

**NOMINATION FOR APWA
PROJECT OF THE CENTURY AWARD
RED RIVER FLOODWAY
WINNIPEG, CANADA**



APRIL 2000



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APWA's Public Works
Projects of the Century
2345 Grand Boulevard, Suite 500
Kansas City, Missouri 64108-2641

RE: Nomination of Red River Floodway
Winnipeg, Manitoba

Dear Sir:

On behalf of the Manitoba Chapter we are pleased to submit eight (8) copies of the nomination package with nomination form for APWA top ten Public Works projects of the century award for the Red River Floodway located at Winnipeg, Canada. This is a significant public works project that is worthy of recognition.

Should you have any questions, please contact the writer.

Yours truly,

Roy J. Houston, P.Eng.
Chair Quality Programs Committee

RJH/af

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Public Works Projects of the Century Nomination Form

Please print clearly

RED RIVER FLOODWAY

Project Name

PROVINCE OF MANITOBA

Managing Agency

MANITOBA CHAPTER

Nominated By

ROY HOUSTON

Name

PROJECT MANAGER

Title

KGS GROUP

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Please include a copy of the above nomination form with each submittal.

Eight copies of submittal should be mailed to:

APWA's Public Works
Projects of the Century
2345 Grand Boulevard, Suite 500
Kansas City, Missouri 64108-2641
Phone: (816) 472-6100

For more information contact the awards administrators at (800) 595-APWA or visit APWA's web resource at www.apwa.net.



EXECUTIVE SUMMARY

The City of Winnipeg with a population of 660,000 is a major centre of commerce, communication, and transportation in central Canada.

Situated in a flood-prone region, Winnipeg is protected by the public works project that is nominated in this submission for the top ten projects in the 20th Century. That project is the Red River Floodway. It protects the city from floods up to about the size of the 1997 flood. It was a massive undertaking requiring almost six years of continuous construction. It required excavation of a 29.4 mile long, 30 ft deep channel around the city, construction of two major concrete control structures, 13 highway / railway bridges, re-routing of a river and aqueduct, seven drop structures to accommodate local drainage, and major modifications to transmission lines, and gas and oil pipelines where they cross the channel.

The event that spurred the provincial and federal governments to plan and construct this monumental project for Winnipeg was the Great Flood of 1950. Over 100,000 people were forced to evacuate their homes in the greatest mass exodus in Canadian history.

After years of debate and controversy following the 1950 flood, Premier Roblin managed to secure a commitment from the federal government to pay 60% of the cost. Planning proceeded immediately, and construction commenced in 1962 and was completed in 1968.

The scale of the project was enormous--the largest of its kind in North America. The volume of earth excavated to form the channel was 100,000,000 cubic yards--exceeding the excavation volume of the Suez Canal and exceeded only by the Panama Canal.

It was designed to carry 60,000 cfs around the City of Winnipeg, and is capable of passing somewhat more with temporary dikes in an emergency.

The Red River Floodway has protected the City of Winnipeg admirably. In the 20 occasions that the channel has been relied upon in the 32 years since its completion, it and the other components of the flood protection system prevented flood damages estimated at more than \$4 billion (US). This tremendous benefit was generated mostly by the Floodway, whose initial capital cost was about \$40 million (US) in the mid-1960's.

The ultimate test of the Red River Floodway came in 1997 when the "Flood of the Century" swept down the Red River Valley from the United States. That flood was more than 50% larger than the 1950 flood but the Red River Floodway was able to successfully protect the city.

There is no doubt that the Red River Floodway has contributed enormously to the ability of Winnipeg to grow and prosper over the last 30 years.

The Red River Floodway has become widely known and is a source of pride among Canadians.



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1.0 THE PROJECT

The Red River Floodway was constructed from 1962 to 1968 to protect the City of Winnipeg, Canada during most flood years. The Red River Floodway is the most significant of four flood control works that protect Winnipeg. The 29.4 mile long, 30 ft deep floodway channel conveys flow safely around the City. It precludes spring floodwaters from rising to a high level that would inundate most of Winnipeg, including the central business district. The location of Winnipeg and the Red River watershed are shown in Figure 1 in the Appendix.

2.0 PROJECT SETTING

2.1 PHYSIOGRAPHIC

Metropolitan Winnipeg is located about 60 miles south of Lake Winnipeg near the centre of the North American continent. It is situated on the bed of a former Pleistocene glacial lake, Lake Agassiz, that once covered much of Manitoba. The remnants of the lake bed form one of the flattest areas in North America. The area slopes gradually downward from North Dakota, at only about three feet per mile. The area is drained mainly by the Red River, which originates near Wahpeton, North Dakota and flows northward into Canada. The Red River follows a meandering course for some 550 river miles across southern Manitoba, and empties into Lake Winnipeg. Rich, organic soil overlies a thick deposit of silt and a highly plastic clay, that is quite impermeable. The river generally flows slowly through a channel about 330 ft wide at Winnipeg. In winding through relatively flat terrain, the river has not cut a very deep channel. With the absence of secondary banks and the flat topography, floodwaters can easily overflow the river channel and inundate a wide area of the valley.¹ Flooding is generally produced by one or more of the following factors:

- Rainy antecedent autumn
- Early frost and onset of winter
- Heavy snowfall
- Late spring thaw
- Prolonged rainfall during the spring

A major tributary of the Red River, the Assiniboine River originates in south-central Saskatchewan, about 430 miles west of Winnipeg and flows into the Red River in downtown Winnipeg. It is generally not a major factor in flooding at Winnipeg since other flood control works have significantly reduced its contribution under flood conditions.

The Red River Floodway is located to the east of Winnipeg. The Floodway channel leads from the Red River at the upstream or southern city limit. It then bends northeasterly around the city for a distance of 29.4 miles to rejoin the river 12 miles downstream of the city's northern limit. In addition to the channel, the Red River Floodway is comprised of the following key components:

¹ J.A. Griffiths, "The Red River Floodway", Canadian Geographic Journal, February 1965; and J.M. Bumstead, "Floods of the Centuries: A History of Flood Disasters in the Red River Valley", 1776 - 1997, Great Plains Publishers, 1997.



- An Inlet Control Structure on the Red River to divert water into the channel (shown in Photo 1)
- An Outlet Control Structure to control the energy of the floodwater re-entering the Red River
- The West Dike of the Inlet Control Structure to prevent floodwaters from bypassing the structure and entering Winnipeg from the southwest

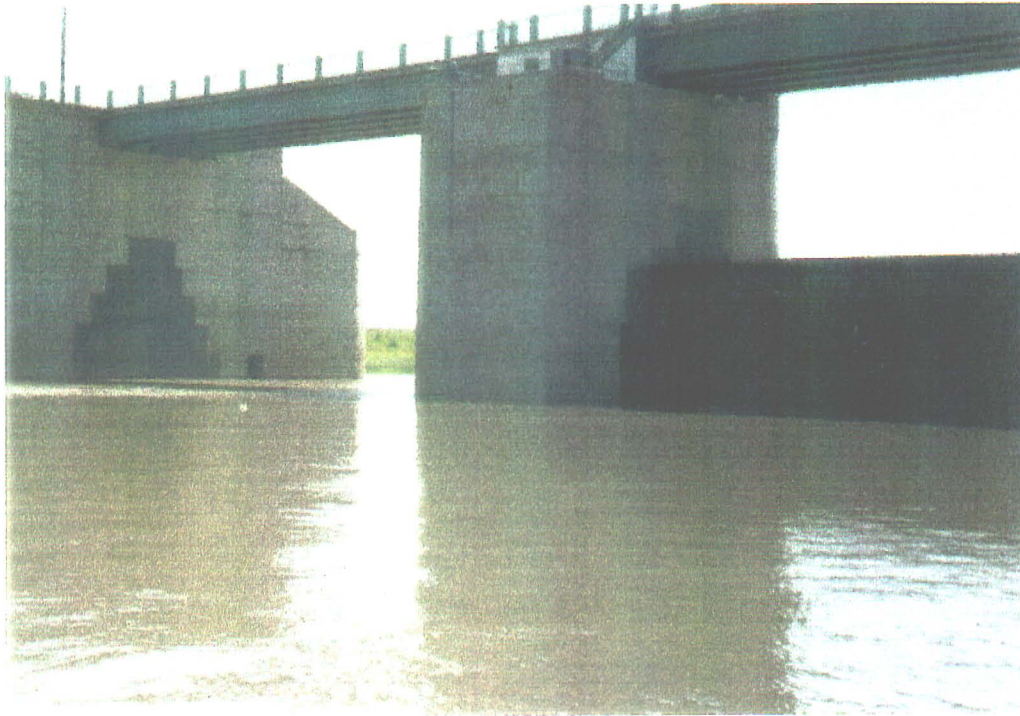


Photo 1: Red River Floodway Inlet Control Structure. Right gate raised for maintenance purposes under low flow conditions.

2.2 CITY OF WINNIPEG

Winnipeg is the capital and economic hub of the province of Manitoba. The commercial district straddles the Red River. Due to the flat topography of the area, water that overtops the banks of the Red River is capable of flooding most of the commercial centre, and a large portion of the adjacent residential zone. Current estimates of the flood damages that would be caused without the protection of the Red River Floodway² are:

1 in 25 year flood = \$ 0.5 billion (US)
1 in 100 year flood = \$ 3.0 billion (US)

² International Red River Basin Task Force Report "The Next Flood: Getting Prepared", April, 2000.



Winnipeg is also a major commercial centre for Canada, and is a transportation hub of the country. Flooding of the City would significantly hamper land transportation facilities and cripple the flow of goods through the region.

3.0 NEED FOR THE PROJECT

Since the early 1800's, the site of present-day Winnipeg has frequently been threatened by severe flooding.

The site suffered a devastating flood on three separate occasions in the 1800's, and experienced a partial inundation on an average of once every 10 years from the early 1800's to the construction of the Floodway. The highest recorded flood occurred in 1826 when floodwaters reached 36.5 ft above the winter ice level and covered the site in up to 15 ft of water. The 1826 flood created a 25 mile wide lake. Prior to the peak, ice movement swept away most of the houses, out-buildings, fences, and livestock of the settlers. The 1826 flood inundated over 900 square miles of southern Manitoba.

Lesser floods inundated the upper Red River Valley towns and farmlands in 1852, 1882, 1904, and 1916. By 1916, Winnipeg had a population of 163,000, was the third largest city in Canada, and Canada's fourth largest manufacturing centre. It was a critical link in the east-west rail transportation and communication systems, the metropolitan centre for western Canada, and was widely regarded as the "Chicago of the North" for its rapid pace of development. With the immense floods of the 1800's fading from memory, new residential neighborhoods were built along the river, and the city remained vulnerable to floodwaters. In 1948, an extensive area of the upper Red River Valley was inundated forcing the evacuation of several towns, and re-awakening concerns about the vulnerability of Winnipeg to floodwaters.

When the flood of 1950 struck, the City of Winnipeg had not experienced a major inundation for some 90 years, and remained virtually unprotected. In early May of 1950, it was evident that the Red River would rise to a disastrous level, and the Canadian government declared a "State of National Emergency" with 400 square miles of southern Manitoba inundated by Red River floodwaters. For weeks, 3,000 Canadian soldiers and thousands of volunteers built sandbag dikes and manned pumping stations, while thousands of people evacuated endangered areas. Ultimately, the rapidly rising river overtopped the sandbag dikes, and large areas of the city were flooded and damaged by sewers backing up from their outlets to the river.

At the height of the 1950 flood, over 10,000 homes were inundated in Winnipeg, some in waters up to 15 ft deep, as water covered 10% of the city. Over 100,000 people were forced to evacuate their homes in the greatest mass exodus in Canadian history.





Photo2: Aerial Photo of Winnipeg during 1950 Flood. Red River can be seen on right of photo. Major streets and residential areas are shown to be flooded in the left side of the photo.

Although Winnipeg's downtown barely escaped flooding, the 1950 flood was the "most catastrophic ever seen in Canada" in terms of extent of damage, the number of persons affected, and economic impact. Over \$85 million dollars (US) were expended to aid flood victims and repair flood damage (equivalent to some \$450 million in 2000 dollars (US)).

The federal and provincial governments had hitherto regarded flooding as a local problem to be addressed by the affected municipalities. In the shock of the severity of the flood damage, the magnitude of the population affected, and the high cost of the 1950 flood, they experienced a dramatic change of attitude. The 1950 flood was clearly a national disaster. The need for flood protection works became obvious to all.

4.0 DEVELOPMENT OF THE PROJECT

4.1 CONCEPT DEVELOPMENT AND PUBLIC ACCEPTANCE

A federal-provincial agreement was struck after the 1950 flood, and funding for dikes and pumping stations was secured. The dikes were built to a level about four feet below the 1950 flood, but were capable of being raised in an emergency.

To ensure against floods equivalent to or greater than the 1950 flood, the federal government undertook an extensive hydrological study and analysis of past flood and runoff characteristics, and plans for an extensive flood control system on the Red River. The study found that the dikes were inadequate to deal with an extraordinary but yet very conceivable flood. They would also be dangerous if a breach were to occur. It was recommended that a floodway channel be built around the east side of Winnipeg with related works on the Assiniboine River. Subsequent studies showed that this system would cost \$50 million (US), with 80% for the Red River Floodway. The floodway was estimated to have a benefit/cost ratio of 2.7.

Manitobans were concerned whether the province could afford such a mammoth engineering project that would benefit primarily the City of Winnipeg. The project was championed by newly-elected Premier Duff Roblin, who formed a minority Conservative government in 1957. The floodway was vehemently denounced by opponents as a monumental, and potentially ruinous, waste of money. Its capital cost of \$40 million (US) was approximately equal to Manitoba's annual net revenue at the time.

Following the formation of a majority government in 1958, Premier Roblin continued to promote the floodway, and managed to secure a commitment from the federal government to pay up to 60% of the construction costs. An agreement was signed, and the provincial government announced that it would build the flood control system. Planning proceeded immediately in routing the floodway, acquiring the lands for a 2000' wide right-of-way, and in designing the components of the floodway. Three years later, contracts for the excavation work were awarded to Manitoba contractors. Work commenced in 1962 and was completed in March, 1968.

4.2 DESCRIPTION OF THE RED RIVER FLOODWAY

The Red River Floodway is by far the largest excavation project ever undertaken in North America, and one of the largest man-made channels in the world. The volume of material excavated exceeded that of the Suez Canal as well as for the Canadian section of the St. Lawrence Seaway.

Three main components of the Red River Floodway³ are as follow:

Inlet Structure

The inlet structure is positioned in the Red River a short distance downstream of the entrance to the floodway channel. Its function is to regulate the flow of the Red River through Winnipeg by diverting a portion into the floodway channel. It is a reinforced concrete structure with a central control tower and two submersible steel gates, each 112.5' wide and 34.8' high. The gates normally rest submerged, about six feet below the summer level of the Red River, to enable boats to pass. In time of flood, the gates can be raised hydraulically to divert flow into the floodway channel to preclude any overflowing of the dikes in Winnipeg.

³ N. Mudry "Major Flood Control Works in Manitoba", January, 1967.



Floodway Channel

The floodway channel follows a semi-circular path around the east of Winnipeg from its entrance, near the southern extremity of the city, to its downstream junction with the Red River below the town of Lockport, ten miles north of the city. The floodway channel is 29.4 mile long, with sloped sides grassed to protect against erosion. It has a base width varying from 380' to 540', a top width from 700' to 1,000' at ground level, and an average depth of 30' with embankments formed from the spoil material. An inner, pilot channel, 4' deep by 54' wide, is set into the bed of the floodway along its longitudinal axis. It carries ground water, seepage and runoff from several streams and large drains. With the low flows confined to the pilot channel, the larger main channel can sustain the vegetative cover required to prevent erosion and degradation.

The final design of the floodway channel was based on a determination of the most economical cross-section that could be excavated to carry a maximum design flood flow of 60,000 cfs with a velocity of no more than 5 ft/sec to prevent erosion. As a result, the floodway has a wide, shallow channel, rather than a deep, narrow channel, with a maximum drop of 18'. As a result of the soil stability studies, the floodway was built with 6:1 side slopes (horizontal to vertical), increasing in steepness to 3:1 in the 67' deep cut through the ridge at Bird's Hill, and flattening out to 9:1 near structures crossing the floodway—to prevent turbulence and any constriction in water flow—with transitional sections of varying slopes.

Outlet Structure

Because of the design limit on the gradient in the floodway channel, the floodway at its exit below Lockport is 14' above the level of the Red River. An Outlet Structure was designed to accommodate the difference in elevation. It is a concrete drop structure that incorporates a rollway and stilling basin. The Outlet Structure was designed to dissipate the energy of the Floodway flow so as to prevent any harmful erosion and scouring of the river channel.

The Red River Floodway was designed to handle a flood of 130,000 cfs with the Floodway channel having a design capacity of 60,000 cfs, and the river channel below the Inlet Control Structure conveying 70,000 cfs safely between dikes in Winnipeg. The floodway is not activated in years of minimal flow. In years of moderate flooding, the floodgates are used when the river flow reaches approximately 40,000 cfs and the gates are set at a height sufficient to divide the floodwaters between the river and Floodway channel.

4.3 CHALLENGES

After developing the political will and sources of funding, the main challenge was the sheer volume of excavation to be done. Excavation of some 100,000,000 cu yards of clay and glacial till in a period of 5.5 years required essentially the entire excavation contracting industry in Manitoba.⁴ Multiple contracts were arranged to share the work and maximize the use of local resources. The excavation continued year round during this period.

⁴ Steve E. Gahbauer, "Distributors enjoy equipment bonanza as Canada's "Big Ditch" Gets Longer", Engineering and Contract Record, November, 1963.



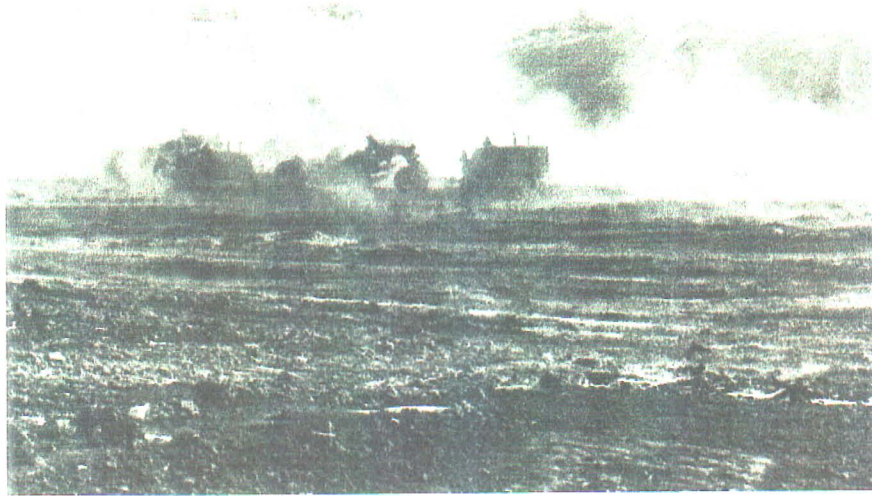


Photo 3: Excavation in winter to use frost penetration to assist mobility of equipment

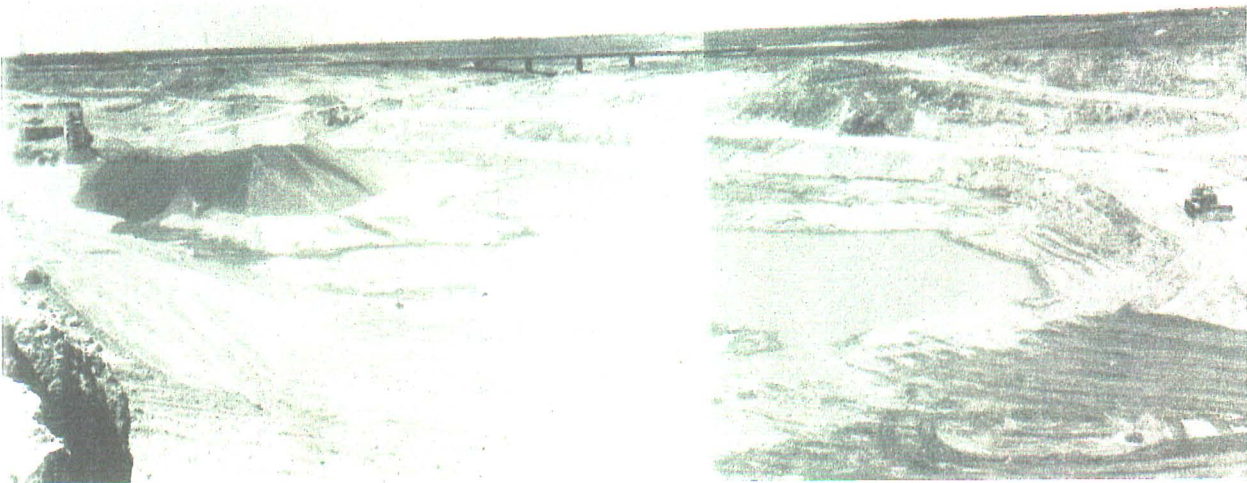


Photo 4: Excavation underway in channel

Challenges arose in dealing with artesian pressures along the floodway route that, if left unchecked, caused blowouts and slope failures. A system of depressurizing wells was required.

Other challenges included:

- Maintaining a riparian flow in the lower reaches of the Seine River where the Floodway route crossed this tributary of the Red River. This was achieved by

constructing a 5 ft diameter pipe under the Floodway channel to carry up to 200 cfs over a distance of 900 ft.

- Developing safe control of flows that often carried large pans of ice. A massive control structure standing some 90 ft high above the limestone bedrock surface does the job. During construction, the entire Red River flow had to be diverted into a specially excavated channel. The structure includes two massive sector gates each 112 ft long and 35 ft high.
- Accommodation of the public and private facilities that were directly or indirectly affected by the Floodway including;
 - Bridges for 7 major highways that are crossed by the Floodway route
 - Bridges for 6 railways
 - An aqueduct under the Floodway to convey the supply of water for the City of Winnipeg
 - Relocation of electrical transmission line towers
 - Gas and oil pipelines relocations
 - Local drainage, accommodated by drainage canals leading to a series of seven drop structures that allow the local runoff to be carried readily away by the Floodway channel.

4.4 INNOVATION

A variety of innovative design and construction techniques were applied to help bring this project to successful fruition:

- The control gates of the Inlet Control Structure are unique and innovative. Their size, shape and configuration allow large ice pans to pass safely with little or no restriction of flow.
- Excavation of wet clay was planned to be done in the winter when frost penetration would facilitate excavation.
- Complex operation planning was required to keep the upstream water levels at or above the "state of nature". A system of monitoring river flows and water levels in the Red, Assiniboine, Seine Rivers and at other key locations in the area was developed. It provides data to assist a comprehensive hydraulic analysis to determine gate openings. This process is in continuous use during the operation of the Red River Floodway.

4.5 ENVIRONMENTAL CONSIDERATIONS

Concern for the environment was less prevalent when the Red River Floodway was planned and designed. Nevertheless, there was consideration for the environment as well as for the social impacts of the Floodway construction process as follows:



- The Floodway route was selected to minimize the expropriation of property.
- Wells that were adversely affected by the reduction in groundwater level that the Floodway caused were extended.
- The impact of lost agricultural land was lessened by developing a system of leasing the rights to produce and harvest hay from the floodway embankments and right-of-way.
- Areas adjacent to the Floodway were effectively drained and resulted in increased agricultural productivity.
- Recreational use of the Floodway has been developed:
 - A ski-hill
 - Tobogganing, sledding and sliding
 - Power-tobogganing permitted within the Floodway property
 - Establishment of an interpretive centre with a walking trail and commemoration to key people.

5.0 BENEFITS ACHIEVED BY RED RIVER FLOODWAY

No sooner was the Red River Floodway completed than it proved of even greater benefit than anticipated. The decade after 1968 saw a trend toward an increased frequency and severity of flooding with the mean annual discharge of both the Red River and Assiniboine Rivers exceeding, by 80% and 60% respectively, that of the period between 1915 and 1968. In 1969, 1970, 1974, 1978, 1979 and 1996, significant flooding was experienced in the Red River Valley south of Winnipeg, costing millions of dollars in damages. Yet, Winnipeg escaped relatively unscathed with the protection provided by the Red River Floodway. In the spring of 1974, 1979 and 1996, the Red River Floodway proved beyond dispute its critical value in protecting the city from potentially severe inundation. In each of these years, the volume of floodwaters approximated that of the Great Winnipeg Flood of 1950, and would have devastated the city, if not diverted by the flood protection system.⁵

Within a decade of its construction, the economic value of the flood control systems was evident to everyone, including its opponents. As of 1999, the Red River Floodway has been operated in 20 of 32 years saving an estimated \$4 billion (US). Considering the cost of the system (80% of which was for the key Red River Floodway) was only about \$40 million (US) in the 1960's, the financial benefits of the system have been outstanding.

⁵ W.F. Rannie, "Red River Flood Control System and Recent Flood Events", Water Resources Bulletin (Amer. Water Resources Association), April, 1980.



The ultimate test of the Red River Floodway came in 1997 when "the Flood of the Century" swept down the Red River Valley from the United States. It produced river flows at Winnipeg that were 50% greater than the 1950 flood. Moreover, by 1997, the City had almost doubled its population and tripled its number of dwellings since 1950.

On April 18th, the Red River floodwaters reached a record height of 54' at Grand Forks (pop. 52,000), North Dakota, where the dikes were overtopped and the downtown severely flooded. Over 35,000 Americans were rendered homeless by the surging Red River floodwaters as the American federal government declared a state of national emergency.⁶ Within a week, the river was swollen to 18 miles in width. It was, temporarily, the largest river in North America, with a greater width and current velocity than the Mississippi River at New Orleans. It flowed north over the border into Canada, heading towards Winnipeg.

Faced with a potentially disastrous inundation, the provincial government declared a state of emergency, and ordered 17,000 residents evacuated from the upper Red River Valley. The Federal Government responded by dispatching 8,500 military personnel who worked seven days a week, around the clock, in aiding rural residents upstream of Winnipeg to build sandbag dikes to protect their homes and businesses, in many cases, to no avail. As the floodwaters approached Winnipeg, there were serious concerns as to how the floodway system would cope with the stupendous flow of water. When the flood crested at Winnipeg in early May, the "natural" peak flow of the Red River was over 162,000 cfs; close to the maximum capacity for which the floodway system was designed. The 1997 flood turned out to be the biggest flood since 1852. It is estimated that the floodwaters, if unregulated, would have reached a height eight feet above the primary dikes in Winnipeg. Photos 5 and 6 show the inlet and outlet of the Red River Floodway, during the 1997 flood.

⁶ Winnipeg Free Press, "Red Sea Rising", 1997.





Photo 5: 1997 Flood. Looking downstream towards Winnipeg – Floodway Inlet Control Structure in centre, Floodway channel carrying floodwaters to right of river. Note flooding upstream of inlet, and no flooding in Winnipeg.



Photo 6: Looking upstream along Floodway Channel (left) and Red River Channel (right). Floodway Outlet Structure in left centre.

With the Floodway in operation, comparatively little damage was done by the "Flood of the Century" within the City of Winnipeg in spite of dire predictions of potential devastation on the approach of an all but unprecedented flow of floodwaters.⁷ However, had the floodway not been in place, and capable of functioning somewhat beyond its design capacity, the "Flood of the Century" would have inundated over two-thirds of the City of Winnipeg, Canada's eighth largest city, and would have caused an estimated \$4 billion (US) in flood damages.

The Red River Floodway has had an historical impact on the development of a major Canadian metropolis. The achievement embodied in the Floodway as a functional design concept is evidenced by its capacity to protect Winnipeg under extreme flood conditions. It now has a symbolic importance to Canadians as it has become widely known and valued. It has saved the Federal Government, the Province, the City, and Manitobans several billion dollars that would otherwise have been required for emergency flood abatement, flood relief, rebuilding, and clean-ups. The Red River Floodway system has had, and will continue to have a positive, socio-economic impact of both a provincial and national significance, and has proven its efficacy, even in excess of its design capacity.

The Red River Floodway has also achieved national and world-wide recognition as an outstanding symbol of man's efforts to control Nature, and the limitations inherent in human efforts to do so given the precarious nature of such undertakings. It is also a prominent symbol of a long-established Canadian tradition of using major engineering works to overcome obstacles, and the vagaries of Nature, to establish and sustain prosperous communities in threatening and / or inhospitable environments.

⁷ Toronto Globe and Mail, "Winnipeg Rescue Hurts Town: Report", May 15, 1998.

6.0 FUTURE USE OF THE RED RIVER FLOODWAY

The Red River Floodway will continue to provide outstanding service for decades to come. In fact, in addressing the enormous potential for flood damage to Winnipeg, there is a movement underway to expand or augment the Floodway system⁸.

7.0 ELIGIBILITY REQUIREMENTS

The Red River Floodway meets all the eligibility requirements for the top ten public works projects of the century:

- It is a complex, innovative, large-scale, engineered project—unique in several ways.
- It is publicly owned (the Province of Manitoba)
- It was planned, designed and constructed in the mid-twentieth century, has provided 32 years of outstanding service to the citizens of Manitoba and will continue to do so for many years to come.
- Consists of multiple structures
- And was constructed over a six year continuous period

⁸ International Red River Basin Task Force Report "The Next Flood: Getting Prepared", April, 2000.



APPENDIX
FIGURE 1



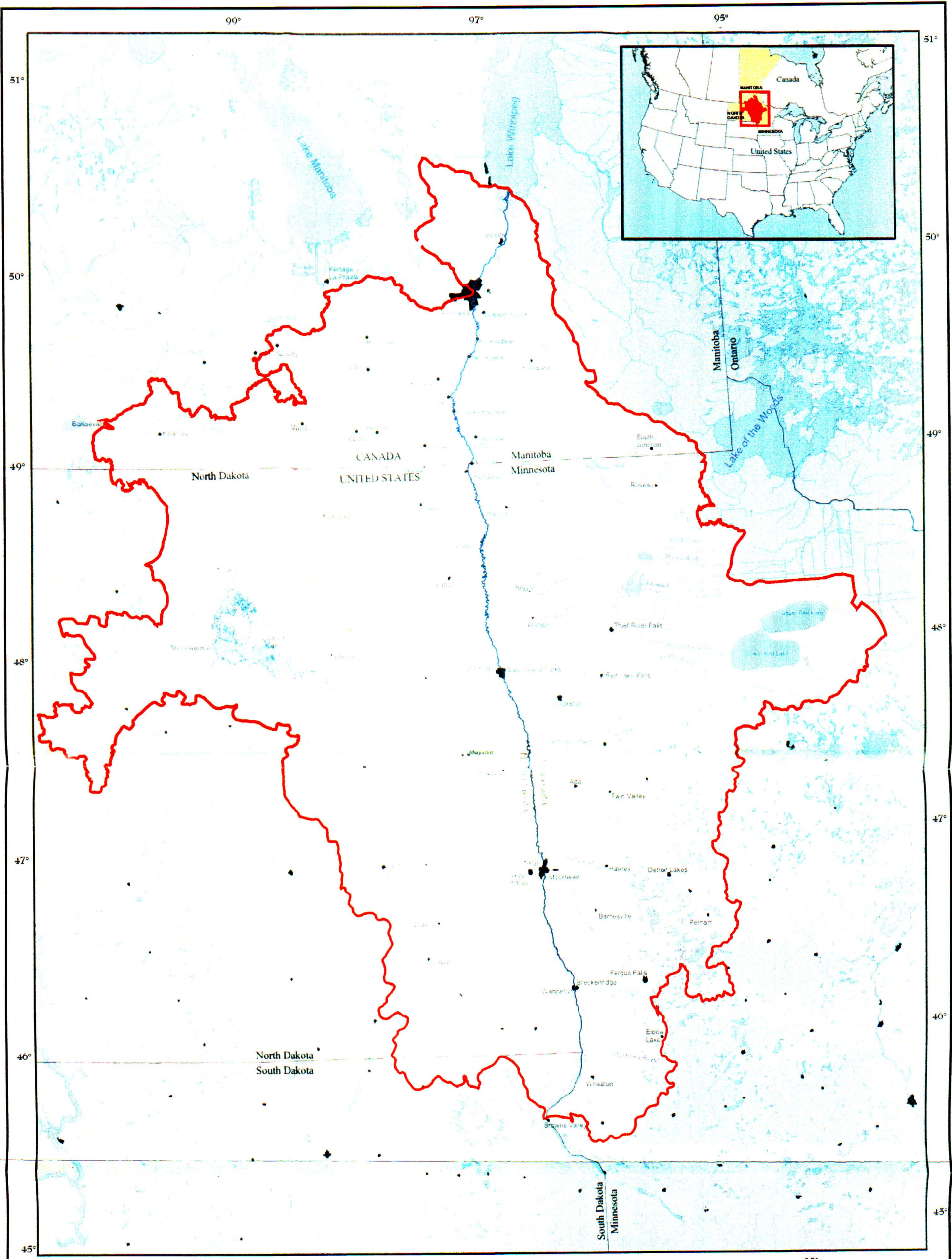


Figure 1 - Red River Basin

(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

Map Generated by
 US Army Corps of Engineers
 St. Paul, MN and Hanover, NH
 February 2000, Version 1.2

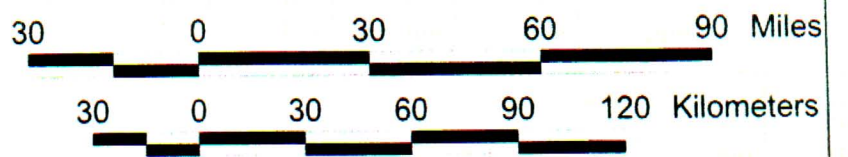
Data Sources

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



Red River Basin Urban Areas