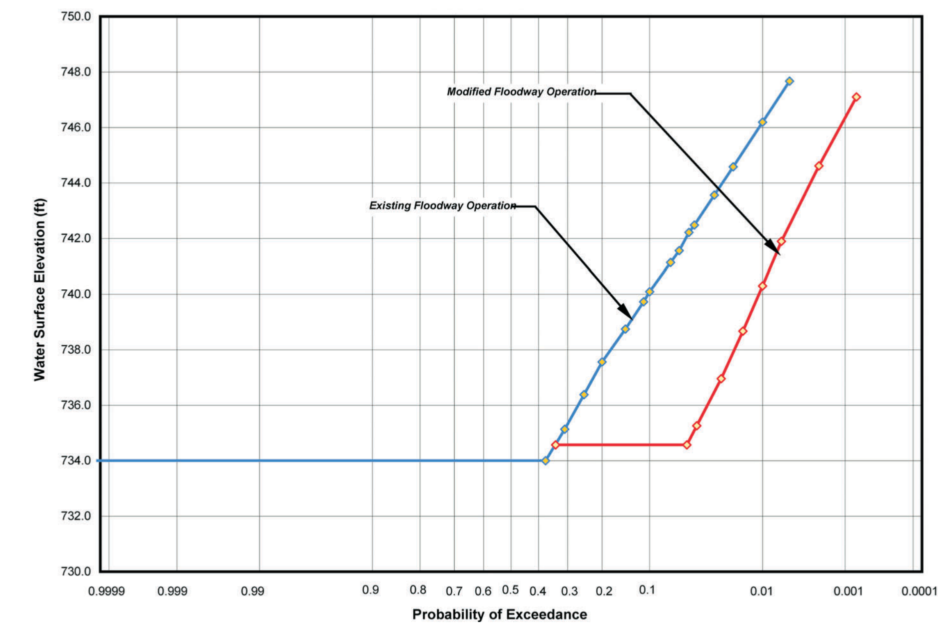
NOVEMBER 2003 | PLATE 3



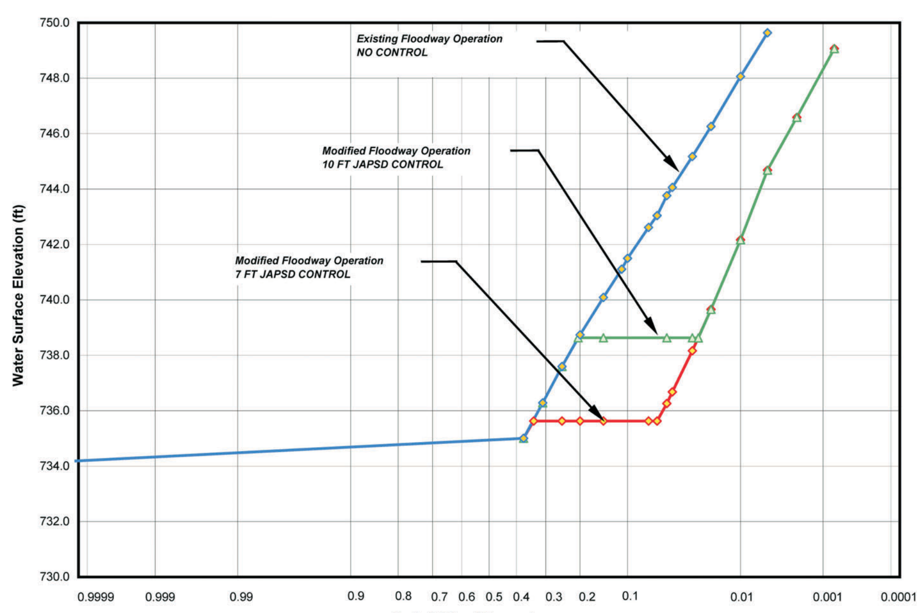
JAMES AVENUE



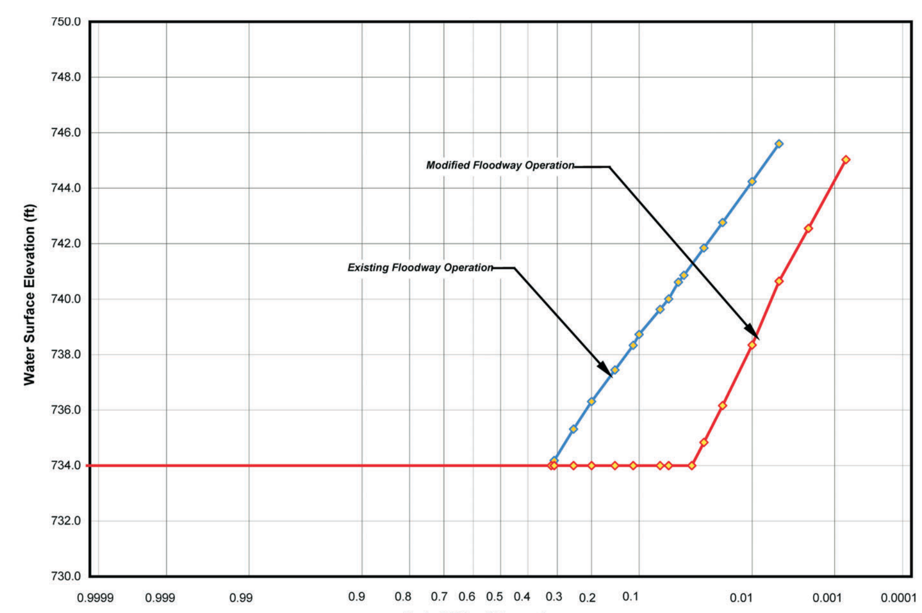
MAGER FLOOD PUMP STATION



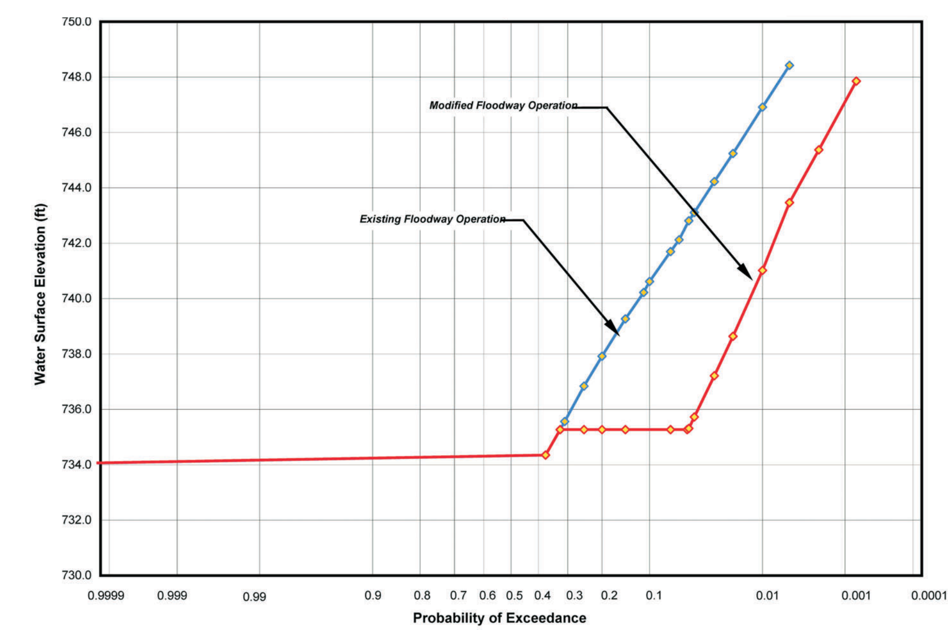
LINDEN FLOOD PUMP STATION



BALTIMORE FLOOD PUMP STATION



ARMSTRONG/NEWTON FLOOD PUMP STATIOIN



COLONY FLOOD PUMP STATION

KGS GROUP | Manitoba CONSERVATION

CONTROL OF SUMMER WATER LEVELS

SUMMER STAGE FREQUENCY CURVES
(JUNE 1 TO SEPTEMBER 30)

NOVEMBER 2003 | PLATE 2

KGS FILE NO.- P:/2002/02-311-06/HYDR/DWGS/REPORT PLATES- APRIL 2003/PLATE 2rev.CDR
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No.	District	Status	Land Use [1]	Area (acres)	Pump Capacity (cfs)	Sewer Capacity (cfs)	Low Basement Elevation (ft)	25.8 ft JAPSD Water Level (ft) [2]	Pump Capacity / Sewer Capacity	Pump Capacity / Reliability Factor	Depth of Low Basement Below 25.8 ft JAPSD Water Level (ft)	Existing Conditions			Modified Floodway Operation (7 Ft JAPSD Control)			Modified Floodway Operation (10 Ft JAPSD Control)		
												Damage ($/acre/yr)	Damage ($/yr)	Weighted Damage ($/yr)	Damage ($/acre/yr)	Damage ($/yr)	Weighted Damage ($/yr)	Damage ($/acre/yr)	Damage ($/yr)	Weighted Damage ($/yr)
1	Assiniboine	Relieved	Commercial	211	55.50	170.00	751.00	754.07	0.33	0.65	3.07	284	59,800	38,900	249	52,400	34,100	264	55,600	36,200
2	Boyle	Relieved	Commercial	59	33.55	22.95	740.00	752.79	1.46	0.25	12.79	2,761	163,700	40,900	2,584	153,200	38,300	2,681	159,000	39,800
3	Colony	Relieved	Commercial	577	83.00	469.69	751.71	754.43	0.18	0.80	2.72	196	113,100	90,200	166	95,800	76,400	178	102,700	81,900
4	Dumoulin	Relieved	Commercial	185	71.00	48.00	750.50	753.64	1.48	0.25	3.14	303	56,200	14,100	267	49,500	12,400	282	52,300	13,100
5	River	Relieved	Commercial	319	37.00	142.00	745.50	753.97	0.26	0.71	8.47	1,660	529,400	377,500	1,547	493,400	351,800	1,607	512,500	365,400
6	Roland	Relieved	Commercial	500	110.00	950.00	751.20	752.43	0.12	0.86	1.23	15	7,500	6,500	13	6,500	5,600	14	7,000	6,000
7	Syndicate	Relieved	Commercial	131	45.10	28.00	743.00	752.23	1.61	0.25	9.23	1,854	242,800	60,700	1,730	226,600	56,700	1,796	235,200	58,800
8	Ash	Relieved	Residential	1817	185.00	1190.00	756.00	755.31	0.16	0.82	-0.69	2	3,600	3,000	2	3,600	3,000	2	3,600	3,000
9	Baltimore	Relieved	Residential	546	91.90	759.27	747.90	754.49	0.12	0.86	6.59	123	67,100	57,600	44	24,000	20,600	84	45,900	39,400
10	Clifton	Relieved	Residential	874	200.00	715.00	754.00	755.41	0.28	0.69	1.41	3	2,600	1,800	3	2,600	1,800	3	2,600	1,800
11	Despins	Relieved	Residential	277	187.17	84.76	736.00	753.97	2.21	0.25	17.97	574	159,100	39,800	180	49,900	12,500	397	110,000	27,500
12	Hart	Relieved	Residential	551	77.40	65.00	743.60	751.80	1.19	0.25	8.20	187	103,100	25,800	63	34,700	8,700	129	71,100	17,800
13	Jefferson West	Relieved	Residential	1411	275.10	394.11	743.01	751.02	0.70	0.37	8.01	179	252,600	94,700	61	86,100	32,300	123	173,500	65,100
14	Jessie	Relieved	Residential	952	109.00	273.00	757.50	754.20	0.40	0.59	-3.30	2	1,900	1,100	2	1,900	1,100	2	1,900	1,100
15	Linden	Relieved	Residential	383	90.40	120.07	748.10	750.95	0.75	0.34	2.85	11	4,200	1,400	7	2,700	900	9	3,400	1,200
16	Mager Drive	Relieved	Residential	1905	76.00	349.62	750.23	754.63	0.22	0.76	4.40	36	68,600	51,900	18	34,300	25,900	24	45,700	34,500
17	Marion	Relieved	Residential	525	187.17	84.76	737.00	753.97	2.21	0.25	16.97	535	281,100	70,300	168	88,300	22,100	370	194,400	48,600
18	Munroe	Relieved	Residential	990	110.00	950.00	751.20	751.38	0.12	0.86	0.18	2	2,000	1,700	2	2,000	1,700	2	2,000	1,700
19	Munroe Annex	Relieved	Residential	457	90.40	120.07	757.50	750.95	0.75	0.34	-6.55	2	900	300	2	900	300	2	900	300
20	Polson	Relieved	Residential	622	81.70	267.00	754.00	751.38	0.31	0.67	-2.62	2	1,200	800	2	1,200	800	2	1,200	800
21	Selkirk	Relieved	Residential	781	156.00	360.00	751.00	751.90	0.43	0.56	0.90	2	1,600	900	2	1,600	900	2	1,600	900
22	St. John's	Relieved	Residential	856	155.00	200.00	754.50	751.71	0.78	0.33	-2.79	2	1,700	600	2	1,700	600	2	1,700	600
23	Alexander	Unrelieved	Commercial	375	42.70	105.00	752.00	753.31	0.41	0.58	1.31	44	16,500	9,600	24	9,000	5,200	27	10,100	5,900
24	Bannatyne	Unrelieved	Commercial	638	117.95		755.00	753.48		1.00	-1.52	2	1,300	1,300	2	1,300	1,300	4	2,600	2,600
25	Mission	Unrelieved	Commercial	1848	109.83	253.91	749.40	752.54	0.43	0.56	3.14	722	1,334,500	746,200	599	1,107,200	619,100	658	1,216,200	680,100
26	Riverbend	Unrelieved	Commercial	591	Temp Pumps	175.00	753.00	755.94	0.00	1.00	2.94	646	381,500	380,700	530	313,000	312,300	586	346,100	345,300
27	Tylehurst	Unrelieved	Commercial	546	No Pumps	180.10	750.20	755.82	0.00	1.00	5.62	1,638	894,500	892,600	1,432	782,000	780,300	1,535	838,300	836,500
28	Armstrong / Newton	Unrelieved	Residential	722	89.30	420.24	743.11	750.69	0.21	0.76	7.58	477	344,200	261,900	435	313,900	238,800	453	326,900	248,700
29	Aubrey	Unrelieved	Residential	1312	185.00	763.00	754.00	755.22	0.24	0.73	1.22	7	9,200	6,700	7	9,200	6,700	7	9,200	6,700
30	Cockburn	Unrelieved	Residential	825	84.00	195.00	753.70	755.12	0.43	0.56	1.42	10	8,200	4,600	9	7,400	4,100	9	7,400	4,100
31	Cornish	Unrelieved	Residential	353	65.90	150.00	750.00	754.86	0.44	0.55	4.86	192	67,700	37,500	165	58,200	32,200	180	63,500	35,200
32	Doncaster	Unrelieved	Residential	385	No Pumps	224.00	758.00	756.20	0.00	1.00	-1.80	2	800	800	2	800	800	2	800	800
33	Douglas Park	Unrelieved	Residential	52	Temp Pumps	3.53	752.40	756.81	0.00	1.00	4.41	145	7,500	7,500	122	6,300	6,300	135	7,000	7,000
34	Ferry Road	Unrelieved	Residential	590	Temp Pumps	213.00	761.50	756.63	0.00	1.00	-4.87	2	1,200	1,200	2	1,200	1,200	2	1,200	1,200
35	Hawthorne	Unrelieved	Residential	644	50.00	174.00	739.50	750.46	0.29	0.69	10.96	831	535,200	367,800	769	495,300	340,400	792	510,100	350,600
36	Jefferson East	Unrelieved	Residential	1045	275.10	394.11	743.01	751.02	0.70	0.37	8.01	522	545,600	204,600	477	498,600	187,000	496	518,400	194,400
37	Laverandrye	Unrelieved	Residential	198	9.53	8.83	744.00	752.79	1.08	0.25	8.79	604	119,400	29,900	555	109,700	27,400	574	113,500	28,400
38	Metcalfe	Unrelieved	Residential	101	48.03	60.03	749.02	754.43	0.80	0.32	5.41	250	25,300	8,100	221	22,400	7,200	236	23,900	7,700
39	Moorgate	Unrelieved	Residential	564	No Pumps	125.00	757.50	757.71	0.00	1.00	0.21	3	1,700	1,700	3	1,700	1,700	3	1,700	1,700
40	Strathmillan	Unrelieved	Residential	216	No Pumps		768.00	758.07	0.00	1.00	-9.93	1	200	200	1	200	200	1	200	200
41	Tuxedo	Unrelieved	Residential	114	Temp Pumps	48.00	744.40	756.20	0.00	1.00	11.80	919	104,700	104,500	853	97,200	97,000	876	99,800	99,600
42	Woodhaven	Unrelieved	Residential	133	No Pumps	40.97	757.00	758.76	0.00	1.00	1.76	14	1,900	1,900	12	1,600	1,600	13	1,700	1,700
									Total Combined Sewer District Damages					**$ 4,049,800**			**$ 3,379,300**			**$ 3,703,900**
									Total of all City Sewer District Damages [3]					**$ 4,454,800**			**$ 3,717,200**			**$ 4,074,300**

(1)	**Total Average Annual Summer Damage for Existing Conditions =**	$	4,454,800
(2)	**Total Average Annual Summer Damage for Modified Floodway Operation (7 Ft JAPSD Control) =**	$	3,717,200
(3)	**Total Average Annual Summer Damage for Modified Floodway Operation (10 Ft JAPSD Control) =**	$	4,074,300
	Total Average Annual Summer Benefit for Modified Floodway Operation (7 Ft JAPSD Control) [(1) - (2)] =	$	737,600
	Total Average Annual Summer Benefit for Modified Floodway Operation (10 Ft JAPSD Control) [(1) - (3)] =	$	380,500

Notes:

1) Commercial districts are assumed to consist of a significant amount of commercial land use.
2) Using water surface level parallel to the Flood Protection Level for a 25.8 ft JAPSD elevation.
3) Includes a factor 1.1 to account for separate sewer district damages.
4) JAPSD refers to James Avenue Pumping Station Datum.

KGS GROUP

Manitoba CONSERVATION

CONTROL OF SUMMER WATER LEVELS

ESTIMATED AVERAGE ANNUAL BASEMENT FLOODING DAMAGES AND BENEFITS

NOVEMBER 2003 | PLATE 4

KGS FILE NO.- P:/2002/02-311-06/HYDR/DWGS/REPORT PLATES- APRIL 2003/PLATE 4rev.CDR
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APPENDICES

APPENDIX A

KGS GROUP PROPOSAL
FEASIBILITY STUDY TO INVESTIGATE THE MERITS OF MANAGEMENT OF RED RIVER WATER LEVELS IN THE CITY OF WINNIPEG

KGS GROUP

KONTZAMANIS ▪ GRAUMANN ▪ SMITH ▪ MACMILLAN INC.
CONSULTING ENGINEERS & PROJECT MANAGERS

September 5, 2002 File No. 02-000-064

Manitoba Conservation
1577 Dublin Avenue
Winnipeg, Manitoba
R3E 3J5

ATTENTION: Rick Hay, P.Eng.

RE: Feasibility Study to Investigate the Merits of Management of Red River Water Levels in the City of Winnipeg.

Dear Mr Hay:

1.0 BACKGROUND

In December 2000, the Province of Manitoba commissioned KGS Group to conduct preliminary studies on the engineering, environmental and socio-economic aspects of two major flood protection alternatives for the City of Winnipeg, the Ste. Agathe Detention Structure and Floodway Expansion. InterGroup Consultants Ltd. was subcontracted to oversee the analysis of the socio-economic effects of the two proposed projects. A progress report was issued in May 2001 and the final report was released in November 2001.

One of the requirements of the study was to investigate the recreation opportunities that may be associated with the flood control alternatives. During the course of the study, interviews with Provincial and Federal government officials, as well as other key persons in the Red River Valley, were conducted. Interviewees were asked to discuss their opinion of the feasibility and desirability of recreation options associated with either the Ste. Agathe Detention Structure or Floodway Expansion. A preliminary review of recreation opportunities developed in other jurisdictions was also undertaken. The results of the analysis indicated that the control of summer Red River levels in the City of Winnipeg through a modification of the floodway inlet structure operating rules merited additional investigation. In addition to the recreational benefits, increased capacity of the City of Winnipeg sewer system at high river level was identified as a positive impact. Given the recent high water levels experienced in June of this year, this portion of the benefits analysis has taken on significant importance as the risk of basement flooding increases. A phase of this study will be dedicated to assessing the one time control of summer operation in 2002.

As a part of the flood protection studies for Winnipeg, three alternatives were considered for control of summer levels.

STRUCTURAL?GEOTECHNICAL?ENVIRONMENTAL?HYDRAULICS?HYDROGEOLOGY?MUNICIPAL?MECHANICAL?ELECTRICAL
3RD FLR. – 865 WAVERLEY ST., WINNIPEG, MANITOBA, R3T 5P4 PH: (204) 896-1209 FAX: (204) 896-0754
560 SQUIER PLACE, THUNDER BAY, ONTARIO, P7B 6M2 PH: (807) 345-2233 FAX: (807) 345-3433

Option 1 – Control using the existing configuration only and increasing upstream levels above the state of nature.

Option 2 – Control using the expanded floodway with increased excavation to reduce the upstream impacts of the control of summer levels.

Option 3 – Significant channel modifications which would allow summer levels to be controlled without exceeding natural levels.

Costs to completely eliminate the effects of summer flooding (Option 3 - Natural Levels) would increase the floodway expansion costs by over $100 Million. This was deemed not to be practical. Option 2 would reduce the impact to upstream levels and could be considered during future optimization of an expanded floodway, if it was decided to pursue Summer Flood Control. For the purpose of this study, only Option 1 is proposed to be studied to assess the financial feasibility of the summer control. Should the scheme appear to be feasible from an economic perspective, substantially greater effort would be necessary to “firm up” the costs and benefits.

This proposal outlines a course of feasibility study that would examine the opportunities and main effects associated with the regulation of summer Red River water levels in the City of Winnipeg.

2.0 OVERALL APPROACH

Based on the understandings of the project at this time, a four-phase approach to the investigation of the opportunities and effects associated with regulation of summer Red River water levels in the City of Winnipeg:

- Phase I: Identify and Outline Opportunities;
- Phase II: Quantification and Analysis of Opportunities; and
- Phase III: Assessment of One-time Operation in 2002
- Phase IV: Assessment of Costs and Benefits

Each of these components is discussed in greater detail below.

Phase I: Identify and Outline Opportunities

This phase of the study identifies economic, social and environmental opportunities resulting from increased regulation of Red River water levels in the City of Winnipeg. The avoidance of adverse effects and the potential for impacts both upstream and downstream of the floodway will also be examined.

Opportunities will be identified through interviews with key stakeholders, including representatives from commercial, recreational and residential groups, along the Red River. Benefits associated with increased sewer system capacity will be based on previous work by KGS Group and discussions with City of Winnipeg personnel.

Tasks to be completed under this Phase include

- Definition of existing and proposed summer water level regime within the City of Winnipeg and upstream. For this study, changes to the existing operation will consider modifications to the existing operating rules only.

- Definition and scope of opportunities for benefits. This would include meetings with key stakeholders and discussions of, as a minimum, the following areas:

    - Recreational opportunities at the Forks and Riverwalk

    - Recreational opportunities associated with the boat, marina and dock users within the City including future development opportunities associated maintaining stable summer water levels in Winnipeg throughout the summer period. (i.e. riverbank development, Marinas etc.).

    - Benefits to the City sewer system for reduced flooding due to high river levels and coincident rainfall events (a similar to that which occurred 1993). This benefit is difficult to quantify at this level of study due to the number of sewer districts involved and complexity of the analyses required to quantify benefits. As such, the assessment will be based largely on an extension of the previous work by KGS Group for the City of Winnipeg.

    - Benefits to the City of Winnipeg Water and Waste Department for reduced operational costs of sewer infrastructure (including Flood Pump Stations and sewer control procedures, secondary dyke sandbagging operations, etc.) during periods of high river levels.

    - Review of the results of the Provincial Committee struck to investigate the potential recreational benefits associated with the expanded floodway.

    - Incorporate input from the Greenway on the Red Committee with emphasis on the identification of potential recreational benefits.

- Definition of the sensitivity of user groups to the range of water level experienced within the City during the summer.

Phase II: Quantification and Analysis of Opportunities and Costs

This phase of the study involves economic and engineering assessment of the opportunities identified in phase I. The economic and engineering feasibility of the opportunities will be evaluated and the costs of each opportunity will be quantified.

Tasks to be completed includes quantifying the costs and benefits identified in the first phase:

- Recreational benefits will be based on accepted values for recreational use, increased tourism, and avoided operational costs

- City of Winnipeg sewer benefits will be based on avoided flooding, maintenance and operational costs. Additional analyses will be conducted to enhance the previous study results. This will include analyses of a greater number of sewer districts than previously considered and development of a more rigorous assessment of the benefits. The Flood Adequacy Review Study considered five districts including; Baltimore, Mager, Marion / Despins, Colony and Linden. Additional effort will focus on the flood pump stations with the lowest activation levels such as Laverendrye, Jefferson, Metcalfe, and Syndicate. This approach will be co-ordinated with input from the City of Winnipeg.

- Qualitative assessments of the benefits of future development opportunities

- Costs associated with increased flooding upstream of the Floodway Inlet structure. This will be based on use of KGS Group's flood damage model, topography upstream of the inlet and information from the Province regarding summer use of this area. This area is directly affected by the operation and will need to be assessed effectively. It is our understanding that the Province and Municipal Staff are currently active in this area. In conjunction with the Provincial data, additional effort by our socio-economic subconsultant, Intergroup, will be made to identify the market gardeners in this area and incorporate them more rigorously into the analysis.

- Development of reasonable compensation alternatives for the Government to consider. A rudimentary assessment of the implications to insurance policies given the potentially reduced risk in the City, will also be investigated. Options will be presented in the report.

- Costs associated with additional operation and maintenance of the Floodway Channel and Inlet structure for year round use.

- An assessment of impacts to the riverbanks associated with changed flow regime within Winnipeg and upstream will be made by KGS Groups geotechnical staff.

- Assessment of alternatives to river level control including upgrading of pump stations, raising the level of the river walks, etc. based on Engineering judgement

- Assessment of mitigation of fish passage and summer navigation concerns.

Phase III: Assessment of One Time Operation in 2002

An overview assessment of the 2002 operation and drawdown limitations will be conducted, including;

- Development of more detailed analyses of maximum recommended daily river drawdown, both within the City, and upstream from the control structure.

- Review of one-time operation scenario followed in 2002

Phase IV: Assessment of Costs and Benefits

This phase of the study will focus on the assessment of costs and benefits of the project. Socio-economic, engineering and environmental costs and benefits will be considered to identify the overall benefits of summer operation of the Floodway. Sensitivity analysis will also be performed to assess the effects of key assumptions under different scenarios.

The primary focus of the efforts will be on basement flooding with recreational benefits analysed separately.

Report Preparation

Following the compilation of the data and assessment of the costs and benefits, a brief report will be prepared describing the methodology used, the data collected and the results of the analysis. Fifty copies of the final report would be prepared for use by the public with technical appendices (10 copies) as appropriate.

3.0 PROPOSED PERSONNEL

The study will be co-ordinated by our Mr D MacMillan with input from R Carson and other KGS staff for the engineering and water control aspects of the project. The socio-economic components of the project will be coordinated by Intergroup Consultants Ltd's John Osler. Intergroup will be responsible for the key person interviews and the definition/quantification of socio economic benefits and costs.

4.0 SCHEDULE / MEETINGS

The total time frame to complete the work will depend on the availability of upstream damage data and the time to compile recreational and tourism data. On that basis, we anticipate that the study can be completed in 5 to 6 months.

During the course of the study we anticipate that we will host three meetings with the Steering Committee as follows.

- ***Initial Scope Meeting*** –review the project scope and study expectations.
- ***Progress Meeting*** – review the study progress, schedule and fee status at the 50% complete point.
- ***Final Draft Report*** – present the study findings and the final draft report. The report will be finalized with input from the Steering Committee.

5.0 ESTIMATED FEES

The fee is estimated to be $98,650 including reimbursable disbursements. A break down of the fees, based on the tasks described above, is given in Table 1.
We are available to discuss our proposal and overall approach with you at your convenience. Please call if you have any questions.

Yours truly,

Dave MacMillan, P.Eng.
Principal

DBM/af

cc: Rick Carson

APPENDIX B

SUMMER WATER LEVEL CONTROL
CORRECTION FACTOR MEMORANDUM

MEMORANDUM

TO:	Dave MacMillan
FROM:	Rick Carson
DATE:	July 25, 2003
PROJECT NO:	02-311-06
RE:	Summer Water Level Control Correction Factor

In the meeting on June 16, an agreement was reached on how to estimate the appropriate reduction factor for the over-estimation of flood damages that results from application of the total probability method for the summer period. The need for this correction factor had been acknowledged in KGS Group's draft report on the studies of summer water level control.

Subsequent to the meeting, Cas Booy suggested a minor refinement to the correction factor using information on rainfall occurrences, and suggested a separate document should be prepared that would show the derivation of the factor used in the report. The rationale described in this memorandum has been prepared to satisfy that need.

The correction discussed in the meeting on June 16 was verified with the following approach:

1. Cas Booy suggested that a histogram of rainfall events be prepared that could demonstrate the distribution of rainfalls through the full season from June through October. That histogram has been prepared and is shown in Figure 1 for a period of record from 1971 to 2000. Only the rainfall amounts that exceed 30 mm are shown because that is believed to be the approximate threshold below which there is no significant difficulty with basement flooding in Winnipeg, regardless of river water level. The distribution is clearly dominated by events in mid- to late summer, with August being the month of the peak number of events. In fact only 12 % of the events occur in the two-month period September/October, in spite of the fact that that period is about 40 % of the total time. As a result of that revelation, only the period of June, July, and August has been used in the further analysis that is described below.

2. It has been rationalized that the correction factor should be directly related to the ratio of the magnitudes of the duration curve of daily river water levels to the frequency curve of annual peaks of river water levels. The latter curve is the one that was used in the total probability method, whereas the former is more appropriate to enable more suitable recognition of the relatively short duration of high river levels over the course of a summer season. Figure 2 shows a comparison of the two curves (frequency vs. duration curve).

3. The duration curve shown in Figure 2 was extended by eye using a best fit that appeared appropriate given the data available. The extension is needed because the last few points on the duration curve are driven by a few points at the peak of the flood events in 1974 and 1996 and does not represent the true probability distribution of extreme floods. The extended curve that follows the trend that the main part of the duration curve exhibits is shown in Figure 3.

4. Figure 4 summarizes the variation in the ratio of the per cent of time that a certain water level would be exceeded (based on the duration curve), relative to its annual probability of being equaled or exceeded according to the frequency curve. The ratio is gradually decreasing at increasing river levels and averages more than 30% for the range of river water levels that would affect the occurrence of basement flooding during severe rainfalls. That ratio is higher than the selected value of 22.5% that has been adopted for the best estimate of the correction factor that was applied in KGS Group's analysis of basement flood damages and documented in Section 5.2.3. of the report. However, it demonstrates that the benefits assumed in the report may well understate the true potential. On the other hand, the B/C ratios that were based on the apparently low estimate of 0.225 for the correction factor were already greater than 1.0 for all cases examined (except extremely pessimistic combinations of parameters in the sensitivity analyses shown in Table 17 of the report). This suggests that if more rigorous analysis were to be carried out, the benefits of summer water level control could be slightly larger than described in the final report. The difference, however, would not be enough to change any fundamental conclusions described in Section 14.1.

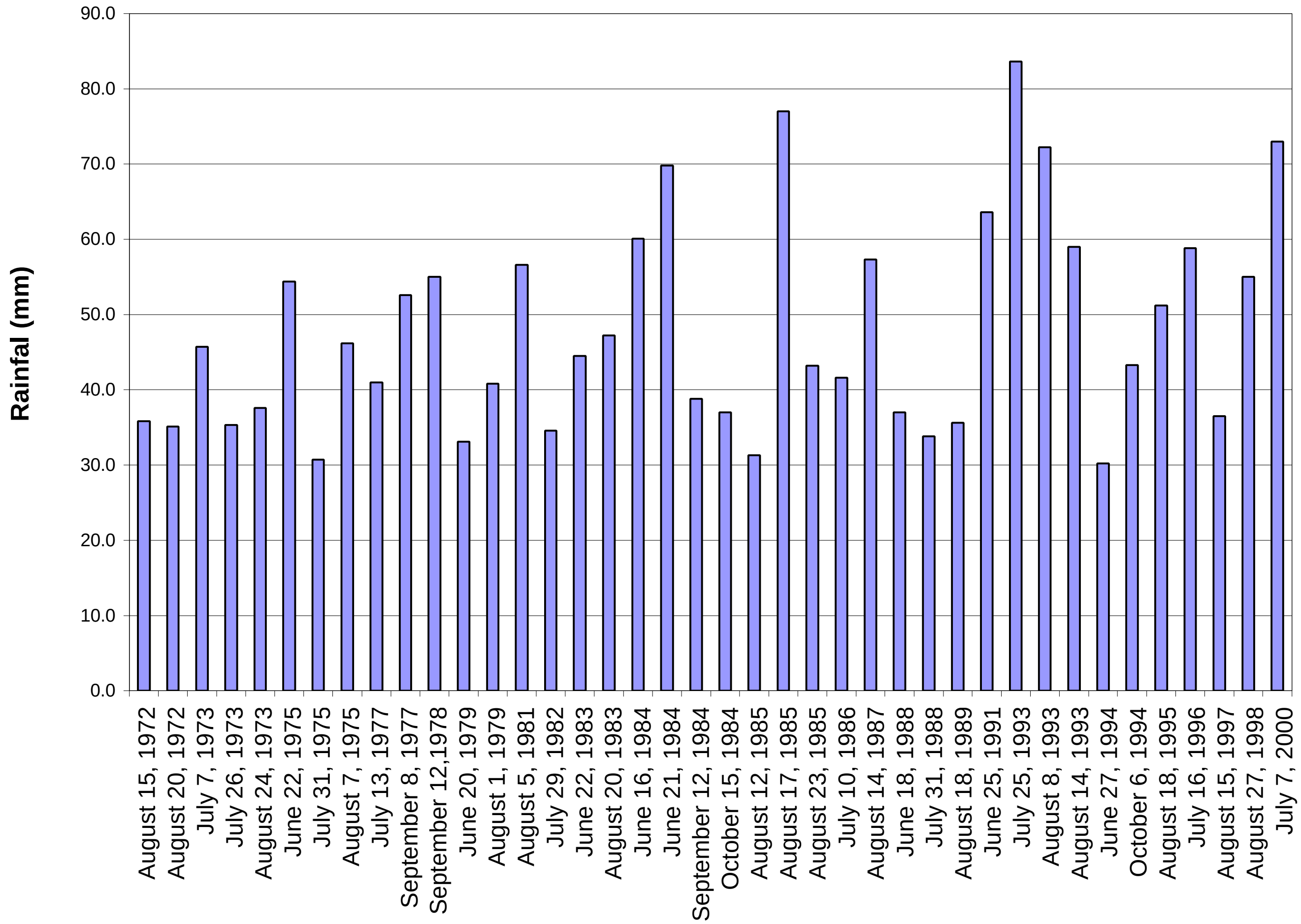


Figure 1. Histogram of Rainfall

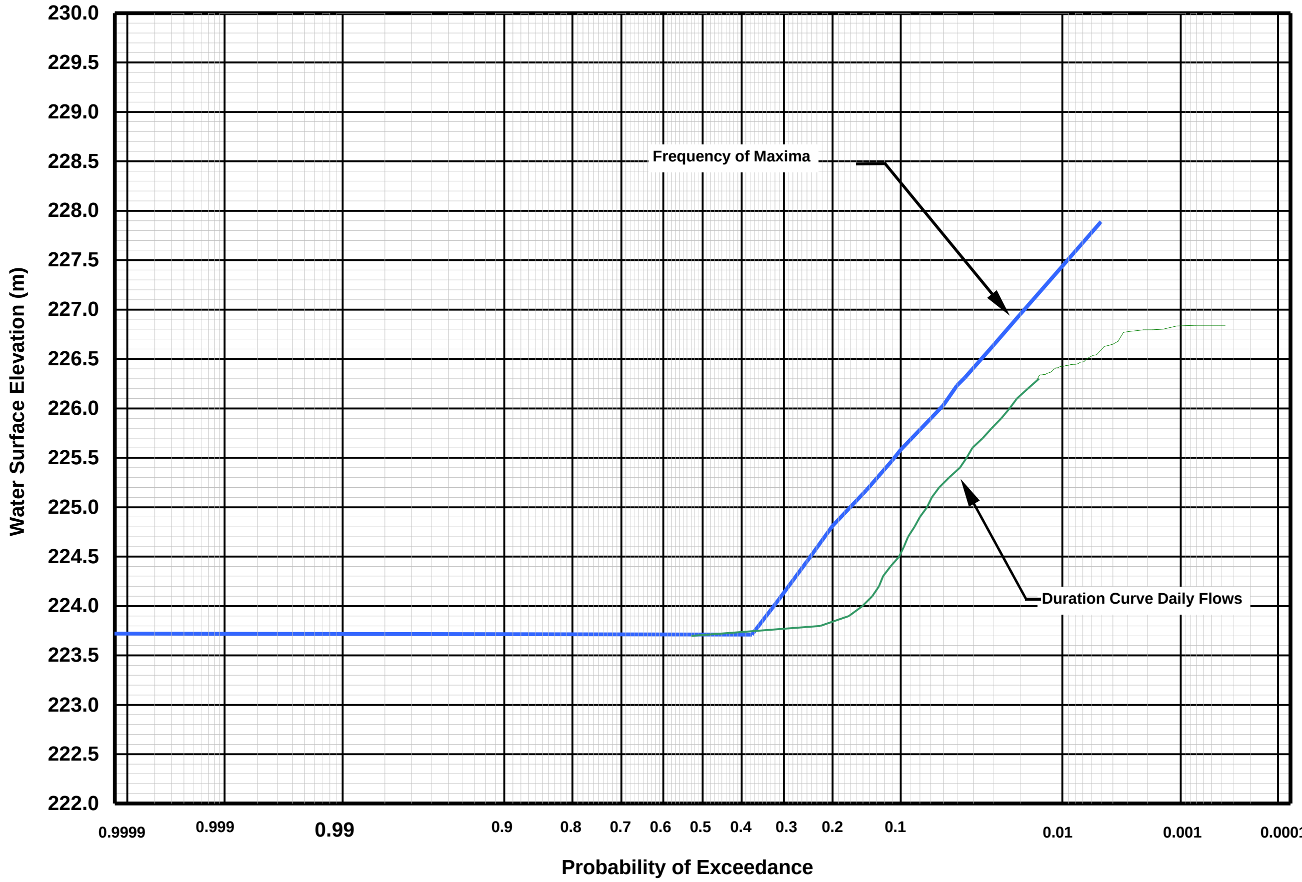


Figure 2. Frequency of Maxima Vs Duration Curve for Summer Stages at James Avenue

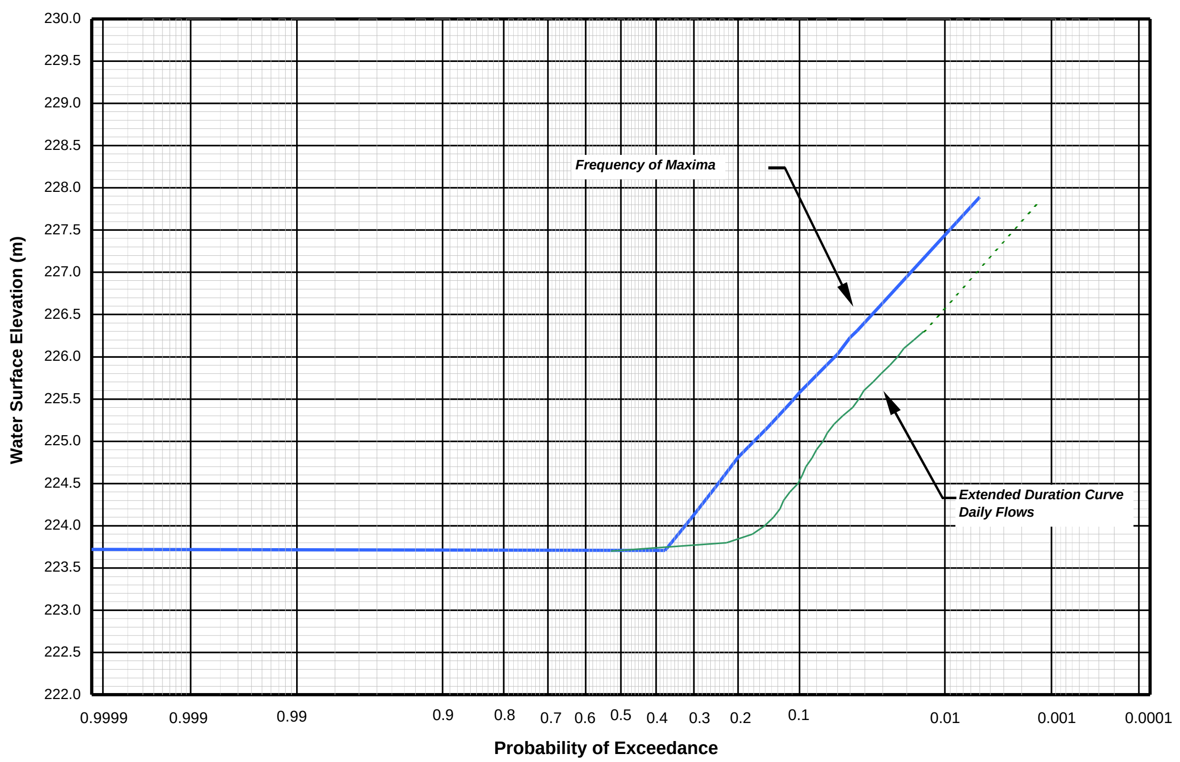


Figure 3. Frequency of Maxima Vs Extended Duration Curve for Summer Stages at James Avenue

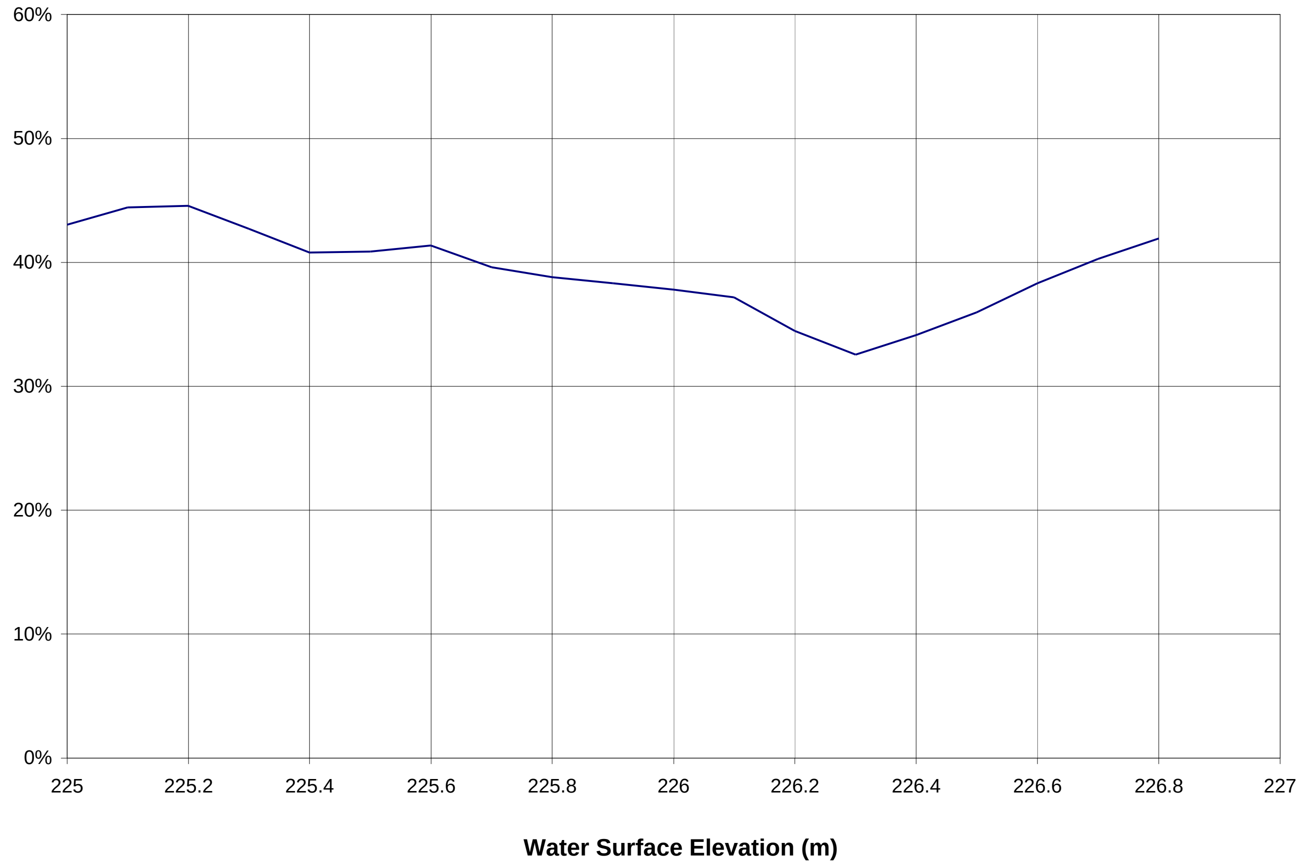


Figure 4. Ratio of Duration Curve Values for Daily Summer Flows to Annual Probability of Exceedance

APPENDIX C

KEY PERSON INTERVIEW PROGRAM QUESTIONNAIRE

APPENDIX C

Background

We are working on a project that examines the costs and benefits of controlling Red River water levels in the City of Winnipeg during the summer months (approximately June 1 to October 15). Water levels in the City of Winnipeg could be controlled using the existing floodway.

We are interested in talking to people who are recreational river users, commercial river users and landowners adjacent to the river. We're trying to understand how summer water levels on the Red River impact people in the City of Winnipeg. Interviews are meant to determine:

- Historical and existing recreation and commercial uses of the Red River in the summer months
- Impacts from changes in the water level, and
- Future opportunities associated with managing summer Red River water levels.

Introduction

Name: _________________
Organization: ___________________
Number of years associated with organization: _______

Historic and Existing Use

1. How have you or your organization used the Red River during the summer over the previous 5-years? Previous 10-years?

2. Have the types of use changed over the years? If so, how?

3. How is this use affected by:
   - Low-water years/high-water years
   - Timing in the summer (monthly, school vacation, etc.)
   - Other variables (cost/operation/weather/events)

4. Can you estimate the number of users in your organization or facility (users/day/month/year)?

Impacts on Costs, Revenues and Activities from Changes to the Water Regime

5. What are your operating expenses/clean-up costs/property damages, when:
   - Water level trigger – at what water level do you start to experience problems?
   - Costs each time this water level is exceeded?
   - Cost per day this water water level is exceeded?

6. What are your business interruption losses/lost revenues when:
   - Water level trigger – at what water level do you start to experience problems?
   - Costs each time this water level is exceeded?
   - Cost per day this water water level is exceeded?

7. What is your lost recreational value/opportunity costs from:
   - Water level trigger – at what water level do you start to experience problems?
   - Costs each time this water level is exceeded?
   - Cost per day this water water level is exceeded?

8. Are there alternatives that can be used if Red River water levels are high? For example:

- Different activities
- Different routes
- Different locations

[Note: Please discuss the implications of using these alternatives (are they more costly, less desirable, etc.)]

9. Are there other considerations that contribute to the impact of changes in water level, such as:

- Timing (June-July-August-September or weekday/weekend)
- Weather
- Rate of Flow/Current
- Others

Future Opportunities from Changes in the Water Regime

10. What would be the ideal summer Red River level for you?

11. If the water regime were regulated to your ideal level:

- How would your existing use change?
- How would your future use change?
- How would other users change?
- What new opportunities would you see arise?

Conclusion

12. Is there anything further that you would like to add?

13. Can you suggest any other organizations that might serve as important stakeholders for this project?

APPENDIX D

FISH PASSAGE IMPLICATIONS AT THE FLOODWAY INLET CONTROL STRUCTURE

KGS GROUP

MEMORANDUM

TO: Dave MacMillan

FROM: Rick Carson

DATE: December 16, 2002

PROJECT NO: 02-311-06

RE: Control of Summer Water Levels in Winnipeg Rivers
Effects on Potential Fish Passage and Navigability at
Floodway Inlet Control Structure

INTRODUCTION

Use of the Red River Floodway (Floodway) to control summer water levels in Winnipeg will require raising the Floodway Inlet Control Structure gates to increase the upstream water level. That action is required to force water to flow into the Floodway channel and around the city, thereby relieving the flood potential along the river in Winnipeg.

The purpose of this document is to address the implications with respect to fish passage and navigation at the Floodway Inlet Control Structure.

COMPARISON OF CONDITIONS WITH AND WITHOUT DIVERSION OF FLOW THROUGH THE FLOODWAY

The potential for fish passage and navigability at the Floodway Inlet Control Structure is related to the velocity of flow over the gates. Consequently, the effects of use of the Inlet gates have been related to velocity of flow, and results are reported accordingly in this document.

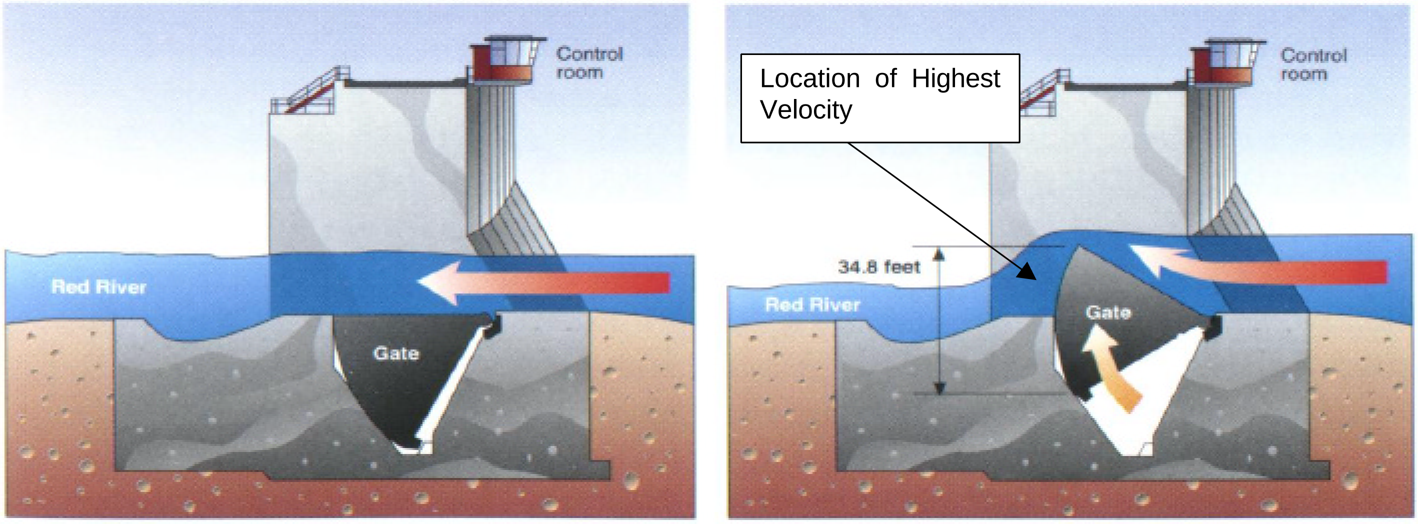
The velocity regime under the existing conditions is described below in Point 1 under "Base Case". For the purposes of preliminary assessment of the concept of using the Floodway during summer floods, two optional modes of operation have been assessed, and are described in Annex A, with comparisons to the "Base Case". Each option has a number of sub-options that depend on the target level that is desired, either in the city or upstream of the Floodway Inlet.

The modified regime that would occur if either of the options for Floodway usage would be selected is described in Point 2 below under "Options of Using the Floodway …".

1. Base Case – No Lifting of Floodway Inlet Control Structure Gates

This case represents the summer periods since the completion of the project in 1968 to the end of 2001. The control gates were never used in the summer during that entire period, and remained in a lowered position within chambers in the base of the structure. Figure 1 shows this configuration and a typical water surface profile through the structure. Figure 2 summarizes the variation in velocity through the water passages of the structure for the summer period of June 1 to October 15, based on the flow records of 1970 to 2001, inclusive.

During a small percentage of time (about 7%) that is represented in Figure 2, the river flows would have been high enough to warrant use of the Floodway (it was not used, however). The velocities during these periods have been estimated as a base condition to which comparisons of the other options described in Point 2 below can be made. The velocities for the uncontrolled condition ranged from 0.1 m/s (0.3 fps) to as much as 2.5 m/s (8 fps). However, during the periods when either of the options of Floodway usage would have been appropriate, the velocities for this base case ranged from approximately 1.7 m/s (5.6 fps) to 2.5 m/s (8 fps).



Control Gate in Normal Position

Control Gate Lifted to Raise Upstream Water Level

Figure 1 – Comparison of Flow Conditions with and without Operation of the Control Gates

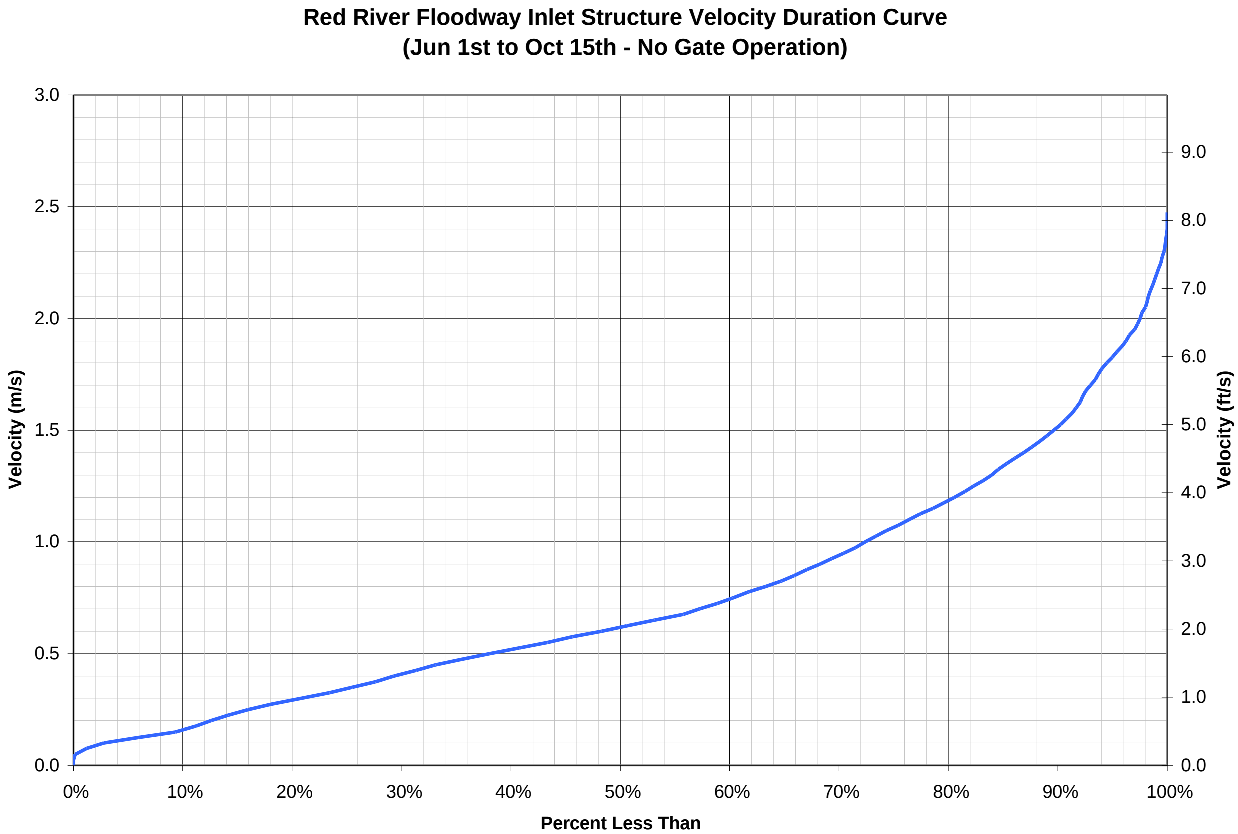


Figure 2 – Duration Curve of Velocity at Floodway Inlet Control Structure

2. Options of Using the Floodway to Mitigate Flood Conditions in Winnipeg

There are a variety of options for use of the Floodway to control summer water levels, as described in Appendix A. However, all have the common trait of requiring the control gates to be raised well above the invert of the structure as shown in Figure 1 (at least 6.4 m (21 ft) above the invert, and as much as 9.1 m (30 ft)). For all cases described in Appendix A, the following range of water level differentials, and maximum velocity of flow over the gates (i.e. the maximum at the location where the falling water jet over the gate enters the tail-water pool) will occur:

- Water level differential from the upstream side of the structure to the downstream side ranging from a minimum of approximately 2.7m (9 ft) to a maximum of approximately 4.6 m (15 ft). Virtually all of this fall in water level profile will occur at the gate as shown schematically in Figure 1

- Maximum velocity of flow over the gates ranges from 7.3 to 11.3 m/s (24 to 37 fps) during all periods that the gates are in operation (i.e. raised above their normal position in the gate chamber)

Since all maximum velocities during the period of operation of the gates will exceed a threshold that could be tolerated by fish that are resident in the Red River, or by watercraft, precise estimation of the duration of various magnitudes within the range quoted above were not defined.

ANNEX A

River Water Level Regimes With/Without Summer Regulation Using Floodway

There are a variety of alternative operation modes and rules that could be adopted to regulate river water levels in Winnipeg. All modes that are being considered in this study are based on the premise of raising the gates at the Floodway Inlet Control Structure during flood events to force excess water into the Floodway. Two major alternative operation modes are:

1. **Select a target water level in the city**

   The selected target (i.e. the maximum water level at the James Avenue Pump Station that would be allowed to occur) could range from as low as el. 7 ft James Avenue Pump Station Datum (JAPSD), to as high as el. 15 ft (JAPSD). The selection will depend on the relative merits of each that will be identified in this study. The water level upstream of the Floodway Inlet would be raised to whatever level is required to achieve the target in Winnipeg. The maximum water level that would be permitted at the Floodway Inlet to achieve such control would be El 231.65 m (760 ft). This mode of operation could be amenable to a concept whereby compensation would be pre-arranged in an agreement with upstream residents, and would be paid on an as-needed basis according to the pre-arranged terms.

2. **Select a maximum water level upstream of the Floodway Inlet and operate to that level to achieve the maximum water level reduction in Winnipeg that is possible**

   The lowest water level that would be desired in Winnipeg would be el. 7 ft (JAPSD). If that low limit could be achieved with an upstream water level below the selected maximum water level upstream of the Floodway Inlet, then only the minimum upstream water level needed to achieve el. 7 ft (JAPSD) would be invoked. This concept of river control would be amenable to a situation in which the land affected up to the El 760-ft (231.65-m) limit would be purchased and owned by the Province.

The main implications of these modes, and other versions of them (such as changing the upstream maximum to El 758 ft (231.0 m) for example, include radical changes in water level in Winnipeg and upstream and downstream of Winnipeg, compared to what has occurred in the past. One means to demonstrate the potential changes in water level regimes is to consider historical water levels and estimate how they would have been different if the new operation mode(s) had been imposed throughout the recorded period. This examination has been done by KGS Group for both modes of operation (as well as for varying versions of each). The results are summarized in the attached tables. Careful examination of these tables can permit comparison of the implications of alternative modes.

Graphical means of summarizing the results of the comparisons of the modes could also be prepared. However, this has been avoided to date because it would result in a large number of abstract graphs that would probably be difficult to compare and contrast.

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme A :
1. Achieve Controlled Target Level at James Avenue, whenever possible
2. Regulate Water Level at Floodway Inlet as Required to Achieve Target at James Ave.
3. Maximum Control Level at Inlet 760 ft

Data for 32 Year Record - 1970 to 2001 Inclusive

	Actual Conditions 1970 to 2001 (inclusive) [1,2,3,4]	Target El 7 James	Target El 8 James	Target El 10 James	Target El 12 James	Target El 14 James	Target El 15 James
Number of Events Requiring Control of Water Levels [3]	21	21	13	9	4	4	3
Number of Times Water Level Exceeds Target El at James Ave [3]	21	4	2	0	0	0	0
Total Duration Water Levels Exceeds Target El at James Ave.(days)	380	27	6	0	0	0	0
Average Duration that Water Level Exceeds Target El at James Ave.(days per event)	18	7	3	0	0	0	0
Maximum Duration that Water Level Exceeds Target El at James Ave. (days) [3]	113	21	5	0	0	0	0
Approximate Probability that Water Level Exceeds Target El at James Ave. (% per year) [5]	66%	13%	6%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 750 ft at Floodway Inlet	3	21	13	9	4	4	3
Total Duration Water Level Exceeds El 750 ft at Floodway Inlet (days)	7	380	275	166	90	42	23
Average Duration that Water Level Exceeds El 750 ft at Floodway Inlet.(days per event)	2	18	21	18	23	11	8
Maximum Duration that Water Level Exceeds El 750 ft at Floodway Inlet (days)	4	113	90	79	62	31	20
Number of Times Water Level Exceeds El 755 ft at Floodway Inlet	0	9	5	4	2	0	0
Total Duration Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	133	84	46	6	0	0
Average Duration that Water Level Exceeds El 755 ft at Floodway Inlet.(days per event)	0	15	17	12	3	0	0
Maximum Duration that Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	73	48	33	5	0	0
Number of Times Water Level Reaches El 760 ft at Floodway Inlet	0	4	2	0	0	0	0
Total Duration Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	27	6	0	0	0	0
Average Duration that Water Level Controlled at El 760 ft at Floodway Inlet.(days per event)	0	7	3	0	0	0	0
Maximum Duration that Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	21	5	0	0	0	0

Notes :

1. For Actual Conditions, Target El assumed to be El 7 ft James
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are acknowledged in these statistics as independent events
4. For actual conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately 6.5 ft James)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme A :

1. Achieve Controlled Target Level at James Avenue, whenever possible
2. Regulate Water Level at Floodway Inlet as Required to Achieve Target at James Ave.
3. Maximum Control Level at Inlet 760 ft

Data for 10 Year Record - 1970 to 1979 Inclusive

	Actual Conditions 1970 to 1979 (inclusive) [1,2,3,4]	Target El 7 James	Target El 8 James	Target El 10 James	Target El 12 James	Target El 14 James	Target El 15 James
Number of Events Requiring Control of Water Levels [3]	6	6	3	1	1	1	1
Number of Times Water Level Exceeds Target El at James Ave [3]	6	1	0	0	0	0	0
Total Duration Water Levels Exceeds Target El at James Ave.(days)	83	9	0	0	0	0	0
Average Duration that Water Level Exceeds Target El at James Ave.(days per event)	14	9	0	0	0	0	0
Maximum Duration that Water Level Exceeds Target El at James Ave. (days) [3]	47	9	0	0	0	0	0
Approximate Probability that Water Level Exceeds Target El at James Ave. (% per year) [5]	60%	10%	0%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 750 ft at Floodway Inlet	0	6	3	1	1	1	1
Total Duration Water Level Exceeds El 750 ft at Floodway Inlet (days)	0	83	54	36	31	17	8
Average Duration that Water Level Exceeds El 750 ft at Floodway Inlet.(days per event)	0	14	18	36	31	17	8
Maximum Duration that Water Level Exceeds El 750 ft at Floodway Inlet (days)	0	47	43	36	31	17	8
Number of Times Water Level Exceeds El 755 ft at Floodway Inlet	0	1	1	1	0	0	0
Total Duration Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	33	31	19	0	0	0
Average Duration that Water Level Exceeds El 755 ft at Floodway Inlet.(days per event)	0	33	31	19	0	0	0
Maximum Duration that Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	33	31	19	0	0	0
Number of Times Water Level Reaches El 760 ft at Floodway Inlet	0	1	0	0	0	0	0
Total Duration Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	9	0	0	0	0	0
Average Duration that Water Level Controlled at El 760 ft at Floodway Inlet.(days per event)	0	9	0	0	0	0	0
Maximum Duration that Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	9	0	0	0	0	0

Notes :

1. For Actual Conditions, Target El assumed to be El 7 ft James
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are acknowledged in these statistics as independent events
4. For actual conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately 6.5 ft James)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme A :

1. Achieve Controlled Target Level at James Avenue, whenever possible
2. Regulate Water Level at Floodway Inlet as Required to Achieve Target at James Ave.
3. Maximum Control Level at Inlet 760 ft

Data for 10 Year Record - 1980 to 1989 Inclusive

	Actual Conditions 1980 to 1989 (inclusive) [1,2,3,4]	Target El 7 James	Target El 8 James	Target El 10 James	Target El 12 James	Target El 14 James	Target El 15 James
Number of Events Requiring Control of Water Levels [3]	4	4	1	1	0	0	0
Number of Times Water Level Exceeds Target El at James Ave [3]	4	0	0	0	0	0	0
Total Duration Water Levels Exceeds Target El at James Ave.(days)	27	0	0	0	0	0	0
Average Duration that Water Level Exceeds Target El at James Ave.(days per event)	7	0	0	0	0	0	0
Maximum Duration that Water Level Exceeds Target El at James Ave. (days) [3]	14	0	0	0	0	0	0
Approximate Probability that Water Level Exceeds Target El at James Ave. (% per year) [5]	40%	0%	0%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 750 ft at Floodway Inlet	0	4	1	1	0	0	0
Total Duration Water Level Exceeds El 750 ft at Floodway Inlet (days)	0	27	12	8	0	0	0
Average Duration that Water Level Exceeds El 750 ft at Floodway Inlet.(days per event)	0	7	12	8	0	0	0
Maximum Duration that Water Level Exceeds El 750 ft at Floodway Inlet (days)	0	14	12	8	0	0	0
Number of Times Water Level Exceeds El 755 ft at Floodway Inlet	0	1	0	0	0	0	0
Total Duration Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	6	0	0	0	0	0
Average Duration that Water Level Exceeds El 755 ft at Floodway Inlet.(days per event)	0	6	0	0	0	0	0
Maximum Duration that Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	6	0	0	0	0	0
Number of Times Water Level Reaches El 760 ft at Floodway Inlet	0	0	0	0	0	0	0
Total Duration Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	0	0	0	0	0	0
Average Duration that Water Level Controlled at El 760 ft at Floodway Inlet.(days per event)	0	0	0	0	0	0	0
Maximum Duration that Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	0	0	0	0	0	0

Notes :

1. For Actual Conditions, Target El assumed to be El 7 ft James
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are acknowledged in these statistics as independent events
4. For actual conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately 6.5 ft James)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme A :

1. Achieve Controlled Target Level at James Avenue, whenever possible
2. Regulate Water Level at Floodway Inlet as Required to Achieve Target at James Ave.
3. Maximum Control Level at Inlet 760 ft

Data for 12 Year Record - 1990 to 2001 Inclusive

	Actual Conditions 1990 to 2001 (inclusive) [1,2,3,4]	Target El 7 James	Target El 8 James	Target El 10 James	Target El 12 James	Target El 14 James	Target El 15 James
Number of Events Requiring Control of Water Levels [3]	11	11	9	7	3	3	2
Number of Times Water Level Exceeds Target El at James Ave [3]	11	3	2	0	0	0	0
Total Duration Water Levels Exceeds Target El at James Ave.(days)	270	18	6	0	0	0	0
Average Duration that Water Level Exceeds Target El at James Ave.(days per event)	25	6	3	0	0	0	0
Maximum Duration that Water Level Exceeds Target El at James Ave. (days) [3]	52	12	5	0	0	0	0
Approximate Probability that Water Level Exceeds Target El at James Ave. (% per year) [5]	92%	25%	17%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 750 ft at Floodway Inlet	3	11	9	7	3	3	2
Total Duration Water Level Exceeds El 750 ft at Floodway Inlet (days)	7	270	209	122	59	25	15
Average Duration that Water Level Exceeds El 750 ft at Floodway Inlet.(days per event)	2	25	23	17	20	8	8
Maximum Duration that Water Level Exceeds El 750 ft at Floodway Inlet (days)	4	52	35	35	31	14	12
Number of Times Water Level Exceeds El 755 ft at Floodway Inlet	0	7	4	3	2	0	0
Total Duration Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	94	53	27	6	0	0
Average Duration that Water Level Exceeds El 755 ft at Floodway Inlet.(days per event)	0	13	13	9	3	0	0
Maximum Duration that Water Level Exceeds El 755 ft at Floodway Inlet (days)	0	34	17	14	5	0	0
Number of Times Water Level Reaches El 760 ft at Floodway Inlet	0	3	2	0	0	0	0
Total Duration Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	18	6	0	0	0	0
Average Duration that Water Level Controlled at El 760 ft at Floodway Inlet.(days per event)	0	6	3	0	0	0	0
Maximum Duration that Water Level Controlled at El 760 ft at Floodway Inlet (days)	0	12	5	0	0	0	0

Notes :

1. For Actual Conditions, Target El assumed to be El 7 ft James
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. Multiple events in one year are acknowledged in these statistics as independent events
4. For actual conditions, these numbers represent the number of times the river level would exceed the normal summer controlled level (approximately 6.5 ft James)
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme B : ***1. Regulate Water Level at Floodway at Max Allowable El (Unless Governed by Rule 2)***
2. If Water Level at James Would Be Less Than 7 ft by Following Rule 1, Surcharge at Floodway Inlet as Required to Achieve 7 ft James

Data for 32 Year Record - 1970 to 2001 Inclusive

	Actual Conditions 1970 to 2001 (inclusive)[1,2,3]	Max Upstream Level 756 ft @ Floodway Inlet	Max Upstream Level 758 ft @ Floodway Inlet	Max Upstream Level 760 ft @ Floodway Inlet	Max Upstream Level 762 ft @ Floodway Inlet
Number of Times Water Level Exceeds El 7 ft at James Ave[4]	21	6	3	4	1
Total Duration Water Levels Exceeds El 7 ft at James Ave.(days)	380	106	60	27	2
Average Duration Water Levels Exceeds El 7 ft at James Ave.(days)	18	18	20	7	2
Maximum Duration Water Levels Exceeds El 7 ft at James Ave.(days)	113	66	51	21	2
Probability that Water Level Exceeds El 7 ft at James Ave. (% per year) [5]	66%	19%	9%	13%	3%
Number of Times Water Level Exceeds El 8 ft at James Ave[4]	13	4	3	2	0
Total Duration Water Levels Exceeds El 8 ft at James Ave.(days)	275	81	36	18	0
Average Duration Water Levels Exceeds El 8 ft at James Ave.(days)	21	20	12	9	0
Maximum Duration Water Levels Exceeds El 8 ft at James Ave.(days)	90	59	30	12	0
Approximate Probability that Water Level Exceeds El 8 ft at James Ave. (% per year) [5]	41%	13%	9%	6%	0%
Number of Times Water Level Exceeds El 10 ft at James Ave[4]	9	4	1	0	0
Total Duration Water Levels Exceeds El 10 ft at James Ave.(days)	166	34	4	0	0
Average Duration Water Levels Exceeds El 10 ft at James Ave.(days)	18	9	4	0	0
Maximum Duration Water Levels Exceeds El 10 ft at James Ave.(days)	79	25	4	0	0
Approximate Probability that Water Level Exceeds El 10 ft at James Ave. (% per year) [5]	28%	13%	3%	0%	0%
Number of Times Water Level Exceeds El 12 ft at James Ave[4]	4	1	0	0	0
Total Duration Water Levels Exceeds El 12 ft at James Ave.(days)	90	3	0	0	0
Average Duration Water Levels Exceeds El 12 ft at James Ave.(days)	23	3	0	0	0
Maximum Duration Water Levels Exceeds El 12 ft at James Ave.(days)	62	3	0	0	0
Approximate Probability that Water Level Exceeds El 12 ft at James Ave. (% per year) [5]	13%	3%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	21	21	21	21
Total Duration of Inlet Gate Operation (days)	n/a	380	380	380	380
Average Duration of Inlet Gate Operation (days per event)	n/a	18	18	18	18
Maximum Duration of Inlet Gate Operation (days)	n/a	113	113	113	113
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	66%	66%	66%	66%
Number of Times Water Level Reaches Max Allowable at Floodway Inlet[4]	n/a	6	3	4	1
Total Duration Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	106	60	27	2
Average Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet.(days per event)	n/a	18	20	7	2
Maximum Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	66	51	21	2
Probability that Water Level Will Reach Maixmum Allowable at Floodway Inlet (% per year) [5]	n/a	19%	9%	13%	3%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are acknowledged in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme B : ***1. Regulate Water Level at Floodway at Max Allowable El (Unless Governed by Rule 2)***
2. If Water Level at James Would Be Less Than 7 ft by Following Rule 1, Surcharge at Floodway Inlet as Required to Achieve 7 ft James

Data for 10 Year Record - 1970 to 1979 Inclusive

	Actual Conditions 1970 to 1979 (inclusive)[1,2,3]	Max Upstream Level 756 ft @ Floodway Inlet	Max Upstream Level 758 ft @ Floodway Inlet	Max Upstream Level 760 ft @ Floodway Inlet	Max Upstream Level 762 ft @ Floodway Inlet
Number of Times Water Level Exceeds El 7 ft at James Ave[4]	6	1	1	1	0
Total Duration Water Levels Exceeds El 7 ft at James Ave.(days)	83	33	23	9	0
Average Duration Water Levels Exceeds El 7 ft at James Ave.(days)	14	33	23	9	0
Maximum Duration Water Levels Exceeds El 7 ft at James Ave.(days)	47	33	23	9	0
Probability that Water Level Exceeds El 7 ft at James Ave. (% per year) [5]	60%	10%	10%	10%	0%
Number of Times Water Level Exceeds El 8 ft at James Ave[4]	3	1	1	0	0
Total Duration Water Levels Exceeds El 8 ft at James Ave.(days)	54	29	16	0	0
Average Duration Water Levels Exceeds El 8 ft at James Ave.(days)	18	29	16	0	0
Maximum Duration Water Levels Exceeds El 8 ft at James Ave.(days)	43	29	16	0	0
Approximate Probability that Water Level Exceeds El 8 ft at James Ave. (% per year) [5]	30%	10%	10%	0%	0%
Number of Times Water Level Exceeds El 10 ft at James Ave[4]	1	1	0	0	0
Total Duration Water Levels Exceeds El 10 ft at James Ave.(days)	36	12	0	0	0
Average Duration Water Levels Exceeds El 10 ft at James Ave.(days)	36	12	0	0	0
Maximum Duration Water Levels Exceeds El 10 ft at James Ave.(days)	36	12	0	0	0
Approximate Probability that Water Level Exceeds El 10 ft at James Ave. (% per year) [5]	10%	10%	0%	0%	0%
Number of Times Water Level Exceeds El 12 ft at James Ave[4]	1	0	0	0	0
Total Duration Water Levels Exceeds El 12 ft at James Ave.(days)	31	0	0	0	0
Average Duration Water Levels Exceeds El 12 ft at James Ave.(days)	31	0	0	0	0
Maximum Duration Water Levels Exceeds El 12 ft at James Ave.(days)	31	0	0	0	0
Approximate Probability that Water Level Exceeds El 12 ft at James Ave. (% per year) [5]	10%	0%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	6	6	6	6
Total Duration of Inlet Gate Operation (days)	n/a	83	83	83	83
Average Duration of Inlet Gate Operation (days per event)	n/a	14	14	14	14
Maximum Duration of Inlet Gate Operation (days)	n/a	47	47	47	47
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	60%	60%	60%	60%
Number of Times Water Level Reaches Max Allowable at Floodway Inlet[4]	n/a	1	1	1	0
Total Duration Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	33	23	9	0
Average Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet.(days per event)	n/a	33	23	9	0
Maximum Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	33	23	9	0
Probability that Water Level Will Reach Maixmum Allowable at Floodway Inlet (% per year) [5]	n/a	10%	10%	10%	0%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are acknowledged in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme B : ***1. Regulate Water Level at Floodway at Max Allowable El (Unless Governed by Rule 2)***
2. If Water Level at James Would Be Less Than 7 ft by Following Rule 1, Surcharge at Floodway Inlet as Required to Achieve 7 ft James

Data for 10 Year Record - 1980 to 1989 Inclusive

	Actual Conditions 1980 to 1989 (inclusive)[1,2,3]	Max Upstream Level 756 ft @ Floodway Inlet	Max Upstream Level 758 ft @ Floodway Inlet	Max Upstream Level 760 ft @ Floodway Inlet	Max Upstream Level 762 ft @ Floodway Inlet
Number of Times Water Level Exceeds El 7 ft at James Ave[4]	4	1	0	0	0
Total Duration Water Levels Exceeds El 7 ft at James Ave.(days)	27	1	0	0	0
Average Duration Water Levels Exceeds El 7 ft at James Ave.(days)	7	1	0	0	0
Maximum Duration Water Levels Exceeds El 7 ft at James Ave.(days)	14	1	0	0	0
Probability that Water Level Exceeds El 7 ft at James Ave. (% per year) [5]	40%	10%	0%	0%	0%
Number of Times Water Level Exceeds El 8 ft at James Ave[4]	1	0	0	0	0
Total Duration Water Levels Exceeds El 8 ft at James Ave.(days)	12	0	0	0	0
Average Duration Water Levels Exceeds El 8 ft at James Ave.(days)	12	0	0	0	0
Maximum Duration Water Levels Exceeds El 8 ft at James Ave.(days)	12	0	0	0	0
Approximate Probability that Water Level Exceeds El 8 ft at James Ave. (% per year) [5]	10%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 10 ft at James Ave[4]	1	0	0	0	0
Total Duration Water Levels Exceeds El 10 ft at James Ave.(days)	8	0	0	0	0
Average Duration Water Levels Exceeds El 10 ft at James Ave.(days)	8	0	0	0	0
Maximum Duration Water Levels Exceeds El 10 ft at James Ave.(days)	8	0	0	0	0
Approximate Probability that Water Level Exceeds El 10 ft at James Ave. (% per year) [5]	10%	0%	0%	0%	0%
Number of Times Water Level Exceeds El 12 ft at James Ave[4]	0	0	0	0	0
Total Duration Water Levels Exceeds El 12 ft at James Ave.(days)	0	0	0	0	0
Average Duration Water Levels Exceeds El 12 ft at James Ave.(days)	0	0	0	0	0
Maximum Duration Water Levels Exceeds El 12 ft at James Ave.(days)	0	0	0	0	0
Approximate Probability that Water Level Exceeds El 12 ft at James Ave. (% per year) [5]	0%	0%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	4	4	4	4
Total Duration of Inlet Gate Operation (days)	n/a	27	27	27	27
Average Duration of Inlet Gate Operation (days per event)	n/a	7	7	7	7
Maximum Duration of Inlet Gate Operation (days)	n/a	14	14	14	14
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	40%	40%	40%	40%
Number of Times Water Level Reaches Max Allowable at Floodway Inlet[4]	n/a	1	0	0	0
Total Duration Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	1	0	0	0
Average Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet.(days per event)	n/a	1	0	0	0
Maximum Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	1	0	0	0
Probability that Water Level Will Reach Maixmum Allowable at Floodway Inlet (% per year) [5]	n/a	10%	0%	0%	0%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are acknowledged in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).

Study of Control of Summer Water Levels in Winnipeg

Comparison of Optional Hypothetical Control Schemes

Rules of Control Scheme B : ***1. Regulate Water Level at Floodway at Max Allowable El (Unless Governed by Rule 2)***
2. If Water Level at James Would Be Less Than 7 ft by Following Rule 1, Surcharge at Floodway Inlet as Required to Achieve 7 ft James

Data for 12 Year Record - 1990 to 2001 Inclusive

	Actual Conditions 1990 to 2001 (inclusive)[1,2,3]	Max Upstream Level 756 ft @ Floodway Inlet	Max Upstream Level 758 ft @ Floodway Inlet	Max Upstream Level 760 ft @ Floodway Inlet	Max Upstream Level 762 ft @ Floodway Inlet
Number of Times Water Level Exceeds El 7 ft at James Ave[4]	11	4	2	3	1
Total Duration Water Levels Exceeds El 7 ft at James Ave.(days)	270	72	37	18	2
Average Duration Water Levels Exceeds El 7 ft at James Ave.(days)	25	18	19	6	2
Maximum Duration Water Levels Exceeds El 7 ft at James Ave.(days)	52	32	28	12	2
Probability that Water Level Exceeds El 7 ft at James Ave. (% per year) [5]	92%	33%	17%	25%	8%
Number of Times Water Level Exceeds El 8 ft at James Ave[4]	9	3	2	2	0
Total Duration Water Levels Exceeds El 8 ft at James Ave.(days)	209	52	20	18	0
Average Duration Water Levels Exceeds El 8 ft at James Ave.(days)	23	17	10	9	0
Maximum Duration Water Levels Exceeds El 8 ft at James Ave.(days)	35	30	14	12	0
Approximate Probability that Water Level Exceeds El 8 ft at James Ave. (% per year) [5]	75%	25%	17%	17%	0%
Number of Times Water Level Exceeds El 10 ft at James Ave[4]	7	3	1	0	0
Total Duration Water Levels Exceeds El 10 ft at James Ave.(days)	122	22	4	0	0
Average Duration Water Levels Exceeds El 10 ft at James Ave.(days)	17	7	4	0	0
Maximum Duration Water Levels Exceeds El 10 ft at James Ave.(days)	35	13	4	0	0
Approximate Probability that Water Level Exceeds El 10 ft at James Ave. (% per year) [5]	58%	25%	8%	0%	0%
Number of Times Water Level Exceeds El 12 ft at James Ave[4]	3	1	0	0	0
Total Duration Water Levels Exceeds El 12 ft at James Ave.(days)	59	3	0	0	0
Average Duration Water Levels Exceeds El 12 ft at James Ave.(days)	20	3	0	0	0
Maximum Duration Water Levels Exceeds El 12 ft at James Ave.(days)	31	3	0	0	0
Approximate Probability that Water Level Exceeds El 12 ft at James Ave. (% per year) [5]	25%	8%	0%	0%	0%
Number of Times Gates must be operated to control flow[4]	n/a	11	11	11	11
Total Duration of Inlet Gate Operation (days)	n/a	270	270	270	270
Average Duration of Inlet Gate Operation (days per event)	n/a	25	25	25	25
Maximum Duration of Inlet Gate Operation (days)	n/a	52	52	52	52
Approximate Probability that Gates Must be Used (% per year) [5]	n/a	92%	92%	92%	92%
Number of Times Water Level Reaches Max Allowable at Floodway Inlet[4]	n/a	4	2	3	1
Total Duration Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	72	37	18	2
Average Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet.(days per event)	n/a	18	19	6	2
Maximum Duration that Water Level Controlled at Maximum Allowable at Floodway Inlet (days)	n/a	32	28	12	2
Probability that Water Level Will Reach Maixmum Allowable at Floodway Inlet (% per year) [5]	n/a	33%	17%	25%	8%

Notes:
1. Flow year 2002 adjusted to represent no control using Floodway
2. Summer Control Period from June 1 (or end of spring flood period if necessary) to Oct.15
3. n/a represents not applicable
4. Multiple events in one year are acknowledged in these statistics as independent events
5. Probability based on statistics of the flow record only. Probability approximated by the number of occurrences divided by the number of years (times 100%).