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FLOOD PROTECTION FOR WINNIPEG

EXECUTIVE SUMMARY:
PART I - VULNERABILITIES
PART II - MITIGATION MEASURES

DECEMBER, 1999

Submitted by:

KGS
GROUP

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INTERNATIONAL JOINT COMMISSION

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EXECUTIVE SUMMARY

I. Introduction

Flood Protection for Winnipeg, is one of several studies 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 is working 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. The consulting firm KGS Group of Winnipeg is conducting the study and a steering committee of representatives from the city, province and federal governments is overseeing 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. There is little margin of error if the City was to face a flood similar to the one in 1997. For a larger flood, the City flood protection defenses need to be improved.

This study has examined the flood defenses, identified areas of vulnerability, and proposed options for reducing the flood risks to the City. The final phase of this study, to be completed in January, 2000, will recommend the highest priority options to improve flood defenses that should be investigated in more detail.

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

The flood protection system in place has limited hydraulic capacity. If that capacity is exceeded there is a high risk of major flood damage. The study estimated potential flood damages 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.

II. Potential Damages

The analysis of potential flood damages demonstrated that, had flood control measures failed in 1997, the total damages to Winnipeg could have been about \$7 60 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 of damages over \$10 billion in the same period.) 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

Table 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*
Natural total flow capable of being managed	169,000	163,000	176,000*
Estimated probability of being exceeded in 50 year period	27 % (estimated in 1958)	43 %	37%

* Note : requires further assessment of wind effects on the "Red Sea" and their effect on the safe water level at the Floodway inlet

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 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 1 68,000 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.

IV. Options for Mitigation

A range of measures were considered to improve the discharge capacity of the existing works, as follows:

1. **Expand Red River Floodway** – this measure would provide the greatest flexibility in selection of desired discharge capability, and could provide capacity up to the 1:1000 year criterion or more
2. **Raise Floodway Bridges** – cost effective, but of limited capacity; probably part of any major changes to the Red River Floodway
3. **Remove East Embankment of Red River Floodway at inlet** – small gain in capacity and needs more analysis; it may be cost effective, but would have potential erosion impacts
4. **Raise West Dike / Raise Red River Floodway Bridges** – cost effective and potentially a basic component of any measure to increase capacity; however, not enough on its own to achieve capacity to protect against 1826 flood magnitude
5. **Construct Ste. Agathe Detention Dam** – very cost effective; for floods exceeding 1997 levels it would reduce flood levels between Ste. Agathe and the Red River Floodway inlet; it would increase water levels upstream of the dam in the Red River Valley above the state of nature, including possible backwater effects south of the U.S. border ; wide flexibility in design discharge capacity
6. **Raise Primary Dikes** – cost effectiveness is doubtful and potential impacts on City infrastructure is uncertain but probably significant; increment in flood discharge capability is limited to about 25,000 cfs
7. **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.
8. **Improve river channel downstream of Winnipeg** – not cost effective, and morphological and environmental impacts on Red and Assiniboine Rivers would be significant
9. **Construct pump station at Floodway Inlet** – not cost effective, and reliance on pumps is tenuous
10. **Construct Eastern Tributaries Diversion** – low ranking in economics and would have significant environmental impacts

To screen and compare these measures, the costs and benefits were estimated for an 1826 level of protection. Raising upstream water levels, such as the Ste. Agathe Detention Dam, are economically attractive, as is straightforward expansion of the Red River Floodway ... This analysis uses conservatively high costs, and does not include optimization of the design or selection of economic hydraulic capacity.

To provide protection against floods with a return period in the range of 1 in 300 years (comparable to the 1826 flood) to 1 in 1000 years, the preferred measure likely would involve expansion of the Red River Floodway, probably in combination with increases in height of the

West Dike to maximize the available Floodway capacity. Alternatively, if increases in flood water levels in the Red River basin upstream of Winnipeg are acceptable, the Ste. Agathe Detention Dam would likely prove to be the most cost effective.

On the basis of the screening assessment of the measures described above, it is recommended that a pre-feasibility level study be carried out on the first six measures. The seventh on the list, relating to improvements of the flood protection system within Winnipeg must be reviewed in more detail to permit a fair comparison with the other available options. The last three on the list are not considered economical, or have serious environmental impacts. They do not merit further consideration.

V. Other Factors Affecting Potential Flooding

The City is vulnerable to a wide range of other factors that affect flooding potential and the ability of the City to respond to flood emergencies. Of particular concern and importance are:

- Reduction in the capacity to deal with internal runoff from snowmelt or rainfall, as a result of rises in river water levels in the City
- The reliable functioning of all the flood control structures, but particularly the Red River Floodway Inlet Control Structure. That structure is in its fourth decade of effective service and will require increasing attention in the coming years. Furthermore, the gates are difficult to inspect and to detect potential problems that could adversely affect reliable operation. Repairs, if required, are fraught with problems, because of the difficulty of accessing the submerged gates.
- Wind and wave conditions at the West Dike of the Red River Floodway
- Inability to raise the crest level of the Primary Dikes in the short time available at the start of a major flood event
- Lack of comprehensive and documented emergency plans for managing extreme floods
- Attrition of knowledgeable staff at the City of Winnipeg and the Province of Manitoba that are familiar with the flood protection system and how to effectively operate it during extraordinary flood events

KGS Group reviewed the modes of failure of each major component of the flood control system, with particular emphasis on the City of Winnipeg flood protection system and the West Dike of the Red River Floodway Inlet Control Structure. The review revealed the City's vulnerability to the limited capacity to deal with internal drainage during periods of high river levels. There are other vulnerabilities to flood conditions (57 were identified), and recommendations for mitigation, and/or for further investigation, are provided in the report. The key recommendations of the study, in addition to the need for hydraulic capacity upgrading, are:

- Investigate the phenomenon of wind setup and wave generation on the "Red Sea" to provide an improved basis for selection of safe freeboard on the West Dike at the Red River Floodway Inlet
- Assess spring operation difficulties at the Portage Diversion, and means to reduce the risk of overtopping and failure in the water retaining structures
- Prepare a comprehensive emergency preparedness manual that would document the actions to follow for floods ranging up to as much as 300,000 cfs in the Red River, including consideration of appropriate responses to failures in the system.
- Implement a Dam Safety Program including stability analyses, investigations, and routine thorough inspections in accordance with the Canadian Dam Association Dam Safety

Guidelines, at each of the Shellmouth Dam, the Portage Diversion, and Red River Floodway and the related structures

- Review staffing at government agencies that are critical to operation and monitoring of the flood control facilities to ensure that effective response to extreme flood events is possible now. Develop succession plans that will ensure sustainability of effective emergency response in the future as experienced staff retire. Mechanisms to engage the private sector in a support role should be developed so that additional competent support is available when required
- Investigate schemes that could permit more routine and effective inspection of the gate system at the Red River Floodway Inlet Control Structure
- Investigate actual constructed materials in the embankment adjacent to the Red River Floodway Inlet Control Structure, and their characteristics with respect to seepage and stability at the high flood levels.

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