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# **FLOOD PROTECTION FOR WINNIPEG**

**REPORT ON:**  
**PART III - PRE-FEASIBILITY STUDIES**

**MARCH, 2000**

Submitted by:

**KGS**  
**GROUP**

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**INTERNATIONAL JOINT COMMISSION  
FLOOD PROTECTION FOR WINNIPEG  
STUDY PART III**

**MARCH, 2000**

# FLOOD PROTECTION FOR WINNIPEG

## EXECUTIVE SUMMARY

### I. Introduction

*Flood Protection for Winnipeg*, is one of several studies that the International Joint Commission has commissioned in its investigation of the 1997 Red River “Flood of the Century” for the Governments of Canada and the United States. For this study, the Commission has worked in partnership with the City of Winnipeg, and the Province of Manitoba to fund the analysis of the flood risk for the City of Winnipeg. KGS Group of Winnipeg conducted the study and a Steering Committee of representatives from the city, province and federal governments oversaw the work.

The study has found that in 1997, the Winnipeg flood defenses worked to the limit of their capacity. Winnipeg escaped the damage that could have occurred if the capacity of the flood protection works had been exceeded, or if there had been failures in one or more of the flood protection structures, or if there had been rainfall during the peak flood period. There is little margin of safety if the City has to face another flood similar to the one in 1997. For a larger flood, the City flood protection defenses need to be improved.

The major flood control facilities that currently provide protection for Winnipeg were reviewed. These are the Red River Floodway, the Portage Diversion, the Shellmouth Dam, and the diking systems and related flood protection infrastructure within the City.

In the first two phases of this study, the flood defenses, identified areas of vulnerability, and proposed options for reducing the flood risks to the City were examined. The final phase of this study, reported in this document, has identified the leading options for improving flood defenses that should be investigated in more detail.

### II. Potential Damages

The flood protection system in place has limited hydraulic capacity. If that capacity is exceeded there is a high risk of major flood damage. Potential flood damages were estimated using an approach that combines:

- hydraulic information on maximum water levels for a range of flood events
- an economic database of assessed values of residential, commercial and public buildings in Winnipeg that were provided by the City of Winnipeg Property Assessment Department
- a Geographic Information System (GIS) database showing the location of properties, buildings, and infrastructure within the City of Winnipeg
- a GIS database of manhole rim elevations (also from the City of Winnipeg) from which to determine topographic variations throughout the City
- estimates of damages that would occur as a function of the assessed value and depth of flooding at a building. This projection was based on a variety of actual damages that have been documented on flood events in other cities, including the massive flooding at Grand Forks, North Dakota in 1997.

The analysis of potential flood damages demonstrated that, had flood control measures failed in 1997, the total damages to Winnipeg could have been about \$760 million. These damages could result from:

- damages to buildings and contents
- temporary relocation costs
- damages to City infrastructure
- flood fighting and emergency response costs.

If a major flood occurs on the scale of that which was estimated to have occurred in 1826, an estimated \$5.8 billion (1999 dollars) in flood damages could be incurred. This flood has approximately a 20% chance of occurring or being exceeded within the next 50 years. There is also an estimated 10% chance that a flood of 250,000 cfs or more could occur and cause of damages over \$10 billion. These damage estimates exclude loss of income caused by the extended shutdown of the majority of the businesses in Winnipeg, and the adverse social implications that would accompany it.

### **III. Current Capacity of Flood Protection Works**

KGS Group has reviewed the individual capacities of each of the major flood protection works and estimated the overall ultimate discharge capacities of the existing system. The values are presented below:

- Flow through Winnipeg downstream of the confluence with the Assiniboine River, 71,000 cubic feet per second (cfs)
- Flow through the Red River Floodway, 73,000 cfs, associated with a maximum upstream water level of 774 ft (a tentative estimate of the level that would not compromise the West Dike from erosion that south winds blowing over the “Red Sea” could cause.)
- Maximum diverted flows of 25,000 cfs from the Assiniboine River at the Portage Diversion, and a reduction of 7,000 cfs due to the Shellmouth Dam

On this basis, Winnipeg is reliably protected against a total natural flow of 176,000 cfs (approximately a 1:110 year flood), which is approximately 7,000 cfs more than the original design (see Table ES-1). This capacity requires a water level upstream of the Red River Floodway Inlet approximately 3 ft above the state of nature for that flow magnitude. The capacity that would not require exceeding the state of nature water level at the Red River Floodway Inlet would be approximately 168,000 cfs.

Protection against a flow greater than 168,000 cfs, or even 176,000 cfs, is possible, if all aspects of the flood fighting campaign were to go well. However, the chance of such a success occurring is low, and reliance on a capacity in excess of 176,000 cfs is unacceptably optimistic.

There is approximately a 37% chance that this reliable capacity of the flood protection system in Winnipeg will be exceeded at least once in the next 50 years.

**Table ES-1. Capacity of Winnipeg Flood Protection System (cfs)**

Item	Flows Adopted in Original Design of Flood Control System (1958)	Conditions That Occurred in 1997	Conditions Associated with Reliable Ultimate Capacity
Reduction in Assiniboine flood contribution due to Shellmouth Dam	7,000	4,000	7,000
Diverted Flow at Portage Diversion	25,000	12,000	25,000
Inflow to Winnipeg from Assiniboine River and other local watersheds	6,300	1,000	6,000
Red River Flow Upstream of The Forks	70,700	79,000	65,000
Diversion at Red River Floodway	60,000	67,000	73,000 <sup>1</sup>
Natural total flow capable of being managed	169,000	163,000	176,000 <sup>1</sup>
Estimated probability of being exceeded in 50 year period	27 % (estimated in 1958)	43 %	37%

Note: 1. Requires further assessment of wind effects on the "Red Sea" and their effect on the safe water level at the Floodway inlet; implies water level about 3 ft above state of nature for this river flow.

#### **IV. Options for Increasing Flood Protection**

A range of measures were studied at a pre-feasibility intensity of assessment:

1. Expand Red River Floodway
2. Add a separate Floodway channel
3. Raise Floodway Bridges
4. Modify East Embankment of Red River Floodway at entrance
5. Raise West Dike / West Embankment of the Red River Floodway
6. Construct Ste. Agathe Detention Structure
7. Raise Primary Dikes in Winnipeg
8. Improve City of Winnipeg Flood Protection Infrastructure – this consists of a wide range of upgrades and additions that must be reviewed in more detail than was possible in this screening level of assessment.

Steps should be taken to significantly reduce Winnipeg's exposure to flood risk. There are precedents of protection of major concentrations of population comparable to Winnipeg for floods of 1 in 500 years to 1 in 1,000 years flood events. There are combinations of measures from the list above that could provide this level of protection for Winnipeg, and would be economically viable. This economic viability is based on accepted methods of analysis. A key recommendation of the study is to implement protection works which would provide security up to the range of 1 in 500 year to 1 in 1,000 year flood.

The results of the pre-feasibility engineering studies show that there are three broad groups of potential mitigation measures that could be implemented. They are summarized in Table ES-2.

**Table ES-2**  
**Summary of Options for Improving the Flood Protection system for Winnipeg**

OPTIONS	LIMIT TO LEVEL OF PROTECTION	PRESENT VALUE OF COST <sup>1</sup> (Millions \$)	PRESENT VALUE OF BENEFITS (Millions \$)	NET BENEFITS (Millions \$)	B/C RATIO
Combination 1 : <ul style="list-style-type: none"> <li>• Expand Floodway</li> <li>• Raise West Dike / West Embankment</li> <li>• Raise Primary Dike in Wpg (average 2 ft )</li> <li>• Improve City Flood Protection Infrastructure</li> </ul>	1 in 500 Year	750	1,200	450	1.6
Combination 2 : <ul style="list-style-type: none"> <li>• Ste. Agathe Detention Structure</li> <li>• Upgrade City Flood Protection Infrastructure</li> </ul>	1in 1,000 Year (at least)	475 <sup>2</sup>	2,000 <sup>3</sup>	1,525	4.2
Combination 3 : <ul style="list-style-type: none"> <li>• Remove East Embankment at Floodway Entrance</li> <li>• Modify 3 to 6 Floodway Bridges</li> <li>• Raise West Dike / West Embankment</li> <li>• Improve City Flood Protection Infrastructure</li> </ul>	1 in 230 Year	240	740	500	3.1

- Note:
1. This cost excludes the cost of upgrades to City internal drainage system that will be required after the overall plan is selected
  2. This cost includes \$21 million for present value of estimated damages that would occur in next 50 years. It does **not include** the cost of obtaining flood easement rights.
  3. This benefit includes the estimated reduction in damages that would be obtained in the area between the Floodway Inlet and the Ste. Agathe Detention Structure

**Combination 1**

This combination would consist of :

- Expansion of the Red River Floodway
- Raising of the crest level of the West Dike and West Embankment at the entrance of the Red River Floodway
- Increasing the Primary Dike crest by an average of 2 ft above the Flood Protection Level, where required
- Improving the flood protection infrastructure in Winnipeg

The expansion of the Red River Floodway could be achieved by a combination of deepening and widening in such a way as to minimize the impact on the adjacent facilities such as bridges

and utility crossings. Potentially high river levels downstream of the Floodway Outlet could cause backwater effects in Winnipeg that limit the cost effectiveness of this option for floods in excess of 1 in 300 year, and make it impractical to prevent all flooding in Winnipeg for flood events greater than about 1 in 500 year magnitude.

This measure should be combined with an improved flood protection infrastructure in the City of Winnipeg. Work would include:

- Flood pumping reliability upgrades
- Installation of land drainage sewer gate structures
- Sewer manhole extraneous flow reduction
- Culvert improvements
- Flood protection upgrades to the South End Pollution Control Centre
- Sewer system isolation in areas protected by secondary dikes
- Procurement of miscellaneous flood fighting equipment
- Riverbank stabilization on public properties
- Upgrades to the Primary Dike System to provide a consistent level of protection throughout the City

Raising the crest level of the West Dike would permit exceeding the state of nature water level at the Red River Floodway Inlet without an unacceptable risk of failure of the West Dike. This permits a significant reduction in the cost of the Floodway expansion, but would cause additional flooding upstream. The issue of compensation to upstream residents for flooding caused by water levels above the state of nature would have to be resolved before proceeding with raising the West Dike.

The cost of Combination 1 as shown in Table ES-1 does not include an allowance for the additional upgrades to the internal drainage system that would be required. It should also be recognized, that the costs of this aspect will be more than for the other combinations.

### ***Combination 2***

This combination offers the greatest latitude in providing security against extreme floods in the Red River that are improbable but nevertheless possible. It consists of constructing a water detention structure across the Red River Valley about 1.5 miles upstream of Ste. Agathe, and enhancing the flood protection system within the City of Winnipeg. The structure would reduce flood flows in the Red River at Winnipeg by detaining water, when necessary, in the flood pool that forms under high flood conditions in the valley between Emerson and Ste. Agathe (the so called "Red Sea").

The detention of water would be controlled south of Ste. Agathe (see Plate 9.1) by building an earth structure about 25 miles long across the valley, with a control structure adjacent to the river that would be capable of passing the normal river flow without undue restriction. The height of the structure across the plain would average at about 20 ft in height. The river control structure would be designed to pass ordinary flows without causing water levels to rise above the river banks. At times of high floods, however, when the flow becomes greater than the capacity of the City of Winnipeg Flood Protection System (approximately at the 1997 flood magnitude), the gates in the Ste. Agathe Detention Structure would be operated to detain water temporarily on the lands upstream of the Structure. The outflow would be maintained at approximately 125,000 to 135,000 cfs depending on the flow in the Assiniboine River. At this



controlled release, the hydraulic capacity of the Red River Floodway and the Red River through Winnipeg would be capable of maintaining water levels that would not cause flooding in Winnipeg.

This measure should be combined with an improved flood protection infrastructure in the City of Winnipeg as proposed for Combination 1.

The major advantage of this combination of measures is that it can provide protection up to at least the 1 in 1,000 year flood magnitude in the area north of the Ste. Agathe site. This would include the residents upstream of the Red River Floodway Inlet Control Structure, in the City of Winnipeg, and in areas north of the City, principally vulnerable areas near Selkirk.

A major drawback is the impact due to increased water levels upstream of Ste Agathe. Under flood conditions equivalent to those of 1826, the water level at Morris, for example, would be an estimated 1.5 ft above the state of nature condition.

Implementation of the Ste. Agathe Detention Structure would require a resolution of compensation to the residents upstream of Ste. Agathe, and/or the cost of increasing the level of flood protection in those communities, wherever that is practical. This cost should then be factored into a revised economic analysis to confirm that this combination of measures would be economically viable. This is clearly beyond the scope of KGS Group's study, and is best resolved by government agencies in consultation with the public.

### **Combination 3**

This includes, in increasing level of priority :

- Modification of the East Embankment at the Red River Floodway entrance to make the channel entrance more hydraulically efficient
- Raising of the upstream 3 to 6 bridges (exact number would be the subject of more detailed study and assessment) over the Floodway to make the channel more hydraulically efficient at flood flows exceeding the 1997 magnitude
- Raising the West Dike / West Embankment to make it possible to sustain a water level of 778 ft at the Inlet Control Structure without a high risk of overtopping the dikes
- Improving the flood protection infrastructure within the City of Winnipeg as is also proposed for Options 1 and 2

This combination could increase the level of security to the 1 in 230 year magnitude at most (approximately a natural flood peak of 210,000 cfs).

However, the increase in water level above the state of nature at the Floodway Inlet would cause increased flooding potential upstream, as described for Combination 1. It would also require resolution before implementation of raising the West Dike.

## **IV. OTHER ISSUES**

Winnipeg was fortunate in 1997 that the flood peak did not coincide with significant rainfall, since the internal drainage system would not have been able to cope with even average runoff in coincidence with the high river water levels that prevailed. This emphasized the need for a review and optimization of improvements to this component of the flood protection system. This



complex undertaking has been postponed until the overall strategy of flood protection improvement has been selected. Combination of both studies would have made this planning process intractable. It is recognized, however, that some of the measures or combinations of measures would require more investment in upgrades to the internal drainage system than others, and this has been noted for those that would be so affected.

A wide range of issues were identified that will require further work and assessment. The flood protection system for the City of Winnipeg is complex and of vital importance to the welfare of the City and the province. It merits far more effort to improve, enhance, optimize, and ensure on-going safety than was possible within the limitations of this study. Over 50 issues that require further review, assessment, and action are listed in the Recommendations in Sections 16 and 17. Although it is difficult to segregate priorities, five have been selected by KGS Group to be particularly worthy of mention in this summary. These are in addition to the obvious need to carry the selection of the flood improvement strategy to a wider spectrum of scrutiny and public debate :

- Preparation of a comprehensive emergency preparedness manual that covers the best plans to manage a wide range of floods, including floods that exceed the design capacity of the protection system by a wide margin
- Establishment of a dam safety program in accordance with the Canadian Dam Safety Guidelines so that the major water retaining structures that are critical components of the flood protection system receive systematic and thorough reviews with respect to modern design practices
- Review, refinement, and possible implementation of measures that would improve the reliability of the Red River Floodway Inlet Control Structure
- A detailed review and investigation of the problem with managing spring ice runs at the Portage Diversion, including assessment of means to mitigate the frequent concern with the safety of the Portage Diversion Structures
- Completion of a hydraulic study of the wind effects on the Red Sea, and how those effects influence the selection of a safe, permissible water level.

# TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY .....	-i-
1.0 INTRODUCTION.....	1
2.0 REVIEW OF PARTS I AND II .....	4
2.1 GENERAL.....	4
2.2 POTENTIAL DAMAGES.....	5
2.3 CURRENT CAPACITY OF FLOOD PROTECTION WORKS .....	5
2.4 OPTIONS FOR MITIGATION .....	6
2.5 OTHER FACTORS AFFECTING POTENTIAL FLOODING.....	7
3.0 OVERVIEW OF STUDY PART III.....	9
3.1 GENERAL.....	9
3.2 DEFINITION OF PRE-FEASIBILITY LEVEL OF STUDY.....	9
4.0 BASIS FOR ECONOMIC ANALYSES .....	12
4.1 GENERAL.....	12
4.2 POTENTIAL FLOOD DAMAGES IN WINNIPEG FOR EXISTING CONDITIONS .....	12
4.3 METHODOLOGY FOR ECONOMIC ANALYSIS.....	13
4.4 ECONOMIC PARAMETERS .....	14
4.5 ESTIMATION OF EXPECTED ANNUAL FLOOD DAMAGES .....	14
4.6 CONSIDERATION OF RISK AND UNCERTAINTY IN ESTIMATION OF FLOOD BENEFITS .....	15
4.7 ASSUMPTIONS REGARDING RED RIVER FLOODWAY OPERATION RULES .....	18
5.0 INCREASE IN PIER HEIGHTS OF RED RIVER FLOODWAY BRIDGES .....	20
5.1 OVERVIEW .....	20
5.2 DESIGN CRITERIA.....	21
5.3 DESCRIPTION OF OPTIONS .....	21
5.4 INTERDEPENDENCIES WITH OTHER MEASURES .....	22
5.5 ESTIMATION OF COSTS .....	22
5.6 ECONOMIC ANALYSIS .....	23
6.0 MODIFICATION OF EAST EMBANKMENT OF RED RIVER FLOODWAY ENTRANCE .....	24
7.0 RED RIVER FLOODWAY- INCREASE OF DISCHARGE CAPACITY .....	25
7.1 GENERAL.....	25
7.2 EXPANSION OF EXISTING RED RIVER FLOODWAY CHANNEL.....	25
7.2.1 Overview .....	25
7.2.2 Preliminary Design Criteria .....	26
7.2.3 Description .....	27
7.2.4 Cost Estimation .....	40
7.2.5 Economic Analysis.....	44
7.3 ADDITIONAL SEPARATE RED RIVER FLOODWAY CHANNEL.....	46
7.3.1 Overview .....	46
7.3.2 Preliminary Design Criteria .....	46
7.3.3 Description .....	46
7.3.4 Cost Estimation .....	52
7.3.5 Economic Analysis.....	53
7.4 ALTERNATIVE FLOODWAY MODIFICATIONS .....	53
8.0 RAISE WEST DIKE AND WEST EMBANKMENT OF RED RIVER FLOODWAY .....	55
8.1 OVERVIEW .....	55
8.2 DESIGN CRITERIA.....	55
8.3 DESCRIPTION .....	55
8.4 ISSUES .....	56
8.5 COST ESTIMATION .....	57
8.6 ECONOMIC ANALYSIS .....	57
9.0 STE. AGATHE DETENTION STRUCTURE.....	58
9.1 OVERVIEW .....	58
9.2 DESCRIPTION .....	58
9.3 PRELIMINARY DESIGN CRITERIA .....	65
9.4 ISSUES .....	71

9.4.1	Environmental Issues.....	71
9.4.2	Impact on Flooding in Southern Manitoba .....	71
9.4.3	Backup Protection for Red River Floodway Inlet Control Structure .....	72
9.5	COST ESTIMATION .....	73
9.6	ECONOMIC ANALYSIS .....	73
10.0	IMPROVEMENTS TO CITY OF WINNIPEG FLOOD PROTECTION INFRASTRUCTURE.....	76
10.1	OVERVIEW .....	76
10.2	CATEGORIES .....	79
10.3	COSTS .....	79
10.4	APPLICATION OF BENEFIT / COST EVALUATION .....	80
10.4.1	“Prudent to do” Projects .....	80
10.4.2	Measures that Protect Against High River Levels .....	80
10.4.3	Measures to Enhance Internal Drainage in the City of Winnipeg.....	80
10.5	RESULTS OF ECONOMIC ANALYSIS .....	81
11.0	INCREASED FLOOD PROTECTION LEVEL IN WINNIPEG.....	83
11.1	OVERVIEW .....	83
11.2	DESIGN CRITERIA.....	83
11.3	DESCRIPTION .....	83
11.4	COST ESTIMATION .....	84
11.5	ECONOMIC ANALYSIS .....	85
12.0	ENVIRONMENTAL CONSIDERATIONS .....	87
12.1	OVERVIEW OF ANTICIPATED ENVIRONMENTAL PROCESS.....	87
12.2	ANTICIPATED APPROVAL REQUIREMENTS.....	88
12.3	STE. AGATHE DETENTION STRUCTURE.....	90
13.0	SELECTION OF PREFERRED OPTIONS.....	92
13.1	OBSERVATIONS.....	92
13.2	COMBINATIONS OF MEASURES TO PROTECT WINNIPEG .....	93
13.3	OTHER CONSIDERATIONS.....	95
14.0	SENSITIVITY ANALYSES.....	97
14.1	VARIATION IN GROWTH OF FUTURE BENEFITS.....	97
14.2	OTHER FLOOD FREQUENCY CURVES.....	97
14.4	ASSUMPTIONS FOR RISK AND UNCERTAINTY.....	99
14.5	EFFECTS OF INCLUSION OF FLOOD DAMAGES DUE TO RAISING WATER LEVEL ABOVE STATE OF NATURE AT FLOODWAY INLET .....	102
14.6	MISCELLANEOUS SENSITIVITY CHECKS .....	102
15.0	CONCLUSIONS.....	103
16.0	RECOMMENDATIONS .....	106
17.0	SUMMARY OF RECOMMENDED FUTURE WORK.....	109

Appendix A	Background of Panel of Experts
Appendix B	Terms of Reference
Appendix C	Computation of Expected Annual Damages
Appendix D	Costs of Floodway Bridge Modifications
Appendix E	Costs of Red River Floodway Modifications
Appendix F	Costs of Ste. Agathe Detention Structure

## LIST OF TABLES

	<b>Page</b>
Table 1	Red River Flood Peaks and Annual Probabilities of Being Exceeded ..... 4
Table 2	Capacity of Winnipeg Flood Protection System (cfs) ..... 6
Table 3	Estimated Flood Damages for City of Winnipeg (\$ millions, 1999)..... 12
Table 4	Confidence Limits to Acknowledge Risk and Uncertainty in Flood Protection Economics..... 17
Table 5	Data on Bridges over Red River Floodway ..... 20
Table 6	Summary of Options to Raise Bridges over Red River Floodway ..... 21
Table 7	Economic Analysis of Bridge Modifications..... 23
Table 8	Economic Analysis of Modifying East Embankment at Red River Floodway Entrance..... 24
Table 9	List of Facilities Potentially Affected by Floodway Expansion ..... 28
Table 10	Estimated Costs of Flood Protection in Winnipeg Against Backwater Effects ..... 41
Table 11	Summary of Economic Analysis of Red River Floodway Expansion ..... 45
Table 12	List of Facilities Potentially Affected by Additional Separate Floodway Channel and Adjustments Required ..... 47
Table 13	Estimated Quantities for Increases in West Dike and West Embankment Crest Level Increases ..... 56
Table 14	Estimated Costs for Raising Crest Levels of West Dike / West Embankment ..... 57
Table 15	Ste. Agathe Detention Structure ..... 65
Table 16	Summary of Potential Damages in Winnipeg and Southern Manitoba ..... 72
Table 17	Summary of Economic Analysis of Ste. Agathe Detention Structure..... 74
Table 18	Improvements to Flood Protection Infrastructure within City of Winnipeg..... 77
Table 19	Economic Indicators for Improvements of Flood Protection System in Winnipeg ..... 82
Table 20	Estimated Costs of Raising Primary Dikes..... 85
Table 21	Economic Indications for Permanent Raising of Primary Dikes..... 85
Table 22	Summary of Combined Measures for Increased Security of Flood Protection – Major Improvements..... 94
Table 23	Summary of Combinations of Measures for Increased Security of Flood Protection – Lesser Capacity Options ..... 95
Table 24	Comparison of Benefits With and Without ..... 100
Table 25	Comparison of Benefits With and Without ..... 101
Table 26	List of Additional Work Action / Required..... 109

## LIST OF FIGURES

	<b>Pages</b>
Figure 1	Flood Damages in Winnipeg for Existing Conditions Within the City ..... 13
Figure 2	Estimate of EAD Using “Monte Carlo” Simulations ..... 16
Figure 3	Estimates of Probability of Failure of Flood Protection System Within Winnipeg... 18
Figure 4	Stage-Discharge Relationship for Existing Red River Floodway (with existing bridges)..... 32
Figure 5	Increase in Discharge Capacity of Expanded Red River Floodway (No Depth Increase) ..... 32
Figure 6	Increase in Discharge Capacity of Expanded Red River Floodway (with 5 Foot Depth Increase) ..... 33
Figure 7	Increase in Discharge Capacity of Expanded Red River Floodway (with 10 Foot Depth Increase)..... 33
Figure 8	Estimated Excavation Quantities for Expanded Red River Floodway (No Depth Increase) ..... 34
Figure 9	Estimated Excavation Quantities for Expanded Red River Floodway (with 5 Foot Depth Increase) ..... 34
Figure 10	Estimated Excavation Quantities for Expanded Red River Floodway (with 10 Foot Depth Increase)..... 35
Figure 11	Stage-Discharge Relationship for Red River at Floodway Outlet ..... 36
Figure 12	Estimated Cost for Expanded Red River Floodway (No Depth Increase)..... 41
Figure 13	Estimated Cost for Expanded Red River Floodway (with 5 Foot Depth Increase). 42
Figure 14	Estimated Cost for Expanded Red River Floodway (with 10 Foot Depth Increase)42
Figure 15	Pie Diagram of Cost Composition for 15 ft Deeper Red River Floodway..... 43
Figure 16	Pie Diagram of Cost Composition for 150 ft Wider Red River Floodway ..... 44
Figure 17	Estimated Net Benefits of Expanded Red River Floodway..... 45
Figure 18	Increase in Discharge Capacity for Additional Separate Red River Floodway..... 51
Figure 19	Estimated Excavation Quantities for Additional Separate Red River Floodway..... 51
Figure 20	Estimated Cost for Additional Red River Floodway ..... 53
Figure 21	Typical Cross Section of West Dike ..... 56
Figure 22	Stage – Discharge Curve for Ste. Agathe River Control Structure ..... 61
Figure 23	Ste. Agathe Detention Structure ..... 68
Figure 24	Ste. Agathe Detention Structure Operation 1 in 1,000 Year Flood ..... 69
Figure 25	Ste. Agathe Detention Structure – Upstream Water Levels ..... 69
Figure 26	Inflow/Outflow Hydrographs for Ste. Agathe Detention Structure During PMF ..... 70
Figure 27	Ste. Agathe Detention Structure – Upstream Water Levels for PMF ..... 70
Figure 28	Probability of Failure for Improved Conditions ..... 82
Figure 29	Increase in Red River Flow for Increased Heights of Primary Dikes in Winnipeg (Relative to Base at El 27.8 ft (JAPSD))..... 84
Figure 30	Variation in Present Value of 50 Years of Benefits..... 99

## LIST OF PLATES

Plate 7.1	Location of Red River Floodway
Plate 7.2	Crossings and Nearby Facilities at Red River Floodway
Plate 7.3	Options for Inlet to Red River Floodway
Plate 7.4	Expansion of Red River Floodway Channel (Sheets 1 to 7)
Plate 7.5	Modification of Red River Floodway Outlet Structure
Plate 7.6	Cross Sections of 500 Foot Expanded Floodway Channel
Plate 7.7	Backwater Profiles for 1 in 1000 Year Flood Event
Plate 7.8	Alignment of Separate Additional Floodway Channel
Plate 9.1	Ste. Agathe Detention Structure Location Plan
Plate 9.2	Ste. Agathe Detention Structure Topographic Area Plan
Plate 9.3	Ste. Agathe Detention Structure Photo Mosaic Area Plan
Plate 9.4	General Arrangement of River Control Structure
Plate 9.5	Ste. Agathe Detention Dam Arrangement of Principal Structures
Plate 9.6	Ste. Agathe Detention Dam Typical Sections
Plate 9.7	Drop Structure at Red River Rat River Diversion
Plate 9.8	Ste. Agathe Detention Basin Rat and Marsh River Control Structures
Plate 9.9	Preliminary Schedule Ste. Agathe Detention Structure
Plate 9.10	Water Surface Profiles With and Without Ste. Agathe Detention Structure (1826 Flood)
Plate 9.11	Water Surface Profiles With and Without Ste. Agathe Detention Structure (1 in 1000 Year Flood)
Plate 9.12	Flooded Areas With and Without Ste. Agathe Detention Structure 1826 Flood
Plate 13.1	Summary of Economic Performance of Preferred Combinations of Flood Protection Measures
Plate 14.1	Sensitivity of Economic Indicators to Discount Rate