

I n t e r n a t i o n a l

J o i n t C o m m i s s i o n

A Report to
the Governments
of Canada and
the United States
on Reducing Flood
Impacts in the
Red River Basin

Living with the Red



NOVEMBER 2000



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The International Joint Commission is a binational organization established by the Boundary Waters Treaty of 1909. The Commission helps Canada and the United States to manage the waters they share in a variety of ways, including investigating and reporting on issues when asked to do so by the two federal governments.

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November 28, 2000

Honorable Madeleine Albright
Secretary of State
2201 C St., NW
Washington, D.C. 20520

Honourable John Manley, P.C., M.P.
Minister of Foreign Affairs
125 Sussex Drive
Ottawa, Ontario K1A 0G2

Dear Secretary Albright and Minister Manley:

We have the honor to transmit herewith the Final Report of the International Joint Commission addressing issues arising from the 1997 flood on the Red River. This report was requested by the governments of Canada and the United States in the reference of June 12, 1997, concerning the causes and effects of damaging floods in the Red River basin, and follows up the Commission's Interim Report of December 31, 1997.

The Commission plans to release the report to the public on December 6, 2000.

Gerald E. Galloway
Secretary
United States Section

Murray Clamen
Secretary
Canadian Section

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the Governments
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Red River Basin**

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NOVEMBER 2000



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Contents

Executive Summary	1
Acknowledgments	5
1. Introduction	7
2. Geography and Flood History	9
3. The Reference	13
4. The Study	15
5. Preparing for the Next Flood	19
A. Flooding in the Red River Basin	19
B. Flow Reduction Considerations.	21
(1) Large Reservoir Storage.	21
(2) Micro-storage	23
(3) Wetlands.	24
(4) Other Factors Affecting Flow	25
a) Drainage	25
b) Urban Levees	26
c) River Ice.	26
C. Protecting Large Population Centers	27
(1) Winnipeg	28
(2) Fargo–Moorhead	32
(3) Grand Forks–East Grand Forks	33
(4) Wahpeton–Breckenridge	34
(5) Selkirk	35
D. The Impacts of Flooding.	35
E. Resilience	37
F. Individual Homes, Small Communities, and Agricultural Areas	38
G. Transportation Corridors (Roads, Railroads, Bridges)	40
H. Pembina River	40
I. Flood Preparedness and Mitigation	42
J. Emergency Management.	46
K. Data and Decision Support.	47
(1) Data and Information	47
(2) Modeling	49
(3) Information Management.	51

6. Environmental Considerations	55
A. Chemical Contamination.	56
B. Interbasin Transfer of Alien Invasive Species	57
C. Protection and Enhancement of the Floodplain Environment	57
7. Managing the Floodplain—Comprehensive, Integrated Planning	59
8. Managing the Flood Challenge—Institutional Arrangements	61
A. The Complexities of an International Basin	61
B. Binational Cooperation	62
C. Additional Responsibilities for the International Red River Board.	65
9. IJC Conclusions and Recommendations	67
Signature Page	77
Bibliography	79
Appendices	
1. Reference	
2. Conclusions and Recommendations of the International Red River Basin Task Force That Have Been Endorsed or Modified by the IJC	
3. The International Joint Commission’s Interim Report to Governments—December 1997	
4. Main Text of the Final Report of the International Red River Basin Task Force—April 2000	
5. Proposed Directive for the International Red River Board	
Figures	
1. Map of the Red River Basin	10
2. Generalized Extent of the 1997 Flood, Including Overland Flow	12
3. Map of the Pembina River Basin	41
Tables	
1. 1997 Red River Peak Flows	11
2. Estimated Recurrence Intervals for the 1997 Red River Flood	21
3. Capacities of Winnipeg Flood Protection System	28

Executive Summary

The flood of 1997 will long be remembered in the Red River basin of Canada and the United States. Over 100,000 people had their lives disrupted for several months and some still suffer from the physical and emotional trauma of the flood. Economic damages in the two countries approached U.S.\$5 billion and flood recovery and mitigation costs continue to grow. Many of those who were not harmed by the flood recognize that their safety was preserved by only a matter of inches or centimeters. With great internal strength, basin residents on both sides of the border met the challenge of the flood but now look to governments to ensure that such destruction never again is visited upon them. At the request of Canadian Prime Minister Jean Chrétien and U.S. President William J. Clinton, the International Joint Commission undertook to analyze the root causes of the flood and to make recommendations as to how damage from major Red River floods could be mitigated in the future.

Since the summer of 1997, the Commission and its binational Task Force have been examining the flood and methods to reduce or eliminate the impacts of future major floods. In carrying out its responsibilities, the Task Force initiated the development of products that will be of continuing utility to the basin, including hydraulic models to aid in analysis of flood flows, high-resolution topographic and land use data for flood-prone areas and a virtual network to link those in the basin dealing with flood issues. The Commission has closely examined the work of the task force, conducted meetings and hearings in the basin, met with leaders at all levels in the public and private sector, and extended the analysis of the Task Force in some measure.

The Commission has come to the conclusions set out below:

- Flooding in the Red River basin is a natural hydrometeorological event. Although the 1997 flood was a rare event, floods of the same magnitude as 1997, or even greater, can be expected to occur in the future.
- The people and property of the Red River basin will remain at undue risk until comprehensive, integrated, binational solutions to flood problems are developed and implemented. Solutions for one part of the basin must take into account the impacts on other parts of the basin.

...what makes a community a place to live in is not the buildings, it's the people—the spirit and faith that are in those people. Water cannot wash that away, and fire cannot burn that away, and a blizzard cannot freeze that away. And if you don't give it away, it will bring you back better than ever.

*Grand Forks Mayor Pat Owens,
April 22, 1997.*

It is hard not to be touched by the sadness and enormous impact that the flood wrought on so many lives. But the flood also demonstrated how crisis brings out the best in people and in communities.

*Winnipeg Mayor Susan Thompson,
October 23, 1997.*

-
- There is no single solution to the flood damage mitigation challenge. To reduce vulnerability to flooding, all possible approaches, including both structural and non-structural damage reduction measures, must be considered as part of a comprehensive plan. This would include, when environmentally, economically and socially justified, development of additional reservoir storage, restoration of wetlands, micro-storage, construction or improvement of levees and dikes, floodwalls and bypass channels, permanent evacuation of high-risk areas, flood-proofing, and the enhancement of flood forecasting and warning systems.
 - The potential flooding of major population centers in the Red River basin needs immediate attention:
 - The risk of a failure of Winnipeg’s existing flood protection infrastructure is high under flow conditions similar to or greater than those experienced in 1997. While, for the most part, the city was spared significant damage in 1997, public safety requires that the city and province focus immediate attention on designing and implementing protective measures to further protect Winnipeg. These measures must respect both the needs of Winnipeg and the interests of those outside the city who might be affected by any such measures.
 - Detailed assessment of the significant flooding risks facing Fargo–Moorhead is required. Studies by the U.S. Army Corps of Engineers and the Federal Emergency Management Agency should be expedited so that appropriate mitigation measures can be identified and quickly implemented.
 - The work currently being undertaken in Grand Forks–East Grand Forks will serve to protect residents from future flood damage but needs to be completed in a timely manner and periodically evaluated for its level of protection.
 - Completion of studies, and development and implementation of proposed projects to protect Wahpeton and Breckenridge, should be expedited.
 - The floodplain ecosystem of the Red River valley will be threatened unless steps are taken to protect it as part of the process of developing flood damage reduction solutions. In addition, steps must be taken to ensure that banned materials are removed from the basin and that storage of hazardous materials on the floodplain is carefully controlled.
 - Governments at all levels need to promote a culture of flood preparedness and flood resiliency in the basin; continue the work begun by the Commission’s Task Force; provide opportunities for multi-jurisdictional problem solving and the exchange of best-practices information; and integrate floodplain management activities into the broader field of watershed and basin management.

The Commission, in this report, has provided 28 recommendations for governments at all levels. The recommendations provide a blueprint for action. The challenge will come in the execution of these recommendations.

Federal, state, provincial and local governments have many well-established and active agencies dealing with various aspects of flooding within their jurisdictions. Non-governmental organizations also fill important flood-related roles. There also is a need for basin-wide binational institutional arrangements to deal with the transboundary issues that will arise, and the Commission finds that this need for a binational approach is generally accepted within the basin.

The Commission proposes to assign certain flood-related activities to its International Red River Board after consultations in the basin and with governments. The Commission also strongly recommends that:

- Governments immediately take steps, on a binational basis, to begin development of a comprehensive flood damage reduction plan for the Red River basin.
- Governments work with the International Red River Board and existing and emerging bilateral organizations to ensure that appropriate arrangements are in place for coordinating and implementing measures for flood-preparedness and mitigation activities, and to implement the recommendations of the Commission found in this report to governments.

A c k n o w l e d g m e n t s

The International Joint Commission (Commission) wishes to acknowledge the advice and work of others, without which this report would not have been possible. The Commission appreciates the information and many thoughtful comments and suggestions it received since the flood of 1997 from agencies, organizations, and individuals, either during the many public hearings and meetings in the Red River basin or through other venues. This dialogue helped to highlight important issues and often provided invaluable first-hand perspectives on the flood and its effects.

The Commission commends the International Red River Basin Task Force for its work, including the sound and very practical short-term guidance that the Commission passed on to governments in 1997, the extensive work that it undertook with respect to preparedness and mitigation for major floods in the basin, and, in particular, the foundation it laid for increased cross-border cooperation and improvements in data networks and modeling of river flows under flood conditions. These contributions will be of great assistance to the governments and residents of the Red River valley for years to come and will serve as the beginning of a legacy that the Commission leaves to the governments for their utilization. The Commission also acknowledges the important contributions to this report made by Commission staff.

Finally, the Commission wishes to express its respect for the people of the Red River basin. Following the terrible destruction and suffering caused by the flood of 1997, basin residents have shown the two countries countless ways in which progress can be made in recovering from flood damage and in becoming better prepared for future floods. The Commission acknowledges the many efforts, great and small, that together are leading to the development of a truly resilient Red River basin community.

I n t r o d u c t i o n

The fall of 1996 in the Red River basin was wetter than normal. Winter brought record or near-record snowfall throughout the basin, and heavy precipitation continued in the early spring of 1997. The snow began to melt in the southern portion of the basin in the latter part of March. Then, a major blizzard swept through the basin in early April leaving up to 48 centimeters (cm), or 19 inches, of snow over most of the valley. Forecasters immediately recognized the consequences. As floodwaters began their inevitable journey downstream, cities and residents intensified their flood preparation efforts. The flood reached record height as it passed Wahpeton–Breckenridge and Fargo–Moorhead, flooding the former but largely sparing the latter. The countries watched in horror as floodwaters claimed Grand Forks–East Grand Forks on April 22 and a major fire burned uncontrolled in downtown Grand Forks. The waters moved northward across the Canada–United States boundary, at which point they formed a great inland sea, stretching to a width of 16 kilometers (km), or 10 miles. Individual homes, communities and farmsteads were inundated and ring-diked communities were evacuated as the floodwaters headed northward toward Winnipeg. City, town and rural residents teamed with the largest deployment of Canadian troops since the Korean War to shore up flood defenses. The Winnipeg Floodway, an excavated channel constructed in the 1960s, diverted floodwaters around Winnipeg. Throughout the basin, over 100,000 people were evacuated. Roads and railway lines were impassable. Lives were disrupted.

Recognizing the devastating effects of the flood on both sides of the border and the need for cross-border cooperation in addressing flood-related issues, U.S. President Bill Clinton and Canadian Prime Minister Jean Chrétien agreed to ask the International Joint Commission (IJC), referred to hereafter as the Commission, to study the flood and its impacts. On June 12, 1997, the governments of Canada and the United States gave the Commission a reference under Article IX of the Boundary Waters Treaty of 1909 to examine and report on the causes and effects of damaging floods in the Red River basin, and to make recommendations on means to reduce, mitigate and prevent harm from future flooding in the basin. A copy of the reference is attached as Appendix 1.

Note on the Commission's and Task Force's Conclusions and Recommendations

1. The Commission endorses most of the conclusions and recommendations contained in the final report of the International Red River Basin Task Force.
2. In view of their particular importance, certain conclusions and recommendations of the Task Force endorsed by the Commission are cited in full in the text of this report. Others are simply mentioned in summary form.
3. In some cases, the Commission has modified conclusions and recommendations advanced by the Task Force. Such modifications are given in full in the text of the report.
4. In other cases, the Commission draws conclusions and makes recommendations of its own. Such conclusions and recommendations are given in full in the text of the report.
5. For convenient reference, Appendix 2 to this report sets out the Commission's position on each of the conclusions and recommendations of the Task Force.

The Commission established a binational Task Force with experts from the two countries to assist it in responding to the reference. Based on advice from the Task Force, the Commission issued an interim report to governments in December 1997. The report identified measures that needed to be implemented in the near term to reduce the potential for damage from a flood in 1998. The Commission held public hearings in the basin to obtain views from the public on the interim report.¹ In April 2000, the Commission received the Task Force's final report and, in May 2000, held public hearings and meetings in the basin² to obtain comment on the information, conclusions, and recommendations of the Task Force.

This report is the final report of the International Joint Commission to the two governments under the reference.³ The report is based on input received from a number of sources: the interim and final reports of the Task Force, views expressed by officials and residents of the basin at public hearings and other venues, and information obtained by the Commission throughout the study.

In this report, the Commission endorses most of the Task Force's conclusions and recommendations, modifies some, and adds some new conclusions and recommendations of its own. Appendix 2 to this report sets out the Commission's position with respect to each of the conclusions and recommendations of the Task Force and indicates where they have been modified or supplemented by conclusions and recommendations of the Commission. A complete list of the Commission's conclusions and recommendations is given in Section 9.

The Commission's interim report to the governments of December 1997 and the final report of the Task Force *The Next Flood: Getting Prepared* of April 2000 are included as appendices 3 and 4, respectively. Together, these documents provide advice with respect to improvements required to be better prepared for future flood events in the Red River basin.

1 Public hearings were held in February 1998 at Grand Forks, North Dakota; Moorhead, Minnesota; Pembina, North Dakota; Ste. Agathe, Manitoba; and Winnipeg, Manitoba.

2 Public hearings were held in May 2000 at Emerson, Manitoba; Fargo, North Dakota; and Winnipeg, Manitoba; meetings were held in May 2000 at Morris, Manitoba, and Grand Forks, North Dakota.

3 The Commission's report is also available on the Internet at www.ijc.org.

Geography and Flood History

The Red River, or Red River of the North as it is known in the United States, flows north from its headwaters in Minnesota to its outlet at Lake Winnipeg in Manitoba, meandering through the flat and fertile valley of the former glacial Lake Agassiz. The river basin occupies substantial portions of North Dakota, northwestern Minnesota, southern Manitoba and a very small portion of northeastern South Dakota. It covers 116,500 square kilometers (km²) or 45,000 square miles, excluding the Assiniboine River basin, which joins the Red River at Winnipeg. A map of the basin is shown in Figure 1.

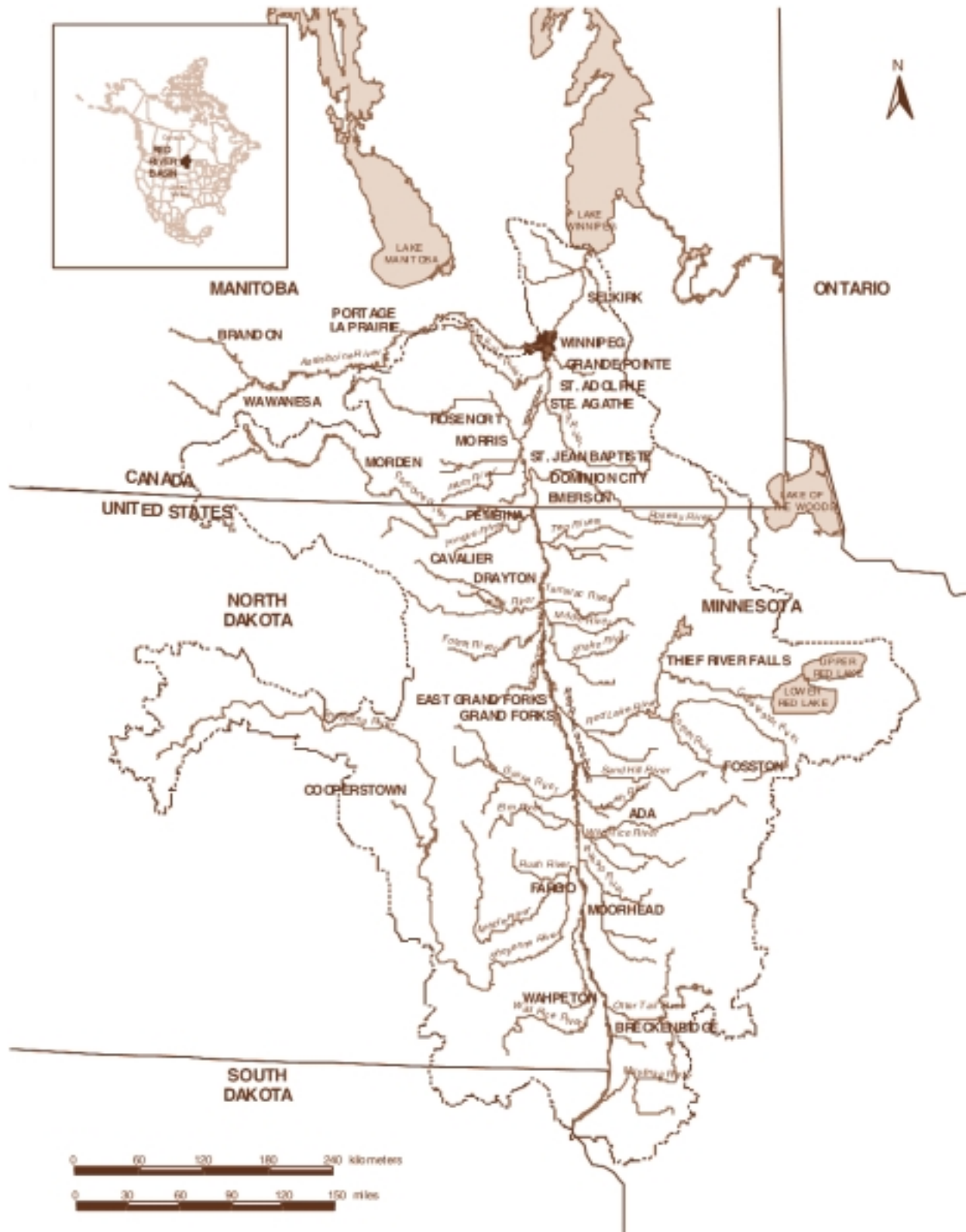
The basin is remarkably flat. At Wahpeton, North Dakota, the elevation is 287 meters (m), or 943 feet, above sea level. At Lake Winnipeg, the elevation is 218 m (714 feet), a difference of only 70 m (229 feet) over a distance of about 877 river km (545 miles). The slope of the river averages less than one tenth of a meter per kilometer (less than one half foot per mile), varying from about 0.25 m/km (1.3 feet per mile) near Wahpeton to 0.04 m/km (0.2 feet per mile) near the Manitoba border. The flattest portion of the basin, located along the river and known colloquially as the Red River valley, is about 100 km (60 miles) across at its widest. During the 1997 flood, the river spread to a maximum width of about 40 km (25 miles) in Manitoba. The floodplain features natural levees⁴ along some reaches of the Red River and its tributaries. When these levees are overtopped or bypassed, land for several miles on each side may be flooded. The floodplain has clay soils with low absorptive capacity that can contribute to flood problems. Furthermore, the river's northward flow increases the potential for ice jams and resultant backwater flooding. The largest floods usually occur following heavy precipitation the previous fall, hard and deep frost prior to snowfall, substantial snowfall, and heavy rainfall or wet snow conditions during the spring breakup.

The largest population center in the basin is Winnipeg, with a population of about 670,000. Other major population centers are: Fargo–Moorhead (population over 100,000), Grand Forks–East Grand Forks (population 60,000), Wahpeton–Breckenridge (population 12,000), and Selkirk (population 9,800). These major population centers are located on the banks of the Red River. The floodplain of the Red River valley is also a highly productive agricultural area. Thus, much of the basin's urban and rural populations are at risk from flooding.

⁴ In the United States, the term "levee" is commonly used for riverside flood control works; in Canada, the term used is "dike." In this report the terms are used interchangeably.

Figure 1

Map of the Red River Basin



Historic analyses show that flows of the Red River are erratic and highly variable, forcing residents along its length to deal with floods and droughts. Major floods have occurred as recently as 1950 and 1979. The spring of 1997 brought the largest flood on record along much of the river. Heavy precipitation fell in the fall of 1996—as much as 15 cm (6 inches) in late October and November—leading to high soil moisture in the basin. Winter brought record or near-record snowfall throughout the basin, with many

areas experiencing two to three times the average. On April 5–6, a blizzard dumped wet snow on the basin. Temperatures remained cool, then warmed suddenly, sending meltwater surging downstream. Table 1 shows peak flows at several locations along the Red River.



North Dakota Institute for Regional Studies, NDSU.

The 1897 flood of the Red River of the North at Fargo–Moorhead.

The 1997 flood had about the same volume of water as did the 1950 flood, but had a peak that was much higher and of shorter duration. In the United States, flood stages at 29 of the 34 recording stations in the Red River basin exceeded previous floods of record. At Winnipeg, the 1826 flood remains the largest on record (it was not recorded in the U.S. portion of the basin). The 1997 flood was the largest in the Manitoba portion since current settlement patterns were established. The map in Figure 2 shows the general extent of the 1997 flood.

Table 1
1997 Red River Peak Flows

Location	Date	Peak Flow *
Wahpeton–Breckenridge	April 15	362 cms (12,800 cfs)
Fargo–Moorhead	April 17	793 cms (28,000 cfs)
Grand Forks–East Grand Forks	April 18	3880 cms (137,000 cfs)
Drayton	April 25	3510 cms (124,000 cfs)
Emerson	April 27–28	3910 cms (138,000 cfs)
Ste. Agathe	May 2	3820 cms (135,000 cfs)
Winnipeg **	May 4	4590 cms (162,000 cfs)

* cms—cubic meters per second; cfs—cubic feet per second
 ** Total discharge at Winnipeg including flows in river channel and the Winnipeg Floodway.

Figure 2

Generalized Extent of the 1997 Flood, Including Overland Flow



The Reference

In its June 1997 reference, the governments asked the Commission to examine and report on the causes and effects of damaging floods in the Red River basin, and to make recommendations on means to reduce, mitigate and prevent harm from future flooding. Acknowledging the need for a cooperative approach to ensure better preparedness and response to future floods, the governments asked the Commission to focus on cross-border cooperation between governments, agencies, communities and other interests.

Extract from Canadian and U.S. Governments' Reference to the International Joint Commission—June 12, 1997

- ...examine and report on the causes and effects of damaging floods in the Red River basin, and to make recommendations on means to reduce, mitigate and prevent harm from future flooding in the Red River basin.
- ...focus on cross-border cooperation of governments, agencies and communities in the basin in its inquiries under this reference.
- ...identify strengths and capabilities, to be able to identify vulnerable areas in effectiveness, emergency preparedness programs and in response planning, and other flood-related problems, and to point the way toward improvements in these measures.
- ...examine and make recommendations on:
 - ...remedial, restorative, protective or management measures that would help to mitigate the effects of flooding;
 - ...innovative measures for flood reduction, damage reduction and future relief options...;
 - ...scientific and technical investigations, applied research or demonstration projects relating to enhanced flood protection and mitigation;
 - ...the relevant information base, including monitoring and alerting networks, and its integration with respect to the Red River basin;
 - ...the objectives, parameters, organization and structure of bilateral cooperation and measures for its improvement;
 - ...a plan or plans of cooperative flood management, flood forecasting, emergency response and flood mitigation;
 - ...any other matters that the Commission deems appropriate and relevant.
- ...take account of the principles of sustainable development and ecosystem management...
- note that a variety of initiatives are underway on various matters pertaining to water or land use management, emergency preparedness and response and environmental data gathering and monitoring...draw upon these initiatives.

Note: See Appendix 1 for full text of reference.

Having urged the Commission to draw upon available expertise, data, technology and relevant studies, the two governments undertook to seek the funds required to provide promptly to the Commission the resources needed to discharge its obligations under the reference. The Commission was asked to provide an interim report by December 31, 1997, identifying near-term measures, and to make a full report, including recommendations for areas requiring further study, before the end of 1998. Because of U.S. funding shortfalls, the scope of study was curtailed and the deadline for the full report was extended to December 2000.

The Study

The Commission established a binational and multidisciplinary International Red River Basin Task Force⁵ to assist with the studies required under the reference. The Task Force was composed of 10 members, five from Canada and five from the United States. As is customary in Commission studies, Task Force members worked in the spirit of consensus and served in their personal and professional capacities, not as representatives of their countries or employers.

The two federal governments provided funds for the study. On the Canadian side, the full share of half the projected cost, or Can\$4 million,⁶ was provided at the outset. On the U.S. side, study funding was subject to the U.S. budget process. Limited U.S. funding was made available in 1997 to enable work on the interim report and subsequent public hearings. Approximately U.S.\$787,000 was made available in October 1998, and approximately U.S.\$100,000 in October 1999. The Task Force was able to leverage the reach of its funds on both sides of the border by partnering with others on areas of mutual interest, such as with the Global Disaster Information Network (GDIN) on the U.S. side and with the city of Winnipeg and the province of Manitoba on the Canadian side. The uncertainty of the amount and timing of U.S. funding caused great difficulties: studies had to be deferred or curtailed, schedules had to be extended, and work plans had to be revised numerous times to reflect changing expectations and understandings regarding the funds available. These funding difficulties also made full binational partnership in the conduct of the Task Force's work much more challenging.

Commissioners visited the basin in May 1997, viewed the ongoing flood and its impacts by helicopter and small plane, and saw the immediate aftermath of the flood and fire in Grand Forks and East Grand Forks. During this visit, Commissioners also received initial briefings by Canadian and U.S. personnel knowledgeable about the flood and efforts to fight it. During September and October 1997, Commissioners and members of the Task Force again toured some of the hardest-hit areas of the basin. They held briefing and fact-finding sessions with civic and community leaders in Fargo, North Dakota; Moorhead, Minnesota; Grand Forks, North Dakota; East Grand Forks, Minnesota; and Morris, Manitoba; and met with political leaders in each of the jurisdictions. Detailed interviews were conducted with families affected by the flood and with civic officials and local emergency management coordinators. Over the duration of the study, Task Force members and Commissioners attended a range of workshops, meetings and forums throughout the basin to hear from members of the public as well as elected and public officials. The Commission kept abreast of initiatives by other groups and jurisdictions in the basin, including by the Manitoba

⁵ Subsequently, in this report, this body will be referred to as "the Task Force."

⁶ The exchange rate during the study was approximately Can\$1 = U.S.\$0.66.

Water Resources Commission, the President's Long-Term Recovery Task Force, the U.S. Army Corps of Engineers' analysis of flood protection measures for the cities of Grand Forks and East Grand Forks, the International Flood Mitigation Initiative (IFMI), and numerous other efforts aimed at ensuring better flood preparedness in the valley. A number of Task Force members represented their agencies or participated in many of these efforts. Credit must be given to federal agencies, and state, provincial and local governments for the recovery plans and mitigation efforts that have been put in place or are in progress. Much has been accomplished, but much remains to be done to ensure that a flood similar to that of 1997, or larger, will never again cause the damage, dislocation and disruption that resulted from the 1997 flood.

The Task Force submitted its interim report *Red River Flooding: Short-Term Measures*⁷ to the Commission in December 1997. In addition to providing a description of the Red River basin and its flood history, the report examined the 1997 flood from a number of perspectives and made 40 recommendations that could be implemented in the near term to help in preventing or minimizing damage from future floods. Among the issues addressed were emergency preparedness, response, recovery, and mitigation.

Based on the Task Force's interim report and what it heard from residents of the basin, the Commission submitted its interim report to the governments on December 31, 1997. In that report, the Commission commended governments and organizations for the spirit of cooperation demonstrated in preparing for and fighting the 1997 flood, and for the efforts being made to better prepare for future floods. Further, the Commission endorsed the recommendations contained in the interim report of the Task Force. It encouraged governments at the federal, state, provincial and municipal levels to work together to implement the recommendations to minimize damage from possible flooding that could occur in the short term. While governments have been responsive to the Commission's recommendations, the Commission notes that there are still areas where additional action concerning cross-border coordination and cooperation on data enhancement and model development would improve flood preparedness. Those regarding data and model development are largely addressed in this report. The interim report recommendation calling for a meeting of senior officials warrants reconsideration in the context of a five-year review of actions taken to prepare for future major floods in the basin. To this end, the Commission recommends that:

IJC Recommendation 1: The federal governments should convene a meeting of senior federal, provincial and state officials in 2002 to undertake policy discussions and an examination of the 1997 flood, with emphasis on review of emergency plans, evacuation procedures and mitigation measures underway.

⁷ *Interim Report of the International Red River Basin Task Force, Red River Flooding: Short-Term Measures*, (December 1997). (Available at: www.ijc.org)

The Task Force's interim report also outlined a plan of study for undertaking further work to prevent or reduce flood damage and to improve tools for planning and decision making for better floodplain management. This plan of study focused on a single aspect of water management—flooding, specifically the flood of 1997—and defined three specific objectives for its investigations: develop and recommend a range of alternatives to prevent or reduce future flood damage, improve tools for planning and decision making, and facilitate integrated flood emergency management in the basin. Alterations to the plan of study were made over the course of the study, both to adjust to funding uncertainties and to reflect the outcome of work undertaken by the Task Force or other organizations.

During the course of its work, the Task Force funded data collection, hydraulic model development, the initiation of virtual databases and communications networks, studies of the social impacts of flooding, and reviews of available information for such purposes as water quality assessments and effects of flood control operations. It teamed with other organizations and agencies in both countries to further common goals. After concluding its major studies, the Task Force prepared and submitted its final report to the Commission.⁸ The Commission has drawn heavily from the Task Force's work for this report to governments and believes that the information and tools the Task Force developed will continue to prove useful to those in the basin who are dealing with floods.

Many people who attended the Commission's public hearings in May 2000 expressed concern over issues not addressed in the Task Force's work. The Commission recognizes that there are many issues associated with floods and flooding, and that it has not addressed them all. This report points out areas requiring further consideration. The Commission encourages the governments to continue the necessary work to ensure appropriate understanding of flood-related issues so that flood preparedness in the Red River basin can continue to improve.

The following chapters describe major issues regarding flood preparedness and mitigation, and offer conclusions and recommendations intended to guide further efforts to reduce flood risks. While the report is submitted to the two federal governments in fulfillment of its responsibilities under the reference, the Commission nevertheless considers its report to be for the people of the basin, and for those governmental and other organizations that work to reduce the devastating effects of large floods.

8 In order to provide context for discussion of the Task Force's conclusions and recommendations, the Task Force's report, less the executive summary and appendices, is included as Appendix 4. The full report is available, along with supporting reports, at www.ijc.org.

Preparing for the Next Flood

A. Flooding in the Red River Basin

The first settlers in the basin established their communities along the Red River—the principal transport route into the region. These settlement patterns set the stage for most of today's flooding problems. Communities located along the water transportation corridor for convenience and to enjoy the beauty of the river. Many were unaware of or ignored the potential flood threat of the river. Floods occur throughout the valley and along the tributaries in various degrees of severity. Some affect small local areas; others affect larger regions. Some last for a few hours or a few days; others disrupt normal activity for periods of several weeks or months.

The relatively flat topography of the basin places most of its residents on or near the floodplain of the river, and for economic and social reasons this is unlikely to change. Flooding can occur in successive years or there can be several years between floods. They can occur as a result of spring snow melt, perhaps aggravated by coincident rainfall, or as a result of heavy summer rains.

In its interim report, the Task Force stated that a flood of the magnitude of the 1997 flood could happen in any year. The Task Force subsequently conducted investigations to gain a better appreciation of the frequency and size of major floods that might occur in the valley, extrapolating from the early flood history of the Red River. It examined sediment deposits and early evidence of settlement, analyzed tree ring histories, and reviewed the regional climate. In addition, the Task Force conducted detailed hydrometeorological analyses in which, using historical data, it simulated 2,000 large floods at Winnipeg. The largest simulated flood had a peak flow of approximately 8495 cubic meters per second (cms), or 300,000 cubic feet per second (cfs). Subsequent statistical analysis by the province of Manitoba has shown that the 1997 flood has about a 90-year recurrence interval at Winnipeg, while the 1826 flood has about a 300-year recurrence interval.

In the U.S. portion of the basin, flow data are not available for the period prior to 1873 when a gauging station was established at Grand Forks. The 1826 flood was not documented in the United States. However, a model was developed to simulate one possible flooding scenario that would yield the discharges experienced at Winnipeg in 1826.⁹ This model shows estimated flood levels¹⁰ of about 6.2 m (20.3 feet) at Wahpeton–Breckenridge, 13.0 m (42.5 feet) at Fargo–Moorhead, 17.4 m (57.0 feet) at Grand Forks–East Grand Forks, and 14.4 m (47.1 feet) at Drayton, with an estimated accuracy of plus or minus one foot.¹¹ Prior to 1997, the greatest flood on record in the U.S. portion of the basin occurred in 1897 with a peak discharge of 2410 cms (85,000 cfs) at Grand Forks. This was significantly less than the peak of 3880 cms (137,000 cfs) at Grand Forks recorded in 1997. In May 2000, the U.S. Army Corps of Engineers issued a draft discharge-frequency study, estimating the approximate recurrence intervals of the 1997 Red River flood at various mainstem locations, based on instantaneous peaks reported by the U.S. Geological Survey.

Recurrence Intervals

Floods are often identified by recurrence interval, such as a “100-year flood.” Recurrence intervals are usually determined by performing statistical analyses on many years of flood elevation and flood discharge data. The more data available, the greater the confidence that can be placed in the estimated recurrence interval. New data, especially for larger and more infrequent floods, help to refine estimated recurrence intervals and often lead to a change in the interval following a large flood.

But what is a 100-year flood? A 100-year flood has a 1-percent chance of being equaled or exceeded in any given year. (A 2-percent chance flood has a one in fifty chance of occurrence in any given year.) The risk of a 100-year flood is the same every year, regardless of whether there was a 100-year flood the year before or 99 years before. A 100-year flood has a 26-percent chance of occurring over the life of a 30-year mortgage, and a 63-percent chance of occurring over the next 100-years. The terms 100-year flood, 100-year recurrence interval flood, 100-year frequency flood, 1-percent flood, 1-percent annual chance flood and, in the United States, base flood all refer to the same event and are used interchangeably.

The geographic area expected to be inundated by a given flood, such as the 100-year flood, can be shown on floodplain maps. Often, building regulations or restrictions are applied within a mapped “regulatory” floodplain, which is usually based on the 100-year flood. Flood risk is not the same everywhere within a mapped floodplain; sites at lower elevations have greater flood risk. It must also be recognized that floods larger than any specific flood used for regulatory or other purposes could occur, and that even sites located outside a mapped floodplain may be at risk from these larger floods.

The severity of a flood, based on statistical analysis, usually varies as it moves downstream. Table 2 shows the estimated recurrence interval of the 1997 flood at various locations along the Red River.

The data concerning past and future flooding produced by the Task Force includes recorded data as well as statistical estimates of extreme flood events. The estimates provide a sound basis for general conclusions concerning flooding. Recent climate variability and possible climate change make for greater uncertainty. Nevertheless, the Commission concludes that:

IJC Conclusion 1: Although the 1997 flood was a rare event, floods of the same size as the 1997 event, or greater, can be expected to occur in the future in the Red River basin. People and property remain at risk from these floods.

9 U.S. Army Corps of Engineers’ UNET model for the Red River, developed by the St. Paul District and further refined by the Hydrologic Engineering Center.

10 Flood elevations in the U.S. portion of the basin are referenced to local gauge height.

11 These model results assume that levees contain flood flows and bridges remain in place.

Flooding in the Red River basin results from the combination of high flows in the Red River and its tributaries, and the topography and development of the basin places people and property at risk. The loss of wetlands and construction of farm and urban drainage have increased runoff from the land into streams and rivers and may aggravate the damage caused by floods. While it is not possible to stop floods from occurring, or to entirely prevent damage from floods, a wide variety of actions can and should be taken that will prevent some damage, and minimize and mitigate the effects of the damage that does occur. Residents and governments at all levels have long recognized the need for flood protection and have been active in taking measures to safeguard businesses, homes, properties, and communities. These measures include construction and operation of reservoirs to contain floodwaters, levees and floodwalls to protect communities, and bypass channels to move the waters around critical areas; relocation of homes and businesses out of the floodplain; construction of agricultural levees and ring dikes around rural homes; use of agricultural practices that prevent rapid runoff; restoration of wetlands; preparation and updating of evacuation plans and flood forecasting and warning systems; and use of flood insurance to mitigate losses when they occur. Much more can and should be done to prepare for the variety of flood situations faced by the population of the Red River basin.

Table 2

Estimated Recurrence Intervals for the 1997 Red River Flood

Location	Estimated Recurrence Interval*	Chance of Being Equaled or Exceeded in Any Given Year
Wahpeton–Breckenridge	140-year	0.7%
Fargo–Moorhead	70-year	1.4%
Halstad	140-year	0.7%
Grand Forks–East Grand Forks	210-year	0.5%
Drayton	140-year	0.7%
Emerson	140-year	0.7%
Winnipeg	90-year	1.1%
* Estimates in the United States provided by the U.S. Army Corps of Engineers; estimates in Canada provided by Manitoba Conservation.		

B. Flow Reduction Considerations

The Task Force and the Commission examined methods that might be considered for reducing the magnitude and timing of the flood flows. During its visits to the basin, the Commission found strong support for seeking methods of storing water in new reservoirs, on fields, or in restored wetlands, with many people noting that the natural and constructed reservoirs not only could reduce flooding but could also provide water storage during drought periods.

(1) Large Reservoir Storage

The record-breaking snowfall during the winter of 1996–1997, capped by a major blizzard in early April 1997, contributed the equivalent of 20 to 25 cm (8 to 10 inches) of water to the Red River basin for the 1997 flood. That equated to 25.9 million cubic decameters (dam³) of water (21 million acre-feet) in the basin upstream of the confluence of the Assiniboine River. Of that amount, 11.1 million dam³ (9 million acre-feet) ran off during the spring, while 14.8 million dam³ (12 million acre-feet) remained on the land, slowly dissipating through



Aerial view of Baldhill Dam near Valley City, North Dakota.

evapo-transpiration, infiltration, and release to streams after the flood. To put this into perspective, the Task Force indicated that the five large U.S. flood control dams in the upper part of the basin (Baldhill, North Dakota; Homme, North Dakota; White Rock, Minnesota; Red Lake, Minnesota; and Orwell, Minnesota) provide over 1.2 million dam³ (1.0 million acre-feet) of flood-control storage. In addition, another 280 water retention projects, developed for water conservation and other purposes, have a potential flood storage capacity of approximately 0.8 million dam³ (0.7 million acre-feet). This latter figure is based on the difference

between the maximum storage potential and the normal storage level and represents the amount of storage available at these structures, if water is at normal storage levels at the beginning of a flood. Holding back a portion of the peak flow can reduce flood damage and the risk of failure of flood protection works.

The Task Force examined the impact on downstream flood levels of “capturing” or holding back large volumes of floodwaters at various locations in the basin. Its analyses included: optimizing current flood control capacity; adding 856,000 dam³ (694,000 acre-feet) flood storage in previously proposed but unbuilt reservoirs in the U.S. portion of the basin; and adding hypothetical storage volumes ranging from 123,000 to 986,000 dam³ (100,000 to 800,000 acre-feet) in the United States.

Potential storage was then compared with the storage required to significantly reduce flood peaks. The Minnesota Department of Natural Resources conducted a simplified analysis to estimate the storage required to reduce the 1997 peak flow at Grand Forks to that of the smaller 1979 flood, that is, from 3880 cms (137,000 cfs) to 2520 cms (89,000 cfs). This reduction required approximately 1.6 million dam³ (1.3 million acre-feet) of ungated flood storage immediately upstream of Grand Forks. Some have noted that if structures were gated, significantly less storage may be required. Modeling conducted by the Task Force found that if 986,000 dam³ (800,000 acre-feet) storage were feasible between Grand Forks and Emerson, it could have reduced the 1997 flood levels at Winnipeg by up to 1.5 m (5 feet).

Economic, social, environmental and other considerations have prevented the construction of the U.S. reservoirs cited above to create an additional 856,000 dam³ (694,000 acre-feet) of flood storage. No combination of sites has been identified to achieve the 1.6 million dam³ (1.3 million acre-feet) of storage needed to reduce the flood at Grand Forks to the 1979 flood level, and it is unlikely that enough sites could be found that would be economically, socially and environmentally suitable. Therefore, reservoir storage can be only a part of a wider strategy to reduce the risk posed by major floods.

The Commission recognizes that large floods occur infrequently and that they are only one aspect of flood management in the basin. Overall flood management must consider large and small floods as well as spring and summer events. Increases in storage, or changes in reservoir operating plans, may prove effective in reducing the impact of smaller floods, and these options require further investigation. For example, most of the existing water retention projects in the basin are operated so that they are full at the end of the spring runoff. As such they can provide little or no flood protection during intense summer rainstorms. Operating these reservoirs at lower levels in the summer may provide unused flood storage at the cost of decreased water supply. Many of the dams that can store floodwaters temporarily would benefit immediately downstream agricultural or undeveloped areas, rather than more distant urban communities. The farther upstream a storage site is located, the fewer flood control benefits it typically provides. The Commission sees initiatives to reduce more frequent floods as complementary to the efforts to reduce damage from major floods and strongly supports continued efforts to alleviate the consequences of smaller floods. Local or regional initiatives should continue to be pursued, with full consideration of the net economic benefits and environmental impacts of such projects. The Commission concludes that:

IJC Conclusion 2: It would be difficult if not impossible to develop enough economically and environmentally acceptable large reservoir storage that alone would reduce substantially the flood peaks for major floods. Storage to reduce flood peaks for more frequent local floods may prove worthwhile and deserves further study.

(2) Micro-storage

From the air, the network of section line roadways in the Red River basin looks like a waffle or an ice-cube tray. The visible lines are generally intersecting road surfaces that are higher than the adjacent lands. Culverts restrict the flow of water from these areas, thus providing some uncontrolled short-term micro-storage. This unintended storage has inspired proposals for a “waffle storage” solution: a basin-wide system to temporarily store floodwater using low relief fields bounded by existing or raised roadways. These pools could then be controlled actively by gates on road culverts or, in a passive system, by undersizing the road culverts to retard runoff. Both of these approaches envisage thousands of micro-storage sites scattered throughout the basin rather than the more conventional flood storage reservoirs discussed above. To be effective for large-volume floods, the stored floodwaters must reduce the peak on the Red River, not just on the tributary where the micro-storage is located. While any storage will reduce flow volume in the Red River, effective reduction of peak flows requires that releases be accomplished on a time-sequenced basis. This in turn requires accurate and detailed forecasts and a sophisticated control system for the micro-storage. Since micro-storage would retard runoff from agricultural lands, it would also increase the duration of flooding on these lands.

If the 1.6 million dam³ (1.3 million acre-feet) of storage needed to reduce the 1997 flood flows at Grand Forks to 1979 flows came entirely from micro-storage, water would have to be stored to an average depth of 1 m (3 feet) on approximately 160,000 hectares (400,000 acres) of land, or about 1800 km² (700 square miles), all upstream from the point where the flood peak would be reduced. Because of storage inefficiencies and because local runoff conditions vary from year to year, achieving the desired flood control effect would require the commitment of well over 1800 km² (700 square miles) to micro-storage. Moreover, micro-storage would require many infrastructure changes. Roads would have to be raised and leveled and, in places, hardened, and culverts would have to be replaced or gated. The Task Force estimated the cost of such improvements would be at least U.S.\$96,500 per square kilometer (U.S.\$250,000 per square mile) or a total cost in the order of U.S.\$175 million. In addition, there would be costs associated with annual operation and maintenance of the system, and requirements to compensate farmers when flooding delays or prevents planting. While these estimates of cost may be high, the Commission suggests that further investigation of associated costs based on local conditions should be pursued.

Micro-storage would also require the development and implementation of detailed plans for separately operating the gates that control water levels in each impoundment to reduce local agricultural flooding, and avoid the possibility of aggravating downstream flooding on the mainstem through inappropriate gate operation. Execution of these plans would require complex supervisory control and a data acquisition system working in conjunction with a fine-resolution distributed hydrologic model. If these problems could be solved, micro-storage could provide some benefits in reducing the impacts of smaller, more frequent floods and could contribute to an overall flow reduction effort for a large flood. The Commission concludes that:

IJC Conclusion 3: Large-scale micro-storage has some potential to reduce flood peaks, perhaps significantly for more frequent local floods, but reliance solely on micro-storage for major flood events would be impracticable and costly. While there are many obstacles to its effective and efficient implementation, the feasibility of micro-storage for flood peak reduction should continue to be analyzed.

U.S. Army Corps of Engineers, St. Paul District



Raised roads near Drayton, North Dakota, capture floodwaters in a "waffle" pattern.

(3) Wetlands

Wetlands serve many useful functions within prairie and riverine ecosystems. They influence flow regimes and water chemistry, contribute to groundwater supplies, and can modify the effects of floods and droughts. They also benefit wildlife and serve as valued habitat in regional and even continental ecosystems. From the early years of settlement,

farmers were handicapped by wet land. Many areas of the Red River lowland were not continuously wet, but during years of heavy snowfall or more than average rain they were not fit for cultivation. These areas were an impediment to agricultural productivity. To support increased crop production, government programs encouraged wetland drainage. One study undertaken for the Task Force reconstructed the pre-agricultural landscape of the Canadian portion of the basin based on surveys in the 1870s. Wetlands comprised 12 percent of the landscape in 1870 but only 3 percent in 1995. Reliable figures on wetland drainage for the basin are not available, but it would appear that the vast majority of Red River valley wetlands were modified by human activity.

Depending on their structure and condition at the time of the flood event, wetlands may retain floodwaters and reduce peak flows or total flood volumes or both. Since little research has been done on this subject in the Red River basin, the Task Force undertook two studies that examined the potential for wetland storage to reduce flows on tributaries during major floods like that of 1997. The Task Force also examined the economics of increasing wetland storage. Based on these analyses, the Task Force concluded that a reduction of total flood volume is possible with expansion of wetlands, but large-scale wetland restoration programs do not appear to be an economically feasible way to reduce damage from major floods in the Red River floodplain.

The Commission notes that hydrologic analyses in other river basins have indicated that wetland storage can lower peak flows during smaller mainstem or tributary floods and minimally reduce the peaks of larger floods. Studies have also indicated that when larger areas are dedicated to wetland storage, the flood damage reduction and water quality improvements can be significant. The Commission notes that wetlands are frequently restored or constructed for their water quality and habitat values with little concern for flood control capabilities and are considered wise public investments. It may also be possible to farm restored wetlands during most growing seasons to minimize the economic impact on agriculture.¹² The more comprehensive potential environmental and social benefits that might accrue from preservation or restoration of wetlands deserve further investigation. The Commission concludes that:

IJC Conclusion 4: Wetland storage can provide an economically and environmentally beneficial method of reducing flood flows for frequent, smaller floods, but wetland storage alone is unlikely to significantly reduce the peaks of large floods on the mainstem of the Red River.

(4) Other Factors Affecting Flow

a) Drainage: Drainage of wetlands and agricultural and urban uses of land are often cited as factors that contributed to the record 1997 flood levels. Since artificial drainage moves water more quickly from where it accumulates to a natural watercourse, this appears

¹² Correspondence from William J. Mitsch, Ph.D., Professor and Director, Olentangy River Wetland Research Park, The Ohio State University, Columbus, Ohio, October 3, 2000.

reasonable. Changes in the time at which water enters a natural watercourse may, however, increase peak flows, cause no change, or even decrease the peak flows, depending on a number of factors. In 1997, record or near-record winter precipitation over most of the basin had saturated the ground, contributing to exceptionally heavy runoff that caused wetlands and other depressions in the land to fill and overflow. In addition, the peak flows on tributaries tended to coincide with peaks on the mainstem, thus exacerbating an already serious situation. The Task Force concluded that wetland drainage and land use practices contributed only a small amount, if any, to 1997 flooding. The significance of timing can be demonstrated by comparing the total flood volumes passing Winnipeg during the 1950 and 1997 floods. While the 1997 flood volume was similar to that of the 1950 flood, the peak of the 1997 flood at Winnipeg was substantially higher due to the coincidence in timing of the runoff throughout the basin. Removing water quickly from the land may provide a benefit in some years; in other years, it may mean that local peaks coincide with mainstem peaks and increase flooding. The Task Force was not able to examine in detail the impact of drainage on floods. This issue requires further study.



The ring dike surrounding St. Adolphe, Manitoba, holds back floodwaters, April 30, 1997.

b) Urban Levees: New urban levees for Grand Forks and East Grand Forks raised concerns about the effects on downstream water levels. The Task Force examined the impacts of the reduction in storage that would occur as a result of constructing higher levees to prevent flooding of the two cities and determined that the storage loss at the peak of major floods would be insignificant compared with the large volume of water in the Red River during these floods. The Commission concurs with this finding. Similar analyses will be required as part of the design of levee improvements elsewhere in the basin.

c) River Ice: Ice formation and accumulation in rivers can cause property damage, erode stream banks, disrupt transportation and hydropower operations, and make flood forecasting difficult. Ice jams occur frequently in the Red River basin and play a role in flooding on some tributaries and at a few locations on the mainstem. They can cause rapid and sometimes severe fluctuations in river levels and can alter the effectiveness of flood protection systems. While not a significant basin-wide factor in the 1997 flood event, ice remains a constant threat during spring melt at many locations. In 1996, a major ice jam resulted in flooding of portions of Selkirk, Manitoba. As the 1997 flood approached, drill holes were made in the ice near Selkirk to weaken the surface. In North Dakota, efforts were also undertaken to reduce ice jams by accelerating ice melting. No ice jam flooding occurred but the evidence is not conclusive as to whether this can be attributed to the drilling. Given the many unknowns in dealing with accumulating ice, mitigation strategies must be based on a thorough study of local conditions and take into account potential impacts on the environment and water quality, and the protection of downstream interests.

While some efforts have been made to catalogue ice jams, no basin-wide inventory exists. The U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL) has developed a national ice jam database that contains a number of events in the U.S. portion of the Red River in which ice affected river stages. The Commission concurs with the Task Force that consideration should be given to incorporating all Red River basin ice jam information into the CRREL database so that ice problems in the basin can be further analyzed.



U.S. Army Corps of Engineers, St. Paul District.

Wild Rice River near
Ada, Minnesota.

C. Protecting Large Population Centers

As noted above, communities, in coordination with state, provincial and federal organizations, can protect themselves from flood damage by retaining runoff before it gets to the floodplain, moving water around communities through bypass channels, or removing structures from harm's way. Although these measures are effective in some circumstances, given the relatively flat terrain in the Red River basin, many communities have found levees to be the only economically justifiable and socially acceptable protection measure. Urban levees are appropriate protection, provided they are evaluated systemically, are set back a reasonable distance from the river, take account of natural functions of the floodplain, and do not affect upstream or downstream flood levels.

If structural improvements are not engineered to withstand the forces of flooding, or if the levees are not high enough or cannot be raised in an emergency to withstand expected flood levels, these systems may give residents a false sense of security. In some instances, all possible sources or pathways for flooding may not have been considered. These sources would include "backdoor" flooding, inadequately plugged sewer systems, unknown seepage paths under levees, inadequate closures at streets and railroads, and inadequate interior drainage. In addition, individual community projects must be evaluated systemically to determine their impacts on those outside the community and downstream and upstream from it.

The Commission considers it most important that those protected by levees understand that a residual flood risk remains even when permanent levees provide a high level of flood protection. Levee elevation design is based on protecting against floods of a certain height or frequency, taking into account the costs of levee construction weighed against the damage prevented. A flood that overtops the designed levee places the people and property behind the levee in jeopardy. The lower the level of protective structures, the more frequently the community is at risk. As part of flood preparedness, communities need contingency plans to deal with the possible overtopping or breaching of their levees.

Recognizing the catastrophic impact of the 1997 flood on Grand Forks, the staggering concentration of damage, and the impact that similar events could have on other large population centers in the basin, the Task Force, with financial support from the province of Manitoba and the city of Winnipeg, carried out an analysis of the flood threat to Winnipeg and developed possible approaches to dealing with this threat. The Task Force limited its review of the flood threat facing Fargo, Moorhead, Wahpeton, Breckenridge, Grand Forks, East Grand Forks and Selkirk to a reconnaissance-level examination. It did not undertake detailed studies of these communities. FEMA and the U.S. Army Corps of Engineers are conducting hydrologic and hydraulic analyses of the Red River in the United States, and the Corps of Engineers is currently completing detailed engineering studies for Grand Forks–East Grand Forks and Wahpeton–Breckenridge.

Edward Bailey, International Joint Commission.



Winnipeg Floodway inlet and control structure, May 18, 1997.

(1) Winnipeg: With a population of about 670,000, Winnipeg is the largest population center in the Red River basin. It suffered comparatively less damage from the 1997 flood than other cities in the basin, owing in large part to the substantial flood defense infrastructure that was constructed following the 1950 flood, coupled with an enormous human effort to raise dikes and to construct a 34-km (21-mile) extension to the west dyke. Prior to 1997, the flood defenses had performed well but the

flood of 1997 stretched them to the limit. The defenses may be inadequate for the next flood of similar magnitude or larger unless they are significantly upgraded. To assess the vulnerability of the city, the Task Force, in collaboration with the province of Manitoba and the city of Winnipeg, reviewed the capacities and vulnerabilities of the flood protection system, examined new structural measures and operational changes, and conducted preliminary engineering feasibility studies of selected measures to increase protection.

Table 3

Capacities of Winnipeg Flood Protection System

Component	Design capacity		1997		Reliable capacity	
	cms	cfs	cms	cfs	cms	cfs
Shellmouth Reservoir	198	7,000	113	4,000	198	7,000
Portage Diversion	708	25,000	337	11,900	708	25,000
Winnipeg Floodway	1700	60,000	1900	67,100	2070	73,000
River Channel	2180	77,000	2260	80,000	2010	71,000
Totals	4786	169,000	4610	163,000	Up to 4986	176,000

The 1997 flood produced flows through Winnipeg that exceeded the reliable capacity of its flood protection system (see Table 3). Nevertheless, the city survived with little flood damage, in part because of dry weather during the flood peak. This, however, provided a wake-up call for the city. The Task Force identified certain vulnerabilities of the current system. In high-priority areas where the consequences of failure would be severe, such as the overall system capacity, the Winnipeg Floodway inlet control structure, and Winnipeg Floodway embankments and dikes, additional investigations were undertaken. Lower priority areas were simply identified. Based on these analyses, the Commission concludes that:

IJC Conclusion 5: Under flow conditions similar to those experienced in 1997, the risk of a failure of Winnipeg's flood protection infrastructure is high. Public safety requires that the city, province and Canadian federal government focus immediate attention on designing and implementing measures to further protect Winnipeg.

There appears to be a general recognition that the current flood defenses of the city must be improved. That recognition must become reality through the design and implementation of appropriate measures. What level of flood can be expected and what level of protection is appropriate? The 1826 flood at Winnipeg, with a peak flow in the order of 6370 cms (225,000 cfs), approximately equivalent to a 1-in-300-year flood, is the largest flood on record. The Task Force estimated that a 1,000-year flood would have a flow of about 8490 cms (300,000 cfs). By comparison, the 1997 flood produced a natural flow through Winnipeg of 4620 cms (163,000 cfs), which is about a 1-in-90-year flood. Given that over 600,000 people could be at risk from an event larger than 1997, and recognizing the importance of the city to the provincial economy, higher levels of flood protection than currently exist must be provided. The Commission recommends that:

IJC Recommendation 2: The design flood used as the standard for flood protection works for Winnipeg should be the highest that can be economically justified or, at a minimum, the flood of record, the 1826 flood.

The Task Force detailed several options for providing an increased level of flood protection for the city. The Commission supports the two-step approach to flood protection for Winnipeg proposed by the Task Force. The first step would secure the city against the recurrence of a flood the size of 1997, and the second would provide an increased level of protection and security with full consideration of the social and environmental implications. As part of the first step, the Commission supports the need for improvements to the east embankment, west dike, primary dikes, and modifications to sewer and land drainage systems.

Pre-feasibility engineering studies identified, for further consideration under the second step, two major structural projects: expanding the existing Winnipeg Floodway and constructing a detention basin at Ste. Agathe. From an engineering perspective alone, these appear to have the greatest potential for providing the needed level of protection. From an economic perspective, initial cost estimates undertaken on behalf of the Task Force indicate that the Ste. Agathe detention project would likely be less costly to construct.

The Commission believes that construction of a detention structure at Ste. Agathe would have implications that go well beyond economics. The project raises very serious social implications, and the Commission believes its construction could adversely affect future development in the region. During its public hearings in February 1998 and May 2000, the Commission heard at first hand the concerns and frustrations of residents upstream of the Winnipeg Floodway and from those who could suffer increased flooding from 100-year events or larger as a result of the proposed Ste. Agathe detention structure. The method of operation of the Winnipeg Floodway was a major concern in 1997, when residents upstream of the Winnipeg Floodway suffered increased flooding as a result of an operating rule that was implemented to provide an increased level of protection to the city. Many residents were troubled by what they perceived as a lack of concern on the part of Winnipeg residents and the operators of the Winnipeg Floodway about what happened outside the perimeter of the city. It was suggested that this perception was reinforced by Winnipeg's publicly manifested view that the crisis as a whole was over once the safety of the city was assured. The Commission agrees with the sentiments expressed by residents upstream of the Winnipeg Floodway that they received neither adequate recognition for the disruption to their lives, nor full and prompt compensation for their losses.

The 500 or more people who attended the Commission's May 2000 hearings at Winnipeg and Emerson reflected the level of public concern over the proposed Ste. Agathe structure. At these hearings, the Commission heard many presentations opposing the structure. Speakers suggested that the Ste. Agathe detention structure would prove to be more expensive than expanding the Winnipeg Floodway when flood easement costs, compensation costs and lost revenues from the rich agricultural land in the area were included. They questioned whether such a structure could be acceptable from an environmental standpoint, and whether upstream communities could be protected by higher ring dikes. They pointed to the social costs of demoralizing a region, pitting those in rural areas against Winnipeg residents, and deterring development by intentionally making the region more vulnerable to floods. The Winnipeg Floodway, they said, had been designed so as not to flood unduly those who are not protected by the system. This approach should also be taken in providing protection for the city against a flood greater than the one that occurred in 1997. They were adamant that they should not be willfully sacrificed for the protection of the city. The Commission fully shares this view.

Clearly, the protection of Winnipeg must be given a high priority. But it is equally clear that proposals for additional flood protection for the city or alterations to the operating rules for the Winnipeg Floodway must take account of the full economic, social and human costs for other areas that would be affected by such measures. A transparent process of open consultation must be established to ensure that residents of such areas have an opportunity to be an integral part of any decision-making process. The Commission considers that the doubts expressed about the efficacy of a detention structure at Ste. Agathe as the solution to Winnipeg's flood problems must be addressed and that there must be a full evaluation of the economic and social costs of the projects proposed. If the consensus is to proceed with such proposals, prompt and complete compensation of damages should be provided to any who are injured as a result. It is noteworthy that the Boundary Waters Treaty would provide for adequate protection and indemnity to persons in the United States who might be injured by an increase in water levels caused by a structure such as that proposed at Ste. Agathe. It is hard to imagine that Canadians should receive less consideration.

The Commission recommends that:

IJC Recommendation 3: The city, province and the Canadian federal government should cooperatively develop and finance a long-term flood protection plan for the city that fully considers all social, environmental and human effects of any proposed protection measures and respects both the needs of Winnipeg and the interests of those outside the city who might be affected by such a plan.

In response to suggestions made by the public in 1998, the Task Force investigated two proposals for increasing the discharge capacity of the Winnipeg Floodway channel—removal of the outlet structure and removal of the inlet weir or plug. Analysis shows that removing the outlet structure could produce a minor increase in flow capacity of 56.6 cms (2,000 cfs) and result in significant erosion. Removal therefore cannot be justified. Lowering the inlet weir crest level by 2.13 m (7 feet) to the level of the Winnipeg Floodway channel would increase the discharge capacity by 1.4 cms (50 cfs). This benefit is insignificant and not worth the complications arising from early entry of ice into the Winnipeg Floodway channel. The Commission concludes that neither of these options should be given further consideration.

In addition to structural measures, there are a number of non-structural protective measures that need to be addressed by the city of Winnipeg. Despite the success of efforts in 1997, more planning for extreme events must be undertaken. The Commission encourages the city to enhance the flooding component of its Emergency Preparedness and Response Plan (EPRP) to address the following:

- emergency evacuation of large portions of Winnipeg;
- emergency response to breaches in flood-retaining structures;
- emergency construction of approximately 80 km (50 miles) of temporary dikes; and
- planning for operation of flood control works during unprecedented flow conditions.

Current efforts to assemble and document emergency procedures should be expanded, with high priority being given to the preparation of a detailed emergency preparedness and response manual. Other prudent measures should also be undertaken including correcting sewer cross-connections, improving the land drainage system, and data acquisition and modeling to enable enhancement of the city's flood preparedness.

(2) Fargo–Moorhead: Fargo is protected by a permanent levee and bypass channel flood control project which was completed in 1961, and by the west Fargo diversion, substantially completed in 1993. Prior to the 1997 flood, the 100-year flood level was estimated to be 11.7 m (38.3 feet). The top of the permanent levees in Fargo is at 12.2 m (40.0 feet), after settling 0.4 m (1.3 feet) from original construction. A record-setting flood crest elevation occurred in 1997 at 12.1 m (39.7 feet). Following the 1997 flood, the recurrence interval for this flood was estimated to be 70 years. Moorhead, on the other hand, has no permanent federal flood control project. Although the design height of permanent flood control projects was exceeded during the 1997 event, both communities avoided major flooding in 1997 by either raising existing levees or building temporary barriers.

Since the 1997 flood, both communities have implemented mitigation measures, including the acquisition of almost 100 floodplain homes, raising and stabilizing existing levees, installing permanent pump stations, and improving storm sewer lift stations and the sanitary sewer system. The city of Fargo is investigating the feasibility of providing permanent protection to areas on the south side of the city that are currently unprotected. Most of the levees built since the 1997 flood are eligible for inclusion in the U.S. Non-Federal Flood Control Works Inspection Program but have not been certified by the Federal Emergency Management Agency (FEMA) as providing 100-year flood protection.

As mentioned previously, the hydraulic model developed to simulate one scenario that would yield the record 1826 flood discharges experienced in Winnipeg shows Red River flood levels at Fargo–Moorhead reaching approximately 13.0 m (42.5 feet), more than 0.8 m (2.5 feet) higher than the level experienced in 1997. Following completion of the Task Force's report, the U.S. Army Corps of Engineers, under contract to FEMA, completed a new flood frequency analysis for the Fargo and Moorhead area. The results indicate that the volume of water running through Fargo and Moorhead in a 100-year Red River flood would be 8 percent greater than previously thought. This increase, in combination with new hydraulic analyses, would raise the 100-year flood elevation by approximately 0.8 m (2.5 feet) to 12.4 m (40.8 feet).

Since the flood of 1997, the residents of Fargo and Moorhead have been hit by several major storms that have caused significant flooding within the two cities. While most of the damage that has occurred can be attributed to the inability of the existing interior drainage systems to quickly carry away runoff from the storm, there is a close relationship between actions needed to deal with these local floods and those required for floods on the Red River. During and following public hearings, the Commission was told that measures aimed at small and local floods would also help Fargo and Moorhead deal with large floods.

It was said that any reduction in 1997 would have been welcome, and that measures to deal with smaller, more frequent floods needed to be addressed. Speakers also regretted that there had not been more analysis of the flooding potential of the two communities. The Commission notes that the Task Force's efforts were focused on the 1997 flood and recognizes that little analysis was made of the specific needs of Fargo and Moorhead.

Fargo and Moorhead face a difficult situation. They are now dealing with two new assessments of large floods (the new 100-year flood level and the possible 1826 level) that indicate flood risks greater than previously thought, and there appears to be significant disagreement about both the determination of flood levels and the actions that should be taken to prevent future damage. Both communities believe that mitigation actions must be taken within the context of a basin plan and must include reduction of flood flows, strengthening of existing protection structures and use of other flood damage reduction techniques. The Commission concurs with this approach. It also understands that Fargo and Moorhead have requested the U.S. Army Corps of Engineers and FEMA to determine more accurately the threat to their communities. Until this work is carried out and solutions aimed at reducing the determined flood risks are developed, Fargo and Moorhead remain at undue risk. The Commission recommends that:

IJC Recommendation 4: The government of the United States, in cooperation with the cities of Fargo and Moorhead and the states of North Dakota and Minnesota, should expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo–Moorhead area.

(3) Grand Forks–East Grand Forks: At Grand Forks and East Grand Forks, the maximum 1997 flood level on the Red River was 16.56 m (54.35 feet) and was estimated to be a 210-year event. Temporary levees built to levels of 15.8 to 16 m (52.0 to 52.5 feet) were overtopped. The resultant damages to the cities of Grand Forks and East Grand Forks were estimated to be U.S.\$3.6 billion. Since the flood, the communities have worked with the U.S. Army Corps of Engineers to develop and implement an appropriate protection strategy. After consideration of several alternative approaches, including use of a bypass channel, the Corps and the communities decided on a plan that raises portions of the existing levee system, sets back and strengthens other portions, and constructs floodwalls in other areas. To accommodate the setback and to reduce the number of homes and businesses at risk, over 1,000 structures have been or will be removed from the floodplain. This U.S.\$350.3-million project is underway and is scheduled for completion by 2006. The project is designed to provide permanent protection from the 210-year flood event, with 1 m (3 feet) of freeboard provided above the 210-year flood level. As part of the overall flood protection plan, a permanent “invisible” flood wall providing the same level of protection to downtown East Grand Forks is now complete. Pending completion of the permanent structures, both communities have taken interim measures, including the raising and stabilizing of temporary levees and improving storm and sanitary sewer



View of Grand Forks,
North Dakota.

systems. The hydraulic model developed to simulate one scenario that would yield the record 1826 flood discharges experienced in Winnipeg shows Red River flood levels at Grand Forks–East Grand Forks reaching approximately 17.4 m (57.0 feet), more than 0.8 m (2.6 feet) higher than the level experienced in 1997. Given that the design level of protection for the permanent flood protection structures for Grand Forks and East Grand Forks is equal only to the 1997 flood, the Commission cautions that the proposed level of protection must be periodically evaluated to ensure that it remains adequate in the face of changing conditions throughout the basin. The Commission strongly supports the inclusion of flood-proofing measures for new buildings in areas that would be protected by the new levees. The Commission recommends that:

IJC Recommendation 5: The government of the United States, in cooperation with the cities of Grand Forks and East Grand Forks and the states of North Dakota and Minnesota, should ensure that the planned flood protection works are promptly and expeditiously completed.

(4) Wahpeton–Breckenridge: In the Wahpeton–Breckenridge area, the 1997 flood reached a level of 5.9 m (19.42 feet). It came within inches of overtopping the emergency levee that had been built to contain the flood at Wahpeton, but the community was not flooded. During the summer and fall of 1997, Wahpeton began construction of permanent levees on its own, but a shortage of funds ended the project before completion, with protection provided only for the south side of the city. Breckenridge's levees were overtopped twice during the 1997 flood, first from the north and then from the south, flooding most of the community and causing damages of U.S.\$30 million. Breckenridge has undertaken a number of flood damage reduction measures since the flood, including removing damaged homes from the floodplain, installing pumping stations, and building levees, and continues to work toward improving the city's flood protection. In response to a request from Wahpeton and Breckenridge, the U.S. Army Corps of Engineers has undertaken flood reduction feasibility studies and is developing multi-featured flood reduction projects for both cities at an estimated cost of U.S.\$9.5 million for Wahpeton and U.S.\$20.5 million for Breckenridge. The Wahpeton and Breckenridge projects will provide 125-year flood protection by raising the top of their levees to 6.6 m (21.8 feet) at the U.S. Geological Survey gauge. The Breckenridge project also includes a diversion of the Ottertail River flows around the community and into the Red River. The hydraulic model developed to simulate one scenario that would yield the record 1826 flood discharges experienced in Winnipeg shows Red River flood levels at Wahpeton–Breckenridge reaching

approximately 6.2 m (20.3 feet), more than a third of a meter (one foot) higher than the level experienced in 1997. With the flood reduction projects for the communities yet to be completed, these communities remain at undue risk. The Commission recommends that:

IJC Recommendation 6: *The government of the United States, in cooperation with the cities of Wahpeton and Breckenridge and the states of North Dakota and Minnesota, should expedite approval and implementation of flood protection plans to reduce the risk of flooding at Wahpeton–Breckenridge.*

(5) Selkirk: The city of Selkirk is located on the Red River north of Winnipeg. It has experienced flooding of waterfront properties and outfalls of the storm water sewer system on numerous occasions in the past. One of the major concerns in the area is ice jamming in the river, which, in 1996, caused levels higher than the flood of 1997. Although the risk of flooding in the city of Selkirk was not examined by the Task Force under its study plan, Red River flows greater than those of 1997 would pose a threat to the city. Prior to the 1997 flood, Selkirk was believed to be protected against the 160-year flood. Analysis following the flood revealed that the present level of protection is likely closer to the 100-year flood level. Thus, there is an immediate need to quantify areas at risk, develop mitigation measures, and increase the level of protection to avoid future flood damage in the Selkirk area. Moreover, downstream impacts on Selkirk must be considered in the development of additional flood protection works for Winnipeg. The Commission recommends that:

IJC Recommendation 7: *The province of Manitoba and city of Selkirk should expedite studies of flood-risk potential in the Selkirk area.*

D. The Impacts of Flooding

The economic toll of the 1997 flood is still being determined on both sides of the border. Homes and businesses were damaged and destroyed. People were kept away from their homes, businesses and stores for months, if not forever. Seeding was delayed and in some cases farmsteads were destroyed by the floodwaters. The estimate of the total economic damages sustained in the basin approached U.S.\$5 billion. The impact of the damage primarily fell on those who lived in the flood's path. The human impacts of the flooding have been difficult to measure. Many people who were forced from their homes, as the floodwaters rose, came back to find everything they owned destroyed, which meant long periods living with friends, in government-provided trailers or in other temporary accommodations. Those who could return to their homes found them filled with muck,

It is very difficult to be objective or unemotional when relating the pain and uncertainty of our lives over the last 10 months. The effect of dislocation, the loss of place, cherished possessions and the ensuing anxiety over disruption in children's development and security, stress on marriages, damage to livelihoods and cost of rebuilding is extremely hard to describe. The emotional gamut for us has run from despair to anger, dismay to worry, acceptance to determination.

Floodplain resident, IJC public hearing, Ste. Agathe, February 12, 1998.

their family treasures saturated by the muddy waters, and their health at risk from molds. Farmers and store owners faced similar challenges. Their ability to survive economically was in question. For a period, few thought Grand Forks and East Grand Forks could recover, and many in Grand Forks, East Grand Forks and the surrounding flooded countryside considered leaving the area permanently.

With the support of governments at all levels and many non-governmental and voluntary organizations, recovery has, for the most part, taken place. But it was not easy. For months, and in some cases years, people did not know where to go or what to do. If they planned to rebuild or repair, they were unable to determine the conditions under which they would be able to do so. Would they be able to rebuild in the same place? At what elevation should a new home be built? How would the proposed solutions to the flood problem in the major cities affect those outside the flood defenses? If another flood occurred, would they be inundated again? Many of these questions remain unanswered and those affected struggle to continue their lives with this uncertainty.

There is no satisfactory way to sum up the collective trauma of the over 100,000 people who were affected by the flood and who struggle to recover, even now, more than three years after the event. The Commission knows from its many visits with local residents, public hearings, and study of the flood that the human toll is high and is real. There is no easy way to assign an economic benefit to the value of knowing one is relatively safe from future floods or the economic cost of the trauma of knowing that you may once again be flooded. Uncertainty about the amount and timing of compensation from governments still are important issues in many people's minds. Many residents upstream of the Winnipeg Floodway who were harmed by increased water levels caused by the way in which the Winnipeg Floodway was operated to save Winnipeg feel that the matter still has not been satisfactorily addressed by the government of Manitoba.

Prairie Farm Rehabilitation Administration.



The Task Force commissioned a review of available literature and research on the human costs of enduring and coping with the flood, flood recovery and dealing with an uncertain future.¹³ This work provided the basis for the findings noted in the box insert on page 37.

The 1997 flood inundated Ste. Agathe, Manitoba.

13 Natural Hazards Center, University of Colorado, *Evaluation of a Literature Review of the Social Impacts of the 1997 Red River Valley Flood* (October 1999). (Available at: www.ijc.org)

The Commission finds that this research is supported by the anecdotal evidence it has obtained during the study and strongly supports the continuation and extension of such investigations and analyses. The Commission recommends that:

IJC Recommendation 8: To improve resiliency in the basin, governments should support enhanced research into the various social dimensions of the flood, including economic, psychological, public health and sociological impacts.

E. Resilience

The residents of the Red River basin must be ready to cope with the next flood. They must be prepared to deal with the challenges of fighting the flood and flood recovery. In other words, they must become resilient to the effects of flooding where they cannot avoid them. The Task Force defined resilience as the ability to bounce back or adapt quickly to the consequences of an extreme natural event, such as a flood. It found that resilience is developed through many measures that reduce the effects of future floods. These measures include accurate and timely warnings, flood control measures, the designation of flood-prone areas as open space, flood insurance, flood-resistant construction, and storm-water management. Flood insurance and its role in improving community resiliency is discussed later in this report. Even with the adoption of structural projects that will reduce flood flows or provide direct protection against floods, many communities and residents will still remain at high risk from major floods. The Task Force outlined non-structural measures that communities can take to help reduce the impact of flooding and give residents the ability to adapt quickly to the consequences of floods. The Task Force also recommended that governments monitor indicators of resilience, such as the extent to which the floodplain is occupied and the number of insured households, since monitoring such factors would not only help identify problems and deficiencies in individual and community resilience, but would also help establish a baseline against which progress can be measured. The Commission strongly supports the Task Force's recommendations that call for effective strategies to improve disaster resiliency in basin communities, and development of flood resilience measures and of the means to monitor resilience in the Red River basin.

The Human Costs of Floods

The flood had a disproportionate impact on women.

In Grand Forks, flood damaged businesses owned or managed by women were twice as likely to remain closed as were others.

Women in the United States were at increased risk of domestic violence after the flood.

Stereotypical gender patterns became more prominent after the flood, to the detriment of women.

The stress to residents in the flooded and evacuated areas of Manitoba was increased by their inability to access timely, relevant flood-warning, evacuation, and recovery information from governments.

The flood tested marital relationships.

Racial and cultural bias was evident in some aspects of recovery in the United States.

A majority (65 percent) of social practitioners dealing with juveniles, the family, mental health, and gerontology in Greater Grand Forks said that their clients were unsettled by the flood.

F. Individual Homes, Small Communities, and Agricultural Areas

Flooding problems in the Red River basin are widespread. Communities of all sizes are affected, as are individual homes, farmsteads and agricultural lands. The flood of 1997 highlighted the need for governments, communities and residents in the valley to actively pursue measures to further safeguard businesses, homes, properties and communities. While many had some level of protection, their protection in many cases was insufficient to withstand the floodwaters of 1997. The Task Force outlined many programs under which flood protection works are being improved, as well as many of the local community protection measures that are currently being assessed or are under construction. The level of effort currently underway to enhance protection throughout the valley is a testament to the respect that many have gained for the river.

Edward Bailey, International Joint Commission.



Ring-diked homes south of Winnipeg. The 1997 flood spared some but inundated others.

Local protection projects must be evaluated systematically, taking into consideration the potential force and direction of floodwaters, seepage and drainage of trapped waters, the natural functions of the floodplain, and the impact of the project on other areas. When structural measures such as levees or ring dikes are the selected option, some risk of failure or overtopping by an extreme event must be considered and appropriate contingency plans must be developed and maintained. Structural protection measures must be designed and

constructed to recognized standards. Otherwise, a false sense of security may develop. In the U.S. portion of the basin, levees in 70 percent of the communities do not meet minimum federal standards and have not been approved under the U.S. Non-Federal Flood Control Works Inspection Program. While this does not necessarily mean that they are inadequate, their structural integrity should be reviewed as many of the levees were built under less than ideal weather conditions, during an emergency situation, and possibly without adequate engineering. The Commission supports the Task Force's recommendation calling for community-built flood damage reduction projects in the United States to be certified by FEMA as providing 100-year or greater flood protection, or to be approved under the U.S. Non-Federal Flood Control Works Inspection Program if less than 100-year flood protection is provided.

Emergency plans in all communities in the basin are fundamental for effective flood preparation, response and recovery. These plans should be reviewed regularly and adjusted in the light of past experience and lessons learned from other communities. Where innovations have proven effective, they should form part of the revised plan. The Commission reiterates the recommendation made in the Task Force's interim report that flood emergency plans for all communities within the basin be reviewed and updated based on lessons learned during 1997.

In the United States, flood protection projects for small communities, individual homes, and farmsteads often cannot meet the benefit-cost criteria for obtaining federal funding, leaving them to rely on whatever state, local, or private initiatives and funding may be available. In Manitoba, over Can\$44 million was made available under a federal-provincial program for moving, raising or diking individual homes, properties and businesses, while up to Can\$60,000 in assistance was available for individual claims. A total of Can\$380 million has been paid out in damage claims and for flood fighting efforts. In the United States, as of September 30, 1997, FEMA had provided over U.S.\$145 million in individual assistance, over U.S.\$39 million in hazard mitigation assistance, and over U.S.\$134 million for flood insurance claims, while the Small Business Administration had provided nearly U.S.\$169 million in home loans.¹⁴

The Task Force suggested that it is not generally economical to protect agricultural land against spring floods in the Red River basin, noting that they often do less damage to crops than floods during the summer growing season. During public hearings, however, several individuals stated that there is a substantial reduction in yield for every day that seeding is delayed. Others stated that the impact of flooding on agriculture should have been given more attention in the study. The Task Force did not address agricultural issues as it understood that crop losses due to the 1997 flood were minimal. It also noted that while locally funded agricultural levees provide some flood protection, typically for smaller, more frequent flood events, the impact of such levees on other areas in the basin has generally not been evaluated but should be considered in taking a basin-wide approach to flood mitigation.

IJC Recommendation 9: Governments at all levels should ensure that in the development of flood mitigation strategies for the basin the needs of small communities, individual isolated farmsteads and agriculture are not overlooked.



Photo by Michael M. Miller, NDSU Libraries, Fargo, ND

The 1997 flood inundates a farm in the upstream portion of the Red River basin.

¹⁴ Final Report of the President's Long-term Recovery Task Force, Minnesota, North Dakota, South Dakota (December 1997).



Highway #75 south of Winnipeg. Flooding of highways throughout the basin disrupted transportation.

G. Transportation Corridors (Roads, Railroads, Bridges)

Major floods often disrupt transportation. This was certainly the case in 1997, when the primary north-south highway corridor (Interstate 29 and Provincial Trunk Highway 75) and the main east-west corridor (US 2) were closed. Regional and local roads were flooded and bridges were closed over the Red River between Fargo and Winnipeg, a distance of over 320 km (200 miles). Primary railroad lines were also under water, requiring the re-routing of rail traffic. Because of the flat terrain throughout most of the Red River valley, roads and railroads will continue to be flooded by major events like that of 1997. One solution to this problem is to raise major transportation routes to reduce the frequency of their flooding. In the flat terrain of the Red River valley, such construction can, however, have unintended effects by retaining or redirecting floodwaters when they break out of the river channel. The raising of any road or rail lines must anticipate possible hydraulic impacts and hydraulic modelers in the basin must be informed of the location of any proposed or actual changes, so that their significance to future flooding can be determined.

H. Pembina River

Spring floods are a natural and common occurrence along the Pembina River, a tributary to the Red River located along the Canada–U.S. boundary. A map of the Pembina River basin is shown in Figure 3. The most significant flooding occurs along the 56.4-km (35-mile) reach between the Pembina Escarpment at Walhalla and the Red River. For more than 50 years, unilateral dike and road building along both sides of the border has been the source of transboundary disputes and tension. Over the years, federal, state, provincial and local governments have undertaken a number of initiatives to find solutions to the problems of transboundary flood management, but none have succeeded. The Task Force provided a common base of information to assist governments and local interests in resolving the issues. It developed detailed mapping of the lower basin and a computer model to simulate various topographic configurations and river flow conditions. The Task Force used the models to test approaches to flooding and flood protection. The resulting flow patterns from each scenario provide a basis for discussion and consideration of options for resolving the flooding problems. Unfortunately, time and resource constraints prevented the Task Force from pursuing the matter to completion.



The Task Force worked closely with the Pembina River Basin Advisory Board in defining various scenarios and has shared the outcome of the studies with them. The Pembina River Basin Advisory Board serves as a valuable forum for the public presentation and discussion of new information on water management and has indicated its interest in pursuing a resolution of the long-standing Pembina issue. There appears to be a general readiness at the local level to resolve the issue, and this opportunity should not be lost.

The Commission has recently been informed of new developments in the United States involving a decision of the North Dakota Supreme Court that upholds orders for the removal of certain illegal dikes along the Pembina River. This development again brings out the evolving nature and difficulty of this issue. The Commission considers that resolution of this transboundary flooding issue will require a commitment of time and resources by government agencies in both countries. The Commission agrees with the Task Force recommendations calling for federal involvement in the process, the modeling of proposed physical changes prior to implementing any plan, and continuing work on the virtual database and decision-support system prototype. The Commission calls on governments to establish a consultative group to work with local interests and encourages governments to commit the necessary resources to resolve the issue. The Commission recommends that:

IJC Recommendation 10: Federal government agencies, in cooperation with the state of North Dakota and the province of Manitoba, should establish a consultative group to work with local interests, including the Pembina River Basin Advisory Board, to resolve the lower Pembina River flooding issue, provide necessary resources for the group, and act to achieve a solution.

I. Flood Preparedness and Mitigation

Residents of the Red River valley have a right to expect that governments at all levels will show leadership and provide guidance in the development and implementation of mitigation measures, including sustained actions to reduce or eliminate long-term risk from flooding and its effects. Canada and the United States differ in their approach to flood preparedness. The United States has a framework for dealing with issues through the National Flood Insurance Program (NFIP), mitigation initiatives under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, and a national mitigation strategy. The Canadian approach is less integrated and tends to be event-driven, with no common programs or frameworks tying activities together. Because of the frequency and magnitude of floods in the Red River basin, it is essential that flood preparedness and mitigation activities become a central focus of comprehensive, integrated basin management.

Unfortunately, mitigation activities receive very little attention except during times of crisis and for a short time thereafter. Ideally, planning and coordination leading to an integrated approach to mitigation must take place on a continuing basis during non-crisis periods so that projects are coordinated, potential impacts are considered, and funds are spent wisely. This had not been the case in the Red River basin. A sense of complacency had set in, government funds for monitoring and environmental work had been cut back, and priorities had shifted to other matters. The 1997 disaster presented an opportunity to rethink mitigation activities as funding was made available from a number of sources, and the will to act was present. The difficulty will be to maintain this interest and government support over the longer term to ensure that lessons learned from the event are carried forward and appropriate basin-wide preparedness and mitigation plans are developed and implemented.

The Commission endorses the Task Force's recommendations regarding the need for an overarching framework for mitigation:

IJC Recommendation 11: Governments should develop a binational integrated approach to mitigation initiatives at all political levels, based on a comprehensive mitigation strategy for the entire basin. In the United States, the strategy should be integrated within the overall national framework.

IJC Recommendation 12: The Canadian federal government should establish a national flood mitigation strategy, or a broader disaster mitigation strategy, and support it with comprehensive mitigation programs.

The Task Force addressed numerous elements of mitigation, including building standards, education, enforcement, floodplain acquisition, and flood insurance. It also encouraged the sharing of information about recovery and rebuilding techniques specific to the Red River basin. These are all elements of a flood mitigation strategy and are essential to reducing the risk of flooding in the basin.

For communities and residents to take responsibility for flood protection, they need to understand where the water will flow under different flood conditions and appreciate their level of flood risk. Efforts need to be made to increase public awareness of flood risks throughout the basin, including for locations that are structurally protected from floods, so that appropriate decisions will be taken to make developing communities resilient to flooding. Initiatives such as FEMA's Project Impact and its transboundary pilot project in the Red River basin, the International Flood Mitigation Initiative, are promising steps aimed at improving resilience to floods.

Within the Canadian and U.S. portions of the Red River basin, the governments have their own policies and regulatory measures for defining flood-prone areas, and each has designated an official or regulatory Red River floodplain. Following the 1997 flood, the Task Force and others developed new data, tools and techniques to improve floodplain definition. The Commission recommends that:

IJC Recommendation 13: Governments should use, at a minimum, the 100-year (1 percent) flood as the basis for floodplain regulations and revise their estimates of the 100-year flood levels based on 1997 and new data that become available.

The Commission notes that Manitoba has specified more stringent floodplain management standards based on historical flood levels. The Commission believes that consideration must be given to greater than 100-year flood protection when the expected impacts of such larger floods are unacceptable. The Commission thus concurs with the Task Force's recommendation to use the 500-year (0.2 percent) flood to inform the public of potential risks of flooding from rare events and as the basis of regulations for siting and flood-proofing critical facilities.

Although regulations in both countries require that new, and in many instances, improved, structures located in the floodplain be elevated to certain levels or protected from floodwaters by other means, the 1997 experience, once again, points to the need for improved enforcement of measures to reduce the impact of such flooding. Lack of enforcement at the local, state or provincial levels of floodplain regulations, zoning bylaws and ordinances resulted in significantly higher damages than would have occurred with more effective enforcement. The Task Force also reviewed building codes and standards for flood hazard areas. Current practices vary throughout the basin and greater attention to this issue is needed to support enhanced floodplain management and flood damage reduction. In order to achieve successful flood damage reduction programs, it will be

necessary to fully integrate building codes and land use restrictions into floodplain management regulations. The Commission endorses the Task Force's recommendation regarding enforcement of building codes, zoning and other regulatory measures. These are only as effective as their enforcement.

IJC Recommendation 14: State, provincial and other appropriate authorities should review the effectiveness of and compliance with the floodplain management regulations in the basin and take steps as needed to improve enforcement.

Buyouts and removal of flood-damaged buildings reduce future flood losses and help build resilience, but only if the land remains permanently vacant. The Task Force questioned prohibitions on the siting of flood control levees on land that was acquired through FEMA's Hazard Mitigation Grant Program. The Commission notes that FEMA and the U.S. Army Corps of Engineers signed a Memorandum of Agreement regarding this issue on March 29, 2000; thus, the Commission believes there is no need for further comment. In the United States, buyout programs proved effective following the 1997 flood and many structures were removed from flood-prone areas through voluntary sales. The Commission encourages Canadian jurisdictions to review this practice and to implement programs of a similar nature to reduce the severity of future flood losses in Canada.

The Task Force described aspects of the U.S. National Flood Insurance Program (NFIP). Flood insurance can be a positive force, promoting flood preparedness, sustainability and resiliency, and it can be a highly effective mechanism for fostering individual responsibility by spreading the cost of flood damage among those who bear the risk. The Task Force discussed incentives and disincentives to purchasing flood insurance. The Commission also heard concerns expressed about certain aspects of flood insurance and insurance coverage. These concerns included allowing basements to be constructed under certain conditions, yet not covering basement contents, and making more than emergency disaster assistance funds available to those who were eligible for but who did not purchase flood insurance.

Under the NFIP, administered through FEMA, flood insurance is made available to residents of communities if and only if the community adopts and enforces floodplain management regulations. New or substantially improved buildings in the regulatory floodplain must be constructed so that the lowest floor, including basement, is at or above the 100-year flood level. Flood insurance for these new or improved buildings is actuarially rated (i.e., based on the actual risk involved).

Under some circumstances, FEMA will grant an exception to a community to allow floodproofed basements if the community adopts an ordinance that specifically controls how basements are constructed and used. Such exceptions have been issued for several communities in the Red River basin. FEMA conducted an assessment of 111 floodproofed

basements constructed in these communities and found only a single failure: the basement floated.¹⁵ Considerable damage occurred to many basements in the Red River basin not constructed to the flood-proofing standards, particularly where the basement areas had been finished for use as living spaces. FEMA recently conducted a study¹⁶ to determine whether it should provide coverage for personal property in basements but determined that the cost would be prohibitive for the consuming public.¹⁷

While money is often made available in the United States following a presidentially declared disaster to those without flood insurance, and was made available after the 1997 flood, it is usually a loan which must be repaid or a means-tested grant. No repayment is expected for flood insurance claims payments. While property may be bought out even when not covered by insurance, these properties cannot be readily identified in advance of the flood and the buyout serves the greater public purpose of reducing future flood damage. FEMA contracted in U.S. fiscal year 2000 to plan and design a comprehensive assessment of the NFIP. Although the scope of the assessment has not been determined, one topic being considered is the relationship between disaster assistance and flood insurance.¹⁸

The Task Force also questioned the length of the 30-day qualification period before flood insurance in the United States comes into effect. It believed 30 days was short enough in the Red River basin to enable residents to await predictions of the spring flood risk before making insurance purchase decisions. U.S. legislation, which applies nationwide, increased the waiting period from 5 to 30 days in 1994. The Red River basin is unusual in that the extremely flat terrain can mean long flood travel times, with floods often being identifiable well in advance. The Commission understands that, under some circumstances, a long qualification period may discourage the initial purchase of flood insurance, particularly if severe flooding usually occurs only at certain times of the year and coverage would not begin until after the highest risk had passed. On the other hand, under other circumstances a short qualification period may discourage the maintenance of flood insurance coverage, since those insured may choose to evaluate risk as floods develop and purchase insurance only immediately prior to a perceived flood threat. The Commission supports measures that will increase the purchase and retention of flood insurance in the U.S. portion of the basin. The Commission understands that FEMA is reviewing the length of the qualification period and suggests that it consider Red River basin experiences within its larger, nationwide review.

As in the United States, standard residential property insurance policies in Canada do not cover flood damage. In Canada, no other source of coverage is presently available. Moreover, since the end of Canada's federal-provincial Flood Damage Reduction Program in 1993, there is a lack of current floodplain information, and there are currently no

15 FEMA, *NFIP Call for Issues Status Report* (June 2000) p. II-2-3.

16 Greenhorne & O'Mara Inc., *Basement Performance Assessment in Minnesota and North Dakota, Report to the Federal Emergency Management Agency* (February 1998).

17 FEMA, *NFIP Call for Issues Status Report* (June 2000) p. I-5-22.

18 FEMA, *NFIP Call for Issues Status Report* (June 2000) p. I-10-29.

incentives to obtain the information needed to assess the overall level of flood risk. The Commission concurs with the Task Force's suggestion that, despite the smaller potential subscription base in Canada and the concentration of the majority of Canada's 1,300 flood-prone communities in the Great Lakes–St. Lawrence River basin, the issue of flood damage insurance deserves examination as a means of placing the risk on those living in flood-prone areas, and of providing an incentive for the adoption of mitigation measures by those at risk.

Issues were raised on both sides of the border regarding crop insurance. These issues were not reviewed by the Commission, but will need to be addressed by governments, ideally as they develop comprehensive basin-wide plans for the Red River basin.

J. Emergency Management

While emergency management operations in both countries were generally successful in dealing with the 1997 flood, the Commission heard a number of concerns about confusion during the time of the crisis. These concerns included not knowing who was in charge and the lack of clear communications with respect to flood warnings and evacuation procedures. With several levels of government in two countries and various emergency organizations involved there was, and still is, considerable apprehension over the way the situation was handled in many areas. In the United States, the President's Long-term Recovery Task Force provided a framework for federal action shortly following the flood and an action plan in December 1997.¹⁹ In Canada, recovery operations and costs were handled through the federal Disaster Financial Assistance Arrangements (DFAA) and the Canada–Manitoba Agreement on Red River Flood Disaster Assistance (1997). At the binational level, the Canada–United States Agreement on Cooperation in Comprehensive Civil Emergency Planning and Management provides a good framework for such emergencies, but does not specifically address local Red River flooding considerations. As indicated in Conclusion 1 of this report, floods of the same magnitude as 1997 or greater can be expected to occur in the future. Emergency management procedures should be fine-tuned for the Red River basin based on the experience gained in 1997. The Commission recommends that:

IJC Recommendation 15: Within the current context of Canada–United States cooperation for civil emergency planning and management, governments should develop more detailed bilateral emergency planning and management arrangements with specific adaptations to Red River flooding.

¹⁹ Final Report of the President's Long-term Recovery Task Force, Minnesota, North Dakota, South Dakota (December 1997).

K. Data and Decision Support

Successful floodplain planning and management, including flood preparedness and mitigation, require reliable, accurate, compatible and accessible data. It became evident early in the Commission's study, when attempting to assemble data needed for an analysis of flood issues, that fragmented and incomplete data and information are major obstacles to better flood planning and preparedness in the Red River valley.

In the early stages of its investigations, the Task Force consulted data users in the basin to identify data needs. Some of the needs identified included better means of accessing data and disseminating it to the public, more efficient data exchange between agencies involved in floodplain management, and greater database integration within the basin. These needs were highlighted throughout the work of the Task Force, not only in relating data across the international boundary, but also within each of the jurisdictions. If appropriate decisions are to be made to reduce flood damage in the future, topographic, hydrometric, meteorologic and other flood-related data must be improved, and systems to make data more readily available and accessible to agencies and the public must be developed. The Task Force pursued several initiatives that provide the basis for better decision support in the basin. These included the development of a distributed database, improved digital elevation mapping and modeling, a Web-based information network, and the conceptual framework for a decision-support system. One of the main objectives of this work was to ensure that data, models and information collected and managed by Canadian and U.S. agencies in the basin would be more accessible for purposes of improved floodplain management and for emergency planning, response and recovery.

(1) Data and Information: Analysis of future flood control measures and of the operation of flood control structures, and the evaluation of different hydrologic scenarios, depend on accurate and detailed topographic mapping of the basin. Topographic data is particularly important in the Red River valley, where small differences in flood levels can mean large differences in the extent of the area flooded. The Task Force found that current mapping of high-risk areas was not adequate for modeling and analysis of flood risk, or for the consideration of flood protection options. Among other things, the Task Force produced high-resolution digital elevation data for the lower Pembina River and for the area south of the Winnipeg Floodway, and analyzed data collection technologies.²⁰ Through these efforts, the Task Force found that airborne laser mapping can be a fast, reliable, and cost-effective method of obtaining three-dimensional data suitable for the creation of a Digital Elevation Model (DEM). There is considerable interest in the development of detailed topographic data by those who recognize its usefulness in supporting floodplain management. While the costs of acquiring high-resolution digital elevation data are substantial, use of these data will yield significant future benefits. The Task Force's work

²⁰ U.S. Army Corps of Engineers, Engineer Research and Development Center, "Evaluating IFSAR and LIDAR Technologies Using ArcInfo: Red River Pilot Study," (in preparation).



Fused imagery, Interferometric Synthetic Aperture Radar (IFSAR) with Light Detection and Ranging (LIDAR), shows topographic relief in the Pembina, North Dakota, area.

in this area and recent mapping by others in the Fargo, Wahpeton and Breckenridge areas provide partial DEM data and lay the groundwork for the acquisition of further high-resolution elevation data.

The Commission supports the Task Force's recommendation that governments pursue the development of a seamless DEM for the basin. This work could best be pursued through a coordinated effort that involves sharing of expertise, funds, and data. Data sets developed should be made freely available without any use or sharing constraints. The Commission recommends that:

IJC Recommendation 16: Development of the digital elevation model for the Red River basin, with high resolution in appropriate high flood risk areas, should be pursued and completed through collaborative initiatives of federal, state, provincial and local governments.

In addition to topographic data, some of the most basic data for flood planning and preparedness are hydrological and climatological data. Over the past two decades, fiscal restraint and budget cuts in government agencies have resulted in considerable reductions in stream gauging and meteorological networks used in flood forecasting and measurement of river flows. The Commission's 1997 interim report contained a number of recommendations for modernizing and flood-proofing hydrometric networks in the basin. According to the Task Force, significant steps have been taken in both countries to address these recommendations. In addition, improvements to the climatological networks have been made. Because of their critical importance in tracking weather systems and forecasting flood events, responsible government agencies should undertake a binational assessment of the existing hydrological and meteorological networks, including soil moisture and snow pack measurements, and ensure that an appropriate network of stations is in place for effective flood forecasting and tracking. This will require governments to make long-term commitments to maintain the networks in a state of readiness and provide data for shared use without cost and in a timely manner. In addition, the Commission recommends that:

IJC Recommendation 17: Federal, state and provincial governments should develop and implement a binational agreement to establish an appropriate network of hydrological and meteorological stations and data exchange for floodplain management and flood forecasting in the Red River basin.

There is a need for consistency in the reporting of river levels along the length of the river. Current practice in the United States is to report river level data and forecasts in terms of the gauge height (local datum) at each gauge site. In Canada, they are reported in elevations above mean sea level (standard datum). This inconsistency can lead to misunderstandings and confusion when assembling basin-wide information. The Task Force also noted a number of concerns with respect to the different vertical datums used as references for surveying and mapping purposes in the two countries. The Commission endorses the Task Force's recommendation regarding datum standardization and encourages governments to convene a meeting of datum experts to discuss datum issues.

(2) Modeling: Mathematical models of the Red River basin play an important role in forecasting floods, predicting the extent of flooding, and planning for future floods. Experience during the 1997 flood demonstrated that improvements to existing models were needed, especially for overland flows, so that better predictions of the extent of flooding could be made.

As pointed out by the Task Force, improvements in flood forecasting procedures have been made in both countries since the 1997 flood. In the United States, the National Oceanic and Atmospheric Administration's National Weather Service has reviewed in detail the technical procedures used to produce forecasts for the Red River. The National Weather Service has several efforts underway to improve these procedures. These include development of a dynamic flood routing hydraulic model (FLDWAV) for the Red River, modification of its models to better reflect overland flows, recalibration of the forecasting system, development of an enhanced system for utilizing snow data, and incorporation of improved soil moisture and precipitation data in Red River forecasts. In addition, the National Weather Service is implementing an Advanced Hydrologic Prediction System that takes into account the relative uncertainty in hydrologic variables. In Canada, the federal and provincial governments, supported by the Task Force, have focused on improvements to the forecast networks and further development and implementation of the one-dimensional unsteady-state hydraulic model (MIKE 11) developed by the Task Force for modeling flood flows. Because the systems are essential to flood preparedness, governments should ensure that resources are made available for their continual improvement and enhancement.

The ultimate objective of flood forecasting is to ensure that residents and emergency managers are kept informed of anticipated river levels so that appropriate action can be taken. At its public hearings and meetings over the duration of the study, the Commission heard many complaints about the inability of the public to understand forecasts. Differences in approaches to communicating forecasts to the public, both between the two countries and among agencies in each country, created confusion during the 1997 flood. While improvements to forecasting techniques will provide better forecasts, the difficulties with communicating these forecasts will likely remain unless coordinated steps are taken by governments and agencies in the two countries to address them. As pointed out by the Task Force in its interim report, effective communication of both technical and non-

technical information is a challenge, especially during disasters like the 1997 flood. In some cases, local officials and individuals did not place credence in early flood forecasts; others did not understand the significance of the forecasts; still others did not know which source was the most credible. The public needs to be made aware of the official source of reliable forecasts. The variables inherent in the forecasts must be easily understood. The Commission re-emphasizes the need to simplify and clarify communication and dissemination of forecast information to the public.

Flood forecasting and communication activities are currently undertaken by the responsible agencies at the federal, state and provincial levels. There are informal arrangements for sharing flood forecasting data and information. The Commission nevertheless supports the Task Force's recommendation calling for the establishment of a Red River Basin Flood Forecasting Liaison Committee to improve communications among forecasters and with the public. The Commission believes that its International Red River Board could undertake this mission. The Commission recommends that:

IJC Recommendation 18: The governments should authorize the Commission to establish a binational Red River Flood Forecasting Liaison Committee under the International Red River Board to improve interjurisdictional coordination and to help ensure that clear, understandable and compatible forecasts are issued to the public.

At the time of the 1997 flood, Red River basin models were not capable of effectively simulating floods involving complex overland flows. To better reflect breakout and overland flows, examine the downstream effects of flood peak reduction scenarios, and evaluate the spatial extent of large floods, the Task Force developed two new hydraulic model applications for the basin. The U.S. Army Corps of Engineers applied the one-dimensional Unsteady NETwork (UNET) model for the Red River from Lake Traverse to Letellier, Manitoba. Klohn-Crippen Consultants, Ltd. applied a similar one-dimensional unsteady-state flow model (MIKE 11) for the Red River from Grand Forks to Selkirk. The model applications have been developed to simulate various flood flows under varying conditions and can thus help answer a myriad of "what if" questions related to the likely effects of flood mitigation and protection works. Detailed information about the models developed can be found in the report of the Task Force's Tools Subgroup.²¹

While much work has been done to improve flood modeling capability, these efforts cannot be considered complete. The accuracy of the models can and should be improved through acquisition of more detailed topographic information, enhancement of real-time data networks, and strengthened hydrologic understanding. The Commission stresses the importance of maintaining and improving the models so that they remain useful for future

²¹ Halliday, R., and Jutila, S., *Hydrologic and Hydraulic Modeling in the Red River Basin, A Report of the Tools Subgroup to the International Red River Basin Task Force* (November 2000). (Available at: www.ijc.org)

floods. The modeling work undertaken by the Task Force focused on the mainstem of the Red River and an application for the lower Pembina River. The latter work is described in this report in the section on the Pembina River. Additional work is needed to further refine existing models and develop new ones to examine more frequent, smaller floods on the mainstem of the Red River and tributary floods, and to address economic, social, and ecological issues related to flooding.

In pursuing improvements in modeling, model developers and operators should remain sensitive to compatibility issues regarding both data input and the actual models themselves. The potential for different same-purpose models to yield inconsistent results can lead to confusion and, at worst, to open disagreement over the “right” answers. To ensure compatibility of model results, the Task Force’s modelers used a common database and calibrated the hydraulic models so that they produced consistent results in the border region. While using two well-coordinated models proved effective in this instance, the Commission suggests that basin-wide problems require basin-wide approaches. The Commission encourages governments to develop basin-wide models in the long term. In the meantime, the Commission endorses the Task Force’s recommendation to support and improve the UNET and MIKE 11 models and further recommends that:

IJC Recommendation 19: As a long-term priority, government agencies responsible for flood forecasting and mitigation measures should develop basin-wide models rather than separate but coordinated models for each country.

(3) Information Management: To satisfy the identified need for better access to data and information in the Red River basin, the Task Force completed the first stage of building a searchable database by identifying information providers and the types of flood-related information they have available. The goal of the database is to make data relevant to floodplain management and flood disaster activities readily available to all interested persons. The Task Force envisioned that the database would be constructed around existing communications and computing technology. This would enable the various information sources to be linked as a “virtual” basin-wide database. Rather than gathering hard-copy information in a central clearinghouse, information would be available electronically. Each of the underlying databases would continue to be maintained and operated by the data provider. Detailed information about the virtual database concept can be found in the report of the Task Force’s Database Subgroup.²²

The integration of computer models with the virtual database would provide a powerful means to analyze flood-related problems in the basin. The concept of a binational information base for floodplain management sparked interest from the Global Disaster Information Network (GDIN), a U.S. federal government interagency program. The goal

²² Simonovic, Sloban P. and Birkenstock, Terry, *International Red River Basin Task Force Database Subgroup Final Report: Red River Flooding* (February 2000). (Available at: www.ijc.org)

of GDIN is to foster effective sharing of disaster-related information through the use of evolving information technologies. GDIN worked in partnership with the Task Force throughout the study on the development of the virtual database, networking, mapping, and a decision-support system. Through these cooperative efforts, the Red River Basin Disaster Information Network (RRBDIN) was launched to draw together data providers and users in a single on-line source to locate and use information on floodplain management issues in the basin (www.rrbdin1.org). The Task Force and GDIN also jointly sponsored “virtual forums”: on-line networking and information sessions. This work should continue beyond the end of the Task Force’s mandate.

The Task Force completed the first stage of building a searchable database for the basin that identified all information providers and catalogued metadata (data about data) for the data sets. Limited funding curtailed further development planned for U.S. metadata. On the Canadian side, a number of roadblocks were encountered in the development of the integrated database. These included lack of accessibility to data, limits on accessibility imposed by security requirements of internal networks, and policies of cost recovery that make access to data expensive for agencies and other data users. These restrictions not only limited the ability of the Task Force to make progress, but, as the Task Force pointed out, could ultimately put the public at risk by limiting public and agency access to data needed to respond to a flood threat or to enable interested parties to consider appropriate mitigation measures. The Commission recommends that:

IJC Recommendation 20: The Canadian government should review its data and information management policies to ensure that topographic, hydrometeorological, and other flood-related data collected under government programs are made available without restrictions or conditions that limit their accessibility.

Since the Task Force issued its final report, the Commission has continued to work with government agencies to further develop the virtual database, which it considers an important element in flood management. Building on the virtual database, a decision-support system would enable the public and flood managers to evaluate the impact of various flood scenarios. The Task Force developed the conceptual model for such a decision-support system. In the United States, the U.S. Army Corps of Engineers is interested in developing a prototype decision-support system for the basin, while the U.S. Environmental Protection Agency is making funds available through the Commission’s International Red River Board to create an information network linking various parties within the basin. The Red River Basin Board, the Red River Institute, and Prairie Public Broadcasting have also shown interest in this work. Ultimately, the Commission envisions collaborative efforts on both sides of the border linking people throughout the basin and leading to real-time information sharing, on-line education, and integrated databases and models in an on-line format, usable by managers and other user groups throughout the

basin and accessible to a broad public. Efforts to date have exploited the most advanced collaborative technologies and laid the groundwork for achieving this vision. The Commission strongly advocates continuation of these important efforts and recommends that:

IJC Conclusion 6: Further improvement and maintenance of the Red River virtual floodplain management database is required. Federal, state and provincial governments and local authorities must maintain a high level of involvement in further database development and in improving data accessibility.

IJC Recommendation 21: Governments should ensure that progress continues in building a binational, virtual network linking the people, data, and models for the Red River basin.

IJC Recommendation 22: Federal, state, and provincial governments should work with basin organizations to complete in a timely manner the development of a prototype decision-support system and establish a cooperative mechanism for coordination and funding its further development and implementation.

Environmental Considerations

There is a risk that when fighting a flood, recovering from its ravages or planning for protection in its aftermath, attention will be focused on dealing exclusively with the direct impact the flood is having or has had on people and their possessions in the floodplain. Insufficient thought may be given to what impact the flood might be having on the natural environment of the floodplain—the river, floodplain flora and fauna and the floodplain ecosystem in general.

The floodplain has long been the site of urban and agricultural development that has severely altered the pre-settlement ecosystem and, in some cases, even threatened its very existence. Ecologically, the habitat quality of the riverine system has been reduced substantially from historic conditions through such actions as channelization, diking, and damming. Land use changes have increased sediment transport. Wetlands have been reduced, fragmented, and degraded. The numbers and types of plant and animal species have been markedly reduced, with some species threatened, endangered, or gone from the region entirely.²³ Despite historical changes, the Red River basin also contains well-recognized treasures, such as the trophy catfish fishery in the Red River mainstem. The flood of 1997 challenged the riverine ecosystem and the recovery and future protection efforts may increase that challenge unless appropriate steps are taken. Future protection efforts may provide opportunities for ecosystem enhancement.

In its interim report, the Task Force highlighted some of the key environmental issues related to the 1997 flood. These included: releases of hazardous materials, both commercial and residential; untreated discharges from sewage and related facilities; handling of dead animal carcasses; contamination of groundwater; human health concerns related to residence flooding; and the potential for a Red River–Upper Mississippi basin hydraulic connection that might result in a transfer of species between basins. In its final report, the Task Force elaborated further on the hydraulic connection at Lake Traverse and flood effects on water quality in Lake Winnipeg.

²³ U.S. Army Corps of Engineers, St. Paul District, and Minnesota Department of Natural Resources, *Environmental Impact Study of Flood Control Impoundments in Northwestern Minnesota* (July 1996).

A. Chemical Contamination

Studies of water quality undertaken during and following the flood revealed elevated levels of bacteria, nutrients and some pesticides along the mainstem of the Red River, but no indications of significant or prolonged detrimental effects were found. Upstream from Winnipeg, fecal coliform densities exceeded only briefly the water quality objective at the international boundary, and then declined to normal levels. Other bacteria measurements showed elevated levels at several locations along the mainstem, but these were fairly consistent with flood events and may have been attributable to municipal and agricultural sources. Bacteriological contamination of groundwater aquifers in areas south of Winnipeg was found to have taken place due to floodwaters entering the aquifers through active wells and improperly sealed abandoned wells. After the flood, Manitoba reported that wells were rehabilitated by pumping, followed by chlorination. Abandoned wells were sealed and several active wells were equipped with proper sanitary seals.

Because of its importance to the economy of Manitoba, both from a recreational and commercial fishery perspective, the Task Force addressed the impact of the flood on the water and aquatic resources of southern Lake Winnipeg. While elevated levels of nutrients, trace elements (cadmium, chromium, arsenic, zinc), and some pesticides were noted, it was not possible to confirm whether these were attributable to the flood event or whether they reflected normal ranges. The only significant finding related to toxaphene apparently released during the flood. Concentrations of this pesticide have increased in fish tissue since 1997 but do not pose a health risk. As recommended by the Task Force, the Commission encourages governments to continue to monitor toxaphene in the Lake Winnipeg ecosystem until concentrations decline to pre-1997 levels. Other trace organics, such as PCBs and DDT, generally increased in fish tissue following the flood event, but their concentrations remained well below consumption guidelines for the protection of human health. Detection of these persistent toxic contaminants, whether related to the flood event or not, is a cause for concern. While voluntary programs may be in place in the various jurisdictions to collect used pesticide containers and other household and on-farm wastes, there does not appear to be a systematic program in any jurisdiction to verify the efficacy of the voluntary programs or to eliminate the potential for accidental release of banned and other hazardous chemicals through enhanced voluntary or mandatory measures. While use of some hazardous materials may be beneficial in agricultural operations when properly used, only minimal quantities should be stored in the 500-year floodplain to reduce the risk to human and environmental health during flood events. There is no cogent reason for banned materials to be stored in the floodplain.

The Commission recommends that:

IJC Recommendation 23: Governments should take immediate steps to ensure that all banned materials such as toxaphene are removed from the Red River basin. Governments should also ensure that potentially hazardous materials are not stored in the 500-year floodplain, although reasonable quantities of such substances could be maintained in the floodplain for immediate use.

B. Interbasin Transfer of Alien Invasive Species

Historically, there has been some movement of waters in time of flood across the continental divide in the upper part of the Red River basin. The Commission heard concerns expressed that the natural connection between the Little Minnesota River in the Mississippi River basin and the Red River in the Hudson Bay basin provided the potential for transferring alien invasive species from one basin to the other. The Task Force examined the issue and concluded that, although the potential for transfer of species between basins appears remote, the issue deserves attention because of the severe consequences it could have for the aquatic environment. The Commission supports the need for studies to examine means of eliminating hydraulic interbasin connections and the need for biological monitoring to identify invasive species that may create a risk to the aquatic environment. If this monitoring were to indicate the potential for transfer of invasive species across the divide, the Commission would encourage immediate action to prevent such transfer. The Commission endorses the Task Force recommendation that any modifications to operating plans or structures associated with Lake Traverse must include consideration of their potential to increase the possibility of interbasin transfers.

C. Protection and Enhancement of the Floodplain Environment

A great deal of effort and large sums of money were devoted to enhancing flood protection works throughout the basin immediately prior to the flood. Most of these were temporary fixes done under adverse weather conditions and in haste. Under these circumstances, little attention was paid to the environment. Flood mitigation policy in both countries must have as its objective both the reduction of damage to persons and property and protection of the environment. As previously discussed, extensive fiscal resources are being devoted to improving the flood defenses of communities and private property throughout the Red River basin. As efforts proceed, it is imperative that the defenses take into account the protection and enhancement of the environment. For example, there may be significant opportunities,

perhaps in conjunction with efforts to prepare for future flood events in the Red River basin, to restore wetlands or improve fish and wildlife resources that have been so drastically affected by human activities. Numerous fish passage restoration or modification projects are already completed or underway in the Red River valley,²⁴ and any new projects should include such consideration. The Commission recommends that:

IJC Recommendation 24: Flood protection projects focus not only on reduction of flood damage but also on protection and enhancement of the floodplain environment.

²⁴ Correspondence from the U.S. Department of the Interior, Fish and Wildlife Service, September 19, 2000.

Managing the Floodplain— Comprehensive, Integrated Planning

The Commission has been impressed with the complexity of the problem confronted by the residents of the Red River basin in dealing with the ever-present risk of flood. Working on a regional basis, as communities, or as individuals, they face a daunting challenge. In the flat terrain, what is done in one part of the basin may have severe consequences for those living in other parts of the basin. Seemingly reasonable attempts to protect a home or a village or a town can cause significant flooding both up and downstream. Efforts to improve urban and agricultural drainage and move water more quickly into streams and rivers can, under some circumstances, intensify flows that already lap at the top of downstream flood protection works. Any construction along the river may permanently destroy valuable habitat and degrade the precious riverine ecosystem.

Time and funding limitations did not allow the Commission to take a comprehensive approach to the solution of Red River basin flood problems. Support by city of Winnipeg and province of Manitoba made possible a more complete look at Winnipeg's flood problems, but even that review did not fully consider the upstream and downstream impacts of possible mitigation measures. Solving the flood damage reduction problems of the Red River basin while concurrently protecting and enhancing the floodplain environment will require full use of all the structural and non-structural methods available. No one approach—reservoir storage, levees, relocation, flood-proofing, micro-storage, wetland restoration—will solve all the problems by itself. *There are no silver bullets.* Whether the challenge is protection of an individual, a community, or the basin as a whole, all approaches to damage reduction should be considered, and, where appropriate, integrated into the solutions. The Commission believes that solutions to the problems of cities, villages and individuals must be sought through a comprehensive examination of the flood damage problems of the basin. Fortunately, technology is rapidly making such broad-scale approaches possible. As previously noted, there have been significant improvements in hydraulic modeling, weather forecasting and remote sensing that cut the time required for studies and broaden the knowledge base of those who must carry out such analyses. The analytical work undertaken by the Task Force has moved the entire basin forward on these issues, but it has only been a first step.

The Commission concludes that:

IJC Conclusion 7: Large and small communities throughout the Red River basin will remain at undue risk until a comprehensive binational multi-faceted solution to the full range of flood problems is developed and implemented. Such a solution will require use of all flood mitigation methods, both structural and non-structural, and must take into account potential impacts on the environment.

The Commission recommends that:

IJC Recommendation 25: Governments immediately take steps, on a binational basis, to begin development of a comprehensive flood damage reduction plan for the Red River basin.

Managing the Flood Challenge—Institutional Arrangements

A. The Complexities of an International Basin

The hydrologic system of the Red River basin is complex. It is influenced by many natural and human forces. To deal with this system, dozens of government agencies and organizations have evolved with management responsibilities or interests in various aspects of its water and land resources. These resources are managed and controlled through myriad federal, provincial, state and local laws, regulations, rules, and ordinances. In addition, there are a number of binational, interstate and international arrangements as well as committees and working groups that oversee and coordinate many aspects of basin water management. The ponderous nature of this labyrinth of agencies and mechanisms calls for better coordination and integration of activities on a basin-wide basis. Preparing for future floods is one component of this broader need.

Major floods capture attention and stimulate remedial action. In the quiet periods between floods, the commitment to action declines as the immediacy and the apparent threat from flooding recedes. Mitigation activities, including the actions recommended by the Commission and the Task Force, need to be implemented over time and adapted as circumstances change. Governments must assume responsibility for providing the leadership and the continuity to ensure that appropriate actions are taken. Because the river basin straddles the Canada–United States boundary, two countries are involved and compatibility and integration of planning and implementation across the border will be critical. *The international boundary dividing the basin must not be a hindrance to achieving sound planning and implementation of basin-wide mitigation activities.* While recognizing that development and management of comprehensive flood damage reduction efforts must remain the responsibility of the various governments, the Commission considers that there is also a need for a basin-wide, binational institutional structure and perspective to address flood management issues and assist in moving forward to deal with their binational components.



Prairie Farm Rehabilitation Administration.

The 1997 flood inundates the U.S.–Canadian border near Pembina, North Dakota, and Emerson, Manitoba.

B. Binational Cooperation

The need for a basin-wide binational approach to transboundary water management issues is generally accepted within the Red River basin. Opinions differ, however, as to the most suitable method to accomplish it. Federal, state, provincial and local governments have many well-established agencies dealing with various aspects of the flood challenge within their jurisdictions. Their responsibilities are established through laws, regulations and local statutes and the agencies are clearly capable of carrying out many of the tasks that need to be done. To meet the challenge of reducing flood risk in the Red River basin, the Commission recommends that:

IJC Recommendation 26: Governments at all levels should undertake the following measures:

- a. Develop and implement comprehensive, multi-faceted plans for concurrently reducing flood damage and protecting and enhancing the natural environment;***
- b. Ensure ongoing institutional support and full multi-jurisdictional participation in further development and maintenance of the Task Force's legacy projects;***
- c. Implement Commission and Task Force recommendations designed to ensure basin-wide flood preparedness and community resiliency;***
- d. Promote a culture of flood preparedness and flood resiliency in the basin;***
- e. Enhance technology and monitoring systems to provide early warnings and early action in the face of impending major floods;***
- f. Ensure binational coordination of flood forecasting and communications of forecasts to the public;***
- g. Provide opportunities for multi-jurisdictional problem solving and the exchange of best practices information; and***
- h. Integrate floodplain management activities into the broader field of watershed and basin management.***

The Commission believes that there is a need for binational institutional arrangements to deal with the transboundary issues that will arise and for monitoring progress in dealing with flood-related issues. Such arrangements should seek to:

1. involve the people of the basin to the highest degree possible;
2. obtain representation from the full range of interests;
3. elicit a wide range of views in all discussions;
4. bring forward views to governments based on consensus; and
5. obtain sufficient funds to support assigned functions.

There are currently two existing and two proposed organizations that possibly could take on all or some of these binational responsibilities. The two existing organizations are:

- The Red River Basin Board; and
- The International Red River Board of the IJC.

The two proposed organizations are:

- The IFMI-proposed Red River Basin Commission, supported by a broad-membership Steering Committee; and
- A possible International Red River Watershed Board of the IJC.

The Red River Basin Board is a not-for-profit corporation chartered under the laws of Manitoba, North Dakota, Minnesota, and South Dakota. It is dedicated to innovation in the management of the Red River basin's water and represents a grassroots effort to address issues in a basin-wide context. Its board of directors has 21 members representing local government (cities, counties, and rural municipalities), watershed boards, water-resource districts, First Nations and Native Americans. The Board recently agreed to expand membership to include representatives from the federal government and environmental organizations. There are also three at-large members and members appointed by the governors of North Dakota, Minnesota and South Dakota and the premier of Manitoba.

The mission of the Red River Basin Board is to develop a comprehensive water management plan that would then be implemented by other agencies within the basin. It also seeks to serve as an information clearinghouse; to provide public information on basin issues; to serve as a forum for discussion, consensus building and dispute resolution, including inter-jurisdictional differences, in the management of surface and groundwater supplies in the Red River basin; and to provide advice to governments on all aspects of water management.

The International Red River Board of the IJC has recently been formed by the amalgamation of two of the Commission's advisory boards, the International Red River Pollution Board and the International Souris–Red Rivers Engineering Board.²⁵ The amalgamated board, whose fundamental mandate is to prevent and resolve water-related disputes between Canada and the United States, will continue to assist the Commission with the responsibilities assigned to it in the Red River basin by the governments of Canada and the United States under the Boundary Waters Treaty. These include maintaining continuous surveillance over the quality of the water and the health of the transboundary aquatic ecosystem, and monitoring plans, policies, and developments that may adversely affect the quality of the water and the health of the ecosystem; reporting on the use and apportionment of the waters; and developing plans of mutual advantage for the use of these waters. The amalgamation provides for an ecosystem approach in dealing with transboundary issues related to the Red River. The Board currently is composed of federal,

²⁵ The functions of the International Souris–Red Rivers Engineering Board have been divided between the new International Red River Board and a newly created International Souris River Board.

state, and provincial members, but is being expanded to provide for local members. As with other Commission boards, members serve in their personal and professional capacity and not as representatives of their governments or agencies.

The Red River Basin Commission is an organization being proposed by the International Flood Mitigation Initiative (IFMI), an ad hoc binational group launched in December 1998 by the North Dakota Consensus Council with funding from FEMA and the province of Manitoba, to address the mitigation of flood damage on the mainstem of the Red River and its tributaries. IFMI participants established a vision, mission, and goals, then worked on a

basin-wide flood mitigation strategy. Initiatives being pursued include: basin-wide coordination and cooperation; public education, research and mapping; and flood resilience. IFMI has pursued funding and organizational arrangements to ensure that work on its initiatives will continue after it presents its final report, in November 2000, to the governors of North Dakota, South Dakota, and Minnesota and to the premier of Manitoba. As proposed by IFMI, the Red River Basin Commission would provide a coordinating framework for government and private sector flood mitigation actions and decisions along the Red River and ensure progress of flood-related activities in the basin. Its membership would include the premier of Manitoba, the governors of Minnesota, North Dakota, and South Dakota, and possibly federal representatives. The Red River Basin Commission would be supported by a steering committee, which would serve as a forum for participants to develop proposals and coordinate the implementation of agreements. The steering committee would include federal, state, provincial, municipal, non-profit and private sector representatives.

An International Red River Watershed Board could implement the international watershed concept in the Red River basin. This concept is still under consideration by the Commission, and will be the subject of a separate report to the Canadian and U.S. governments by the Commission in due course in response to their request on watershed boards.

What is a Watershed Board?

IJC international watershed boards...would provide a much improved mechanism for avoiding and resolving transboundary disputes by building a capacity at the watershed level to anticipate and respond to the range of water-related and other environmental challenges that can be foreseen for the 21st century. This includes effective coordination of government institutions at various levels, acquisition and fostering of expertise, knowledge and information about the ecosystem of the watershed, consultation with and involvement of the full range of interests concerned, including the public, and above all the flexibility to identify and deal with unforeseen developments. This improved mechanism could be implemented without substantially affecting existing institutions.

The Commission is vitally interested in coordinating the new watershed boards with any regional (e.g. provincial-state) structures that may already exist. This will in some instances, be facilitated by inviting members of regional institutions to serve on, or be associated in some way with, the relevant IJC watershed board.

...[F]ederal, provincial, state and other forms and levels of government will all continue to play important roles in transboundary water and environmental issues. In the Great Lakes basin, the IJC's Great Lakes Water Quality boards have served as neutral forums in which federal, state and provincial decision-makers could meet to discuss issues, develop ideas, coordinate activities, reconcile differences and achieve efficiencies in water quality policies and programs that further the common interests of the region and both countries. This is a role that permanent IJC international watershed boards could be given a mandate to play in other transboundary basins.

Permanent IJC international watershed boards would provide governments at all levels, and the public at large, with independent binational institutions composed of persons expert in, and in some cases with responsibilities for, the watershed. The boards would encompass the public, private and non-governmental sectors, but would be committed to acting in the common interest.

International watershed boards...would be available for monitoring, alerting, studying, advising, facilitating and reporting on a broad range of transboundary environmental and water-related issues.

*International Joint Commission, The IJC and the 21st Century
(October 1997).*

C. Additional Responsibilities for the International Red River Board

Throughout this report, the Commission has identified a number of flood-related functions and tasks that need to be pursued by governments and others. The Commission believes that its amalgamated International Red River Board, with expanded local membership, can assist in the ongoing work in the basin by assuming some of the transboundary flood-related functions that have been identified.

The Commission has developed a proposed directive for its International Red River Board, which includes the flood-related responsibilities set out in Recommendation 27. The proposed directive is attached as Appendix 5. Concurrent with the release of this report, the Commission will distribute the proposed directive in the Red River basin and will hold hearings in the basin to obtain public input on the proposal. The Commission will also discuss the proposed directive with governments to confirm its mandate and to explore funding options.

The Commission recommends that:

IJC Recommendation 27: Governments should assign the following functions to the International Joint Commission for implementation by the International Red River Board:

- a. Monitor progress by the governments (federal, state, provincial, municipal) in implementing the recommendations of the Commission's report on Red River basin flooding, and in maintaining and advancing the work of the Task Force's legacy projects;***
- b. Encourage governments to develop and promote a culture of flood preparedness in the Red River valley;***
- c. Encourage government efforts to develop and implement a long-term strategy for flood mitigation and emergency preparedness;***
- d. Encourage the sharing of accurate and timely transboundary information to support the development of improved flood forecasting techniques and procedures for early flood warnings and to improve communication of flood forecasts;***
- e. Provide through the activities of the Board a forum for the exchange of best practices and for other flood-related information on preparedness, mitigation, response, and recovery, to assist in transboundary problem solving;***
- f. Promote the application of innovative technologies for supporting flood modeling and mapping;***

-
- g. Monitor the adequacy of data and information collection networks (meteorological, hydrometric, water quality) for flood preparedness, forecasting and mitigation, within the larger context of overall water management needs in the basin;*
 - h. Monitor potential transboundary effects of flood mitigation and other works in the basin, and encourage cooperative studies necessary to examine these effects;*
 - i. Encourage governments to integrate floodplain management activities in watershed and basin management;*
 - j. Interact with all levels of government to help decision makers become aware of transboundary flood-related and associated water management issues; and*
 - k. Assist in facilitating a consultative process for resolution of the lower Pembina River flooding issue.*

The International Red River Board will not be in a position to assume all flood-related functions in the basin. Many of these responsibilities fall within the direct authority and mandates of the federal, state, provincial and local governments and should be carried out by them. The Commission notes that there is considerable activity in the basin focused on development of effective bilateral institutional arrangements to facilitate planning, coordination and execution of flood mitigation programs. The Commission emphasizes the need for such arrangements to include federal as well as state and provincial participation. In recognition of the continuing potential for major flooding along the Red River, the Commission recommends that:

IJC Recommendation 28: The federal governments, in cooperation with the state and provincial governments, should work with the Commission and its International Red River Board, as well as with existing and emerging bilateral organizations, to ensure that appropriate arrangements are in place to coordinate and implement measures for flood preparedness and mitigation activities and to implement recommendations of the Commission.

The Commission looks forward to cooperating with governments and other organizations in the basin.

I J C C o n c l u s i o n s a n d R e c o m m e n d a t i o n s

Throughout this report, the Commission has referred to the work of the International Red River Basin Task Force and to its conclusions and recommendations. As noted earlier in the text, some of the recommendations have been repeated as Commission recommendations while others have simply been referred to in a general way. Appendix 2 summarizes the Commission's position with respect to each of the recommendations of the Task Force. The following lists all of the Commission's conclusions and recommendations, including those from the Task Force's final report that the Commission endorses but did not restate.

IJC Conclusions

Conclusion 1: Although the 1997 flood was a rare event, floods of the same size as the 1997 event, or greater, can be expected to occur in the future in the Red River basin. People and property remain at risk from these floods.

Conclusion 2: It would be difficult if not impossible to develop enough economically and environmentally acceptable large reservoir storage that alone would reduce substantially the flood peaks for major floods. Storage to reduce flood peaks for more frequent local floods may prove worthwhile and deserves further study.

Conclusion 3: Large-scale micro-storage has some potential to reduce flood peaks, perhaps significantly for more frequent local floods, but reliance solely on micro-storage for major flood events would be impracticable and costly. While there are many obstacles to its effective and efficient implementation, the feasibility of micro-storage for flood peak reduction should continue to be analyzed.

Conclusion 4: Wetland storage can provide an economically and environmentally beneficial method of reducing flood flows for frequent, smaller floods, but wetland storage alone is unlikely to significantly reduce the peaks of large floods on the mainstem of the Red River.

Conclusion 5: Under flow conditions similar to those experienced in 1997, the risk of a failure of Winnipeg's flood protection infrastructure is high. Public safety requires that the city, province and Canadian federal government focus immediate attention on designing and implementing measures to further protect Winnipeg.

Conclusion 6: Further improvement and maintenance of the Red River virtual floodplain management database is required. Federal, state and provincial governments and local authorities must maintain a high level of involvement in further database development and in improving data accessibility.

Conclusion 7: Large and small communities throughout the Red River basin will remain at undue risk until a comprehensive binational multi-faceted solution to the full range of flood problems is developed and implemented. Such a solution will require use of all flood mitigation methods, both structural and non-structural, and must take into account potential impacts on the environment.

IJC Recommendations

Recommendation 1: The federal governments should convene a meeting of senior federal, provincial and state officials in 2002 to undertake policy discussions and an examination of the 1997 flood, with emphasis on review of emergency plans, evacuation procedures and mitigation measures underway.

Recommendation 2: The design flood used as the standard for flood protection works for Winnipeg should be the highest that can be economically justified or, at a minimum, the flood of record, the 1826 flood.

Recommendation 3: The city, province and the Canadian federal government should cooperatively develop and finance a long-term flood protection plan for the city that fully considers all social, environmental and human effects of any proposed flood protection measures and respects both the needs of Winnipeg and the interests of those outside the city who might be affected by such a plan.

Recommendation 4: The government of the United States, in cooperation with the cities of Fargo and Moorhead and the states of North Dakota and Minnesota, should expedite the study of flood risk potential and implement plans for flood protection measures for the Fargo–Moorhead area.

Recommendation 5: The government of the United States, in cooperation with the cities of Grand Forks and East Grand Forks and the states of North Dakota and Minnesota, should ensure that the planned flood protection works are promptly and expeditiously completed.

Recommendation 6: The government of the United States, in cooperation with the cities of Wahpeton and Breckenridge and the states of North Dakota and Minnesota, should expedite approval and implementation of flood protection plans to reduce the risk of flooding at Wahpeton–Breckenridge.

Recommendation 7: The province of Manitoba and city of Selkirk should expedite studies of flood-risk potential in the Selkirk area.

Recommendation 8: To improve resiliency in the basin, governments should support enhanced research into the various social dimensions of the flood, including economic, psychological, public health and sociological impacts.

Recommendation 9: Governments at all levels should ensure that in the development of flood mitigation strategies for the basin the needs of small communities, individual isolated farmsteads and agriculture are not overlooked.

Recommendation 10: Federal government agencies, in cooperation with the state of North Dakota and the province of Manitoba, should establish a consultative group to work with local interests, including the Pembina River Basin Advisory Board, to resolve the lower Pembina River flooding issue, provide necessary resources for the group, and act to achieve a solution.

Recommendation 11: Governments should develop a binational integrated approach to mitigation initiatives at all political levels, based on a comprehensive mitigation strategy for the entire basin. In the United States, the strategy should be integrated within the overall national framework.

Recommendation 12: The Canadian federal government should establish a national flood mitigation strategy, or a broader disaster mitigation strategy, and support it with comprehensive mitigation programs.

Recommendation 13: Governments should use, at a minimum, the 100-year (1 percent) flood as the basis for floodplain regulations and revise their estimates of the 100-year flood levels based on 1997 and new data that become available.

Recommendation 14: State, provincial and other appropriate authorities should review the effectiveness of and compliance with the floodplain management regulations in the basin and take steps as needed to improve enforcement.

Recommendation 15: Within the current context of Canada–United States cooperation for civil emergency planning and management, governments should develop more detailed bilateral emergency planning and management arrangements with specific adaptations to Red River flooding.

Recommendation 16: Development of the digital elevation model for the Red River basin, with high resolution in appropriate high flood risk areas, should be pursued and completed through collaborative initiatives of federal, state, provincial and local governments.

Recommendation 17: Federal, state and provincial governments should develop and implement a binational agreement to establish an appropriate network of hydrological and meteorological stations and data exchange for floodplain management and flood forecasting in the Red River basin.

Recommendation 18: The governments should authorize the Commission to establish a binational Red River Flood Forecasting Liaison Committee under the International Red River Board to improve interjurisdictional coordination and to help ensure that clear, understandable and compatible forecasts are issued to the public.

Recommendation 19: As a long-term priority, government agencies responsible for flood forecasting and mitigation measures should develop basin-wide models rather than separate but coordinated models for each country.

Recommendation 20: The Canadian government should review its data and information management policies to ensure that topographic, hydrometeorological, and other flood-related data collected under government programs are made available without restrictions or conditions that limit their accessibility.

Recommendation 21: Governments should ensure that progress continues in building a binational, virtual network linking the people, data, and models for the Red River basin.

Recommendation 22: Federal, state, and provincial governments should work with basin organizations to complete in a timely manner the development of a prototype decision-support system and establish a cooperative mechanism for coordination and funding its further development and implementation.

Recommendation 23: Governments should take immediate steps to ensure that all banned materials such as toxaphene are removed from the Red River basin. Governments should also ensure that potentially hazardous materials are not stored in the 500-year floodplain, although reasonable quantities of such substances could be maintained in the floodplain for immediate use.

Recommendation 24: Flood protection projects focus not only on reduction of flood damage but also on protection and enhancement of the floodplain environment.

Recommendation 25: Governments immediately take steps, on a binational basis, to begin development of a comprehensive flood damage reduction plan for the Red River basin.

Recommendation 26: Governments at all levels should undertake the following measures:

- a. Develop and implement comprehensive, multi-faceted plans for concurrently reducing flood damage and protecting and enhancing the natural environment;
- b. Ensure ongoing institutional support and full multi-jurisdictional participation in further development and maintenance of the Task Force's legacy projects;
- c. Implement Commission and Task Force recommendations designed to ensure basin-wide flood preparedness and community resiliency;
- d. Promote a culture of flood preparedness and flood resiliency in the basin;
- e. Enhance technology and monitoring systems to provide early warnings and early action in the face of impending major floods;
- f. Ensure binational coordination of flood forecasting and communications of forecasts to the public;
- g. Provide opportunities for multi-jurisdictional problem solving and the exchange of best practices information; and
- h. Integrate floodplain management activities into the broader field of watershed and basin management.

Recommendation 27: Governments should assign the following functions to the International Joint Commission for implementation by the International Red River Board:

- a. Monitor progress by the governments (federal, state, provincial, municipal) in implementing the recommendations of the Commission's report on Red River basin flooding, and in maintaining and advancing the work of the Task Force's legacy projects;
- b. Encourage governments to develop and promote a culture of flood preparedness in the Red River valley;
- c. Encourage government efforts to develop and implement a long-term strategy for flood mitigation and emergency preparedness;
- d. Encourage the sharing of accurate and timely transboundary information to support the development of improved flood forecasting techniques and procedures for early flood warnings and to improve communication of flood forecasts;
- e. Provide through the activities of the Board a forum for the exchange of best practices and for other flood-related information on preparedness, mitigation, response, and recovery, to assist in transboundary problem solving;
- f. Promote the application of innovative technologies for supporting flood modeling and mapping;
- g. Monitor the adequacy of data and information collection networks (meteorological, hydrometric, water quality) for flood preparedness, forecasting and mitigation, within the larger context of overall water management needs in the basin;
- h. Monitor potential transboundary effects of flood mitigation and other works in the basin, and encourage cooperative studies necessary to examine these effects;
- i. Encourage governments to integrate floodplain management activities in watershed and basin management;

-
- j. Interact with all levels of government to help decision makers become aware of transboundary flood-related and associated water management issues; and
 - k. Assist in facilitating a consultative process for resolution of the lower Pembina River flooding issue.

Recommendation 28: The federal governments, in cooperation with the state and provincial governments, should work with the Commission and its International Red River Board, as well as with existing and emerging bilateral organizations, to ensure that appropriate arrangements are in place to coordinate and implement measures for flood preparedness and mitigation activities and to implement recommendations of the Commission.

Task Force Conclusions Endorsed but not Restated by the IJC²⁶

Conclusion 7: There is general recognition in the region that flooding in the lower Pembina River basin has been profoundly affected by the construction of dikes and of roads that act as dikes on both sides of the boundary. Rectifying the transboundary flooding consequences of these structures will require action in both countries and there appears to be a general readiness to take such action.

Conclusion 8: Further improvement and maintenance of the [virtual] Red River floodplain management database [initiated by the Task Force] is required. Federal, state and provincial governments and local authorities must maintain a high level of involvement in further database development and in improving data accessibility.

Task Force Recommendations Endorsed but not Restated by the IJC

Recommendation 2: Future ice jam information from the entire basin should be incorporated into the [U.S. Army Corps of Engineers' Cold Regions Research Engineering Laboratory] CRREL Ice Jam Database so that ice problems in the basin can be analyzed further. Where feasible, historic ice jams from the Canadian portion of the basin should be entered.

Recommendation 3: Communities in the United States portion of the Red River basin should ensure that community-built flood damage reduction projects are certified by FEMA for 100-year or greater protection, or should participate in the Non-Federal Flood Control Works Inspection Program.

Recommendation 5: Based on results from hydraulic model studies, modify the east embankment of the [Winnipeg] Floodway to improve the performance of the Floodway entrance to lower upstream water levels and increase capacity.

²⁶ Annotations in square brackets are IJC comments for clarification of context.

Recommendation 6: The west dike [upstream of the Winnipeg Floodway inlet] should be raised to allow a water level elevation of 778 feet (237 m) at the Floodway inlet structure with appropriate freeboard.

Recommendation 7: The primary diking system [for Winnipeg] should be raised where economically feasible to the elevation specified in existing legislation.

Recommendation 10: Modifications to the sewer and land drainage systems [of Winnipeg] should be optimized and undertaken once the overall plan for Winnipeg flood protection is determined.

Recommendation 11: The City of Winnipeg should give immediate high priority to the preparation of a detailed emergency preparedness and response manual.

Recommendation 12: Operating rules for new flood control measures [for Winnipeg] should be designed to accommodate all flow regimes, even those beyond design capacity. The public should be consulted on any proposed new operating rules.

Recommendation 15: The 500-year flood (0.2 percent flood) should be defined throughout the Red River basin and used to inform the public of the potential risks of flooding from rare events, including the need to buy flood insurance in the United States, and as the basis of regulations for siting and flood-proofing critical facilities.

Recommendation 16: Both North Dakota and Minnesota should consider adopting the new International Building Code that includes requirements for design and construction in flood hazard areas.

Recommendation 17: The National Building Code of Canada should specify design and construction standards for buildings in flood hazard areas such as the Red River basin. Floodplain construction requirements should be incorporated into the Manitoba code when available.

Recommendation 18: Federal, state, provincial, and local governments in the Red River basin, in conjunction with the private sector, should continue to develop, refine, and implement effective strategies to improve the disaster resiliency in basin communities. Efforts should be made to increase public awareness of flood risks throughout the basin.

Recommendation 21: The Canadian federal government should include in the Disaster Financial Assistance Arrangements provisions to allow for the permanent removal of structures in areas subject to repeated flooding.

Recommendation 25: Recovery, rebuilding, and mitigation expertise and information should be widely shared across the border in advance of flooding.

Recommendation 26: Measures of flood resilience should be developed, and a system should be established to monitor resilience in the Red River basin.

Recommendation 28: Given the transboundary nature of the [Pembina River] basin and the potential for federal involvement in funding and monitoring any agreement, federal agencies from both countries should be engaged in this process [to determine and implement solutions to flooding problems] as well.

Recommendation 29: Changes in the road network and diking system in the lower Pembina basin should be modeled by the hydrodynamic model prior to implementation of any plan to ensure that there are no unintended consequences.

Recommendation 30: The virtual database and decision-support system prototype that the Task Force has begun to develop for the Pembina basin should be continued by relevant agencies in Canada and the United States.

Recommendation 32: Any modification to existing operating plans or physical structures associated with Lake Traverse that could increase pool elevation must be accompanied by features that eliminate the southward movement of water into the Little Minnesota River.

Recommendation 34: Governments should continue to monitor toxaphene in the Lake Winnipeg ecosystem until concentrations decline to pre-1997 levels.

Recommendation 35: Hydrometric and meteorological data networks necessary for flood forecasting should be improved and maintained in a state of readiness to forecast future floods.

Recommendation 36: New geographically related data collection in the United States should be in accord with the North American Vertical Datum of 1988.

Recommendation 37: For consistency and accuracy, data used in models should take into account the differences in data at the border. Because datum conversions can affect data accuracy, any conversions between standards should be noted and reported along with the data.

Recommendation 38: U.S. National Geodetic Survey and the Geodetic Survey of Canada should convene a forum of datum experts [~~in the year 2000~~] to discuss Red River basin datum issues and develop a long-term transition plan [for resolving datum differences between the two countries].

Recommendation 39: All key data providers in Canada should make available at no cost and with no restriction the data sets necessary for the Red River floodplain management and emergency response, and regional or basin-wide modeling activities.

Recommendation 40: Data providers should remain responsible for maintaining and replicating the data sets [in the developing virtual database].

Recommendation 44: The U.S. National Weather Service should implement its Advanced Hydrologic Prediction System in the Red River basin as an early priority.

Recommendation 46: Confirm the flood peak reduction findings of Chapter 3 [of the Task Force's final report of April 2000] for large floods and examine reductions for smaller floods by implementing distributed models on tributaries such as the Mistinka, Wild Rice and Maple Rivers.

Recommendation 48: Conduct surveys of secondary roads, particularly in the central portion of the basin, with differential global positioning systems, and incorporate the results into the hydraulic models.

Recommendation 50: Measures should be taken to ensure that data supporting the operation of the hydraulic models and model outputs can be made widely available.

Signature Page

Signed on the 28th day of November 2000 as the final report of the International Joint Commission to the Governments of Canada and the United States on reducing flood impacts in the Red River basin, as requested in the June 12, 1997 reference.



L. H. Legault
Chair, Canadian Section



Thomas L. Baldini
Chair, United States Section



Robert Gourd
Commissioner



Susan B. Bayh
Commissioner



Alice Chamberlin
Commissioner

B i b l i o g r a p h y

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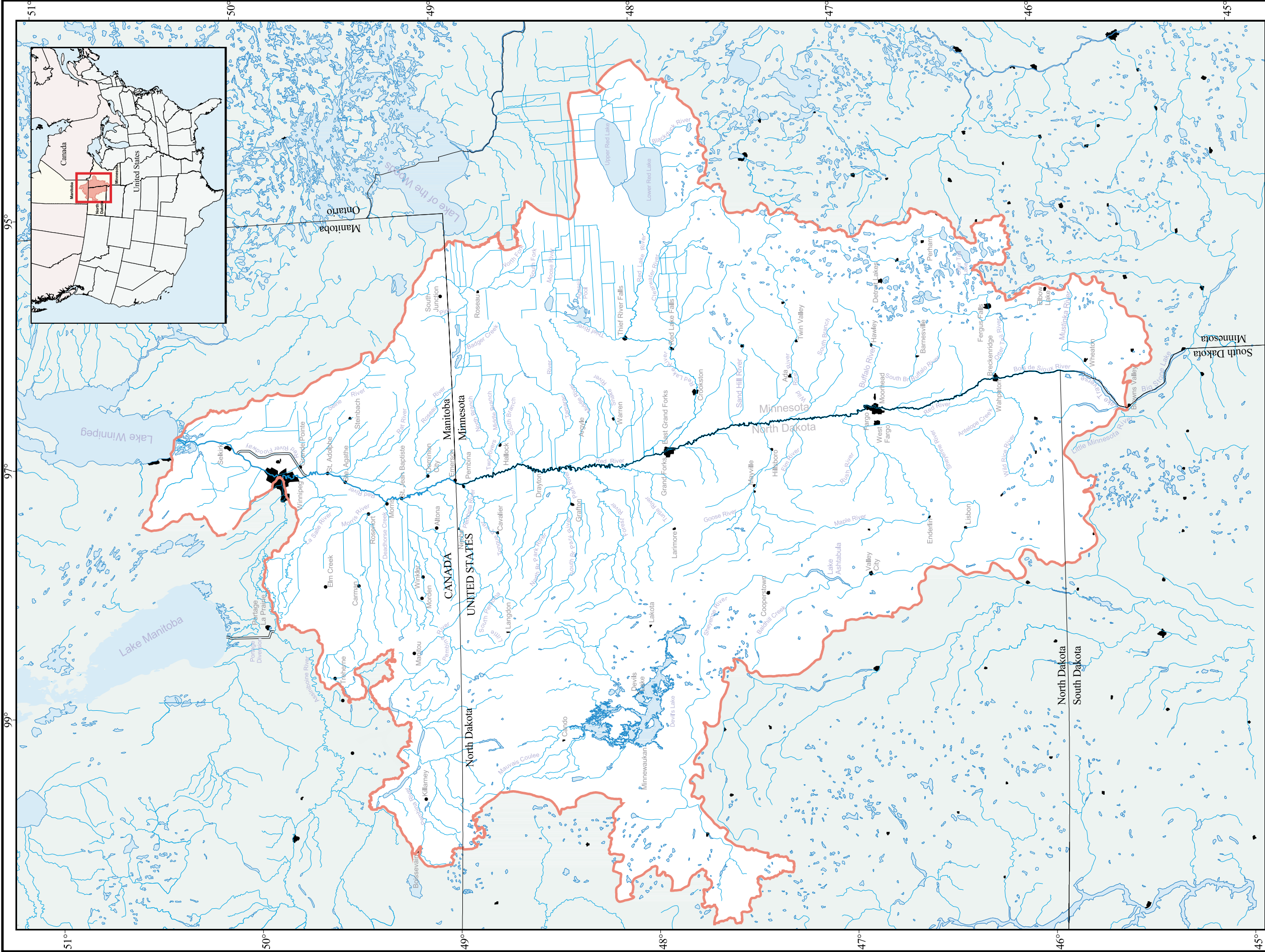
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Red River Basin

(excluding Assiniboine River)

Map Projection - Lambert Equal Area
Central Meridian - 100 degrees West
Reference Latitude - 50 degrees North

Data assembled and provided by:
Ecological Research Division
Environment Canada, Regina Office
Scale - 1 : 2 000 000

Data Sources

ESRI Digital Chart of the World:
Land Use Characteristics Database

United States Geological Survey:
State Boundaries
1:500,000 Hydrologic Unit Boundaries

Water Survey of Canada:
HYDAT and HYDEX databases
Canada Prairie Farm Rehabilitation Agency:
Watershed Basin



30 0 30 60 90 Miles

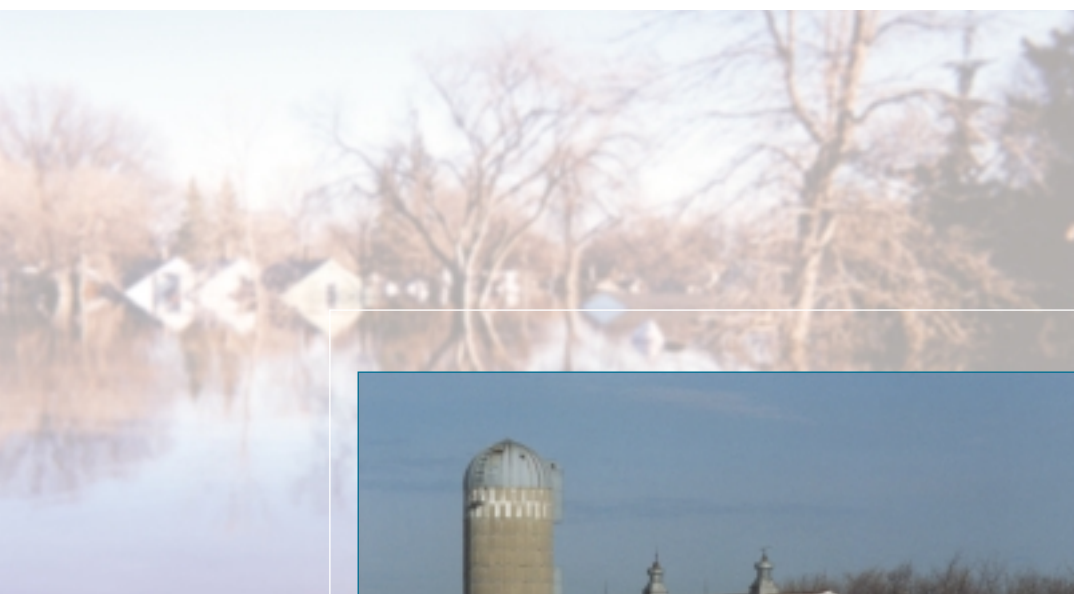
30 0 30 60 90 120 Kilometers

Red River Basin



Urban Areas





International
Joint
Commission

Commission
mixte
internationale