A RIVER RUNS NORTH

Managing an International River

Second Edition

By Jay A. Leitch and Gene Krenz

Red River Basin Commission
May 2013

The Red River Basin Commission (RRBC) is a group of people working together to achieve common goals for water protection and management within the Red River Basin.

The Red River Water Resources Council is a nonprofit corporation dedicated to water management coordination in the Red River of the North Basin. The council serves as a forum for the exchange of information among the states of Minnesota and North Dakota and the province of Manitoba on matters related to the wise use of water and related land resources.

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Preface (Second Edition)

A River Runs North was first published in 1993 and updated with an addendum in 1998. By popular request, this Second Edition does the following:

- Updates facts and figures where appropriate,
- Incorporates the 1998 addendum into the main body,
- Adds a chapter on recreation, and
- Adds a chapter on recent flooding (1993 to 2011).

Every attempt was made to retain original text from 1993 and 1998. However, no attempt was made to distinguish between original and updated material.

The subject matter coverage in this book is not intended to be comprehensive. The intent is to introduce readers to Red River issues, including divergent perspectives where appropriate. Readers are encouraged to refer to other sources for more in-depth coverage.

Additionally, *A River Runs North, Second Edition*, is available online at www.redriverbasincommission.org. The online version contains numerous "hot links" that readers can click to access some of the many other useful sources of information on the Red River of the North.

Preface (First Edition)

The watershed of the Red River of the North encompasses an area approximately the size of Pennsylvania and occupies parts of Minnesota, North Dakota, South Dakota, and Manitoba. Through its center and across the fertile, flat bed of former glacial Lake Agassiz, the Red River meanders lazily northward. No, it is not the same Red River lonesome cowboys sang about around their campfires, nor is it familiar to many who live elsewhere. But its history is as tempestuous and colorful as that Texas river or others like it, and about its first inhabitants and its intrepid pioneers songs may yet be sung.

The pages which follow in the chapters of this book are intended to convey images and provide glimpses of an evolving Red River Basin and to help the reader acquire a clearer vision of not only how the basin has changed but of what it has become. If the book succeeds in making a point, it will be simply that the basin is always changing and is always more than meets the eye. The basin is, like the book, something quite different for each and every reader. It is the sum of what we both know and feel. . .a combination of things perceived.

This book is dedicated to helping those who read it capture a clearer understanding, a sharper perception of the Red River watershed and how it is managed. More than a few people helped make the book a reality. At the top of the list is the board of directors of the Red River Water Resources Council who saw the need for such a book. The current board consists of Ron Harnack, John Wells, Kent Lokkesmoe, David A. Sprynczynatyk, Francis Schwindt, and Gene Krenz. A special debt of gratitude is owed to Larry Whitney of the Manitoba Water Resources Branch, whose insightful comments on various drafts proved invaluable. Larry Knudtson left no stone unturned in searching for missing information, and Melissa Miller and Brenda Bosworth contributed their editorial skills, artistic talents, and computer wizardry throughout.

Acknowledgements

The authors want to thank those who made this Second Edition possible. First, thanks to Bob Backman and Chuck Fritz, who saw the ongoing need for this type of book and encouraged others to support it financially. Second, the North Dakota State Water Commission and Manitoba Water Stewardship who provided financial support.

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Of course, no one but the authors are responsible for the content of this book. We take full responsibility for any remaining glitches, any errors or omissions, and any content that any readers find objectionable.

Foreword

A river is really the summation of the whole valley.
To think any river as nothing but water is to ignore the greater part of it.
Hal Borland from *Beyond Your Doorstep: a Handbook to the Country*
1962, 1990, Lyons Press.

Rivers are innate to the planet Earth, having been here since water first condensed in the planet-forming process. Over the millennia, rivers have been a force in shaping the land surface and have evolved into complex ecosystems that support a myriad of different organisms. Rivers have always been important to humans. Certainly, they helped to expand civilization and, more recently, have been important for economic development around the world. Rivers play a prominent role in our literature, art, and music. Scott Slovic has said (in an editorial review of T. S. McMillin's *The Meaning of Rivers*) "Rivers not only wind their way across the American continent, but course through American literature and art." I know as a youngster I was transported into another world by the adventures of Huckleberry Finn and Tom Sawyer. Recently, during a church service, I was stirred by singing the beautiful African American spiritual, *Peace Like a River*. And, there are literally thousands of artistic depictions of rivers. One of my favorites is Gordon Montenson's woodcut titled *The Red River*.

Most of us know something about the recognized, great rivers of the world. Rivers, such as the Nile, Amazon, or closer to home, the Mississippi, have been part of our education. According to the Minnesota and North Dakota school standards, rivers are typically studied in the fourth grade. Generally our knowledge of rivers is about their history and geography. We learn precious little about rivers as ecosystems and even less about river watersheds. These are characteristics that affect us more directly and should be a priority of our education about rivers. An amalgam of limited knowledge of rivers and their watersheds, together with a poor understanding of policy-making (something we might label as *collective ignorance*), leads to the development of intransigent problems that affect a large cross-section of citizens.

In the first edition of *A River Runs North,* Gene Krenz and Jay Leitch took an important first step in our understanding of the myriad of problems of the Red River of the North while introducing us to the valley's labyrinthine structure of water management organizations. In this second edition, Leitch does much to expand this understanding. However, not all of Leitch's treatise is about the troubles in river city. This new edition adds a chapter that tells about the rich recreational history of the Red River as well as the numerous present-day opportunities. Jay Leitch is well qualified by education, research, and personal experience to bring to us this holistic view of the Red River Basin. His scholarly research leading to numerous articles pertaining to water management and resource economics provide a solid basis for his examination and assessment of the Red River and its watershed.

There is much information of importance in this book for water management professionals, public policy-makers, and educators. *A River Runs North* presents a view of the basin's history and an examination of the present to invoke a vision of the future. This realistic, sometimes critical, assessment could provide impetus for a more perspicacious method of watershed management. This is something for which all citizens of the basin can hope.

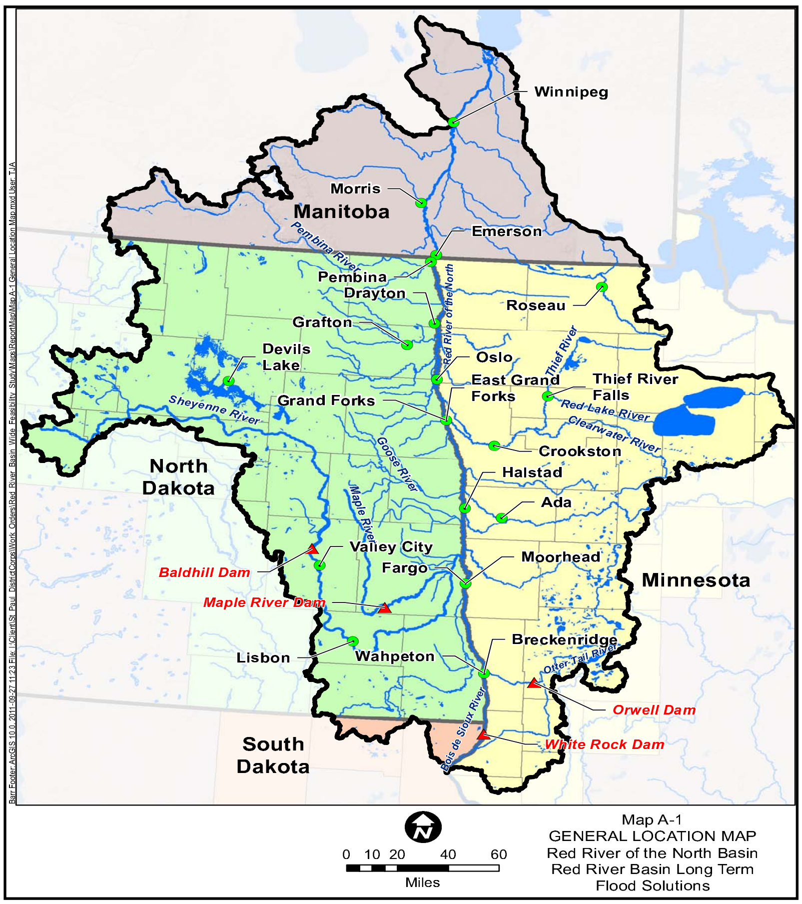
Gerry Van Amburg

Chapter 1

The Red River: A System Intact

Introduction

The ***Red River Valley***[1] is 17,000 square miles of incredibly flat real estate occupying substantial portions of eastern North Dakota, northwestern Minnesota, and southern Manitoba. A fraction of 1 percent of the valley's total area is just below Lake Traverse Dam in extreme northeastern South Dakota. One of the most productive agricultural areas in the world, the quality of the valley's cereal and feed grains, sugar beets, sunflowers, potatoes, and a host of other row crops is world-renowned.



Red River of the North

The area drained (the ***watershed)*** by the Red River of the North is part of the Hudson Bay drainage system. Through its center runs the Red River of the North, at times meandering lazily within its banks, at times spreading out over the surrounding flat lands for miles. The Otter Tail River in Minnesota, which is usually thought of as a ***tributary***, is in fact, the main extension of the Red River, comprises the true source and headwaters area, and was initially named the Red River. Flows in the Red River are erratic and highly variable. They range from virtually no flow, such as what happened during the summer of 1988, to over 130,000 ***cubic feet per second*** (cfs), in Grand Forks in 1997. Zero flow conditions were recorded for Fargo-Moorhead and several other locations along the river from 1932 to 1941, for two days in 1972, and for ten days in 1976 (USGS 2011). At the same time, records indicate that major ***flooding*** prevailed generally throughout the ***basin*** in 1882, 1883, 1893, 1897, 1916, 1943, 1947, 1948, 1950, 1952, 1965, 1966, 1969, 1975, 1978, 1979, 1989, 1997, 2001, 2006, 2009, 2010, and 2011. (SRRRBC 1972 and Crist 1990).

It has been said that the ***Red River Basin*** always has a water supply problem…either too much or not enough!

[1] Bold, italicized words and phrases are explained in more detail in the Glossary (page 135).

Glacial Lake Agassiz

The Red River Valley is not a valley in the usual sense of being formed by erosive forces. Rather, it is part of the area once occupied by glacial ***Lake Agassiz*** through which the Red River of the North now flows. Lake Agassiz (Figure 1-1), at its greatest extent, was about 700 miles long and nearly as wide.

According to Upham (1895), the maximum surface elevation was about 700 feet above the present level of Lake Winnipeg. The total area inundated at one time or another by Lake Agassiz was 367,000 square miles, though at no single time did the lake cover this entire area. Lake Agassiz reached its maximum size of nearly 135,000 square miles about 10,000 years ago (Teller and Clayton 1983). The lake was, at that time, almost twice the size of North Dakota.

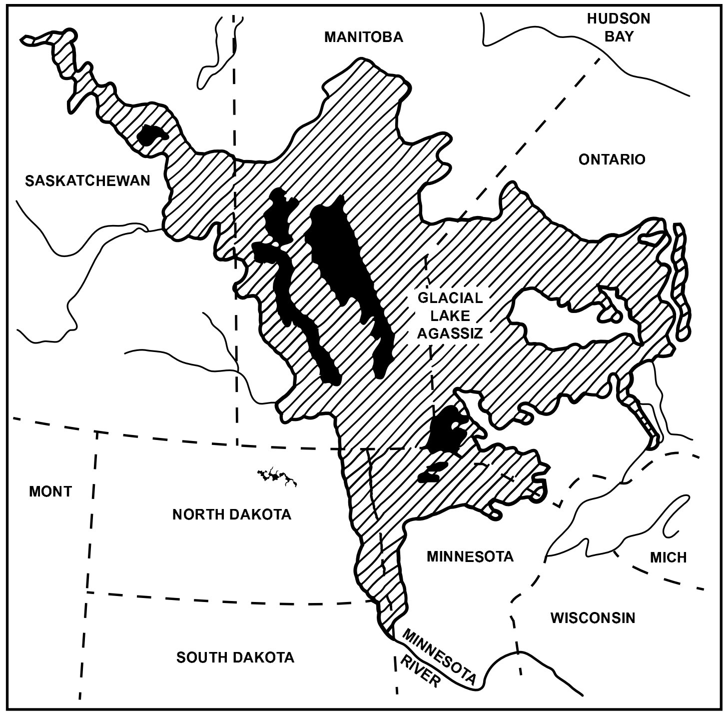


Figure 1-1
Glacial Lake Agassiz
Source: NDSWC 2012

Lake Agassiz existed for about 4,500 years, from nearly 12,000 years ago until almost 7,500 years ago (Teller and Clayton 1983). It was formed when the late Wisconsinan ice sheet (a glacier) blocked northward-flowing rivers. The lake increased and decreased in size depending on whether the ice sheet was advancing or retreating. Lake Agassiz is believed to have drained, for a time, eastward through northern Minnesota and southward into Big Stone Lake and through the present valley of the Minnesota River. Later, the receding glaciers permitted the lake to drain northward into the Tyrrel Sea, a much enlarged predecessor of present day Hudson Bay.

Canadian Lakes Winnipeg, Winnipegosis, Manitoba, and Nipigon are all modern day remnants of glacial Lake Agassiz, as is Lake of the Woods, which is shared by Canada and the United States (Bluemle 1977). Minnesota's Upper and Lower Red Lakes are the only remnants of glacial Lake Agassiz located exclusively in the United States portion of the basin.

The Red River Valley

Only in North Dakota does the Red River Valley assume essentially the same shape as glacial Lake Agassiz. The area of former Lake Agassiz in Manitoba is much larger than the area drained today by the Red River (Figure 1-2).

The Red River Valley is approximately 60 miles wide at its widest point and 315 miles long, as measured from Lake Traverse at the southern end to Lake Winnipeg at the northern end. It is one of the largest truly flat landscapes in the world (roughly the size of Denmark). The elevation at Wahpeton, North Dakota, is 943 feet ***mean sea level*** (msl). Lake Winnipeg is at elevation 714 feet msl. The fall in elevation from Wahpeton to Lake Winnipeg is only 229 feet over a distance of about 545 river miles. The ***slope*** of the ***main stem*** of the Red River averages about six inches per mile, varying from approximately 1.3 feet per mile in the vicinity of Wahpeton, North Dakota, and Breckenridge, Minnesota, to 0.2 foot per mile near the Manitoba border. Channel widths of the river vary from 200 to 500 feet, and average depths at bank-full stage range from 10 to 30 feet.

In addition to the almost imperceptible northward slope of the valley, there is a gentle slope toward the center from each side. Tributaries entering from both sides cross the valley with slight northerly trends.

Between the drainage lines of the tributaries there are areas from 5 to 15 miles wide that have no watercourses.

Soils in the bed of Lake Agassiz vary considerably. Most of the old lake bed is covered with deposits of very fine silts and ***lacustrine*** clay to depths of as much as 150 feet (Bluemle 1977). Sandy beaches were formed at the lake's margins. Where rivers emptied into the lake, deltas were formed by deposits of rock, gravel, and sand.

The valley is underlain by ***cretaceous rocks***. A source of artesian water in North and South Dakota is found in one of these formations, the Dakota Sandstone. In the northern portion of the valley, water is found in gravel beds deposited by glacial action.

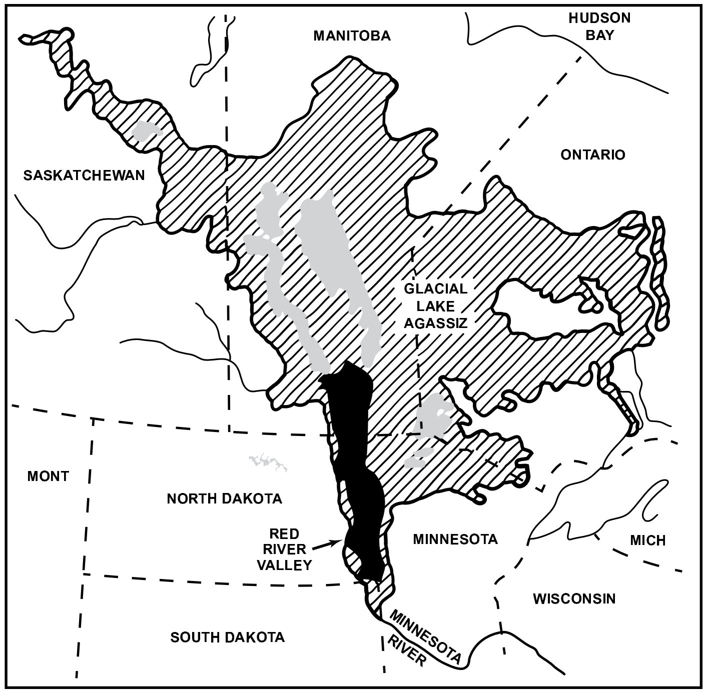


Figure 1-2
Outline of Red River Valley
Source: NDSWC 2012

The Red River Basin

The Red River Valley lies within the larger ***Red River Basin*** (Figure 1-3). The Red River Basin includes not only the old lake bed (Red River Valley) but also about 28,000 additional square miles, for a total of about 45,000 square miles. Of the total, nearly 40,000 square miles are in the United States (including the 3,810-square-mile, currently noncontributing Devils Lake Basin). The remaining 5,000 square miles (exclusive of the Assiniboine River and its tributary, the Souris) are in Canada. The Red River Basin constitutes an area roughly the size of Pennsylvania or Mississippi.

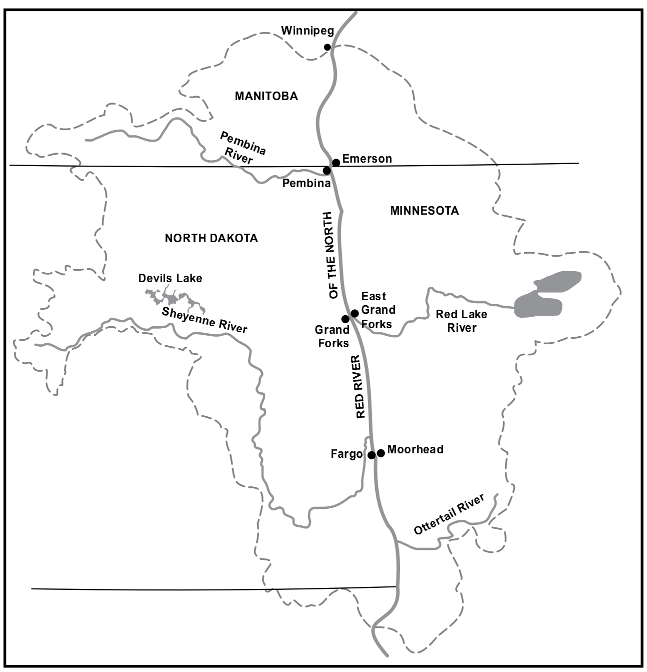


Figure 1-3
Red River Basin
(excluding Assiniboine River Basin)
Source: NDSWC 2012

The total drainage area of the Red River Basin (i.e., watershed) is shared by Manitoba, North Dakota, Minnesota, and South Dakota, in the amounts of 11, 47, 41, and 1 percent, respectively.

At the margins of the Red River drainage basin, elevations range between 1,200 and 1,600 feet msl, but the boundaries are not precisely defined. Along much of the east and west perimeters of the basin, the landscape is so flat that many swamps and marshes drain with equal ease to either side. Along the western side are wide belts where the drainage systems were modified by accumulations of ***glacial drift*** and ***moraines*** left by the ice of the glacial epoch. ***Surface water*** collects in these areas in innumerable kettles, potholes, and sloughs, where it stands until it evaporates or seeps away. If precipitation were greater, these areas would overflow, and erosion might again make the drainage pattern more discernible (SRRBC 1972).

East of a north-south line drawn about 30 miles east of the main stem of the Red River, the country is heavily timbered. West of this line, it is open prairie, nearly treeless except along streams and where shelterbelts have been planted. Although this line varies, during the current wet cycle, it has shifted west.

The Basin: A Complex System

The Red River Basin, like any other river basin, is complex. Its 30-odd principal parts, called subwatersheds or ***subbasins***, bear the names with which we are all familiar: Wild Rice, Sheyenne, Turtle, Park, Pembina, Roseau, Aux Marais, Plum, Morris, Tamarac, Red Lake, Buffalo, and Otter Tail. There are others, of course, and the ones we are most familiar with are those located near where we live or vacation. Most sources on the Red River Basin name ten major subbasins on the North Dakota side of the Red River, ten on the Minnesota side, and five in Manitoba for a total of 25 (Figure 1-4).

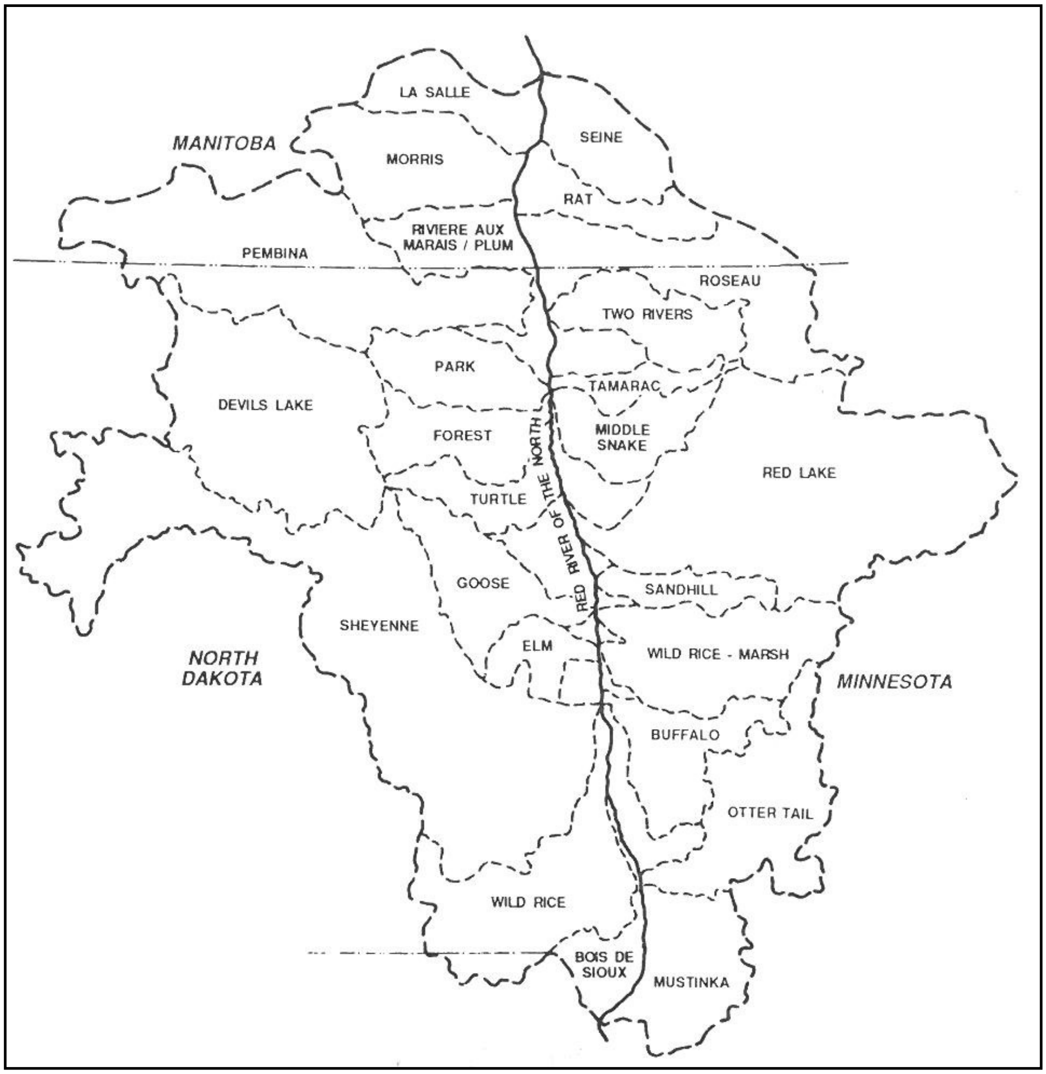


Figure 1-4
Major Subbasins

Each of the Red River's tributaries is unique. They differ in length. They flow in different directions. Some overtop their banks quickly as the result of summer rainstorms. Others flood only during the spring ***runoff*** period when snow cover is far above normal. Still others behave in a variety of ways depending upon local topography, soil types, soil moisture conditions, freeze/thaw cycles, land management practices, and a host of other factors. At times, each can be calm or unpredictable, dangerous, destructive, and unforgiving, but never do all of these traits manifest themselves in all of the tributaries at the same time.

Manitoba and North Dakota share the Pembina subbasin. The Roseau watershed is shared by Manitoba and Minnesota. Each of the 25 subbasins can, in turn, be divided into several smaller watersheds exhibiting a variety of characteristics. So the number of variables at work at any one time in the basin—over which man has only partial control—is in a state of flux, never constant, always changing.

One need only multiply the number of watersheds and subwatersheds by the short list of variables that could be at work in each of them at any one time to begin to sense the Red River Basin's complexity. Computers have helped us immensely in understanding how the system works. Computers make possible the translation of complex phenomenon into mathematical models. With a surprising degree of accuracy, such models can forecast the buying habits of Sunday shoppers, predict the sales of cross-country skis under certain snow conditions, or explain how thunderstorms develop.

Models designed and used by the National Weather Service, US Army Corps of Engineers, US Geological Survey, and Manitoba's Hydrologic Forecasting Centre have made their forecasts regarding flood crests, volumes, and other hydrologic factors increasingly timelier and more accurate. Computer models are used to better understand the behavior of ground water ***aquifers.*** They can help us understand and even visualize how the Red River Basin is behaving or likely to behave.

Looking Back to Look Ahead

There was a time when the Red River Basin was very different from what it is today. The area that would one day become the Red River Basin has been covered several times by gigantic inland seas stretching from the Gulf of Mexico into Canada or from the East Coast to the Rocky Mountains. Ocean levels had risen dramatically as a result of melting ice caps, the climate was warm and humid, and the midsection of the country was at the bottom of a sea several hundred feet deep.

Over geologic time, inland seas come and go, glaciers advance and retreat, climates change, land forms are modified, and wind and water continue their relentless struggle to polish the surface of a planet that is constantly being modified by uplifting and subsidence.

Understanding what has happened over a span of millions of years is difficult, if not impossible, for those of us who lack specialized training. But understanding how the land we occupy was shaped and reshaped in more recent times is something we can understand and profit from knowing.

Geologists tell us that sometime between 7,000 and 10,000 years ago, the climate of what was to become the Red River Basin began warming. The Wisconsinan ice sheet had retreated some considerable distance to the north, and the climate was in a state of flux with long periods of arctic-like weather mixed with extended periods of drought and much warmer temperatures. To be sure, more often than not, it was still cold and damp and inhospitable, but the climate was


Michael Michlovic

Maple River survey varves. Varves are thin layers of sediment deposited in still waters. The light layer is usually deposited in summer. In the winter, when sediment input is reduced, a darker layer is formed.

moderating and beginning the slow process of changing into the climate of today. Over the centuries, rising temperatures triggered the growth of untold species of vegetation, some of which can still be found and others which long ago disappeared.

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Whitetail deer are common in the Red River Valley.

As temperatures continued to rise and as flora adapted to the rigors of a climate still harsh by present day standards, various forms of life began moving into the area. In the beginning, wildlife may have used the area like a summer pasture, with even the hardiest retreating during the winter months to the protection of the eastern and southern forests. But eventually, as the harshness of the climate softened, more and more species began making the area their home throughout the year. In doing so, they were setting the stage for the descendants of people who had hunted in the area, probably as much as 10,000 years earlier, to return.

The most recent 20,000 years is but a moment in geologic time, but it may be the most important increment of time in the history of the Red River Basin because it is likely that sometime within that period humans first left footprints somewhere in the basin. For all but the last 200 or so years, the basin's behavioral patterns were dictated mostly by nature, although natives used burning for game management. Since that time, human attempts to deal with the forces of nature have changed the face of the Red River Basin and made it behave in ways that are more predictable, less natural, but still not always totally satisfactory to the human controller.

Some believe there are present day examples of flora and fauna that are also returning to areas they previously inhabited. There is speculation, for example, that some "exotic" (or "***invasive***") species may merely be returning to their former habitats, centuries after being forced out by glaciers (Leitch and Tenamoc 2001).

They Came From the West

It is impossible to know for sure just who the first people in the basin were, but most believe their forefathers were Asians who, 20,000 years ago, crossed the Aleutian ice and land bridge that joined what is now Siberia and Alaska. About 15,000 years ago, tribes began to filter from the north and west into the area east of the Rocky Mountains foraging for food.

Plano hunters first populated the habitable portions of the prairie. Lake Agassiz began to dry up, and the Plano people moved in to inhabit the newly opened territory. We learned of these first people through the discovery of two skeletons, one found in Browns Valley, Minnesota, near the southern tip of Lake Traverse, and the other near the eastern boundary of the Red River Basin near Pelican Rapids, Minnesota (Michlovic 1979).

Evidence suggests these were the Clovis and Folsom people (O'Keefe et al. 1985). They started fires; shaped rudimentary tools from wood, bone, and stone; and used animal hides for clothing. Above all else, they were hunters who drifted with the game. No evidence has been found to suggest that they stayed for long in any one place. Their presence is far better documented in the Pacific Northwest and in the upper portions of the Missouri River Basin, but it seems probable they spent time in the Red River Basin, thus becoming the area's first human residents.

Their migration patterns are largely a matter of speculation, but they likely occupied the area for hundreds of years and then left for periods of hundreds of years. Robinson's *History of North Dakota* (Robinson 1966) suggests that "there was a long, dry interval of two thousand years or more from about 4,000 B.C. to 2,000 B.C." that dried up the lakes and made game scarce. As the climatic pendulum swung in a sweeping, centuries-long cycle from wet to dry to wet again, and as the vegetation changed, these first hunters moved in and out of the area. These first valley residents left scant evidence of their having been here.

Then From the East

About 2,000 years ago, Native Americans from the forests of Minnesota and Wisconsin began moving onto the grasslands of the Red River Basin. Like those who had come into the land before them, they were hunters and foragers whose habits and existence were forged by their need to secure food. It seems likely that the location and character of their camps were determined largely by the availability and movement of game.

The early Native Americans tended to prefer the Red River Valley and the drift prairie to the west to the drier Missouri River country. The Red River and its tributaries provided some protection from the elements, water for drinking, wood for their fires, and habitat that attracted the wildlife they hunted. Odds and ends of forest growing in clumps on elevated, dry patches of ground away from the river were more in keeping with their woodland culture than the drier, treeless prairies to the west.

By 1300 A.D., these early inhabitants were beginning to adopt a stronger sense of place, a stronger sense of permanence and stability. They may have even stayed long enough in some places to plant and harvest gardens of squash and gourds. This is significant, less from the fact that they did it than from the fact that the climate enabled them to do so.

Red River Basin Commission

Red River Basin.

There is no way to be certain how far beyond the borders of the Red River Basin they explored. Surely they must have done so, if only to satisfy their curiosity about what lay beyond. But they did not venture far for long; the Red River Basin was their home territory. One bit of evidence that points to this is the manner in which they handled their dead. These early, semi-permanent inhabitants of the Red River Basin temporarily placed the bodies of their dead in trees and on scaffolds. Later, several skeletons might be buried together with a variety of artifacts in a burial pit. Mounds that could be round, oval, or linear were built over such pits.

The drift prairie in North Dakota marked the western edge of a mound-building cultural area that included the woodlands of Minnesota, Wisconsin, Iowa, and beyond. Mounds have been found in the valleys of the Red, Sheyenne, and James rivers, and near Devils Lake in North Dakota. Their existence in Minnesota and Manitoba, particularly in the eastern, wooded portions, is well-documented.

Boundaries on the Move

Like the weather, tribal movement and jurisdiction were dynamic. Over time, the basin was occupied by a succession of tribes, including the Hidatsa, Crow, Sioux, Cheyenne, Cree, Assiniboin, Yanktonai Dakota, Teton Dakota, and Chippewa (also known as Ojibway) (Robinson 1966). For the most part, the principal homes of these tribes were somewhere else, usually in the wooded, more protected areas of Manitoba and Minnesota, beyond the borders of the Red River Basin.

Unlike the more sedentary Mandan tribe, which had occupied the valley of the Missouri River several hundred years earlier and engaged in a variety of agricultural activities, the early tribes of the Red River Basin remained hunters and foragers. They moved in and out of the area with the shifting winds of climate, food supplies, and conflicts with other tribes. Near the middle of the 18th Century, the principal tribes of the Red River Basin were the Cree, Cheyenne, and Yanktonai Dakota.

The Cree, a large tribe of Algonquian-speaking people, lived in Manitoba between the Red and Saskatchewan Rivers. Their hunting grounds touched only northeastern North Dakota and northwestern Minnesota. Because they were attracted to the bison[1] of the prairie, they eventually evolved into “Plains” and “Woods” bands. The Cheyenne were likewise an Algonquian-speaking people. At least part of the tribe moved from their homes in south-central Minnesota to an area southeast of Lisbon, North Dakota, where the sites of 70 of their former lodges have been found. Difficulty with the Chippewa forced the Cheyenne to move on. In about 1770, the Cheyenne moved to the Black Hills.


Red River Basin Commission

Weather extremes in the basin.

The Yanktonai Dakota resided in the Minnesota woods until about 1700. Driven out by the Chippewa, they left the area around Mille Lacs and migrated to near the Big Sioux River of southwestern Minnesota and eastern South Dakota and to the James and Red River Valleys.

By the middle of the 19th Century, the Red River Basin was shared by the Cree in Manitoba and by the Chippewa and Yanktonai Dakota in Minnesota and North Dakota. It was more a case of a particular tribe having laid claim to certain hunting grounds than having staked out a permanent place to live.

Toward the end of the 1700s, the Arikara (Rees) were coming up the Missouri River from Nebraska. By 1770, their territory reached well into South Dakota, where they bartered corn for bison robes and meat. Even though the eastern tribes had probably begun to grow their own corn late in the 18th Century, they were still primarily hunters when the first European settlers entered the area.

[1] “Bison” is the proper name of the animal more commonly referred to as “buffalo” of the American plains.

Today, the Fort Totten Indian Reservation, on the south shore of Devils Lake in North Dakota, is home to the Spirit Lake Tribe. A small part of the Sisseton Indian Reservation is in extreme southeastern North Dakota. The Sisseton Reservation, most of which is in South Dakota, is home to the Sisseton and Wahpeton bands of the Santee (Eastern) Sioux Tribe.

Two reservations are on the Minnesota side of the Red River. The White Earth Indian Reservation is occupied by the White Earth Band of the Chippewa Tribe. The Red Lake Indian Reservation, occupied by the Red Lake Band of the Chippewa Tribe, is in extreme northeast-central Minnesota in the headwaters area of the Red Lake watershed.

There are two First Nation reserves in the Manitoba portion of the basin, both occupied by members of the Ojibway Tribe. The Roseau River Reserve, a few miles north of Emerson, is occupied by the Roseau River Anishinaabe First Nation. The Swan Lake Reserve, adjacent to Swan Lake on the Pembina River, is occupied by the Swan Lake Band First Nation.

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A hawk keeps watch from a hay bale.

Precious Little Sign

Primordial inhabitants used the basin's resources in ways much different than they are being used today. They were first and foremost hunters and foragers for food. They were almost constantly in motion, and as a result, their impacts are barely discernible. Traces can be found which document their presence here, but they left the land essentially unblemished.

It is equally important to note that while the Red River Basin system was intact until European settlers began arriving in large numbers and introducing changed cultural practices, the basin was not perfect to a human observer. There were times in the years preceding settlement when the waters of the Red River were contaminated by decaying carcasses of bison that had broken through the ice and drowned. At other times, ravaging floods scoured the land, uprooting trees and killing wildlife. Some of the area's greatest floods, both in terms of volumes and peaks, occurred long before we began keeping detailed records of such things, long before we began to change the face of the land. Droughts and wildfires also occurred.

Besides the changes brought about by humans, the kinds of changes that are occurring today in the Red River and the basin it drains—changes caused by the forces of nature, including climate—were occurring in the pre-settlement period, probably on a scale surpassing today's. The Red River Basin was an area moving toward, but never reaching, an elusive natural equilibrium. The river was ever so slowly cutting to grade, and the area was gradually turning from a semi-swamp into a plain covered with grasses more than six feet tall that stretched to the horizon and beyond.

The Winds of Change

Earliest European settlement in the basin occurred in Canada. Their experiments with agriculture probably involved planting small vegetable gardens and growing feed for animals. Because they lacked seeds capable of producing plants which could mature and produce during a relatively short growing season, their early efforts produced mixed results. At the same time, these early Scottish settlers must have caught a glimpse of the soil's fertility and its productive potential.

They were a stubborn and hardy lot, having come too far to be turned aside by the elements or the natives and fur trappers who saw themselves as having bought the land with their own courage, toil, and sweat, and their own brand of perseverance. The stage was set for settlement and the beginning of what the Red River Basin is today.

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Chapter 2
The Red River: A System in Transition

Introduction

The Red River Basin is a complex hydrologic system. Its behavior is influenced by natural forces and by human activities. Our ability to alter nature to suit our needs is, of course, limited. We do tamper with the weather, however, and we are fairly successful in suppressing hail, for example. Climatological data and reduced insurance rates support that claim. We can even increase the amount of rain falling from a given cloud formation provided certain conditions exist. Yet, we cannot make it rain all of the time even when the right cloud formations are present, and we can never make it rain when they are not. We have not been able to dictate the last day of frost in the spring or the first killing frost of fall. The wind blows when it wants and in the direction it chooses.

We can track weather systems with sophisticated radar technology, and we can watch those systems move across our television screens during the news, but we cannot shift them around. If nature dictates it is to snow in Detroit Lakes, Minnesota, it will snow in Detroit Lakes. If the streets of Emerson, Manitoba, are to be covered with sleet on the 16th of November, they will be covered. In short, we can do little to influence the weather and other natural phenomena occurring around us, although some scientists contend that we are undertaking a grand, global experiment by adding gases to the atmosphere.

The small bands of hunters who came into the Red River Basin some 10,000 years ago looking for game already knew what we have come to know: that the forces at work in nature were beyond their control, and that they could do nothing to change them. But they also knew—though they may never have discussed it—that it was possible to soften the impact of nature on their lives. In short, they learned to adapt. The animal skins they wore to protect themselves against cold and the shelters they built to keep dry were practical responses to their most fundamental needs, but they were symbols of their having adapted, as well. They adapted as a need presented itself, and we have been doing the same thing ever since.

Coping with the forces of nature at work in the Red River Basin has always been a matter of adapting, and to adapt, one must change.

Those early hunters adapted in subtle ways and only slowly. Their needs were simple, and they asked little of the land. Success for them was a bountiful hunt and a warm fire. Their skills in crafting tools, pottery, and clothing improved with both practice and man's instinctive need to make things better. The rate at which change took place for them was slow. They built no bridges to cross rivers or streams. They waded across when needed, swam when they had to, waited until high water subsided, or went elsewhere. Their trails through the tall grasses were game trails, worn smooth by centuries of use. They constructed no roads, no culverts, no permanent homes. They adapted and they changed, but in doing so, they left the land unblemished.

Substantial change of a kind that can be seen, even measured, began only after the arrival of the first European settlers and the "opening up" of the land with the plow. They practiced their own unique brand of adaptation and took the first uncertain steps toward making the basin what it is today. The history of settlement in the Red River Basin is a history of adaptation and change.

Coming Into the Land

French fur traders were likely the first Europeans to plant vegetable gardens adjacent to the Red River or its tributaries. Before 1800, they grew small plots of barley and oats at the mouth of the Winnipeg River. Between 1800 and 1808, Alexander Henry produced large crops of root vegetables, squash, cucumbers, melons, and cabbage at Pembina. Henry's men also kept chickens and put up large amounts of hay. In 1811, these activities influenced Hudson's Bay Company to accept a proposal by Thomas Douglas, the Earl of Selkirk, to bring permanent farm settlers to the heart of North America (Coues 1897).

The first permanent settlement by Europeans in the Red River Basin was at the ***confluence*** of the Assiniboine and Red Rivers in what is now Manitoba. In 1811, Lord Selkirk purchased a large tract of land from Hudson's Bay Company (Figure 2-1), which spanned parts of what are now North Dakota, South Dakota, Minnesota, Saskatchewan, and Manitoba, and encompassed thousands of square miles. However, in light of the United States' claim of jurisdiction to the 49th degree of North Latitude, the "Selkirk Grant" was effectively limited to the Canadian portion of the original grant (Ross 1972).

Figure 2-1
Original Selkirk Grant
Source: NDSWC 2012

Lord Selkirk selected an area which ran north and south approximately 100 miles from Pembina (located in today's North Dakota) to Lake Winnipeg (Figure 2-2). In 1812, several Scottish families emigrated to the area (Robinson 1966). Known as the "First Brigade," since they were the vanguard of others to come, they settled at the Selkirk Colony site near what is now Winnipeg, Manitoba. Accustomed to a difficult life in the hills of Scotland, these hardy people were always receptive to an opportunity that might improve their lot.

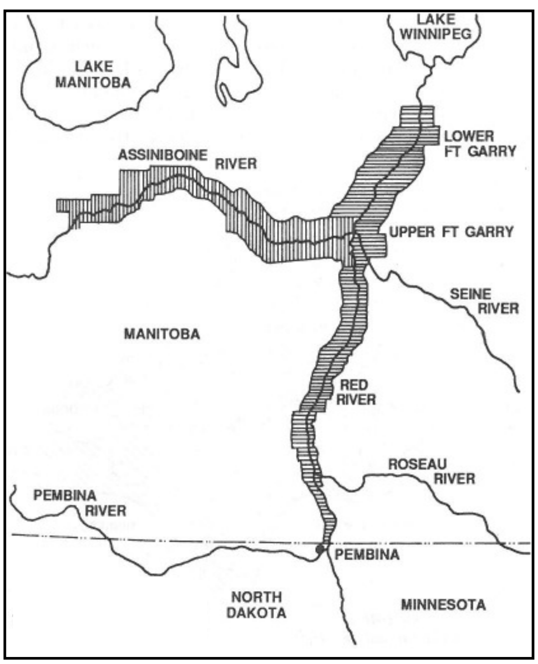


Figure 2-2
Selkirk Settlements
1812-1870

These Scottish settlers were the first permanent settlers to plow the fertile soils of the Red River Valley. In fact, they introduced fall plowing shortly after their arrival for improved yield and more efficient use of the short growing season. They were the first to notice fall-plowed land was more susceptible to wind erosion than land where the stubble remained. They built the first known man-made dam in the Red River Basin (Ross 1972).

The First Brigade's spirit of adventure and enterprise was challenged by the North-West Company, which waged a continuing battle with Hudson's Bay Company for trapping and trading rights. As a consequence, settlers sought refuge at Pembina, and spent their first winter there.

In May 1813, they returned to the original colony and planted their first crop. "A small supply of seed wheat, procured from Fort Alexander, an Indian trading post on the Winnipeg River, turned out exceedingly well" (Ross 1972). But success in building a colony capable of sustaining itself was not easy. Wolves, which had once preyed on the young, old, and weak of the local bison herds, now posed grave danger to the colonists since the bison had moved south, but not all of the wolves had gone with them. Bird depredation virtually wiped out their second crop. Colonists spent several winters hunting out of Pembina. The availability of bison meat made it possible for them to conserve what little grain they harvested for seed rather than grind it into flour (Ross 1972).

Caught in the middle of the North-West/Hudson's Bay feud, several members of the colony were killed, and many fled again to Pembina. But by the spring of 1818, most had returned to the settlement to plant a crop. "The industry of the settlers was amply rewarded by the results at harvest time; forty-fold was a common return, and in one case, for a bushel of barley sown, fifty-six were reaped; and for a bushel of seed potatoes, 145 bushels" (Ross 1972).

The 1818 harvest must have lifted the spirits of the colonists and confirmed Lord Selkirk's belief that Red River Basin soils were extremely fertile. Still, nothing was to come easily. Grasshoppers destroyed crops the following year. Many of the settlers escaped to Pembina and to what they thought to be the less demanding life of the hunter.

By June 1820, many of them had arrived back in the colony. Two-hundred-fifty bushels of wheat were seeded, and the entire harvest was saved for seed (Ross 1972). A period of relative calm for the colonists seemed to begin at about this time. Crop harvests were generally excellent, and problems with the North-West Company disappeared as a result of its 1821 merger with Hudson's Bay Company. A scheme to manufacture bison wool clothing and tanned hides proved disastrous, but the colony was beginning to acquire a certain look of maturity and permanence.

The winter of 1825-26 was difficult; 33 lives were lost in a snowstorm. In spring 1826, as if to pile adversity upon adversity, settlers were introduced to the first major flooding on the Red River since their arrival. On May 2, the water rose nine feet in 24 hours, and by May 5, all settlers had abandoned their river dwellings to seek higher ground. The river continued its rise for 19 days. It was not until the middle of June that settlers were back in their homes (Ross 1972). One person drowned, and settlers caught a glimpse of what the Red River continues to do to this day when its banks are overtopped by the spring melt.

Alexander Ross, a member of the colony, describes conditions as they existed in the months and weeks before the flood:

> The previous year had been unusually wet; the country was thoroughly saturated; the lakes, swamps, and rivers, at the fall of the year, were full of water; and a large quantity of snow had fallen in the preceding winter. Then came a late spring, with a sudden burst of warm weather, and a south wind blowing for several days in succession; the snow melted at once, and Red Lake, Otter-tail [sic] Lake, as well as Lake Travers [sic], all overflowed their banks. To these causes must be added the large quantities of ice carried down by the Red River, which came suddenly in contact with the solid ice of Lake Winnipeg [sic]; and thus stopping the current, seemed to have caused the great overflow of back water on the level surface of the plains; this opinion is strengthened by the facts, that as soon as the ice of the lake gave way, the water began to fall, and it fell as rapidly as it rose (Ross 1972).

Without knowing it, Ross was describing conditions similar to those triggering many modern day spring floods throughout the basin. At the time, there were reports that a flood in 1776 had reached even higher elevations, and local Indians claimed floods equal to the 1826 flood had occurred in 1790 and 1809 (Robinson 1966). If, indeed, there is any validity to such claims, it is worth noting that the Red River of the North has a history of flooding and that many of the basin's record floods are known to have occurred before man began to change the face of the land with roads, drainage ditches, and cities.

Upper Basin Settlement

As far as permanent settlement is concerned, no major extension of the Selkirk Settlement across the boundary into the American portion of the Red River Basin ever occurred. Permanent settlement in the Minnesota and North Dakota portions of the basin was more the result of the area's serving as a transportation corridor between the Selkirk Settlement and St. Paul (Minnesota) than its proximity to the settlement. Minnesota's upper Mississippi region was settled prior to the upper Red River Basin. Pembina became an important source of trade goods and a major link in the transportation network which developed between St. Paul and the lower Red River Basin.

While the Red River of the North is the longest north-flowing river in the United States, it is not the only north-flowing river. There are at least 20 others in North America (such as the MacKenzie and Athabasca rivers in northwest Canada) and many on other continents including the world's longest river, the Nile, that flow north.

Because the Red River flows north, we sometimes get confused between the "upper" and "lower" basins. The upper basin is where the river starts, in the south for the Red River. The lower basin is downstream, in the north for the Red River.

The Pembina Connection

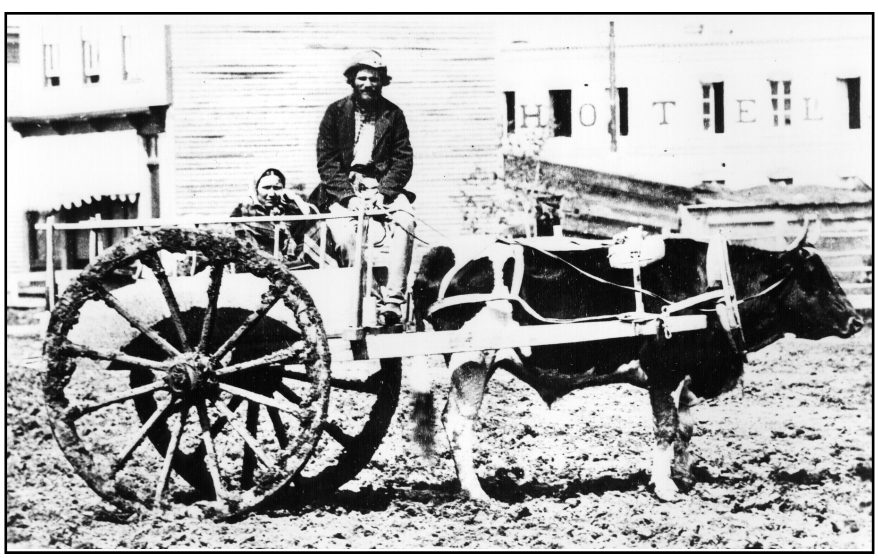
Pembina and the ***Métis*** population living there also played an important role in shaping early settlement patterns in the upper portion of the basin. In 1823, when the exact location of the international boundary was established, about 350 people, mostly hunters, were living in Pembina (Robinson 1966). All but one of the 60 cabins were south of the border. But the population was not stable. In fact, in 1836, only 13 years later, no one was living there. Representatives of the Earl of Selkirk and Hudson's Bay Company had concluded that dividing settlers between Fort Douglas (located near the original colony) and Pembina weakened the colony and that all settlers should be moved to Fort Douglas (Robinson 1966).

The attraction to Pembina for the Métis and others was strong. To the south and west ranged the herds of bison that provided both meat and hides, the primary basis for Métis trading activities. Moreover, many of them farmed small acreages fronting on the rivers, thus adding to their trade goods. Most were squatters who never bothered to establish legal claims to the land.

As a general rule, hunters kept about half of what they killed, selling what meat they did not need to settlers and their surplus hides to the fur companies. They hauled some to the Selkirk Settlement or to St. Paul (Robinson 1966). Bison hunting by the Métis of Pembina tied central and eastern North Dakota to the Selkirk Settlement. But more importantly, it provided the hides that constituted the chief commodity to be carried to the growing fur market on the Upper Mississippi.

Along both sides of the Red River were trails over which the products of the Northern Plains were carried to the Selkirk Settlement, St. Paul, or points in between. The mode of transportation was the Red River cart.

The Métis built the carts entirely of wood, sim-



Historical and Cultural Society of Clay County

A Red River cart.

ply and inexpensively. They used two large wheels, wrapping them with buffalo rawhide instead of iron tires. Such wheels would not sink into marshy ground as readily as ordinary ones. The boxlike body of the cart, resting on the wooden axle, rode high, making fording streams easier. A single ox (or horse or mule) could pull a cart with a load of eight or nine hundred pounds. One Métis usually drove from two to six carts. Except for the ox pulling the first cart, each oxen would be tied by a strap about its horns to the rear of the cart ahead.

Though crudely made and noisy because of the wheels screeching on the wooden axles, the carts provided effective transportation. They were a means of conquering distance, of overcoming the remoteness of Red River country. They and the level, treeless plain made it possible to carry freight to St. Paul and the immediate area for a fraction of the cost of transporting an equivalent amount by water to Hudson Bay (Robinson 1966).

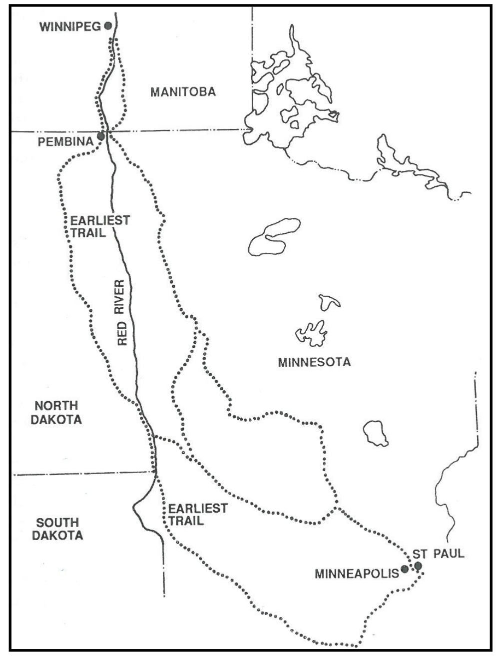


Figure 2-3
Red River Cart Trails

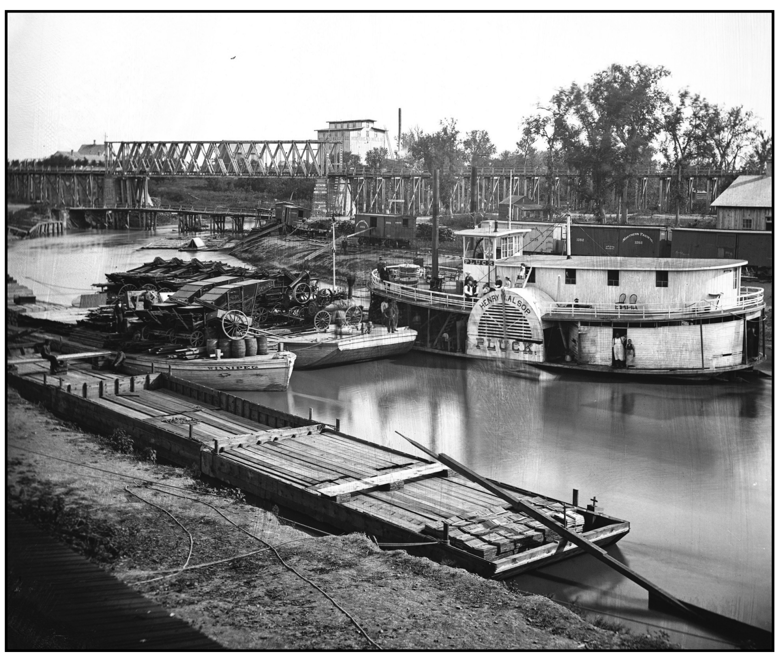
The earliest trail led south along the Red River from Pembina to Lake Traverse and followed the Minnesota River southeastward (Figure 2-3). Other trails were used as well, but the trail that had branches on both sides of the Red River for its entire length was probably the most important in terms of influencing settlement in the upper basin. By 1850, hundreds of carts were making the trip each year.

The Steamboat Era

The era during which the Red River carts creaked along the Red River Valley trails was short-lived. By the end of the 1850s, the fur trade was dying, and a new kind of trade was emerging. Groceries, such as coffee, tea, and sugar, became increasingly more important trade items, and the share of trade devoted to furs diminished. The fur industry was the victim of reduced demand. The Red River cart industry was the victim of its own plodding pace.

During the winter of 1857-1858, Sir George Simpson, then governor of Hudson's Bay Company, signaled the beginning of the end for Red River cart traders when he made arrangements to bring English imports to the Selkirk Settlement by way of St. Paul (Robinson 1966). His decision to move imports through St. Paul rather than through Hudson Bay was undoubtedly prompted by cost. It was cheaper to bring goods through St. Paul, and he wanted to reduce those costs even more (Robinson 1966).

Anxious to supply the Selkirk Colony with trade goods, several St. Paul entrepreneurs set out to determine the navigability of the Red River. Having done so, they offered a reward to the first person who floated a steamboat on the river.



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The steamboat Pluck in 1880 tied up to the Fargo side of the river, several barges loaded with farm machinery, and flatboats laden with lumber and wooden shingles.

The *Anson Northrup*, named after its owner, was on the river in 1859. It was the only steamer moving trade goods on its north-south route between 1859 and 1871. Four additional boats were built between 1871 and 1874, all by a group which counted among its members future railroad magnate, James J. Hill. Two additional boats, the *Manitoba* and the *Minnesota,* were constructed in 1875 by a group of Winnipeg, St. Paul, and Moorhead merchants who resented the monopoly enjoyed by the Hill group (Murray 1967).

Steamboating on the Red River lasted 53 years. At its height, it was a bustling, vibrant business, with steamboats carrying a variety of trade goods on the Red River between the Selkirk Colony and Georgetown (Minnesota), the head of navigation. "In April, 1875," for example, "a reporter counted five steamboats, six barges and eleven flatboats at the Moorhead levee." The last Red River steamboat, the *Fram,* sank at Grand Forks in 1912 (Robinson 1966).

The Railroads

Red River carts and steamboats played important roles in the settlement of the upper Red River watershed. It was the advent of the railroad, however, that really opened the basin to settlement (Murray 1967). By 1878, lines had been built from Duluth to Moorhead, Minnesota, and from St. Paul to Winnipeg (Figure 2-4). The two principal developers were the St. Paul and Pacific Railroad and the Northern Pacific Railroad companies. The financial panic of 1873 dealt a devastating blow to both companies. As a consequence, Northern Pacific sold its controlling interest in the St. Paul and Pacific Railroad, which went bankrupt. James J. Hill was there to pick up the pieces and, with the help of associates in Manitoba, completed gaps in the system and "provided the first rail service between the lower valley and the outside world" (Murray 1967).

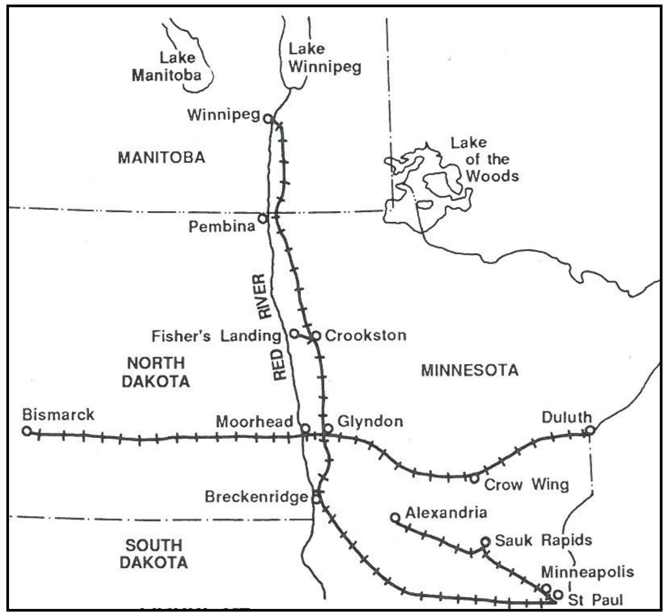

Figure 2-4
Railroads in the Red River Area
1869-1878

Settlers and Speculators

As well as providing the vital trade link between the lower valley and St. Paul, railroad companies devoted substantial dollars to promote the Red River Valley and adjacent areas. Their promotions and advertising stimulated interest of boom proportions (Hudson 1985). "Some of the railroads had land to sell, and all of them needed to build up traffic. Both the Manitoba and the Northern Pacific had land grants in Minnesota, and the Northern Pacific had been given nearly a fourth of North Dakota. They offered their lands on easy terms and sought in every way to develop the new country" (Robinson 1966).

Both lines made it relatively easy for farmers to own land. They sold their holdings at an average of $5.00 to $6.00 per acre (Taylor 1873), gave discounts on cash purchases, provided credit where needed, and even granted rebates on the purchase price to those farmers who improved their land soon after they occupied it (Peterson 1927).

Settlers who came to North Dakota and Minnesota could also acquire land by purchasing it from the federal government or by meeting the requirements of the *Homestead* or *Timber Culture Acts*. In the case of the *Homestead Act*, a settler acquired title to 160 acres of land after meeting certain residence requirements and after paying total fees of $18. Under terms of the *Timber Culture Act*, a settler could acquire 160 acres of land by planting 10 acres of it to trees. After eight years, he could acquire title if 675 living trees were found on each of the 10 acres (Robinson 1966). Canada's *Dominion Land Act* of 1872 contained provisions for acquiring 160 acres of "Dominion/Crown Lands" for a small fee after three years of residency.

Not all of those who acquired land stayed. Some were speculators who purchased land, hoping it would increase rapidly in value as the number of settlers continued to increase. Others qualified under the *Homestead* or *Timber Culture Acts*, but then left the area.

During the so-called boom years (1870-1878) in Minnesota and North Dakota, changes were occurring in Manitoba as well. Farms were no longer restricted to the river lots of the Selkirk era. Settlers could be found throughout the upper and lower valley. "The Norwegian homesteaders…chose land along the tributaries of the Red River; and they, like the Ontario settlers in Manitoba, did not hesitate to take land at a distance from supply centers" (Murray 1967).

The boom years of settlement ended in a series of bust years because of crop overproduction on both sides of the border. "With homesteaders steadily breaking more land, acquiring new machinery, and increasing production, the needs of the Manitoba area were not sufficient to absorb a normal crop in the lower valley." Good growing conditions created an unmarketable surplus in 1877 (Murray 1967) and even though wheat was shipped from Winnipeg by steamer, conditions did not improve. Similar poor market conditions existed south of the border.

The names Dalrymple, Dunlop, Grandin, Harbaugh, Lockhart, Childs, and Woodward are a few of those associated with the renowned Red River Valley ***bonanza farms*** (Briggs 1932). Bonanza farms, with thousands, sometimes tens of thousands of acres under the plow (Drache 1964), are looked back upon wistfully as a kind of romantic interlude in the settlement of the Red River Basin. They were that, of course, but viewed from a broader perspective, they were much more. Bonanza farms on both sides of the river continued to demonstrate that agriculture could be successful in the Red River Valley at a time when depressed prices and the elements of nature were seriously challenging that belief.

Red River Basin Commission

An abandoned farmstead in the Red River Valley.

Changing Times

By 1885, farmers on both sides of the international border had transformed substantial acreage in the valley into productive farms, but much land still remained untouched. In the Manitoba area, 740,000 acres in the ***Rural Municipalities*** of Diberville, Marquette, and Dufferin were incorporated into farms in 1890, but only 121,054 acres or approximately 16 percent of this occupied area was in crop. The Rural Municipalities of Morris, Portage la Prairie, and Selkirk were no further advanced, where only 92,844 acres out of a total of 1,355,172 acres were being tilled. Only 56 percent of the farmland in Wilkin, Clay, and Norman counties in Minnesota was in crop; the percentage was even lower in Polk, Marshall, and Kittson counties (Murray

1967). In North Dakota, 80 percent of the land in farms was being cropped, but substantial portions were not yet parts of farms.

Land Drainage

Speculators undoubtedly kept some areas out of production, but "the major reason for undeveloped land was the lack of adequate drainage in the valley" (Ellis 1939). Several large, permanent marshes were present in the basin. "Other sections of the Red River lowland were not continuously wet, but during years of heavy snowfall or more than average rain, they, too, were unfit for cultivation" (Ellis 1939). "The extent of drainage problems varied from year to year, but from the beginning Red River farmers were handicapped by wet land" (Murray 1967).

Early efforts to remedy the wetness problem were taken by the St. Paul, Minneapolis, and Manitoba Railroad when it began constructing 15 drainage ditches to carry floodwater away from the railroad embankment. Its success encouraged, among others, Donaldson, Harbaugh, and Lockhart (bonanza farmers) to start similar projects on their lands (Palmer 1915). Recognizing the need for drainage work, Minnesota passed a comprehensive bill to deal with the problem in 1883. It allowed farmers to petition for drainage projects, made available a hearing and appeals process, provided a means of assessing cost, and developed procedures for drain maintenance (Palmer 1915). The Minnesota law was expanded in 1887, and a similar law was enacted in North Dakota in 1893.

Red River Basin Commission

A field drainage ditch.

In Manitoba, an 1879 provincial drainage act provided for a survey of wet areas, creation of drainage districts, and construction of drainage ditches by rural municipalities. "By 1881 approximately 200 miles of ditches had been excavated at a cost of nearly $100,000" (Minister of Public Works 1882).

Several aspects of drainage are worth noting:

- The manner in which the Red River Valley is farmed today is a direct result of the drainage works that were installed over the years;
- Without drainage, substantial sections of the valley would be too wet to farm;
- Farmland which is now wet on only an intermittent basis would be subject to longer and more frequent wet conditions if existing drainage features were removed; and
- Drainage continues today.

The first land drainage was accomplished by "eyeballing" ditches with, at best, rudimentary equipment. Then came better equipment and surveying tools to more efficiently drain water from the land's surface. Next were larger equipment, land planes, and lasers to do even more efficient and more precise surface drainage. Until the early 21st Century, nearly all drainage in the Red River Basin was to remove surface waters. However, in recent years, with higher land values, higher commodity prices, and improved technology, subsurface tile drainage has moved into the basin, facilitated by the latest in GPS and precision farming technology (Leitch and Randall 2011).

Crops.

Problems of Another Kind

Although the lack of adequate drainage ditches kept substantial portions of the valley out of cultivation, other obstacles slowed development as well. The reliance on wheat as the area's major crop was one. Failure of production costs to decrease correspondingly with the declining price of wheat was another. Weed infestation depleted soil moisture and reduced both quality and yields. "Wild mustard was prevalent in the valley as early as 1882, and within another three years wild buckwheat, lambs quarter, cockle, wild oats, French weed, and wild sunflowers appeared" (Murray 1967).

Still, the most important reason for the difficulties and shortcomings of agriculture in the valley was the resistance of farmers to crop diversification. Diversification has since taken place on a scale difficult for early settlers to envision, but it did not happen overnight. Reasons for resisting diversification were many, including:

- Good to excellent yields of wheat and other small grains were common;
- Producing wheat did not require specialized, expensive machinery;
- Farmers had acquired a certain level of expertise in growing a single crop;
- Most farmers lacked knowledge about raising livestock so far north;
- Farmers often lacked knowledge about alternative crops and farm enterprises;
- Almost no good quality cattle were available in the area; and
- Many farmers believed that the cost of housing and feeding better quality cattle was too high.

Most of the obstacles to farm enterprise diversification have been removed. Knowledge made available from government and universities about crop or livestock alternatives and new and improved farming techniques played a role in breaking down farmer resistance. Broader credit sources, improved terms, and breakthroughs in agricultural technology assisted as well. The overriding force was a recognition by farmers that it made good sense to move away from a single-crop type of agricultural economy characterized by periods of boom followed by periods of "bust."

Looking Ahead

The process of diversification continues today as markets, government regulation, and changing needs wield growing influence over farming practices and profit margins. The hunters of 10,000 years ago adapted in subtle ways to meet a set of simple needs. Somewhat more complicated were the steps taken by Selkirk colonists to adjust to their new environment. New challenges not dreamed of by the earliest settlers faced the homesteaders who came into the country a half century later. Like their predecessors, valley residents of today must continue to adapt if the maturing process is to continue and if they are to succeed in maintaining the quality of life they now enjoy.

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Chapter 3

Soil and Water Resources

Introduction

A river basin occupies an area that may have its own climate, geography, economy, and other characteristics that make it unique. Residents may view the basin from different perspectives based on their personal value systems, but it can be described objectively in terms of geography and natural and physical resources.

Land Forms

Three distinct land forms—drift prairie, flat plains, and hills—are found in the Red River Basin (Figure 3-1). Each is the result of glacial activity about 10,000 years ago when ice hundreds of feet thick scoured the landscape and meltwater runoff carried soil and boulders to new locations.

The drift prairie consists of rolling plains broken by low ridges of hills and shallow coulees. "Surface water is distributed among shallow pothole lakes, a few ***meandering streams*** and rivers, man-made impoundments, and small marshes" (SRRRBC 1972). Vegetation consists of both short and medium height grasses in intermittent, small patches and groves of deciduous trees along streams.

Red River Basin Commission

Broad, flat plains in the northern area of the Red River Basin.

The broad flat plains are the terrain left behind by glacial Lake Agassiz. They have a few meandering streams and rivers. Natural drainage is poor due to extremely flat land surface. Tall grasses, together with deciduous trees along the streams, are found in the better drained portions. Poorly drained portions have sparse and scattered areas of boreal forest growing out of and interspersed with peat bogs.

Red River Basin Commission

Drift prairie in the Devils Lake portion of the Red River Basin.

Plateaus with broad, smooth tops and steep-sided knobs with small tops characterize the hills portion. Surface water is found in deep water lakes, meandering streams and rivers, and marshes. Mixed hardwood and coniferous trees are characteristic of these areas.

Some Definitions

The water resources of a river basin are usually described in terms of surface water and ground water. ***Surface water*** is found in lakes, potholes, rivers, and streams. ***Ground water*** is found below the ground's surface in ***zones of saturation*** where all the pores of a material are filled with water under pressure greater than atmospheric pressure. The top of such a zone is the ***water table***.

Atmospheric water can be found in the form of solids, liquids, and gases, and is the source of both surface water and ground water. Not all of the atmospheric water that precipitates upon a basin's land, however, becomes a part of either the surface or ground-water resource in the sense that it can be measured. ***Vadose water*** is water occurring in the ***zone of aeration*** between the land surface and the water table.

Some familiarity with the basin's land forms, climate, and ***hydrology*** is important to understand the relationship of atmospheric, surface, and ground water. Climate is the dominant natural factor in determining water availability in the basin.

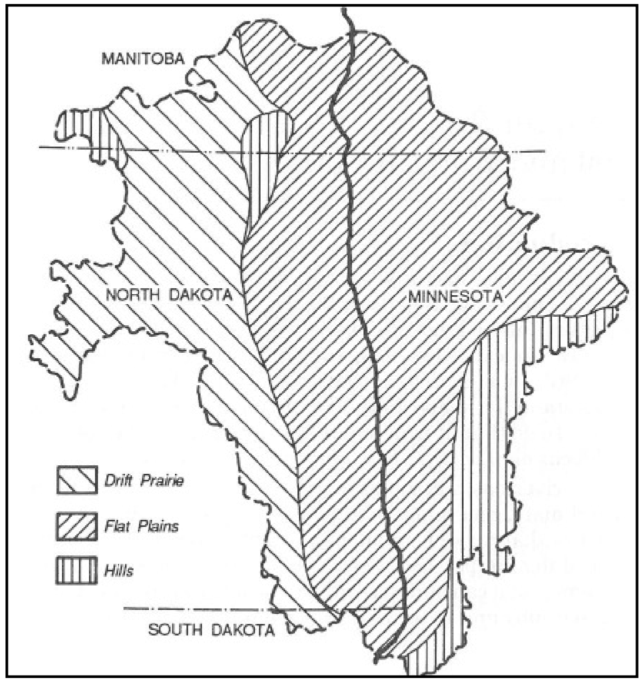


Figure 3-1
Land Forms in the Red River Basin
SOURCE: SRRBC 1972, Water Resources Branch, Manitoba Department of Natural Resources 1990, and NDSWC 1990.

Climate

The Red River Basin has a semi-arid to humid continental climate. Moderately warm summers, cold winters, and rapid, sometimes drastic, changes in daily weather patterns are characteristic of the region. Marked fluctuations in weather are common as the result of passing weather fronts and shifting high and low pressure systems. Temperatures have ranged from a maximum of 118° Fahrenheit (F) in August, to minimums of -55°F in January and February. The annual mean temperature is about 40°F. Temperatures of 85°F to 95°F are common in summer, with temperatures dropping to -40°F in winter. Such weather extremes are typical of mid-continental climate.

About three-fourths of the basin's precipitation occurs as rainfall during April through September, and almost two-thirds comes during May, June, and July. Most summertime precipitation comes from thunderstorms. November through February are the driest months, with precipitation averaging about one inch per month.

The Hydrologic Cycle

The ongoing circulation of water in the earth's atmosphere, on the earth's surface, and beneath the earth's surface is called the ***hydrologic cycle***. Water circulates from the land surface and the oceans to the atmosphere by ***evapotranspiration*** (ET) and comes back to earth as precipitation (Figure 3-2). In the Red River Basin, some of the evaporated moisture is derived from rivers, lakes, and potholes and from the transpiration of plants growing in and outside of the basin. This water precipitates on to the soil and water bodies of the basin.

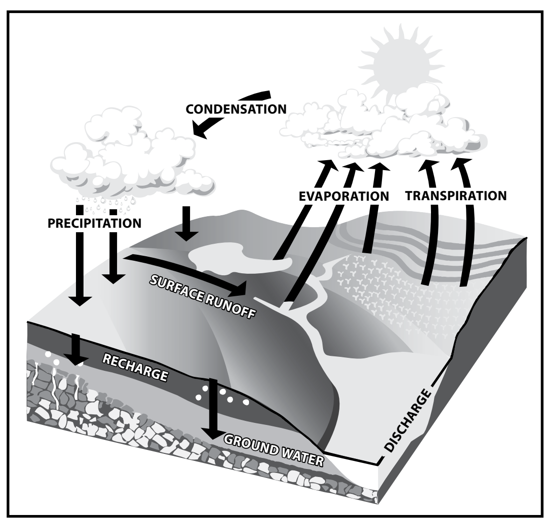


Figure 3-2
The Hydrologic Cycle
SOURCE: NDSWC 2011.

The rate of evapotranspiration depends on ***ambient temperature,*** wind, vegetation density, and availability of water. ET can be relatively high on the surface of a small lake on a warm, windy day. The annual ET for Devils Lake, North Dakota, is as much as 35 inches. In other words, the lake level is reduced by up to 35 inches through evapotranspiration during the year.

As water is moved around the earth, across the earth's surface, or through soil and bedrock, each new set of conditions in which the water is found generally represents a new set of circumstances in which the water must reach a new equilibrium. The new equilibrium can involve changes in both water quantity and water quality. This process can be very slow to very fast, depending on conditions (Ripley 1988). Water can take one or all of three routes as it falls to earth. Some of it evaporates before it reaches the earth's surface, some will run across the surface as runoff, and some will infiltrate into the earth's surface (Figure 3-3).

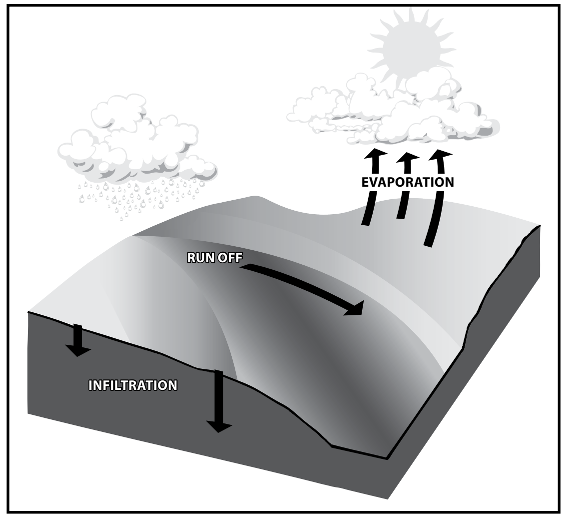


Figure 3-3
Routes Precipitation Can Take
SOURCE: NDSWC 2011.

Water can take any number of alternate paths driven by gravity or evapotranspiration, but ultimately, it returns to the atmosphere, remains on the surface of the ground, or enters the ground. Moisture can, for example, be captured by the leaves of a tree and later be transpired back to the atmosphere. Another example is rain falling directly upon a river or a lake, bypassing the runoff pathway but ending up as water on the surface of the earth.

Precipitation

Prior to the current wet cycle, the basin's average annual precipitation ranged from about 17 inches per year in the west to about 24 inches in the southeast (Figure 3-4). The overall average for the basin was 20.5 inches, equivalent to 51.3 million ***acre-feet*** (maf) over the approximately 45,000 square miles of the basin. Precipitation during the wet cycle that began in 1993 has averaged up to almost 6 inches more per year.

In any year, for any part of the basin, precipitation can vary from as little as 8 inches or less during drought years to 36 inches or more during some of the wettest years. Some parts of the basin receive abundant moisture in the same year other parts experience drought.

Other parts of the hydrologic cycle can be profoundly impacted by the timing and magnitude of precipitation events. Evaporation and transpiration are increased by

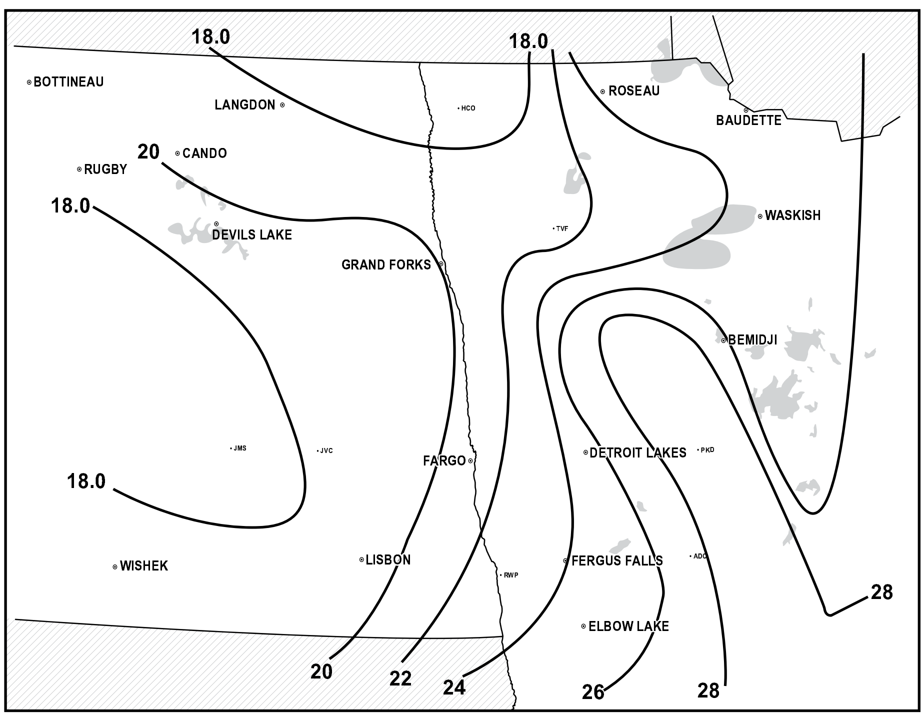


Figure 3-4
Average Annual Precipitation (inches)
SOURCE: NDSWC 2012.

large amounts of rainfall spread out evenly over a summer. Large quantities of snow coupled with a slow spring thaw will result in substantial ***recharge*** to the soil zone and aquifers.

The topic of wet and dry cycles is receiving a lot of attention in the basin. There are many theories about how long the cycles might be, but the important point is that sometimes it stays wetter than average for a number of years and sometimes it is drier than normal for a number of years. A wetter-than-average cycle began in the basin in 1993 and continued through the present. This wet cycle resulted in widespread, saturated soil conditions and most of the natural storage basins (i.e., lakes, ***wetlands***, depressional areas) overtopping their banks. This current wet cycle is a large part of the cause of the floods of the past 20 years.

Surface Water Runoff

Water can travel several routes after falling to the earth's surface. The main routes of runoff and surface water are (1) downhill toward generally larger bodies of water, (2) upward into the atmosphere (evapotranspiration), or (3) down through the surface (***infiltration***) (Figure 3-5). Where poor or non-integrated drainage exists, the movement to ever larger bodies does not occur or, at best, not fully or readily.

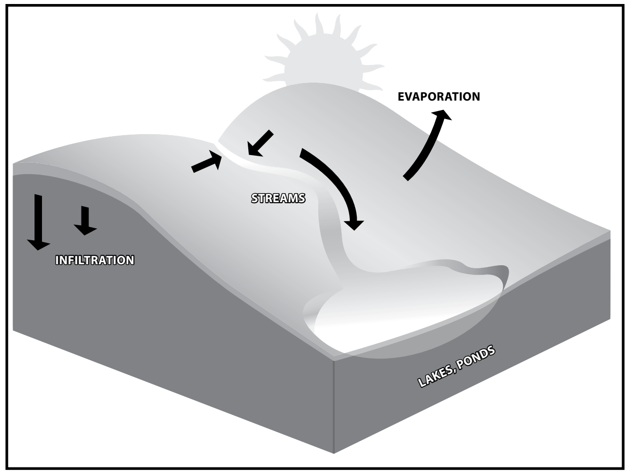
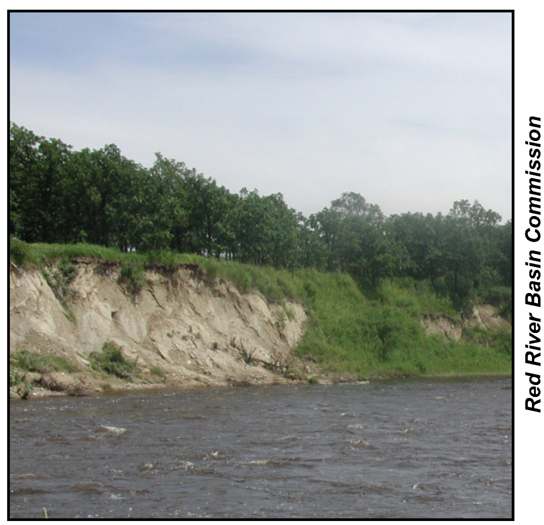


Figure 3-5
Routes Runoff Can Take
SOURCE: NDSWC 2011.

At some locations the flow is almost always downward, at others it is always upward, and at still others the flow may reverse directions at seasonal, annual, or multi-year periods. There are also surface water bodies that receive water from the subsurface (***discharge***) in one portion of the surface water body and contribute water back to the subsurface (recharge through infiltration) in another part of the same body of water (Ripley 1988).

Rivers and Streams

Rivers and their tributaries are one of the main features of the basin's runoff system. As a consequence of mid-continent climatic variability, the surface water resources of the Red River Basin are highly variable. Flows range from virtually no flow, such as happened during the 1930s and as recently as 1988, to well over 100,000 cfs during spring floods.



Excess runoff can lead to bank erosion.

In its simplest form, discharge means the outflow of water. Use of this term is not restricted as to course or location, and it can be used to describe the flow of water under a bridge, from a pipe, or from a drainage basin. Discharge from a pipe is usually calculated in gallons per minute (gpm). Discharge or streamflow from a drainage basin is measured in cfs and acre-feet (af). One cfs is equal to the discharge in a stream cross-section one foot wide and one foot deep, flowing with an average velocity of one foot per second. The amount of water flowing through such a cross-section is 60 cubic feet (448.8 gallons) per minute. An af is the quantity (volume) of water that would cover one acre (43,560 square feet) to a depth of one foot.

A network of ***gaging stations*** exists in subbasins throughout the basin to measure discharges and to collect hydrologic data. Several types of equipment are used to take measurements. Gages can be long term, short term, permanent, temporary, high flow, low flow, or continuous. Measurements are taken on a continuous, daily, weekly, monthly, or occasional basis, and the type of information measured varies from station to station. Some collect only hydrologic data, while others may measure temperature, sediment transport, specific conductance, or a host of chemical constituents. The gaging station network is maintained through federal, state, provincial, and local cooperation. In 2011, there were approximately 150 gages being operated for a variety of purposes in the basin (Figure 3-6). Data from most of these stations is available on the Internet.

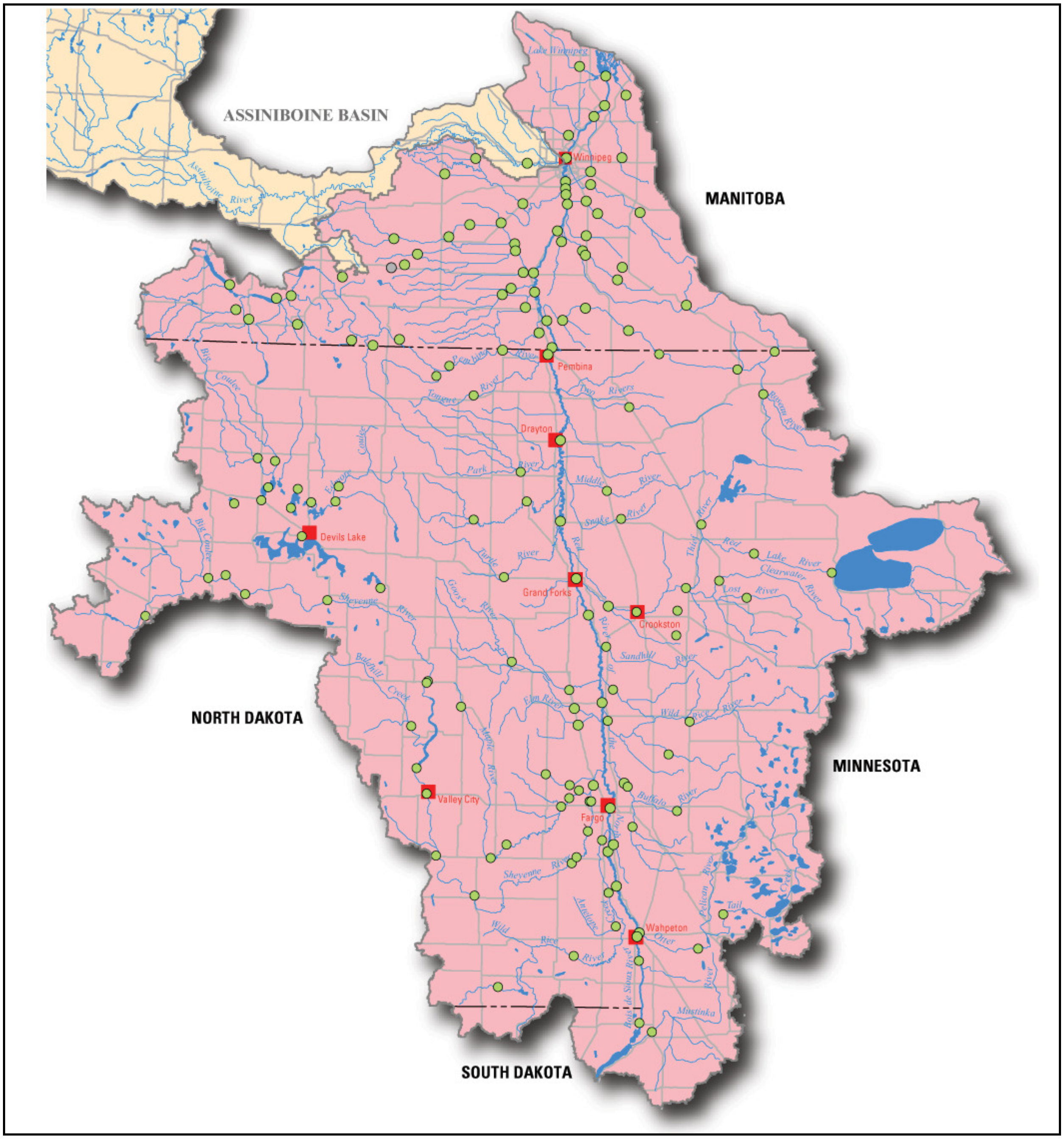


Figure 3-6
Stream Gaging Stations
Green dots correspond to stream gages maintained by the USGS or Environment Canada
SOURCE: http://nd.water.usgs.gov/floodinfo/red.html (Accessed November 14, 2011).

The amount of water added to the main stem of the Red River from its tributaries and the Red River's contribution to Lake Winnipeg varies from year to year and from season to season. Average annual discharge of selected streams, based on data collected by the gaging station network, varies from 837,000 af for the Red Lake River to only 36,000 af for the Forest River (Figure 3-7).

Hydrographs

A ***hydrograph*** is a graphical depiction of the amount of water passing a certain point in a watercourse during a period of time (e.g., second, hour, day). The vertical axis expresses water volume or depth and the horizontal axis expresses time (Figure 3-8).

The ***flood peak*** is the highest point of the hydrograph and ***flood duration*** is the length of time the water is above ***flood stage***. Hydrographs are important in understanding flooding and how to minimize flood damages. (See the chapters on flooding for more on hydrographs.)

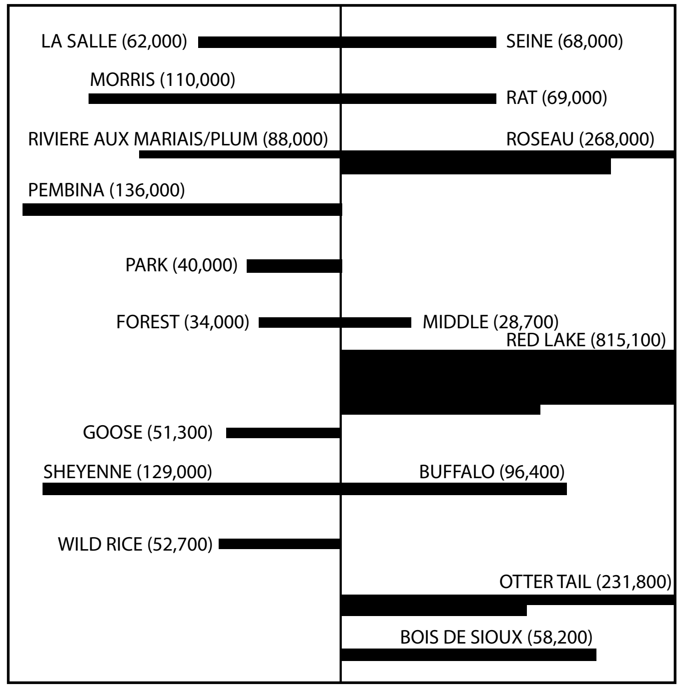


Figure 3-7
Average Annual Discharge of Selected Subbasins (acre-feet)
SOURCE: NDSWC 2011.

Lakes and Reservoirs

Another primary component of the runoff system is surface water bodies which store precipitation and runoff. Runoff is stored in large lakes such as Minnesota's Upper and Lower Red Lakes, whose levels are controlled by outlet structures. The combined surface of these two lakes is about 440 square miles, with managed storage dedicated to water supply and flood control. A conservation pool in excess of 950,000 af is maintained through operation of control features installed to regulate lake levels.

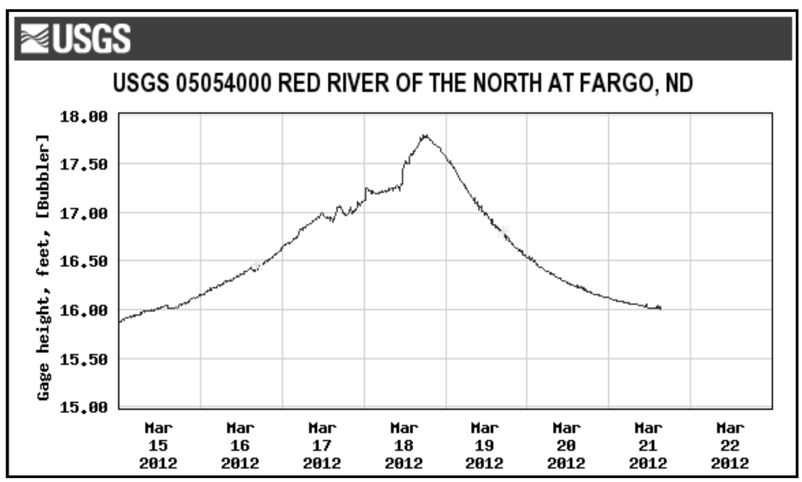


Figure 3-8
Hydrograph: Red River at Fargo, ND
Source: http://nwis.waterdata.usgs.gov/nwis/uv/?site_no=05054000&PARAmeter_cd=00065,00060 (Accessed March 22, 2012).

Devils Lake in east central North Dakota is another large lake capable of storing substantial quantities of runoff. The volume of Devils Lake has varied from less than 10,000 af to over 1.5 maf. However, Devils Lake is unusual in that it has no natural outlet until the water gets extremely high. This is called a closed basin. (See the chapter on Devils Lake beginning on page 115.)

Runoff in the Red River Basin is highly variable. Reservoirs play a critical role in regulating flows for water supply, flood control, recreation, and hydropower. Major reservoir storage in the basin includes Stephenfield (3,645 af/water supply) and Morden (3,150 af/water supply) in Manitoba, Traverse (137,000 af/flood control) and North Ottawa (16,000 af/flood control) in South Dakota and Minnesota, Orwell (13,100 af/flood control and 13,100 af/water supply) in Minnesota, and Ashtabula (18,000 af/flood control and 69,500 af/water supply) and Homme (1,100 af/flood control and 3,550 af/water supply) in North Dakota. There are many other dams in the North Dakota portion of the Red River Basin that provide flood control benefits and are even in excess of 5,000 af of storage. More retention areas are still being planned to help reduce peak flows in the Red River and its major tributaries.

Red River Basin Commission

Homme Dam recreation park.

In addition to naturally occurring wetlands, numerous shallow impoundments have been constructed and maintained by private interests and a variety of federal, state, provincial, and local water management entities. All new urban developments in most areas require construction of holding ponds to catch runoff from the development. This is because the impervious areas, such as roofs, parking lots, and roads, no longer allow infiltration of water.

Soil Zone Water

Water can move upward into the atmosphere as either transpiration through plant activity or as evaporation from the soil surface, or it can move downward as deep percolation past the root zone toward the ground-water system (Figure 3-9). Water that does not pass through to the ground-water system remains in one of the basin's larger storage systems, the vadose zone. The volume of water stored in the vadose zone can be equal to or several times greater than the volume of water stored in the basin's major reservoirs.

Water stored in the upper soil zone has been at or near capacity in many parts of the Red River Basin since the current wet cycle began in 1993. While some drying may occur during late summer and early fall, melting of higher than average snowfalls during spring has kept the top soil zone saturated resulting in higher than average rates of spring runoff.

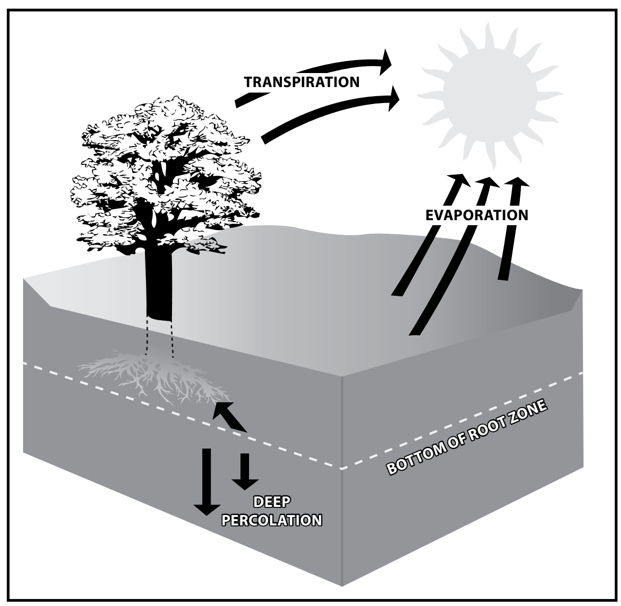


Figure 3-9
Routes Soil Zone Water Can Take
SOURCE: NDSWC 2011.

Ground Water

Ground water underlies the land surface throughout much of the basin, though not all of it is easily accessible, of acceptable quality for human and other uses, or found where it is needed. Generally, the basin's ground water occurs in two major rock types: unconsolidated rocks and bedrock. Unconsolidated rocks are loose beds of gravel, sand, silt, or clay. Bedrock, as the term implies, is generally solid and unbroken rock, but it varies greatly from only slightly consolidated deposits of clay or sand to hard rock such as

Red River Basin Commission

shale, limestone, greenstone, slate, or granite containing numerous fractures (MNDNR 1976 and Paulson 1990).

Zones of saturated rock, sand, gravel, or silt materials that can readily store and transmit water are called ***aquifers***. Some rock formations yield much larger quantities than others (Lindvig 1988). In the Red River Basin, ground water is obtained mainly from aquifers in the Pleistocene glacial drift such as glacial drainage channel deposits, lake deltas and beach deposits, outwash deposits, and small bodies of sand and gravel contained within till. Small yields of water, generally of inferior quality, are obtained from bedrock aquifers underlying the glacial drift (SRRRBC 1972). About 30 billion gallons of groundwater are withdrawn each year from wells in the Minnesota portion of the Red River Basin (Reppe 2005).

During Pleistocene time, glaciers moved southward over the Red River Basin at least three and possibly four times. They were heavily laden with rock fragments transported by the ice as it advanced. Glacial deposits consist mostly of till and glacial lake silt, neither of which yields much water. However, the glacial drift does contain some water-yielding sands and gravels that form some of the better aquifers in the basin. Bedrock valleys were filled with glacial deposits consisting mostly of impermeable till, but also with sand and gravel in places. Glacial deposits are found throughout the basin except in areas of bedrock outcrop. Their thickness is variable, but averages 150 to 200 feet in North Dakota, 200 feet in Minnesota, and 80 feet in Manitoba.

Buried deposits of sand and gravel are scattered throughout the glacial drift, though few are more than local in extent. As a result, the chance of tapping one or more of such layers with the zone of saturation at any particular site is uncertain. The yields available from such materials are small and usually adequate only for limited domestic supplies.

Red River Basin Commission

Gravel pit.

Well yields from bedrock are generally less than from glacial drift. Water quality tends to be diminished as well. While bedrock aquifers can be tapped nearly anywhere in the Red River Basin in North Dakota (SRRBC 1972), they are generally not present in Minnesota, where Precambrian rocks directly underlie the glacial drift. Although not usually considered as aquifers, the Precambrian igneous and metamorphic rocks in Minnesota may yield small amounts of water for domestic supplies where formations are weathered or fractured (MNDNR 1976). Limited quantities of water are also found in the water-bearing fractures of the Precambrian rocks underlying the eastern portion of the basin in Manitoba. Larger quantities of water can be found in the carbonate bedrock (limestone and dolomite) formation generally occupying the Red River Valley portion of the basin, but the water ranges from slightly saline to very salty and, as a consequence, is not potable in some areas. East of the Red River, it is used for domestic supplies. In some cases, saline water is used for stock when other supplies are unavailable.

How Much is Enough?


Red River Basin Commission

Rivers are a type of surface water.

A basin's total water resources consist of the sum of the surface water stored in its lakes and streams and water stored in the soil zone or beneath the land surface under water table conditions. It is measured in terms of flow (cfs) or volume (gallons and af), and is either adequate or inadequate in meeting the demands of a variety of uses. Its adequacy or inadequacy is also measured in terms of its quality.

While this book is more focused on water quantity, there are many sources with information on water quality. The United States Geological Survey has published an overview of the basin's water quality (Stoner et al. 1998). The International Red River Board, a division of the International Joint Commission, reports on water quality for the entire basin in the United States and Canada. The Minnesota Pollution Control Agency, North Dakota Department of Health and Manitoba Conservation and Water Stewardship each maintain web sites (www.pca.state.mn.us, www.ndhealth.gov/wq, and www.gov.mb.ca/conservation/waterstewardship/index.html, respectively) with water quality information for the contributing watersheds of the Red River of the North Basin.

There is also the matter of timing. Is water available on a consistent basis? Is it available when needed? Are there times when it is "too" available? In the following chapters, matters such as flooding (The "Too Much" Problem) and water supply (The "Not Enough" Problem) are discussed in detail. Dealing with issues such as flooding or meeting the basin's water supply demands is an important facet of water management. The reader is likely to discover that water management issues in the basin are numerous, complex, and difficult to resolve.

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Chapter 4

A Place to Relax: River-based Recreation[1]

Earliest documented recreational uses of the Red River began after World War I when people started to use the river to swim, fish for fun, and relax. However, the Red River faded as a place for leisure as the west-central Minnesota lakes country developed, transportation improved, and the belief took hold that the river was dangerous. Recently, there has been a renewed interest in the river as a recreational resource. Recreational use continues to grow up and down the valley.

Early Recreation

No doubt Native Americans, fur trappers and traders, and early basin settlers used the river occasionally as a recreational resource. Most likely, early residents and visitors to Winnipeg saw the Red River as a place to play, since that area was settled far earlier than the upper basin.

Eric Sevareid (1968) spent time with members of the Winnipeg canoe club in 1930 on his epic journey down the Red River. The brochure for Winnipeg's first "Greater Winnipeg Red River Day" on September 8, 1957, included the following regarding recreation in years past: "Another disappointment is the lack of river drives, swimming facilities, and winter activities, such as tobogganing, skiing, ice skating, sleigh rides, and horse racing on the river. Years ago we had all those winter activities, and they are pleasant memories to those who remember" (Red River Day Committee 1957, p. 7).

Historical and Cultural Society of Clay County

Dommer's boathouse.

Winnipeg not only had a canoe club before World War II, they also had a swimming club with 2,500 members. They did not swim in indoor pools, they swam in the rivers!

Swimming was popular as well in Fargo-Moorhead in the 1930s. Dommer's Boat House was a popular spot for swimming, boating, and "hanging out" by the river. "They are so anxious to bath in the Red River dam they sneak in between racks of canoes and change their clothing," Frank Dommer complained in 1932 (Clay County Historical Society, 2000, p. 76).

> Dommer's boathouse was a favorite place to hang around to watch people on the river in the rented rowboats and canoes, or those diving from the three-level diving platform midstream, which was removed after a local boy broke his back in a dive (Sprague 2000 p.3).

[1] This chapter is new in the Second Edition due to the ever-increasing interest in using the Red River as a valuable community asset.

Winter recreation was popular, with toboggan slides, ice races, and ski hills. From 1935 to 1942, Fargo had a 140-foot-high ski jump with a landing zone on the river, using the river bank on the Moorhead side for reducing speed. It was the largest ski jump scaffold in the country and it hosted regional competitions. The Civil Aeronautics Board asked that it be removed in 1942 as it posed a hazard to air traffic (Cass County Historical Society 2000).

Using the Red River as a recreational resource was about to change, again.

Taboo Period

"Taking chances doesn't pay. The river is dangerous night and day." So said 250 signs installed by the river in 1945 throughout Fargo and Moorhead.

Interest in the upper Red River as a recreational resource began to fade during and after World War II. From about the 1950s to the 1980s, parents and community leaders depicted the Red River as dangerous, dirty, and generally a place to be avoided. Use of the river as a place for outdoor leisure activities took a 180 degree turn for the next few decades.

The river has claimed about one life a year, largely due to low head dams and lack of water safety education. The low head dams, also known as "killing machines," would trap unsuspecting swimmers or overturned boaters, holding them in an undertow near the dam, often until drowning. All of these dams in the US have been or are scheduled to be retrofitted (Table 4.1) by replacing the concrete structure with strategically placed boulders. The new "dams" are safer for human users and allow passage of migrating fish (Aadland 2010). This leaves only the St. Andrews Lock and Dam, near the river's mouth, as originally built.

Table 4-1. Red River Dams

Dam	Closest City	River Mile	Status/year
Kidder	Breckenridge, MN	546	Retrofit w/boulders, 2000
Christine	Christine, ND	495	Retrofit w/boulders, 2011
Hickson	Hickson, ND	482	Retrofit w/boulders, 2011
Fargo South	Fargo-Moorhead	458	Retrofit w/boulders, 2003
Midtown	Fargo-Moorhead	452	Retrofit w/boulders, 1999
Fargo North	Fargo-Moorhead	448	Retrofit w/boulders, 2002
Riverside	Grand Forks, ND	296	Retrofit w/boulders, 2001
Drayton	Drayton, ND	203	Retrofit planned
St. Andrews Lock and Dam	Lockport, MB	23	Lock, dam, and bridge

To the casual observer, the Red River appears to be dirty, which many people equate with unhealthy and, thus, discouraging recreational uses. These negative views of the river were fostered by real or perceived water quality issues prior to modern municipal wastewater treatment and sanitary sewer systems. However, today's municipal wastewater treatment plants return water to the Red River that is cleaner than the water that was withdrawn. In

Brent Wacha, City of Fargo

Hickson Dam before retrofit.

Nathan Boerboom, City of Fargo

Hickson rapids, after dam retrofit.

addition, farmers were thought to be responsible for excessive chemical application, resulting in herbicides and pesticides finding their way to rivers and streams. Today's farm operators have more information and better tools available to apply precise amounts of chemicals, leaving minimal water quality issues resulting from agriculture.

The river still looks "dirty" today. However, that is just what it is, dirt (i.e., soil) suspended in the water. The valley's fine clay soils are picked up and transported to the river and remain in suspension, causing the dirty look of the river.

Water quality issues may still exist, but they are usually isolated and are frequently remedied promptly. A recent study of the urban impact on Red River water quality confirmed impacts are infrequent and isolated (Ivashchenko 2009). In short, people stayed away from the river, when, in fact, it is neither dirty nor dangerous. Once community leaders became more aware of what the river had to offer, the taboo period came to a close.

Modern Times

Today there are recreational facilities from one end of the river to the other. Attitudes about the river have come a full 360 degrees, back to where people think of the river as a valuable resource. Many communities on the river have one or more river-related festivals each year (Table 4.2). Some communities have summer and winter festivals, and most include some type of fishing derby.

The Red was recently designated a Canadian Heritage River as a way to encourage public appreciation and use.

The City of Winnipeg was the first to formally recognize the recreational potential of the Red River. A Heritage Advisory Committee was formed in 1988 in part to promote The Forks, at the junction of the Red and Assiniboine Rivers, as a valuable resource. The centerpiece of downtown today, The Forks is Winnipeg's top tourist attraction and is the site for more than 100 community festivals throughout the year.

Table 4-2. A Sampling of Red River Activities

Summer:
Rod and Reel Rally, Drayton, July
River Arts, Moorhead, select Tuesdays in summer
Headwaters Day, Welles Memorial Park, Breckenridge, 2^{nd} Sept. Sat.
Vince Herding Youth Fishing Derby, Wahpeton, 1^{st} May Sat.
Dick Bell Catfish Tournament, Wahpeton, 1^{st} June Sat.
Red River Festival for 4^{th} Grade Students, Wahpeton, 2^{nd} May Wed.
Blue Goose Day, Wahpeton, 1^{st} June Sat.
Carp & Sucker Fishing Derby, Wahpeton, 2^{nd} August Wed.
Race the Red Canoe/Kayak Race, Fargo, June
Tour de Forks, walk, run, bike, Grand Forks, September
SS Ruby tours, Moorhead, summer
Youth fishing clinics and derbies, Fargo and Moorhead, summer
Canada Day at the Forks, Winnipeg, July 1
International Trails Day, Manitoba, 1^{st} Saturday in June
Canadian Rivers Day, 2^{nd} Sunday in June
Dragon Boat Festivals, Winnipeg, June and September
Canada Day at The Forks & St. Boniface, Winnipeg, July 1
Catfish Derbies, Selkirk
Womens Weekend, canoe, Breckenridge to Ft. Abercrombie, June
Winter:
B-B-BRRR Winter Classic, bike race, Fargo, January
Ironman Outdoor Curling Bonspeil, Winnipeg, February
Ice Fishing Derby, Wahpeton, 1^{st} March Saturday
Iceman Triathlon, Grand Forks, February
Assiniboine Credit Union River Trail, ice skating, Winnipeg, all winter
Horse-Drawn Wagon Rides, Winnipeg, all winter
Red River Sled Dog Derby, Halstad to East Grand Forks and back
MCA Curling Bonspiel, Winnipeg - January
Actif Epica Bike Race, St. Malo to St. Boniface, February
Festival du Voyageur, St. Boniface, February
Ice Fishing Derbies, Selkirk & Netley Creek
Fireworks at the Forks, New Year's Eve, Winnipeg

Winnipeg was far from alone in recognizing the role the river could play in enhancing the quality of life for residents. In 1989, believing it was time to promote a new attitude about the river and explore ways to develop the Red River as a recreational resource, a team of architects from the American Institute of Architects called the Regional/Urban Design Assistance Team (R/UDAT) produced an intensive review and analysis of resources along the Red River in Fargo and Moorhead (R/UDAT 1989).

City of Winnipeg

The Forks in Winnipeg, MB.

R/UDAT proposed the creation of an organization to act as "River Keeper." They also proposed plans to educate people about maintaining the ecological health of the river, ideas for expanding the river's recreational use, and plans to build a "rediscovered" riverfront area in the downtown Fargo-Moorhead area. These visions could be accomplished through the combined actions of a River Keepers organization (www.riverkeepers.org), Fargo and Moorhead government offices, and by educating the public to appreciate and to be stewards of the river.

Today, the Red River hosts parks, picnic areas, trails, golf courses, and fishing accommodations. Cities proudly list the river as one of their community's amenities. From Headwaters Park in Breckenridge to catfish fishing at Lockport, the river is now a key element in community life.

Types of River Recreation

River recreation is of two types: those activities that are river dependent and those that are river associated. River-dependent activities include fishing, swimming, and boating. River-associated activities include walking trails, parks, golf courses, and some winter uses.

River-Dependent Recreation

River-dependent recreational activity depends on the river as a part of the experience. For example, without the river there could be no fishing or boating. These are also called water-based recreational activities.

Fishing: The City of Selkirk calls itself "the Catfish Capital of North America," adding that the Red River is known for producing some catfish weighing more than 50 pounds. The Red River has become known as a trophy channel catfish fishery (Breining 1999). The former (now second

Red River Basin Commission

Taking care of the Red River.

place) state record channel catfish, a 33-pound giant, was caught in the Red River. There are several Red River catfishing guides, catfishing derbies, a Red River fishing blog, and a Minnesota DNR Red River fishing booklet (MN DNR 2002).

The City of Winnipeg extensively promotes the fishing resources of the Red. European anglers have visited the Red in recent years to seek large carp.

In addition to channel catfish, another 57 species of fish are found in the Red River (Franzin et al. 2003). Red River anglers go after walleyes, goldeye, crappie, smallmouth bass, and several other popular sport fish.

Through the efforts of Native tribes, Minnesota DNR, North Dakota Game and Fish, and Manitoba Ministry of Natural Resources, lake sturgeon are being re-introduced into the Red River and its tributaries (Abraham 2008). The White Earth Band has been stocking about 20,000 fingerlings each year and DNR has been stocking over 150,000 fry each year in the Red River watershed's lakes and rivers. The sturgeon is the only fish species in the Red River for which there is no open fishing season.

Jay Leitch

Red River catfisherman.

There are now at least a dozen well-used public boat launches up and down the river from the headwaters to Lake Winnipeg. Parking lots at these launches are often full to capacity on summer weekends, and busy during the week as well. Some communities have fishing piers and platforms or have made other accommodations for shore anglers.

Red River Basin Commission

Red River recreation.

Fishing on the Red River isn't limited to the open water season. Anglers can be seen fishing through the ice in many places along the river. Their small communities of ice shacks also dot the frozen surface in popular fishing holes.

Fishing is not limited to hook-and-line, as the Red River is a popular spot for bowfishers to pursue the plentiful carp using archery equipment.

Progress of an ongoing program called "Reconnecting the Red," which has been a real boon to fisheries and fishing, includes "to date, 33 barriers to fish migration have been eliminated in the Red River of the North watershed…. Four mainstem barriers (three in the US) remain on the Red River" (Aadland 2010, p. 89).

Canoeing and Boating: Perhaps the most famous canoe trip on the Red River was Eric Sevareid's trip in 1930. He, age 17, and Walter Port, age 19, canoed from St. Paul to Hudson Bay, a trip of 2,250 river miles. Their trip has been replicated only a few times since then. In 2011, Ann Raiho and Natalie Warren became the first women to successfully canoe this route (Upnorthica.com 2011).

The Minnesota DNR developed a master plan for canoeing and boating on the Red River in 2002 (Leitch et al. 2002). They also developed a 3-map set, *Red River of the North: A Water Trail Guide* (MNDNR 2009), to promote and facilitate travel on the US portion of the river. The maps annotate the scores of recreational facilities and hazards on the river.

River Keepers

S.S. Ruby tour.

River Keepers of Fargo-Moorhead organized a Millennium Canoe Tour in 2000. The group started in Breckenridge, stopping in nearly every community along the way, and ended 34 days later with a celebration in Selkirk. In late 2000, the White House declared the Red a Millennium Trail. Since 2001, River Keepers has operated a 34-foot pontoon, the *S.S. Ruby*, on the river, providing 45-minute tours or charters for up to 17 adult passengers.

On all but the weekends with the worst summertime weather, you can see paddlers and boaters leisurely making their way along the river. Several vendors rent canoes and kayaks for use on the river. The Red River is also included in several canoeing guidebooks (Breining 1999).

River-Associated Recreation

Many types of outdoor recreation in close proximity to the river do not depend on the river, but are often there because of the river. The river and its wooded banks provide pleasant and protected surroundings for spending leisure time. Additionally, maintaining open space next to the river helps keep the ***flood plain*** free from structures susceptible to flood damage. The river is no longer something to be feared, but rather, something to enjoy.

Parks, Paths, and Trails: Most communities along the river have pedestrian or bicycle trails. A recent study of river recreation in Fargo-Moorhead found that one-third of the people surveyed near the river were bicycling (Karlsson, 2006). Paths are also used by walkers and joggers in summer and skiers and snowshoers in winter.

River Keepers

2011 Fun Race.

Some skiers and snowmobilers also make their way onto the sinuous path of the river when its waters are frozen in the winter. More than one community has recently hosted "bikeicicle" races on the ice. Caution must be taken whenever venturing out on to the frozen surface of the river, especially in urban areas. Thin ice or open water can be a hazard in sharp river bends, near bridge supports, or around storm sewer outlets.

Red River State Recreation Area and Sherlock Park Campground at River Mile[1] 297.2 in

[1] River Mile refers to the distance from the headwaters to the mouth of the river. For example RM 297.2 is 297.2 miles upstream from the mouth of the river at Lake Winnipeg.

Grand Forks are perfect examples of changing land uses next to the river and recognizing the recreational values of the river. The location is the site of a neighborhood destroyed by the flood of 1997 (see Chapter 6). There are 72 campsites, restrooms with showers, a playground, picnic tables, and access to hiking and biking trails at the site.

The recreation area and campground are part of the Greenway, a 2,200-acre natural open space in the heart of Grand Forks, North Dakota, and East Grand Forks, Minnesota. The Greenway features several parks, campgrounds, two golf courses, three disc golf courses, over 20 miles of multi-purpose trails, bank fishing sites, and much more. The Greenway provides a unique opportunity for year-round outdoor recreation activities in an urban setting.

Fort Daer Campground at River Mile 158.4 in Pembina is another example of riverside development in support of recreation. There is a concrete boat ramp, a dock, 12 campsites, restrooms with showers, picnic tables, shelters, fire rings, a fish cleaning station, and a playground.

Sailing on Lake Winnipeg.

Red River Basin Commission

Birding: Birding is one of the most popular outdoor leisure pastimes in the United States and Canada. Birders can find approximately 300 species of birds in the ***riparian*** areas of the river (O'Connor 2000). Birding tours are available in some communities.

The past few years have witnessed the return of bald eagles along the banks of the river. Eagles are frequently seen flying over the river in search of fish or waterfowl or resting in the riparian forest.

Wood ducks are another example of a species making a comeback along the river. Several organizations have placed hundreds of wood duck nest boxes in trees near the river. River Keepers has placed over 300 in the upper watershed of the Red River.

Golfing, Frisbee Golf, Ball Diamonds: Areas adjacent to the river are popular spots for developing sporting facilities that are flood resistant and/or resilient. Golf courses are common along the river. Some communities have Frisbee golf facilities in their riverside parks. Ball diamonds, volleyball courts, and horseshoe pits are common in the transitional area between the river and the community's built-up area.

Hunting: The Red River Valley was once known as a biological desert, due to lack of suitable habitat for most native species. However, at least two species have reached such numbers that they are now considered nuisances in urban areas. Whitetail deer numbers have become so high in urban areas that communities have organized controlled hunts to thin the herds. Wild turkeys have invaded the river bank habitat and can be seen in groups of 50 or more in towns as well as in the countryside. These species provide excellent hunting opportunities for sportsmen and women on both sides of the Red River. Bowhunting for deer is especially popular in the riparian forest.

Today, many communities along the banks of the Red River have well-groomed and developed parks, golf courses, walking/biking trails, picnic areas, boat ramps, ball diamonds, and volleyball courts that allow and encourage residents to enjoy the river in their leisure time. The Greenway in Grand Forks and The Forks in Winnipeg are excellent examples of how the Red River is being used to provide recreational opportunities to basin residents and visitors. These facilities are well suited for lands adjacent to the river which are subject to frequent flooding. More and more land adjacent to the river is becoming available for public recreation as communities buy out riverside homes and move them away from flood danger. Most of the recreational features built today are designed to be flood resistant as well as resilient due to the potential for frequent flooding.

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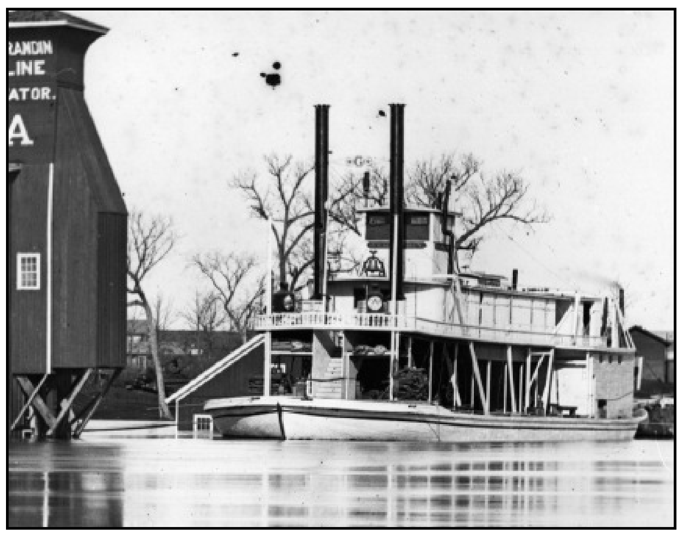
Chapter 5
The "Too Much" Problem: Flooding[1]

Introduction

Settlement patterns long ago set the stage for most of today's flooding problems in the Red River Basin. The availability of natural resources along the waterways as well as a transportation method enticed the first permanent residents of the region to settle this riparian land before the upland areas. Fertile river bottom soils, when they weren't plagued with wetness problems, were well-suited for growing crops. Trees, scarce on so much of the prairie but found along waterways, were a source of fuel and building materials and provided wildlife habitat that produced part of settlers' food supply.

Living near the river or one of its tributaries was a matter of advantages and disadvantages. One major advantage was convenience. The closer people located their homes to the Red or one of its tributaries, the less time and energy they had to spend hauling water. Sometimes, however, the convenience of living near the water was quickly overshadowed by the hard lessons learned when flooding inundated river towns and farms. Why, then, did so many people build close to the water? They did so for reasons of convenience and accessibility and, sometimes, because they lacked knowledge about the river.



The J. L. Grandin tied up to the Grandin Line's Fargo grain elevator during the 1881 flood.

Floods occur in various sizes and degrees of severity in the Red River Basin. Some affect areas as small as a few city blocks; others impact hundreds of thousands of acres. Some last a few days or even a few hours; others disrupt normal activity for several weeks or months. While flooding can occur several years in succession, many years can also go by flood free. Settlers could live for years along the main stem of the Red River without acquiring any first hand experience with flooding, seemingly making their location choice a good one. Unfortunately, by the time they did witness their first major flood, investments in farmstead buildings or business enterprises were likely too great to either abandon or move to higher ground. So they stayed and coped.

The Causes of Flooding

The sole cause of flood damage to property is human activity (e.g., houses, roads, schools, crops, businesses) in areas subject to high water. Without human activity, there would be no flood damage. The river

[1] Because much has happened regarding flooding since this chapter was initially written, Chapter 6 was added to cover flooding issues since 1993.

is the river when the water is low or when it is high. It is humans who defined high water as "flooding" and it is humans who define the "flood plain." However, humans have learned quite a bit about what causes the water to be high in rivers and lakes.

ANSWERING WHY RED RIVER FLOODS SO BADLY AND OFTEN. (Wheeler 2011, p A2). It is widely accepted that the Red River flowing northward is a primary reason for spring flooding in the valley. The idea is that the snow and ice melts in the southern valley first and flows northward to where all is still frozen. However, this explanation is not correct. If a still-frozen stream to the north were to be the cause of flooding to the south, then there would be ice jams backing up the flow at the interface between melted river and still frozen river. And while ice jams are often a serious problem on the tributaries, they have never been a big deal on the Red itself. The reason the Red River floods so badly and often is that it is a meandering river in a shallow channel in the bottom of an almost flat plain. Because of the too-gradual northward slope, it takes too long for water to get downstream, and so it backs up and spreads out over the land.

Historically, most flooding in the Red River Basin occurs as the result of runoff from late fall rainstorms and spring snowmelt. The magnitude of such flooding can be aggravated by rainfall coincident with or immediately after the snowmelt. Other floods can occur as the result of heavy rains from large summer thunderstorms (USACE 1980 and Leitch and Shultz 2003). This water accumulates, overflows the roadways when it has reached sufficient depth, and inundates section after section of land as it moves overland in the direction of the regional slope until reaching stream channels. (SRRRBC 1972).

Topography, land use, watershed size and shape, weather, and antecedent conditions each influence an area's flooding potential. Where people build influences the extent of flood damage.

Topography

Elevations above mean sea level (msl) in the basin range from about 2,300 feet msl in the highest upland areas to 789 feet msl where the river crosses into Canada and 755 feet msl at Winnipeg (Miller and Frink 1984). In the Red River Basin, where slopes are relatively gentle, the result is slower-moving water and longer duration main stem floods. "The slow rise of floodwater to a peak on the main stem gives enough time to keep the loss of human life at a minimum, but property damage can be extremely high" (Carlyle 1984).

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Flooding.

The upper reaches of many of the Red River's tributaries, which are characterized by well-defined drainage areas and greater slopes, can accommodate faster-moving water resulting in shorter duration floods (Figure 5-1).Water movement characteristics are affected by the presence or absence of man-made structures such as bridges, roads, dams, dikes, and diversions. Most of the year, the basin's rivers in both their upper and lower reaches are quite peaceful. By early summer in most years, streamflow decreases rapidly, and several rivers have little or no flow during the winter (USACE 1980).

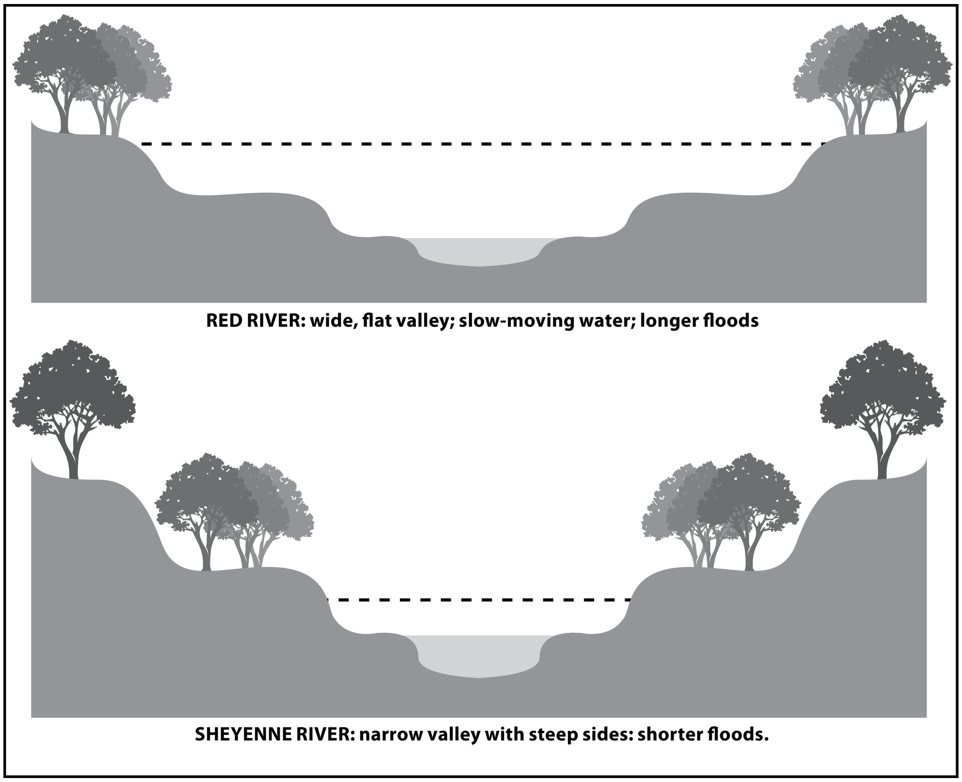

Figure 5-1
Floodplain Characteristics as an Influence on Flood Durations
(Main Stem and Tributary)
SOURCE: NDSWC 2011.

Land Use

The manner in which land is used within a watershed may influence the amount of runoff water that eventually enters a stream, river, or lake. Developed and undeveloped agricultural land, especially hay and pasture land, has a tendency to absorb water and retard its movement, less so when the ground is frozen. City streets and parking lots, on the other hand, readily shed water, as do full and overtopped ponds and lakes.

Land use within a basin is also a factor in determining the magnitude of flood damages. Damages can be extremely high in urban and built-up areas and when flood prevention measures such as dikes and floodplain and ***floodway*** management fail. Maintaining open spaces, such as parks or golf courses, in flood prone areas minimizes damages.

Basin-wide, about 300 communities are flood-prone, and over 3 million acres of land are subject to flood damage. Of this amount, nearly 1 million acres are located adjacent to the 550-mile long main stem of the Red River. The floodplain of the Red River main stem, which constitutes less than 10 percent of the basin's total area, generally does not extend much beyond 10 to 15 miles on either side of the river. As a consequence, the land subject to river flooding is only a small portion of the total land within the basin. While not extensive, the floodplain areas are very important (USACE 1980).

Along the main stem, more than 90 percent of the nearly 1-million-acre floodplain is devoted to agriculture (Whitney 1990 and USACE 1980). Moreover, most of the population of the basin is in the floodplain area. Ten cities with populations over 2,500, together with about 30 smaller communities, are potentially affected by floods. The most critical flood-prone area extends along the Red River main stem and includes the low-lying portions of Wahpeton, Fargo, and Grand Forks in North Dakota; Breckenridge, Moorhead, and East Grand Forks in Minnesota; and Emerson, Morris, and St. Adolphe in Manitoba. Almost all of the Canadian cities in flood-prone areas are ring-diked to withstand a 100-year (1 percent) flood event.

Flood damage to Winnipeg has been eliminated for all but the very large low frequency floods since completion of the Red River Floodway and Portage Diversion on the Assiniboine River. For example, flood damages in Winnipeg in 1979 were reduced from an estimated $630 million to less than $5 million by operation of the flood control works. Additionally, about 75 percent of the farmsteads in the Manitoba portion of the Red River Valley are ring-diked or on raised pads. By comparison, relatively few farmsteads have been ring-diked in the Minnesota and North Dakota portions of the Red River Basin, and most of those are downstream from Grand Forks.

Size/Shape of Watershed

The size and shape of the watershed, its topography and soils, and the timing and amount of precipitation determine the volume of runoff water that an area can produce, the frequency of flooding, and the duration of individual floods. For example, smaller watersheds have a tendency to produce localized flooding more frequently after heavy rainstorms. On the other hand, larger watersheds are more inclined to produce floods in conjunction with heavy spring snowmelt. Because of limited ***channel capacity*** relative to the size of the watershed, the river's ability to accommodate flood flows is somewhat limited.


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Extensive rural flooding occurred in 2009.

The shape of a watershed influences the timing of when tributary peak flows enter the main stem and whether or not they contribute to the main steam peak. If a tributary's peak flow enters the main stem days before the main stem peaks, it will not add to the depth of the main stem's peak. If the tributary's peak flow enters after the main stem's peak has passed, it will not contribute to the main stem's peak. If, however, the tributary's peak flow enters simultaneous to the main stem's peak, it will increase the depth of the main stem's peak and make flooding worse. Think of it as driving in rush hour traffic: leave early or leave late to avoid the rush, but leave at peak time and contribute to congestion. This is what is meant by ***timing***.

Weather Patterns and Antecedent Conditions

Conditions over the basin associated with major, widespread flooding include all or most of the following: heavy precipitation in the fall, hard and deep frost prior to snowfall, substantial snowfall, late and sudden thaw, heavy rainfall and wet snow during the spring breakup of ice, and rapid spring thaw (Carlyle 1984).

Soil moisture content, depth of frost, temperatures, and precipitation patterns are all factors that can influence the nature and magnitude of floods. The presence or absence of one or more of these factors can dramatically change the character of a particular flood. A heavy snowpack and a rapid melt, for example, almost guarantees some level of flooding. A heavy snowpack combined with high temperatures and significant rainfall during melting can produce devastating results. Yet, at the same time, a heavy snowpack together with dry soil profiles and a slow melt may result in only minor flooding or no flooding at all. Numerous factors, largely beyond our control, play a role in determining where floods occur, how damaging they are, and how long they last.

"Antecedent conditions" is a term that captures the status of these weather patterns before the spring melt starts. The extent of soil saturation and the level of surface water in ponds and lakes are especially critical antecedent conditions. When the soil is saturated, it freezes more readily and cannot absorb much, if any, spring runoff. Similarly, when ponds and lakes are full, or overtopped, they have no capacity to retain runoff water or to delay its reaching the main stem.

The Size of the Problem

Flooding problems in the Red River Basin are widespread and can severely impact regional economies. Agricultural lands, city infrastructures, homes, and businesses are vulnerable in spite of costly flood damage reduction measures. Losses to personal and public property can reach catastrophic proportions (USACE 1980).

The magnitude of flood damages varies from year to year and from region to region. An example of regional variability occurred in 1989 when people living in the southern reaches of the Red River Valley experienced a near record-breaking flood, while the remainder of the Red River Basin had few problems.

Red River Basin Commission

Flooding.

Average annual flood damages expressed in 1992 dollars for the entire basin were approximately $62 million with about 28 percent ($17.5 million) of the total occurring on the main stem and the remaining 72 percent ($44.5 million) occurring on the tributaries. While current data on basin-wide average annual flood damages have not been compiled, potential costs for composite urban damages in the basin were estimated at $3 to $4 billion and agricultural flood damages were estimated to approach or exceed $1 billion for a single 100-year flood in 2011 (RRBC 2011).

Nature of Flooding

Tributary streams, with more deeply entrenched channels in their upper reaches and steeper slopes to move water quickly, are usually capable of containing flows from snowmelt. As the slope of such streams becomes less steep, and channel capacities decrease in the flat valley, floodwaters overtop the channel and move overland.

When certain weather conditions prevail over the entire basin of the river, major flooding may spread over 1,000 to 2,000 square miles and may last for four to six weeks (Carlyle 1984).

Somewhat unique, when compared to nearby rivers, are the natural levees found along the reaches of several of the tributaries and along the main stem itself. These levees, sometimes as much as 5 feet high, are the result of river overflow and sediment deposition during past floods. As a consequence, "river stages during flood periods may be above surrounding ground levels, but when the levees are overtopped or circumvented, lands for several miles on each side may be flooded" (SRRRBC 1972).

Frequency of Flooding

Gaging data for basin floods prior to 1873, when a river gage was established at Grand Forks, are not available in the United States. Early records for the vicinity of Winnipeg indicate that several major floods occurred in the 1800s, the most notable of which were those of 1826, 1852, and 1861 (Clark 1950). All of these floods exceeded most of the greatest floods of the 20th Century by several feet, although measurement may not have been as accurate in the early 19th Century (SRRRBC 1972). The 1826 flood destroyed the Selkirk Colony and delayed further settlement for several years (Ross 1972, Heron). Table 5-1 reflects the basin's major ***historical*** (unrecorded) and ***recorded floods*** on the main stem through 1993. Data on more recent floods are included in the following chapter.

Table 5-1
Major Historical and Recorded Floods on the Main Stem of the Red River* Through 1993

YEAR	COMMENTS
Historical Floods[a]	
1776	U.S. Geological Survey records (1952) reference a Mr. Nolan (1826) who states that this flood was larger than the 1826 flood (Ross 1972).
1790	Stages were about 4 feet lower than during the 1826 flood.
1809	Stages were about 4 feet lower than during the 1826 flood.
1815	Water was remarkably high, overflowing its banks to a considerable distance at Fort Daer near Pembina.
1824	Listed as one of the worst floods known, along with those of 1825 and 1826.
1825	Listed as one of the worst floods known, along with those of 1824 and 1826.
1826	Maximum known flood at Winnipeg. Stages about 15 feet above ordinary flood height. Ice on the river reached extraordinary thickness of 5 feet 7 inches at Winnipeg (Ross 1972).
1852	Flood was higher by 1 or more feet than that of 1882, at and below Grand Forks.
1853	No farming was done in the Red River Valley near Pembina due to the floods of this year and the previous two years.
1861	This flood may have exceeded the 1897 flood.
Recorded Floods[b]	
1882	Sixth highest flood since 1852 at Winnipeg, with 68,000 cfs discharge at Grand Forks.
1893	Flood was most serious between Grand Forks and the International Boundary, with 53,300 cfs discharge at Grand Forks.
1897	Flood followed an extensive prairie fire in 1896 and a wet fall followed by a severe winter. Largest flood of record at Grand Forks. It included two peaks with a maximum discharge of 85,000 cfs at Grand Forks.
1950	54,000 cfs discharge at Grand Forks. Caused $100 million of damages and forced between 70,000 and 100,000 people to evacuate their homes.
1979	Flood was second largest after 1897 at Grand Forks (now #5 after 1997, 2009, and 2011).

* Miller and Frink 1984, Whitney, Manitoba Water Resources Branch 1992.

Ross, Alexander. 1972. *The Red River Settlement: Its Rise, Progress and Present State*, 1856, London, repr. Hurtig Publishers, Edmonton, Alberta, Canada. 1972.

[a] Historical floods are those that occurred prior to river level gages and accurate records.
[b] Recorded floods, or floods of record, are those documented from river level gages by appropriate agencies.

Records kept at various points since 1873 indicate that major flooding prevailed in significant portions of the basin in 1882-83, 1893, 1897, 1916, 1943, 1947-48, 1950, 1952, 1965-66, 1969, 1975, 1978-79, and 1989.

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Debris left by floodwaters creates a structural impediment in a river.

The greatest flood of record in the United States portion of the basin (until 1997) was in 1897, with a peak discharge of 85,000 cfs at Grand Forks. "Severe blizzards during the winter of 1896-97 produced heavy snow accumulations evidenced by drifts as deep as 20 to 30 feet which nearly covered many houses" (SRRRBC 1972 and USACE 1980). Warm weather came suddenly in the spring. A swift breakup produced ice jams and increased flood stages; much of Grand Forks and East Grand Forks were inundated.

Flood Prevention Measures Implemented

Floodplain management is a complex issue. The importance of dealing with floods is recognized, but implementing solutions is difficult for a variety of reasons. Consensus regarding an acceptable mix of ***structural*** and ***nonstructural measures*** is often highly elusive. The cost-sharing requirements for a particular solution or combination of solutions can be burdensome to local sponsors or even beyond their abilities to pay. Sometimes, the sacrifice of property by individual property owners is necessary to accomplish project purposes. These and other factors influence the numerous choices which have to be made before a flood damage reduction project or program can become a reality. The makeup of an acceptable program for reducing flood damages is likely to include a mixture of structural and nonstructural measures.

Structural Measures

Structural measures (Figure 5-2) are those features of a flood damage reduction program which are, in a sense, designed to keep floodwaters away from people and property. Dikes, levees, floodwalls, dams, and diversions are easily recognized structures. Snagging and clearing projects remove trees and other flow-retarding debris from floodways and stream channels. Channel improvement projects accelerate the movement of water during floods.

Throughout the 19th Century, residents of the valley tended to abandon homesteads temporarily and flee to higher ground when river floodwaters posed a serious threat. The first major structural measures to deal with basin flooding were not built until the mid 1900s.

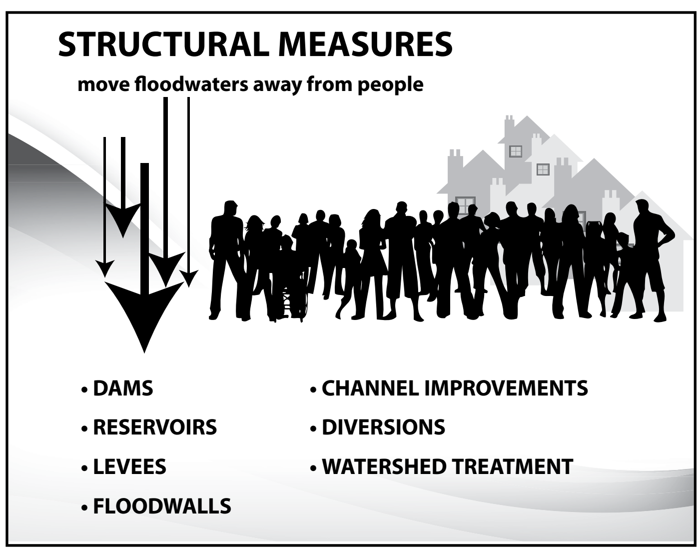

Figure 5-2
Structural Flood Damage Reduction Measures
SOURCE: NDSWC 2011.

Flood Storage: There are many examples of man-made flood storage in the Red River Basin. For example, several reservoirs were constructed in the upper watershed, in part to store floodwaters. In 1948, the Lake Traverse and Mud Lake Dams were constructed on the Bois de Sioux River south of Wahpeton, North Dakota. Baldhill Dam, also in North Dakota and upstream from Valley City, was built in 1951. Orwell Dam, on Minnesota's Otter Tail River near Fergus Falls, was constructed by 1953. These projects all provide some degree of floodwater storage. They are complemented by scores of smaller floodwater retention structures throughout the basin (RRBC 2011a).

Constructed Flood Storage Upstream of Fargo-Moorhead

Lake Traverse	75,100 af
Mud Lake	78,600 af
Orwell	12,800 af
Baldhill	70,300 af
North Ottawa	16,000 af
Maple River	60,000 af
	312,800 af

The combined, total room available for storing floodwaters in these six reservoirs is about 312,800 af. However, there may be times when only a part of that capacity is available. Further, the benefit of storing floodwaters in these and other locations is entirely dependent on when it is captured, when it is released, and how releases affect the main stem ***flood crest***.

The Red River Floodway: A series of intermittent wet years, beginning with the flood of 1948 and followed closely by the great flood of 1950, prompted governments and residents of the valley to begin in earnest to seek solutions to flood problems. The flood of April-May 1950 was the most extensive and prolonged flood experienced north of Grand Forks up to that point in the 20th Century (Carlyle 1984 and Miller and Frink 1984). Before it was over, several communities south of Winnipeg had been evacuated, standing barely visible in the middle of a lake 20 miles wide. One-eighth of Winnipeg was eventually covered with water. As many as 10,500 homes were inundated, and, at the height of the flood, between 70,000 and 100,000 residents had evacuated the flooded area. Damage estimates ranged to as much as $114 million (Carlyle 1984 and RRBI 1953).

Red River Basin Commission

Below the spillway - Red River Floodway.

In the wake of the 1950 Red River flood and subsequent floods on the Red and elsewhere in Manitoba, a Royal Commission, after two years of study and evaluation, recommended construction of the Red River Floodway. Completed in 1968 at a cost of $62.7 million—which was shared between the province of Manitoba and the Canadian federal government—the floodway represents the largest structural measure yet undertaken in the basin. Unlike Lake Traverse, Lake Ashtabula, and Lake Orwell, which are designed to store flood flows for later release, the floodway passes some part of flood flows around Winnipeg. It allows all water in the Red River to flow through Winnipeg during normal flows, but whenever the discharge is greater than 30,000 cfs, the water flow is divided between the Red River and the floodway. "Downstream from Winnipeg, the banks of the Red River are generally high enough to contain flood flows to Lake Winnipeg" (Carlyle 1984).

Other Structural Measures

A high degree of protection is afforded Winnipeg by the Red River Floodway and the Portage Diversion project. The Sheyenne River Flood Control Project, which diverts floodwaters around West Fargo and Horace, also provides substantial protection for those communities.

Of the remaining flood-prone urban centers, Grand Forks-East Grand Forks, Fargo-Moorhead and Wahpeton-Breckenridge are the best protected, yet they, along with other urban areas, are still vulnerable to substantial damages from very large floods that can be expected to occur on the average of once in 200 to 500 years. "The best level of protection exists to the north of Grand Forks, where flooding in the valley is deepest, most extensive, and most prolonged. Twelve towns in this area have earthen dikes completely or largely encircling the built-up areas" (Carlyle 1984).

Red River Basin Commission

A farmstead ring dike.

Canadian sites have permanent dikes that protect to approximately the 100-year flood level. "On the American side of the border, encircling dikes, containment levees, and concrete floodwalls, mostly temporary, afford varied levels of protection against rising waters" (Carlyle 1984).

Approximately 1,600 farms, largely in the northern section of the valley, could be protected against over-the-bank flooding by properly constructed ring dikes (Congressional hearing 1979). Many of these are protected by such dikes today.

Levees built by individual farmers along a short stretch of the Red River north of Grand Forks, following flooding in the early 1970s, were only partially successful in containing the 1979 flood. A lawsuit which grew out of the construction of those dikes has been settled. The corrective plan agreed to by parties involved, which included among other things the lowering of the dikes, has been implemented.

Small Retention Structures: The Red River Valley contains no natural storage sites of any consequence other than shallow depressions (i.e., wetlands). Unacceptably large capital investment cost requirements, permanent loss of highly productive farm land, and flat topography combine to make the creation of large storage reservoirs in the valley impractical. Compounding the problem is the lack of large, undeveloped storage sites in the headwaters of the tributaries. As a consequence, storage opportunities are limited to

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Under the right conditions, off-channel storage can reduce flood damages.

smaller dams. These small dams, including "dry" ones where the reservoir is usually empty (such as the Maple River Dam southwest of Fargo), reduce local damages during smaller spring floods and after heavy rainfall but have little impact on reducing flood peaks along the main stem of the Red River.


Red River Basin Commission

Flooding.

On tributaries on the North Dakota side of the river, a majority of the smaller "retention" dams were constructed under the direction of the US Soil Conservation Service, or during the 1930s, as Civilian Conservation Corps or Works Progress Administration projects. All but a few of them are solely for the purpose of reducing flooding. Several small dam sites are being evaluated by the Red River Joint Water Resource Board in North Dakota and the valley's local water resource districts. In Minnesota, the trend is toward multi-purpose structures which provide flood control, low-flow augmentation, and wildlife benefits (Thul 1990). Single-purpose reservoirs with small storage capacities are being built in Canada for purposes of flood and erosion control (Carlyle 1984).

Something called the ***waffle plan*** has been investigated as a floodwater retention method (EERC 2005). When viewed from above, the system of rural roads in the basin looks like a checkerboard or a waffle. Rural roads generally encircle a one-square-mile section of land. The Waffle Plan envisions temporarily holding water in these sections (i.e., holes in the waffle) to be released when the main stem's capacity is adequate to pass the water without flooding.

Nonstructural Measures

Structural measures form the centerpiece of the basin's existing flood damage reduction efforts. While such measures can be effective, they are often expensive, provide a false sense of security, are opposed by many local citizens, and encourage rather than discourage development in flood-prone areas. As a result, structural measures are often only a partial solution to flooding problems.

Nonstructural flood damage reduction measures (Figure 5-3) are designed to keep people away

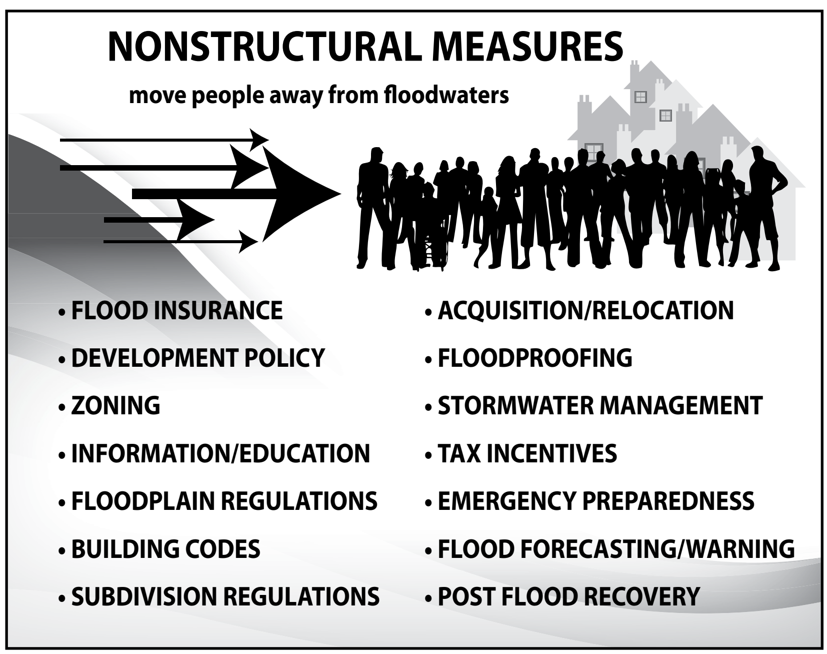

Figure 5-3
Nonstructural Flood Damage Reduction Measures
SOURCE: NDSWC 2011.

from floodwaters. Instead of controlling floodwaters, nonstructural measures concentrate on managing development activities.

Elusive Remedies

Much time, energy, and money has been invested in flood control projects and in community floodplain management programs throughout the basin. Yet flood losses continue, for a variety of reasons. Problems are large and complex, requiring innovative but technically and economically feasible solutions. At any given time, dozens of projects are being evaluated and pursued by one or several governmental agencies. But, the "high return" projects have already been built and, under the best of circumstances, implementation is difficult.

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A conference held by The International Coalition for Land & Water Stewardship (TIC), one of the first organizations seeking to unite citizens and coordinate responses to land and water issues across the political boundaries of the Red River Basin. TIC evolved into the Red River Basin Commission.

Selecting implementable alternatives grows more difficult within a framework of increasingly restrictive state, provincial, and federal laws. Reaching agreement on the local level about acceptable options is difficult where long-held and emerging value systems collide.

Coordination and negotiations among states, provinces, and federal governments are almost always a requirement. Intergovernmental and international agreements can take years to forge and even longer to implement.

Dealing effectively with a host of persistent flood problems still found in the basin will require some very difficult water management decisions in both the short and long term. Solutions will involve effective communication, cross-boundary compromise, and coordination among technicians, politicians, and citizens.

More of the problems and solutions from more recent flooding are presented in the next chapter.

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Chapter 6

Flooding: 1997 to 2011

Annual precipitation in the Red River Basin started an above-average trend about the time this book was first published, in 1993. Now, 18 years later, that trend has persisted (Table 6-1). Annual precipitation in Fargo from 1993 to 2010 was 29 percent above "average,"[1] or 5.72 inches extra, on average, each year. It was drier than average in Fargo just 2 years out of 18 and wetter than average 16 years. Annual precipitation in Grand Forks was 11 percent above "average," or 2.23 inches extra, on average, each year.

Some refer to times of wetter-than-average precipitation as a "wet cycle." The research on weather patterns and climate change is inconclusive about how long the cycles last, what causes them, or even if they are cycles. What is known in the basin is that it floods more frequently during wet cycles and water is scarcer during dry cycles.

These cycles and swings are characteristic of ***mid-continental climate*** extremes. The Red River Basin is nearly smack in the middle of the North American continent, so we can expect the extremes to continue (Goden and Godon 2002). Knowing they will continue encourages basin residents to prepare for the ups and downs of water levels.

Table 6-1. Annual Precipitation, 1993 – 2010
Fargo, ND, and Grand Forks, ND

	Fargo		Grand Forks	
		Deviation from		Deviation from
Year	Actual	Average	Actual	Average
	----------inches----------			
1993	21.90	+2.46	22.52	+2.92
1994	23.10	+3.65	23.89	+4.29
1995	21.53	+2.08	26.44	+6.84
1996	20.42	+0.97	18.32	(-1.28)
1997	25.84	+6.39	19.11	(-0.49)
1998	31.75	+12.30	22.74	+3.14
1999	25.31	+5.86	21.74	+2.14
2000	34.75	+15.30	24.66	+5.06
2001	20.25	+0.80	21.51	+1.91
2002	24.81	+5.36	21.89	+2.29
2003	18.42	(-1.03)	17.76	(-1.84)
2004	25.99	+6.54	21.38	+1.78
2005	30.44	+10.99	24.64	+5.04
2006	17.15	(-2.30)	15.38	(-4.22)
2007	26.23	+6.78	21.09	+1.49
2008	30.82	+11.37	24.33	+4.73
2009	24.89	+5.44	17.83	(-1.77)
2010	29.48	+10.03	27.77	+8.17
Avg. annual deviation from "normal"	+5.72 (+29%)		+2.23 (+11%)	

Source: North Dakota State Climate Office (http://www.ndsu.edu/ndsco/***)***

This chapter is about some of the more recent, serious floods in the basin (Table 6-2) and what is being done to reduce future flood damages. The flood of 1997 made the record books as the #1 flood of record in

[1] The evening weather report gives the day's temperature above or below "average" or "normal," which is a 30-year average, recalculated every ten years. The 30-year "average" (for the 1961 to 1990 period) annual precipitation in Fargo in 1993 was 19.45 inches. By 2010, the "average" annual precipitation in Fargo was 22.69 inches (1981 to 2010, unofficial), which reflects the increase due to several years of "above average" precipitation.

Fargo and Grand Forks. That record was broken just 12 years later in Fargo by the flood of 2009, which peaked 1.12 feet higher. Several smaller, but nevertheless serious, floods have also occurred during the current wet cycle.

Flooding in Manitoba has been similar to upstream areas in North Dakota and Minnesota. However, flood control works, especially in Winnipeg, have reduced damaging flood peaks.

Winnipeg constructed a dike system and flood pumping stations in 1950. The Red River Floodway was completed in 1968. The Portage Diversion was built in 1970. Retention as Shellmouth Dam was available after 1972. Each of these measures has reduced the flood peak in Winnipeg by about 10 feet (Winnipeg.ca 2011).

Historic data indicate the 1826 flood peaked at 37 feet and the 1852 flood at about 35 feet in Winnipeg. The greatest peak in recent time was 30.3 feet in 1950. The flood of 1997 peaked at 24.5 feet, but without flood control it would have been 34.4 feet.

Table 6-2. Top 10 Recorded Flood Stages in Fargo and Grand Forks

Crests for Red River of the North at Fargo

Rank	Stage (ft.)	Date
1	40.84	3/28/2009
2	39.72	4/18/1997
3	39.10	4/7/1897
4	38.81	4/9/2011
5	37.34	4/15/1969
6	37.13	4/5/2006
7	36.99	3/21/2010
8	36.69	4/14/2001
9	35.39	4/9/1989
10	34.93	4/19/1979

Crests for Red River of the North at East Grand Forks

Rank	Stage (ft.)	Date
1	54.35	4/22/1997
2	50.20	4/10/1897
3	49.87	4/14/2011
4	49.33	4/1/2009
5	48.81	4/26/1979
6	48.00	4/18/1882
7	47.93	4/6/2006
8	46.09	3/20/2010
9	45.93	4/21/1996
10	45.73	4/11/1978

Source: http://water.weather.gov/aphs2/crests (accessed 8/14/2011)

The 1997 Flood[1]

In 1997, the tempestuous Red River of the North demanded its history of flooding be re-examined. Long-time basin residents expressed shock and surprise as the Red River continued to rise beyond their expectations. Several were heard to say, "We've never had water levels that high here before." The 1997 flood established a water level mark in the Red River Valley unseen for generations. Historical records, however, show an even bigger flood probably did occur. Flooding will always be part of life in the Red River Valley, but coordinated water management can reduce the injury and damage. Residents must educate themselves to the risks of floods. No dike, dam, or diversion will provide complete protection from all flooding. Residents must learn to live with floods and work to reduce the risk and damage they will bring in the future.

Flood records in Manitoba, dating to the early 1800s, reveal the most severe flood of modern times occurred in 1826. However, measurement tools and recordkeeping were less precise 175 years ago, so we can't be sure of the very early flood levels. The 1997 flood, however, was the largest ***recorded flood*** up to that time in North Dakota. There have been ***historical floods*** close to the magnitude of the 1997 episode. At Grand Forks, the 1997 flood was four feet higher than the 1897 flood and six and a half feet higher than the 1979 flood. Increased development and population in 1997 resulted in greater economic losses than in previous years.

[1] Volumes have been written about the 1997 Red River of the North flood. This section introduces readers to the principal issues and concerns. For more details, see the sources in the reference list and: (1) *The Floods of 1997*, 1997, A special report by the North Dakota State Water Commission; (2) *Fighting Back: The Blizzards and Floods in the Red River Valley, 1996-97*, 1997, by the Staff of The FORUM, Forum Communications Company, Fargo, ND; (3) R. A. Halliday, 2009, *Flood Preparedness and Mitigation in the Red River Basin*, International Joint Commission, Ottawa and Washington, DC; (4) IJC, 2000, *Living with the Red: A Report to the Governments of Canada and the United States on Reducing Flood Impacts in the Red River Basin*, International Joint Commission, Ottawa and Washington, DC; and (5) L. Douglas James and Scott F. Korom, 2001, "Lessons from Grand Forks: Planning Structural Flood Control Measures," *Natural Hazards Review* 2(1):22-32.

1997 Flood Management and Preparedness

In the United States, numerous local, state, and federal agencies combined to plan, coordinate, and respond to the 1997 flood emergency. Using an umbrella approach, the Federal Emergency Management Agency (FEMA) provided preparedness, response, mitigation, and recovery assistance. Federal efforts were complemented by state emergency management, natural resource, and water quality agencies. Additional assistance was provided by local water resource districts and emergency management teams. Based on February 1997 flood forecasts, the US Army Corps of Engineers began advanced flood response measures. Contracts were arranged for labor and materials to be stockpiled at key locations. Orwell Lake, Lake Traverse and Lake Ashtabula were all ***drawn down***.

Red River Basin Commission

Flooding in the basin.

Emergency efforts were organized by a flood management task force in Manitoba. Established in April 1997, the group was chaired by Manitoba's Water Resources Branch with representatives from provincial departments, the City of Winnipeg, Manitoba Hydro, University of Manitoba, Canadian Armed Forces-Engineering Division, and Acres International (engineering consultants). The task force assessed flooding and recommended emergency measures to the provincial emergency management organization, the City of Winnipeg, and local authorities. The group also initiated evacuation and re-entry procedures. Task force recommendations for early flood preparation saved livestock, grain, transportable resources, materials, and supplies, and made sandbags available throughout the basin. Additional action was taken to prevent ice jam related flooding in the Selkirk and Breezy Point areas north of Winnipeg. Along several reaches of the river, helicopters dropped a fine layer of sand to accelerate melting and break-up of the river ice. A local work force using specialized equipment bored an estimated 45,000 holes to weaken the ice at key locations. No serious problems associated with ice jamming occurred. A more controlled study, however, would be needed to determine if those efforts helped.

Minnesota National Guard

Military assistance during a flood.

Military assistance was provided and welcomed in both countries. Military personnel, with an array of equipment, mobilized to support the flood fighting effort. The US Army Corps of Engineers provided technical assistance, resources for constructing emergency works, assistance in implementing emergency measures, and overall coordination of flood fighting. Assistance focused on emergency diking, overcoming access problems, flooding surveillance and reporting, evacuations, safety, and security.

The Nature of the 1997 Flood

The flood of 1997 was the culmination of forces, rather than an isolated atmospheric event. A history of flooding in the basin indicates nearly all large floods are preceded by unusually heavy snowfall and a late spring blizzard or rain storm. Above-average precipitation occurred throughout the Red River Basin in the fall of 1996. High soil moisture at freeze-up caused lessened capacities for infiltration and the likelihood of higher runoff in the spring. Snowfall in some areas of the basin was three times the average and below normal temperatures were experienced during the winter and early spring. A late blizzard from April 4 to 6 blanketed the basin with up to 12 inches of wet snow, equivalent to 2.66 inches of water.

Cooler than normal temperatures delayed melting for nearly one week. In mid-April, daily temperatures increased dramatically. Widespread melting occurred quickly, with high runoff. The delay in melting followed by the sudden increase in temperatures contributed to the proximate timing of the Red River and Red Lake River crests in the Grand Forks area.

Flooding along waterways was worsened by uncontrolled ***overland flow*** impacting one area after another as it overtopped grid roads and gradually moved through the basin. Adding to the challenge of high water levels, high winds caused damaging, erosive waves. Power lines to some valley communities were knocked down by the heavy sleet accumulation. More than 100,000 basin residents were evacuated from their homes, including the entire population of Grand Forks and East Grand Forks, to ensure their safety as the river waters threatened.

The flood of 1997 became the #1 flood on record in Fargo and Grand Forks and #3 in Winnipeg (Table 6-2). Hydrographs depict the flood crest level, the duration of the flood, and the volume of water passing a certain point in the river (Figure 6.1). Hydrographs are for a unique point in the river. Flood stages and flows are related to the shape of the ***river's cross-section*** at that point (Figure 6.2). The reported flood stage is the depth from the bottom of the river at the gage. However, some stages are reported in terms of height above msl. Fargo's gage is near the water plant intake just south of the Midtown Dam. The Grand Forks gage is near the Sorlie Bridge.

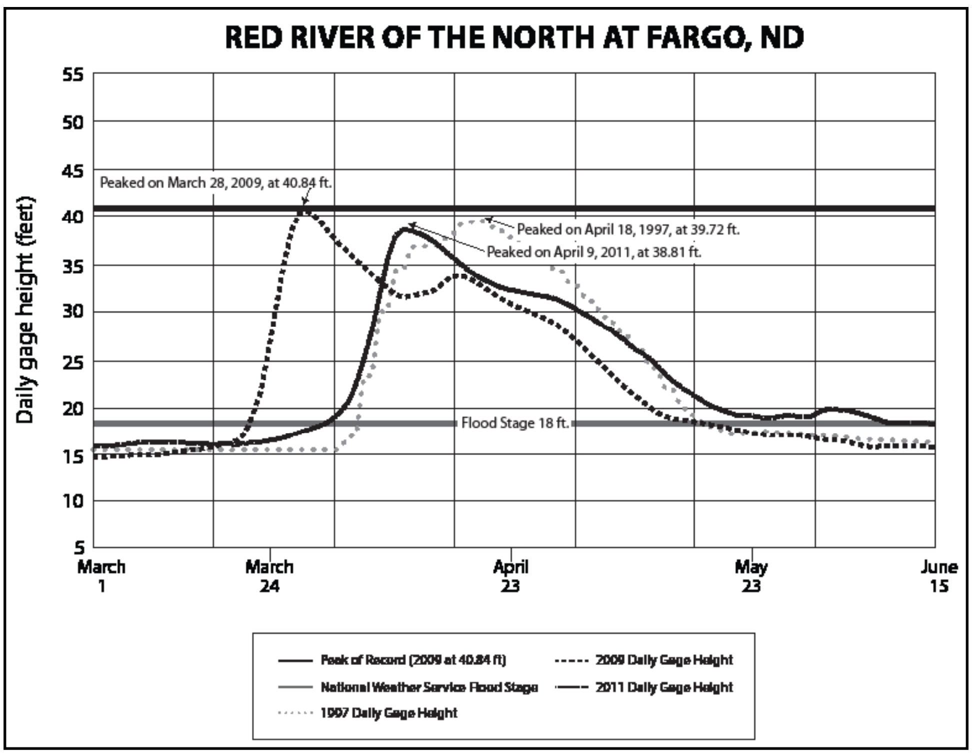

Figure 6-1
Hydrographs of the 1997, 2009, and 2011 Floods in Fargo
SOURCE: NDSWC 2011.

Flood Forecasting

Forecasting the river crests for the flood of 1997 was greatly hampered by unknown amounts of water coming from overland flows. Generally, forecasts are based on gage readings from tributaries and on the main stem of a river. However, a large portion of the water in the Red River Valley resulted from water not moving within the normal ***river channels*** (Figure 6.2). Forecasting the impact of this overland flooding on future river crests became difficult because there were no automated gages to measure the extent of the flows. Overland flooding caused a substantial delay in estimating crests in the Red River Basin, particularly in Grand Forks. Forecasts of crest elevations at various locations, however, became more accurate as the flood proceeded.

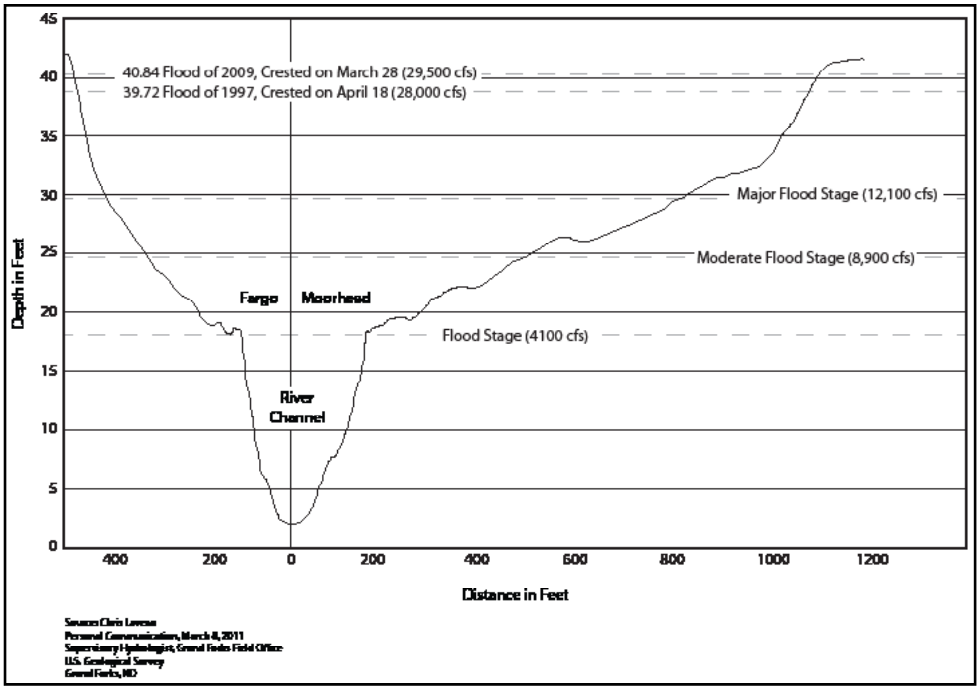

Figure 6-2
Red River Cross-Section at Fargo
Source: USGS 2011, NDSWC 2013.

After the April 4 to 6 blizzard, a revised forecast was issued in Manitoba on April 9. Manitoba's emergency diking was based on this forecast. Forecast crest elevations were again revised upward on April 18 and 20, when the crest at Grand Forks was higher than predicted. The river crested at Wahpeton-Breckenridge more than nine feet above flood stage on April 15-16. The peak at Fargo-Moorhead occurred on April 18 and at Grand Forks/East Grand Forks on April 22. Further north at Drayton, the peak occurred on April 25, at a level two feet higher than the 1979 flood. Record and near-record peak discharges also occurred along several tributaries throughout the Red River Basin. Flood damages in Ada, Wahpeton-Breckenridge, Fargo, and Grand Forks-East Grand Forks were severe. At the inlet to the Red River Floodway just south of Winnipeg, floodwaters crested 1.5 to 1.7 feet higher than the range forecasted. In this general area, the communities of Ste. Agathe and Grande Pointe were hardest hit.

Red River Basin Commission

Dikes helped save many structures from incurring major flood damages.

Performance of Major Flood Control Works

Existing and temporary flood protection works were tested in both countries. In the United States, emergency levees and protective works were constructed in 37 communities. Efforts were successful in all communities but Breckenridge, Ada, Grand Forks, and East Grand Forks. The flood of 1997 remains the #1 flood in Grand Forks-East Grand Forks. The iconic *Grand Forks Herald* photo of downtown buildings destroyed by fire and surrounded by floodwaters was seen around the world (Figure 6.3).

Figure 6-3
Downtown Grand Forks
SOURCE: Grand Forks Herald, April 1997.

In Fargo, flood damage was limited to 40 homes. The Lower Sheyenne River Flood Control Project successfully diverted water around the community of West Fargo. North of Grand Forks-East Grand Forks, dikes protected several smaller towns and individual farmsteads. The English Coulee Dam (flood storage pool of 5,889 af) prevented serious flooding on the west side of Grand Forks. The extensive dike system in Fargo-Moorhead also protected against the record levels that occurred along that reach of the river.

Flood protection systems in Manitoba were developed following extensive damages incurred during the 1950 flood. The Red River Floodway diverted nearly half of the peak flow, preventing serious flooding in Winnipeg. A record flow of 66,000 cfs in the floodway was recorded; the previous peak was 42,000 cfs in 1979. The West Dike of the floodway inlet control structure had to be extended and raised. Workers constructed 16 miles of new dike and raised and/or reinforced another 10 miles. In addition to the floodway, the Portage Diversion was used to divert almost all of the flow from the Assiniboine River northward to Lake Manitoba. In Winnipeg, only a small percentage of the approximately 800 properties protected by emergency diking were damaged.

Red River Basin Commission

Red River Floodway.

Further upstream on the Assiniboine River, the Shellmouth Dam was used to alleviate downstream flooding. The dam reduced the peak from 10,000 cfs to 1,600 cfs, providing considerable protection for downstream communities. South of Winnipeg, thousands of Manitobans live in the nine ring-diked communities of Emerson, Letellier, Dominion City, St. Jean Baptiste, Morris, Rosenort, Brunkild, St. Adolphe, and the Roseau River Indian Reserve. In March, dikes around these communities were widened and raised. The ring-diked communities became islands at the height of the flood. Although the ring dikes held, many of the individual dikes around rural homes and businesses did not.

Environmental Considerations

Flooding is a natural phenomenon and, in the absence of human development, does not cause environmental damage. With no humans, everything is natural and there are no anthropocentric standards to measure against. However, with development in the floodplain comes the potential for water, soil, and air contamination from a variety of sources.

It took several years to accurately identify the environmental impacts of the 1997 flood. The event created an impact on the groundwater resources in the basin. Many water wells were contaminated by floodwaters. Microbiological contamination of domestic wells resulted from floodwaters leaking into unprotected casings and from poorly constructed and unsanitary wells. Unsealed, abandoned wells inundated for an extended period also contributed to contamination. Aquifer and well restoration measures consisted of pumping floodwaters and contaminated groundwater from individual domestic and abandoned wells, field water quality testing, and disinfection of the wells and water supply lines.

There were some localized water pollution issues when fuel oil tanks located in flooded basements leaked and spread fuel.

A variety of preventive measures, however, were effective and efforts to move or safeguard hazardous materials were largely successful. Concern lingers, however, that the nature, volume, and location of hazardous materials is not well known throughout the basin.


Red River Basin Commission

Flood water recedes, clean up begins.

The physical, emotional, and economic toll of the 1997 flood was enormous and left a lasting legacy. The 1997 flood was influential in improving flood forecasting practices, water level and flow monitoring, flood management and preparedness, flood-fighting, flood works infrastructure, and programs for flood damage reduction. Cooperation among experts and authorities at local levels and between Canada and the United States is critical in dealing with future flood events.

With some exceptions, the Red River Valley flood control works and related infrastructure performed well during the 1997 flood. However, a coordinated systems approach is needed, requiring new flood control measures to account for negative impacts in other parts of the basin. It is difficult to precisely estimate all of the economic, environmental, and social costs of this type of disaster.

Post-1997/2009 Flood Damage Prevention Measures

Calls for better protection and planning came during and immediately following the flood of 1997. In the United States and Canada, a considerable amount of work was required to repair or construct new dikes and to raze, relocate, or repair damaged buildings and properties. Other long-term non-structural measures include zoning and stricter compliance with existing policies and new legislation for floodplain management. In addition to concerns from agencies, private individuals, and community groups, short-term measures to prevent or minimize damages have been formally recommended and documented by the ***International Joint Commission*** in its report, *Red River Flooding, Short-Term Measures* (December 1997).

Amphibidex machines being used in Manitoba to break up ice on the Red River, 2009.

Ken Gillespie

Manitoba water agencies undertook a detailed, independent review of Manitoba's flood forecasting efforts, preparedness, operation of flood control works, and flood fighting response to assess overall capabilities with a view to improve any identified deficiencies.

The North Dakota State Water Commission reviewed the state's floodplain management policies and held public meetings throughout the state to assess the effectiveness of current legislation and gather concerns or suggestions for improvement. Recommendations for improved floodplain management were published as part of the 1999 State Water Management Plan.

The Minnesota Department of Natural Resources has developed regulations to strengthen the floodplain management program. Evaluation of the program will continue, to seek additional improvements to provide better protection.

Local leaders discuss options to help reduce flood damages.

Red River Basin Commission

Countless local units of government sought methods and funding to protect their citizens. Many non-profits and special interest groups went to work to ensure what happened in Grand Forks would never happen again.

The International Joint Commission created a bi-national task force to investigate the causes of flood damage in 1997 and seek ways to mitigate damage from future floods. They concluded a future flood of even greater magnitude than in 1997 was possible and the governments of the US and Canada should do what is necessary, working with state/provincial and local leaders, to minimize damages resulting from flooding in the future. The IJC Task Force did not realize that the even-larger flood, in many parts of the basin, would happen just 12 years later, in 2009. Most communities, governments, and individuals were better prepared for that flood, but it still caused considerable damage and cost millions to fight.

The flood of 2009 re-ignited calls for action.

Individuals and federal, state/provincial, and local governments along the Red River spent well over $1 billion in the 13 years following the flood of 1997 to protect themselves from future floods. Some examples of action taken since 1997 include:

- Breckenridge-Wahpeton constructed **7 miles of permanent levee/floodwall system**, a 2.9-mile-long Highway 75 diversion channel, and **removed 30 homes** from the flood plain (St. Paul District 2000, 2000a).
- Moorhead **removed 100 houses** and spent millions **upgrading sewage lift stations** and constructing neighborhood levees.
- Fargo **removed 250 houses** and plans to remove dozens more, spent millions on local levees, and recently **increased the setback requirements** on new home construction.
- Oakport ***township*** (Clay County, north of Moorhead), which was hit hard by the 2009 flood, **removed 40 houses** and may remove another 20 to make room for a **6-mile long dike**. The $25.3 million state and locally funded project will provide 100-year flood protection to 750 acres and 450 homes. The dike is being built to 3 feet above the 2009 flood level. Buyout areas will be converted to green space where practical (BRRWD 2010).

Red River Basin Commission

Moving a house away from the River.

- Governments and individuals in Canada have also spent millions implementing **ring dikes** and other flood-proofing measures.
- Communities continue to put in place both **structural and non-structural flood control measures**. The largest effort in Cass and Clay counties is a plan to build a diversion to divert floodwaters around the cities of Fargo and Moorhead, much like Winnipeg's diversion (aka Red River Floodway). The F-M diversion is in the planning stages as of this writing.
- Efforts are ongoing to develop **upstream storage and retention**, including micro-storage such as the ***waffle plan*** and wetlands restoration.
- Structures built in flood prone areas are required to be **elevated above potential flooding levels**.
- Extremely accurate **digital elevation floodplain maps** have been developed through a basin mapping initiative using ***LiDAR***; this multi-million dollar effort was co-sponsored by many agencies and will be useful in more precisely determining flood risks at very high resolution.

The Nature of the 2009 Flood

Residents and officials were surprised in late winter of 2009 when it began to look like another major flood was looming on the horizon. However, the conditions were right (*North Dakota Water* 2009). The ground was saturated when it froze at the start of winter. There was high winter snowfall. A March 22 rainstorm added several inches of rain to the mix. Another snowstorm during the flood contributed to already high flows. The melt was quick.

Red River Basin Commission

South River Drive, Moorhead, MN, April 2009.

In anticipation of major flooding, all flood control reservoirs were drawn down to ensure maximum storage for runoff (USACE, 2011). Unfortunately, upstream storage is limited in the watershed. For example, the two major storage facilities upstream of Fargo, Lake Traverse/Mud Lake and Orwell Reservoir, have a maximum flood storage capacity of about 166,500 af, or roughly 11.5% of the volume of water that flowed past Fargo while the river was in flood stage in 2009 (about 1,429,626 af) (Bertchi 2011). The flood crest could have been 11% higher without the storage, or not, depending on timing of contributing flows.

- March 9 - Communities along the Red prepared for what was first predicted to be a major flood. In Fargo, for example, the prediction was for a flood crest between 35 feet and 36 feet. However, before the flood peaked, the prediction was increased several times as weather conditions changed and more streamflow data became available.
- March 16 – Governor Hoeven declares statewide flooding disaster.
- March 19 – NWS raised predicted level to between 37 feet and 40 feet.
- March 22 – NWS raised predicted level to a range of 39 feet to 41 feet.
- March 26 – NWS raised predicted level to a range of 41 feet and 42 feet.
- March 28 – NWS raised predicted level to a possible 43 feet.

These ongoing changes in the predicted flood crest kept residents on edge and scrambling to raise dikes and protect property.

The Red River eventually peaked in Fargo at 40.84 feet at 12:15 a.m. on March 28 and began a slow decline (Figure 6.1). The river dropped below flood stage (18 feet) on April 20, 2009, setting a new record flood level in Fargo-Moorhead. More than 30 basin communities were hit with major flooding, seven setting flood-level records.

Grand Forks was ready for the 2009 flood, having spent hundreds of millions on flood protection since the devastating 1997 flood. The river crested at 49.33 feet on April 1 in Grand Forks, below their protection level of 52 feet (Figure 6.4).

The 2009 flood was the second worst on record in Manitoba, and only 23.6 inches lower than the flood of 1997. Although there were many evacuations and some flood damages, the Portage Diversion and temporary flood fighting measures kept damages to a minimum. Ice jams were a factor contributing to 2009 damages in Manitoba.

The Nature of the 2011 Flood

Communities began preparing to fight the 2011 flood in mid-

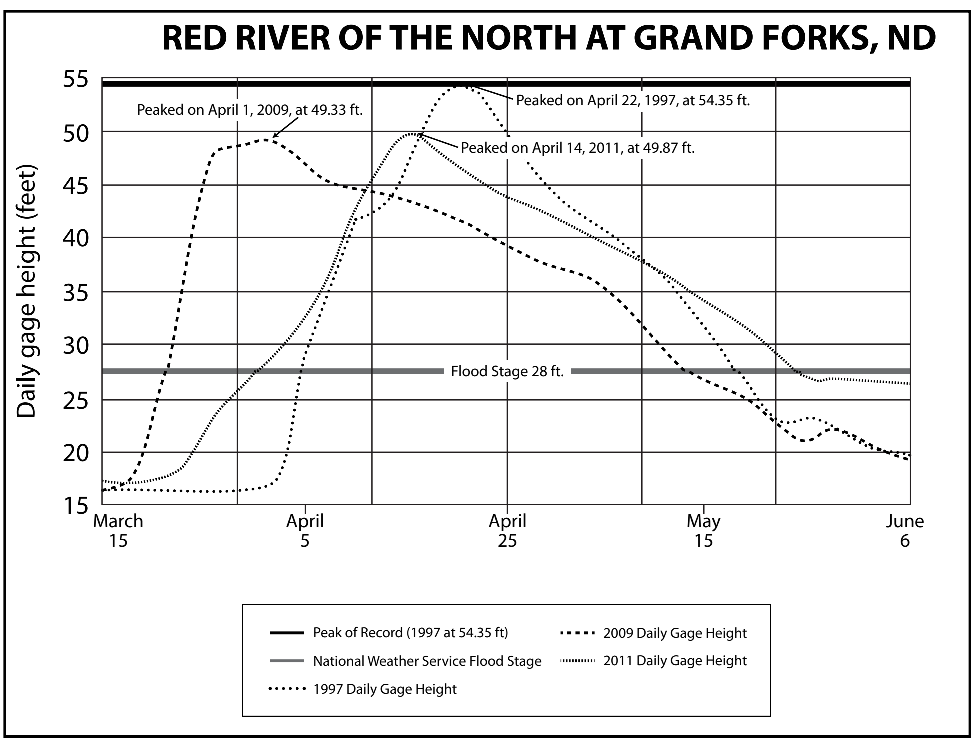

Figure 6-4
Hydrographs of the 1997, 2009, and 2011 Floods in Grand Forks
SOURCE: NDSWC 2011.

February. Several million sandbags were prepared and stored where they would not freeze. The Red River came up slowly at first, seemingly a "perfect melt" for a couple of weeks. Temporary clay dikes were constructed in several communities and last-minute buyouts of flood prone homes proceeded. Then the NWS predicted a chance of a record flood, accelerating flood fight preparations.


Red River Basin Commission

Main Avenue Bridge looking toward Moorhead from Fargo.

The Red River crested in Fargo at 38.81 feet on April 9 (Figure 6.1), somewhat earlier than predicted, and fortunately, much lower than it could have been. This was the fourth highest flood of record for Fargo-Moorhead. Just as F-M was breathing a little easier, record overland flooding began in northern Cass and Clay counties, largely due to floodwaters from the Sheyenne and Buffalo Rivers entering the Red River near the time it crested. Interstate 29 and hundreds of miles of other roads were inundated or washed out and closed for days.

In the northern Valley, or the lower watershed, flooding was less of an issue. Grand Forks had a crest of 49.87 feet on April 14, well below the city's protected level of 54 feet (Figure 6.4). The Red crested at Pembina at 51.92 feet on April 23. It crested in Winnipeg at 229.244 meters above sea level on May 3.

The 2011 flood, while only fourth in terms of its crest in the F-M area, set several other records. A record amount of money was spent preparing to fight the flood; overland flooding was of record proportions in several areas; and the mileage of roadways flooded, closed to travel, and washed out in the upper watershed was a record. The Red River in Fargo was above flood stage for 77 days in 2011, smashing the previous record of 61 days. It went below flood stage for 3 days, then back above flood stage for another 73 consecutive days, due largely to heavy summer rainfall, for a season total of 150 days.

It is also possible that a record amount of water, at least in recent times, flowed past some points of the river. The US Army Corps of Engineers (Bertschi 2011, 2012) estimates that[1]:

- 1,285,200 af flowed through Fargo-Moorhead during the 1997 spring flood;
- 1,366,700 af flowed through Fargo-Moorhead during the 2009 spring flood;


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Flood water spreads out across the valley.

[1] These acre-feet estimates represent the total flow above a baseline of 4,100 cfs. These numbers represent the area under the flood hydrographs.

- 1,386,500 af flowed through Fargo-Moorhead during the 2011 spring flood (April 1 through June 8); and
- Another 772,500 af flowed through Fargo-Moorhead due to summer rains in 2011 (June through August).

These total flow numbers are an indication of runoff water volumes upstream. Although the flood crest in Fargo-Moorhead in 2011 was nearly 2 feet lower than in 2009, slightly more water went through town. This difference is due to timing: more rapid melt occurred in 1997 and 2009 than in 2011. Had all other conditions in 2011 been similar to 1997 or 2009, the flood of 2011 would have been the highest flood crest ever in Fargo-Moorhead.

The third major flood in three years may have also resulted in a record amount of concern about protection from future floods. Community leaders began saying, "we have to get out of the sandbag business and find more permanent solutions."

Red River near Main Avenue Bridge in Fargo, ND, 2011.

Concerns Fade

Not long after floodwaters recede, temporary dikes are removed, and damages are repaired, the memories of flooding also recede. People and governments soon loose their zeal for action as other events take over in their daily lives. Although some follow-through and action does occur, it is far less than what was anticipated and/or promised when flooding was still in the forefront of people's minds.

A check on progress six years after the flood of 1997 showed (Halliday 2003):

Washed out road.

> The broad consensus…was that the Red River basin is unquestionably in a better position to withstand a flood like the 1997 event now [2003] than it was at the time of the flood (p. 27)…there has been significant attention paid to implementing the recommendations to governments made by the IJC in its report, *Living With the Red*…expenditures to date are in the order of hundreds of millions of dollars and that similar amounts will be spent in the next five years.… The recommendations that have achieved the most success are those that involve…structural measures identified in the IJC report…. That said, there are some patterns of activity in response to the recommendations that give cause for concern. The recommendations that have achieved relatively little success are those that involve multiple agencies (p. 46)…a community may resist adopting higher regulatory elevations [for several reasons] (p. 27).

2009.

March 2010.

Sign marking flood level in Gimli, MB, 1996.

Allowing access to homes on the wrong side of a contingency dike involves building stairs over it. Moorhead, MN 2009.

Resistance to moving away from the river may include:

- People have nice homes and great views of riparian woodland,
- The cost of moving out of a designated floodplain could be high,
- There are no easy/painless alternatives for residents or politicians,
- Individuals feel "protected" by government buyouts, bailouts, insurance, and the thousands of volunteers who rush in to help when it floods.

> Once individuals have developed the floodplain, they subject the local community to the potential for considerable financial loss. If the individuals bore the entire flood-damage loss themselves, flood-plain development would be of little concern to the government—except as a moral responsibility to the individual who suffers due to his own disregard for the flood hazard. However, the individual is rarely willing to accept full responsibility. Government units usually bear the expense of flood fighting, evacuation, damage to private property, and repair of public utilities. Heavy public investment must therefore follow private investment on floodplains.… Intelligent planning and regulating of development in these floodplain areas is imperative, therefore, if damage from flooding is to be reduced (LeFever et al. 1999).

Repetitive losses of insured properties are a substantial issue (King 2005). For example,

> Between 1977 and 1995, the National Flood Insurance Program [NFIP] paid out $806,591 for repeated storm damage to a suburban Houston home that was valued at $114,480.… Critics say the program, rather than acting as a safety net against catastrophic damages from hurricanes [or floods], has become a taxpayer-funded subsidy to coastal [and floodplain] home owners and real estate interests to build and buy homes in high-risk areas (Gaffney 2010).

- Local governments are afraid of losing property tax base when areas are declared off-limits or structures are removed from the floodplain.
- Local governments are also afraid of losing population. They fear that people who are forced to relocate away from flood prone areas may move to another community, or if the risks of flooding are made clearer, people may not come to those communities.
- There may be a potential for environmental issues with some structural measures, such as flood walls and cutoffs, which might protect existing floodplain structures.

Red River Basin Commission

Flood losses.

- Local leaders, for whatever political or economic reasons, allow development where they may feel it isn't appropriate. "It is, perhaps, an unfortunate fact that, even given the benefit of sound planning advice, city governments almost always tend to "cave in" to pressure from interests that stand to profit from ill-advised development" (LeFever p. 56).

  Several areas at flood risk in Fargo continued to develop after the flood of 1997. Expensive new houses were built in the footprint of the 1997 flood. Only after the more catastrophic flood of 2009 did authorities get more serious about flood plain developments.

- Previous flood fighting success makes people assume they'll win again next time.

- There is the "We can beat it" mentality (Kolpack 2011). There are those river-side residents who refuse to give up in spite of the ongoing costs of flood fighting and buyout offers from the city, largely because they have successfully fought past floods. Also, because NFIP, local governments, USACE and National Guard, and FEMA will be there to help in times of major flooding.

What is the answer? There are 1,500 government units in the basin, many of which have a say in regulating the flood plain. This has been referred to as the "Tyranny of small decisions" (Leitch 2003). It has been suggested by many that a single water authority is needed to make the difficult decisions.

Following the flood of 1997, two local water professionals expressed divergent opinions about what could be done to reduce flood damages. One suggested better coordination among local permitting authorities and stiffer restrictions about construction in the floodplain (Leitch 2003). Another suggested it was a "triumph" to construct residences in the floodplain and engineering solutions were evidence it was possible (Langness 2003). The flood of 2009 demonstrated we can't be too bold about encroaching on the flood plain, which is a moving target.

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An alternative to traditional sandbags used in Fargo, 2011.

After the flood of 2009 struck the communities of Fargo and Moorhead, The FORUM editors opined:

> As flood home buyouts accelerate in Fargo and Cass County, more attention should be focused on keeping structures out of harm's way…. If we hadn't built in a flood zone, buyouts would not be needed…. The lesson in the county buyouts and the ongoing Fargo city flood-properties buyout program is clear: don't build near the river. But not everyone in government…got the message.… The community has learned a lot…since 1997. However, a most important lesson—don't build in harm's way—isn't getting through to everyone. (*The FORUM* editorial May 25, 2010)

Following the flood of 1997, the City of Fargo had concluded "home buyouts probably became the city's most important tool for flood mitigation. Protective diking and topographic and code changes also play important roles in minimizing future flood problems" (Stensrud 1999 p. 32).

When the next dry cycle hits the Red River Basin, everyone needs to be reminded that it will get wet again—and the current #1 flood of record will be dwarfed at some time in the future.

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Chapter 7
Drainage: A Continuing Issue

No area on earth has been so intensively drained
for agriculture as the Red River Valley (Waters 1977).

Introduction

Managing the water resources of the Red River Basin is complicated for a variety of reasons, including the fact that the river is a complex system. Many basin residents, on the other hand, view the river as a natural resource to be managed or "fixed" from time to time to better serve people, either directly or indirectly. It should be noted, however, while they may agree rivers can be managed for someone's good, they frequently disagree about whom that someone is or what specific management options should be used.

Because the river is used in so many ways by so many, a collision of management strategies is almost inevitable. Other factors such as limited funding or cumbersome land acquisition procedures can impede progress. But generally, it is the lack of agreement about exactly how to solve a particular problem or to meet a specific need that makes projects and programs so difficult to implement.

Agricultural land drainage is a case in point. Probably no other water management practice in the basin is more controversial or misunderstood. A wide spectrum of viewpoints exists on the subject. At one end of that spectrum is the idea that, without drainage, the Red River Valley would be a useless swamp. At the other end is the belief that most, if not all, of the region's water management problems would be solved if only the drainage practices implemented over the past century and a half were undone. In between these ends of the spectrum lie a wide range of viewpoints. In this chapter, that range of viewpoints will be explored and discussed within the context of a basin-wide drainage system that has evolved over time.

Jay Leitfch

Installing patterned drainage near Glyndon, MN.

It is important to distinguish between drainage of ***wet lands*** (two words) and drainage of ***wetlands*** (one word). Wet lands are areas where the soil is saturated to a level prohibiting equipment use or inhibiting plant growth. There may or may not be surface water present on wet lands. Wetlands are legally defined areas according to their plant, water, and soil characteristics. Documents defining the many types of jurisdictional wetlands may be over 100 pages long. There are many legal and also many biological definitions of wetlands and they often overlap or conflict. Wetlands are the subject of "no net loss" legislation in some US jurisdictions.

Agricultural Land Drainage

The purpose of agricultural land drainage is to remove water in excess of the needs of crops during the growing season which, if not removed within a certain time period, could either destroy crops or substantially reduce yields (Whitney 1990, Sprynczynatyk and Backstrand 1984). It is important to note that agricultural drainage systems are not flood control systems (Carlyle 1984, Whitney 1990). They do provide some degree of enhanced drainage of spring floodwaters and they may advance the time when seeding becomes possible, but their flood control benefits are incidental to their primary purpose of removing excess water from agricultural lands during the growing season (Whitney 1990).

Removing excess water through drainage increases land's agricultural productivity in several ways. By increasing the depth of the root zone, for example, more plant food is made available and plants are more drought resistant. In addition, increased amounts of oxygen are made available to plant roots in better ventilated soils, soil bacteria grow better, soil temperatures are increased, and earlier planting is possible (U of M Extension 2011).


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A field drainage ditch.

Land drainage that successfully removes excess soil moisture in cropland saves time and money and enables more acres to be put into production. It is no longer necessary to return at a later date to finish seeding or harvesting.

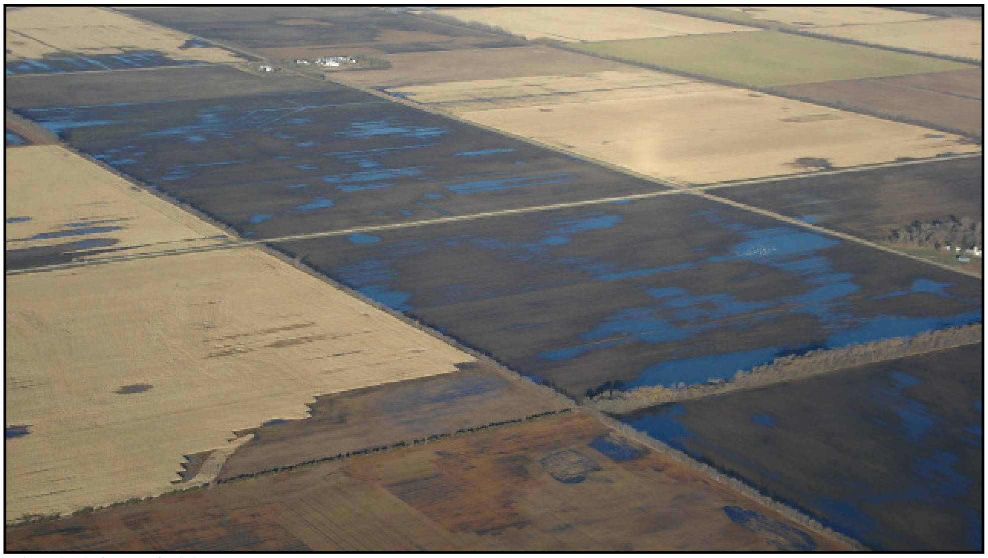
In the Beginning

Throughout most of the 19th Century, substantial portions of the Red River Valley were either temporary or permanent wetlands or wet lands. Early settlement throughout the basin was largely along river channels and in well-drained areas. "The wettest areas, which the early settlers avoided, were generally located midway between the Red River and the highland to the east and west" (Carlyle 1984).

So long as land was available, the practice of bypassing the wet areas continued, but with the advent of the railroad and the influx of new settlers, this picture changed dramatically. Access to markets in eastern Canada and the United States increased the demand for agricultural land throughout the basin. "It has been said that the first immigrants who got off the train shouldered their belongings, took family in tow, and walked uphill out of the flat, waterlogged lands in the Red River Valley until they found suitable lands to settle" (Whitney 1990).

Inevitably, the availability of well-drained lands dwindled to a point where they were no longer available. Predictably, attention then turned to poorly drained lands which, though potentially suitable for agriculture, were in many years little more than shallow lakes, sloughs, or bogs.

Natural levees built by the deposition of silt during floods along Manitoba rivers such as the Assiniboine and Red prevented natural surface drainage from reaching the rivers. As a result, extensive swamps, marshes, and bogs were formed when water from the upper part of the watershed was trapped in low ar-



Flooded farm fields.

eas of the valley. The same levee-building process took place east and west of the main stem of the Red River in Minnesota and North Dakota (SRRRBC 1972).

Boyne Marsh, St. Andrews Bog, and Elm Creek in Manitoba are examples of permanent wet areas which benefited agriculture when drained. "These lands are now numbered among the best in the province—because of drainage." (Whitney 1990). Prior to drainage, large, permanent marshy areas existed between Minnesota's Wild Rice and Red Lake Rivers. The townships of Scandia and Hubbard, west of Beltrami, had large permanent marshy areas. There were also large areas north and west of Ada in Pleasant View, Anthony, Halstad, Shelly, and Good Hope townships. These areas are in the Sand Hill and Wild Rice-Marsh subbasins (Murray 1967).

Permanent wet areas did not constitute the only areas where wet conditions made it difficult, if not impractical, to farm. Farmers settling on what appeared to be drier lands in the upper valley found that during wet years their total usable acreage was much reduced. Other portions of the Red River lowland were not continuously wet, but during years of above average rain or snowfall they were often unfit for cultivation (Murray 1967).

On the margins of the basin, certain areas required extensive drainage to make farming feasible. The Devils Lake Basin, a historically noncontributing (i.e., a closed basin) portion of the Red River watershed in North Dakota, is one such example (Sprynczynatyk and Backstrand 1984).

"The extent of the drainage problem varied from year to year, but from the beginning, Red River farmers were handicapped by wet land" (Murray 1967).

Early Drainage Activities

The first drainage in the basin was rudimentary and done by hand or with horse-drawn equipment. In areas where it was too wet to use horses, a machine called a capstan ditch plow was sometimes used. In this practice, single teams of horses positioned on solid ground on each side of the ditch under construction drew cables across rigidly fixed capstans. When the small scraper attached to the cables reached drier ground, its contents were removed using another team (Sprynczynatyk and Backstrand 1984).

Technology

Early drainage activities undertaken by hand with shovels or with the aid of horses were at times based on "eyeball" surveying techniques. Even after surveying equipment became more sophisticated and accurate, removing excess water from land continued to be the main objective. Drainage was difficult considering the equipment available. It was accomplished in early years without benefit of the engineering expertise employed in designing and constructing the drainage works being installed today. Modern day, on-farm drains and smaller laterals are frequently constructed by farmers using powerful farm tractors and earth-moving equipment. Huge earth-moving equipment of the kind employed in highway construction or dam building is commonly used in constructing larger ditches and primary canals.

Land drainage has gone beyond surface ditches and canals, the earliest method of removing excess water. Some low areas are drained using drain tile buried below the surface. As Red River farmland became more valuable, more wet lands were drained using systems of buried tile to draw down water levels in saturated soils. About the same time, land planes were used to both level fields and to slope the surface toward an outlet. Next were laser-guided ditching equipment and planes to provide more precise drainage. Most recently, laser-guided equipment is being used to bury grid-like systems (i.e, general field drainage) of plastic drain pipe.

Consideration is now given to the type of crop to be raised on drained land. Certain specialty crops have little tolerance for excess moisture, and losses can occur within a few hours of inundation. Cereal crops also have limited tolerance for excess water, but most losses may be prevented if water is removed within 36 hours. Forage crops can withstand flooding for up to four days during the active growing season without showing yield reductions. Excess water on native hay and pasture lands should be removed within 10 days to prevent losses (Whitney 1990).

David Hopkins

Equipment used to bury continuous plastic drain tile in fields.

And the Law

The states of Minnesota and North Dakota and the province of Manitoba may never adopt a uniform set of standards to recognize differences in the tolerance of various crops to wetness conditions. But to a greater or lesser degree, these and numerous other factors are now being considered in the design of drainage works. One hundred years ago, they were not.

Just as the equipment and technology used in constructing drainage works has changed and design standards have become more formalized and focused, so too have the attitudes of citizens and government evolved about agriculture land drainage. It is commonly accepted, for instance, that parties engaged in drainage a century ago—be they individual farmers acting independently or through a governmental agency—gave little, if any, thought to the adverse impacts the measures they were installing might have upon other values such as wildlife, water quality, or flooding. Wildlife was in great abundance, and habitat seemed plentiful. "Water quality" was a term not yet part of most vocabularies and the effects of drainage on flooding, if any, were unknown. Much of this has changed because, throughout the basin, a body of drainage law has been evolving which requires the impact of drainage on other values be measured and mitigated where appropriate. The laws about drainage of wet lands are mostly concerned about the movement of water onto another person's property and the potential harm that could entail.

Manitoba: Early examples of the relatively limited drainage undertaken in Manitoba prior to passage of the *Drainage Act of 1880* involved construction of off-take drains to the Assiniboine River and some drainage constructed in association with new railway construction. The 1880 act provided for a general survey of wet areas, creation of drainage districts, and digging of ditches by rural municipalities. "By 1881 approximately 200 miles of drains had been excavated at a cost of nearly $100,000" (Murray 1967).

In 1883, the provincial government enhanced the drainage of a sizeable marshland area, making it suitable for agriculture. The incentive for doing so was strong, since ownership of the land in question passed from the dominion to the provincial government as a result.

Still, drainage did not begin in earnest until 1895 when the *Land Drainage Act* was enacted. Among other things, it authorized creation of independent drainage districts and provided a framework for implementation of large-scale organized drainage in the province (Whitney undated).

Not all of the drainage districts formed under the authority of the 1895 act were successful. Several of the 24 districts organized throughout the province were dissolved early in their development because of "peculiar topographical, engineering, political, or financial problems." Still, notwithstanding these problems, by 1930 approximately two million acres were being administered by drainage districts throughout Manitoba (Whitney undated).

Surviving districts were not without their problems. Landowners complained of not receiving benefits in accordance with their assessments, maintenance was lacking, and district drains were being forced to handle "foreign water" exported into the district drainage system from outside the district.

The difficult economic conditions of the 1930s aggravated the problems of the districts. Payment of debts incurred to implement drainage works fell behind and maintenance fell even further behind. The Finlayson Commission, which was appointed by the province to find "mutually acceptable" solutions to the problems of drainage districts, recommended, among other things, that drainage maintenance districts be established. The *Land Drainage Act of 1936* provided the necessary legislative authority, but instead of agreeing to pay one-third of the cost of maintenance activities, the province limited its annual share to an amount equal to one-half percent of the capital expenditures in each district (Whitney undated).

In 1947, the province appointed Mr. M. A. Lyons, a former Deputy Minister of Public Works, "to examine the financial contribution of the province to the districts and the problem of foreign water" (Whitney undated).

The Lyons Commission recommended that the province assume: (1) two-thirds of the cost of construction and maintenance of drains carrying foreign water, (2) one-third of the cost of construction and maintenance of drains intercepting and carrying local water originating in the district, and (3) 100 percent of the cost of reconstruction of major floodways carrying foreign water through the districts of the Red River Valley.

This policy remained in effect for the next dozen years; however, the ability of the districts to properly carry out their mandate, even with this increased provincial support, again came to question due to a number of factors (Whitney undated).

Conversion of land to the production of higher-valued crops, which required a higher drainage standard, coupled with demands for other services such as health, education, and transportation, acted to impair the districts' ability to keep pace with funding needs (Whitney undated).

As a consequence, another Royal Commission was appointed to evaluate how municipalities could better deal with the financial aspects of drainage. The commission's recommendation was that the province assume full responsibility for drains other than those of a purely local nature. Adopted in 1965, the commission's recommendations are the cornerstone of the current system employed by Manitoba to deal with agricultural land drainage.

Today, all new private land and municipal drainage work must be licensed under the *Water Rights Act of 1988*. In addition, the province of Manitoba uses a systems approach to the reconstruction of works under its jurisdiction. This means that, in building a new project or reconstructing an old one, consideration is given not just to the new components but to the entire system from on-farm drains to major outlets. "In allocating funds to the removal of excess rainfall from agricultural land, priority is given to the maintenance and reconstruction of existing agricultural drainage systems" (Whitney 1990).

Drainage projects proposed by the province are not subject to the Water Rights Act, but may be subject to federal environmental legislation. Works proposed for lands under federal control, such as railways and First Nations reservations, are not subject to the Water Rights Act (Stonehouse 2011).

Flooded farm fields in 2002.

Conservation Districts, authorized in 1959, permit a number of municipalities to coordinate their efforts with respect to all aspects of water management, including drainage. Since the first district was formed in 1972, a total of 18 districts have been formed, five of which are located either wholly or partly within the Red River Basin. Provincial policy is to pursue the formation of additional districts.

> Conservation districts play an important role in water management planning but, with the exception of 4 conservation districts, do not construct or maintain drainage works. Four conservation Districts agreed to assume responsibility for maintenance of Provincial Waterways within their boundaries and have continued to maintain these drains and drains constructed by municipalities within their boundaries. One conservation district has chosen to partner with the province in licensing of drainage under the Water Rights Act. (Stonehouse 2011).

Minnesota: The history of agricultural land drainage in the Minnesota part of the Red River Basin closely parallels Manitoba's. The timing and pace of drainage activities in Manitoba and Minnesota are remarkably similar.

Initially, the approach to drainage in Minnesota was more complex than in Manitoba, with state, county, and municipal authorities independently building drains. The responsibility for drains eventually went to the county, but instead of delegating that responsibility to a drainage district, the board of county commissioners retained authority (Carlyle 1984).

As more and more drainage works were installed, particularly on cleared highland to the east of the valley, problems arose in Minnesota that duplicated those caused by the flow of water from the uplands of Manitoba (Carlyle 1984).

As was the case in Manitoba, some of the very earliest drainage was undertaken by railroad companies. In 1879, to protect its roadbed in the valley, the St. Paul, Minneapolis, and Manitoba Railroad constructed 15 drainage ditches ranging from one-half mile to 16 miles long. Though modest in size when compared to those implemented later, the project was a success, and it encouraged area farmers to begin similar projects on their lands (Murray 1967).

Minnesota's first comprehensive drainage act was passed in 1883. Among other things, the act outlined a process for petitioning for drainage projects, authorized hearings and appeals for those whose land would be involved, established the means of assessing the cost of each project, and spelled out procedures for maintaining the drains. In 1887, the Minnesota legislature expanded the Act of 1883 to include provisions that (1) allowed state lands to be assessed for drainage improvements, (2) permitted county units to issue bonds and to use their general funds for drainage expenses, and (3) made possible the creation of permanent drainage districts on both a county and township basis (Murray 1967).

Legislation passed in 1955 provided a basis for management of water resources on a watershed basis. The watershed approach, which also addressed artificial drainage, was soon adopted for large portions of the Red River Basin. New drains and those being rebuilt automatically come under the control of watershed districts. Jurisdiction of unreconstructed drains is retained by county commissions unless they voluntarily transfer their authority to the watershed districts. Some counties that are in watershed districts retain control over these drains (Carlyle 1984).

The evolution of Minnesota drainage law is, of course, far more complex than this brief summary. Current drainage law is the result of dozens of individual legislative actions and court rulings over the years since the mid-1800s; it continues to change. Certainly, one of the more far-reaching and innovative initiatives, passed in 1991, is the concept of "no net loss" of wetlands.

Installing plastice drain tile near Glyndon, MN.

The state's regulatory authority over drainage increased in 1991 with the passage of the *Wetland Conservation Act* (WCA). WCA embodies the concept of "no net loss" and provides a mechanism for guiding the future of wetlands in Minnesota. Numerous organizations representing a broad spectrum of interests discussed, debated, and negotiated compromises on this important wetland legislation (Gibson 1990). WCA was clear evidence that attitudes toward wetlands in Minnesota had swung 180 degrees since statehood (Leitch and Randall 2011).

WCA regulates activities that impact wetlands through draining, filling, and in some cases, excavating. The intent of the act includes minimizing the unintended effects of wetland drainage on other landowners and the public in general. One notable provision of the act is the state legislature's finding that it is in the public interest to:

1. achieve no net loss in the quantity, quality, and biological diversity of Minnesota's existing wetlands;

2. increase the quantity, quality, and biological diversity of Minnesota's wetlands by restoring or enhancing diminished or drained wetlands;

3. avoid direct or indirect impacts from activities that destroy or diminish the quantity, quality, and biological diversity of wetlands; and

4. replace wetland values where avoidance of activity is not feasible and prudent. (Harnack 1990).

This finding establishes the basic foundation of the law, commonly referred to as "sequencing," which requires landowners proposing to impact wetlands to first attempt to avoid the wetland impact (i.e., to avoid drainage), second to minimize any unavoidable impacts, and finally to replace any unavoidable impacts with wetlands of equal or greater public value. Replacement wetlands typically consist of restoration of previously drained wetlands, creation of new wetlands where none previously existed, or purchase of credits from a "bank" of such previously established wetlands. WCA rules provide detailed requirements for the size, location, type, and other characteristics of replacement wetlands. The act also provides for exceptions to the sequencing requirement of the bill. For example, exceptions currently include wetlands that were cropped six of the ten years prior to passage of the act and wetlands that have been created as a result of beaver dam construction or the blockage of culverts through public roadways.

The act required development of state rules for the program. WCA statutes and rules have been amended numerous times since the act was originally enacted. The most recent (and most-encompassing) rule revision occurred in 2009, with statute amendments occurring as recently as 2008. While many of the details change and WCA continues to evolve, none of the amendments have changed the central requirement of the act to avoid, minimize, and replace wetland impacts (Lemm 2011).

The authority for implementing WCA lies primarily with local governments, usually the county or city. Where watershed districts exist, however, it is not uncommon for counties and cities to delegate authority to implement WCA to the watershed district.


Red River Basin Commission

Grass and tree buffer.

North Dakota: In 1882, seven years before statehood, North Dakota passed legislation which enabled landowners to "drain and reclaim land." North Dakota did not have the large, marshy areas characteristic of Manitoba or Minnesota, but during wet years, the total acreage available for cropping was substantially reduced by the presence of excess water. These wetness problems also prevented the building of roads, forcing farmers to "take long, circuitous routes in order to haul grain to market" (Murray 1967). By 1890, over 72,000 acres of land had been included within established districts (Sprynczynatyk and Backstrand 1984), and records of the North Dakota State Water Commission indicate that at least that many acres had benefited from drainage outside of districts.

In 1893, four years following statehood, the 1882 law was repealed and new legislation passed which provided for establishment of boards of drain commissioners to oversee drainage activities. Boards were established in several counties and drainage took place at a rapid rate. During the 30-year period after 1890, an additional 1.2 million acres came under the jurisdiction of the drainage districts. The 1893 law did not regulate drainage in areas where boards of drainage commissioners were not established (Sprynczynatyk and Backstrand 1984).

Still, drainage activity in North Dakota, as well as in the Manitoba and Minnesota portions of the basin, was sporadic. Wet conditions, as might be expected, tended to generate increased drainage activity. Conversely, dry conditions resulted in dramatic downturns in construction of drainage works. The pace of drainage activity was sharply curtailed in the 1920s (Augustadt 1955). During the drought of the 1930s, drainage came to a virtual standstill. Drainage districts were no longer being formed. The demand for additional drainage was negligible, and in fact, most of the existing drains were filled with blow dirt. Between 1920 and 1940, less than 200,000 new acres came under the jurisdiction of the drainage districts.

Legislation in 1957 provided that anyone wishing to drain a pond, slough, or lake which had a drainage area of 80 acres or more had to obtain a permit. A 1975 law made individuals who drained without a permit subject to prosecution, gave local water management entities the authority to close illegal drains, and required that districts consider the downstream impacts of proposed drains (Sprynczynatyk and Backstrand 1984).

Red River Basin Commission

Pothole.

Since 1975, much greater emphasis has been placed on enforcing the state's drainage laws. In 1981, the State Legislative Assembly passed another drainage law designed to more closely regulate drainage activities. Applications for surface drains are evaluated by the State Engineer to determine whether or not the drainage is of statewide or interdistrict significance. In making that determination, the following criteria are considered:

- The size of basin and area of wetland being drained;
- The effect, if any, upon property owned by the state or a political subdivision;
- The extent to which sloughs, ponds, or lakes having recognized fish and wildlife values will be drained;
- Whether a meandered lake will be drained;
- The effect the drainage will have on another water management entity;
- Whether the drainage works being contemplated would convert previously noncontributing areas into permanently contributing areas; and
- For good cause, the State Engineer may classify any proposed drainage project as having statewide or interdistrict significance or determine the proposed drainage is not of statewide or interdistrict significance.

If the State Engineer declares the drainage works contemplated in the permit application to be of statewide or interdistrict significance, the application is returned to the local water resource district, and a hearing is held. Local officials must consider a number of specific items in approving or disapproving the permit. If the State Engineer determines the proposed drainage is not of statewide or interdistrict significance, the decision of the local water resource district is final unless appealed to a court. Upon approval by the district, an application to drain becomes a permit to drain.

North Dakota's approach to wetlands management dramatically altered the circumstances under which additional agricultural drainage can occur. The changes are manifested in the state's no-net-loss program. The North Dakota program was created by the 50th North Dakota Legislative Assembly and implemented effective July 1, 1987. It was the first of its kind in the United States. However, the no-net-loss part of the law was repealed during the 1995 Legislative session. The 1995 change to drainage law also included the need for a permit to drain "temporarily ponded sheetwater" of more than 80 acres.

The Federal Role

Though there are obviously both subtle and not-so-subtle differences in the drainage laws of Manitoba, Minnesota, and North Dakota, they are understandably similar. After all, the forces which triggered the need for such laws in Manitoba were essentially the same forces at work in Minnesota and North Dakota, i.e., the rapid influx of settlers seeking land to farm and the substantial acreages of permanently or intermittently wet areas which did not lend themselves to sustained farming without drainage. History records that the evolution of drainage law within the province and the two states followed similar tracks in terms of both timing and substance . . . up to a point.

Today, in Manitoba, drainage law remains largely a provincial prerogative. In the United States, however, the influence of the federal government—both directly and indirectly—has grown rapidly since the mid-1950s, beginning with passage of the *Fish and Wildlife Coordination Act*. The act requires that agencies of the federal government involved in drainage projects must consult with the US Fish and Wildlife Service concerning the conservation of wildlife resources. The intent of the act is to prevent the loss of wildlife habitat and to provide, where possible, the development and improvement of such resources.

In the US, the *National Environmental Policy Act* (NEPA), passed in 1969, was intended to promote efforts which would prevent or eliminate damage to the environment, including wetlands, and to stimulate the health and welfare of man by advancing his understanding of the ecological systems and natural resources of the nation. This act, though broad in scope, impacts on drainage both directly and indirectly. An example of a direct, specific federal impact on drainage can be found in *Executive Order 11990* issued by President Jimmy Carter in 1977. This order directed federal agencies to take action to minimize the destruction and loss of wetlands and to preserve and enhance the natural and beneficial values of wetlands.

In many ways, though, the single most significant federal act relating to agricultural drainage may be the *Food Security Act of 1985*. This federal legislation, which is popularly called the 1985 Farm Bill, contains several conservation provisions. Major components include the Conservation Reserve Program, which offers producers help in retiring highly erodible cropland; a "Sodbuster" provision, which requires that landowners have an approved conservation plan before planting annually tilled crops on highly erodible land; and a "Swampbuster" provision, which largely prohibits the production of annually tilled crops on newly converted wetlands.

Red River Basin Commission

Wild turkeys thrive near the Red River.

It is this Swampbuster provision that embodies federal policy on wetlands preservation and, in so doing, creates a new framework within which agricultural drainage can occur. Producers who drain wetlands and plant commodity crops on converted lands are penalized by losing their federal program benefits for that crop year. The loss of benefits is applicable not just to the converted wetland but to the entire farm. Undoubtedly, for some landowners, the potential loss of benefits could translate into serious cash flow problems.

In applying for US Department of Agriculture farm programs, such as crop insurance, Farmers Home Administration loans, Conservation Reserve Program annual benefits, etc., farmers must certify that they are not producing crops on land that was converted from wetlands after December 23, 1985 (the date the Food Security Act was passed).

Changing Values, Changing Times

The drainage network in place today in the Red River Basin "has thousands of miles of principal drains and probably tens of thousands of miles of small laterals and on-farm channels." (Carlyle 1984). The Red River Valley is among the world's largest artificially drained landscapes.

Owners of millions of acres of farm land in the Red River Basin have benefited from drainage. In decades past, when drainage works were being installed at a rapid rate, few argued that the adverse impacts of drainage outweighed the benefits. But new attitudes about natural resources in general and about water management in particular are changing all of that. The collective body of laws and rules and regulations which now governs how and under what circumstances agricultural drainage can occur continues to change to better reflect the values and priorities of a society that understands actions taken in one water management sector inevitably impact either beneficially or adversely on other sectors. Water management in a vacuum is no longer acceptable.

Flooding of the Red River of the North main stem is a function of the volume and timing of runoff from its drainage basin. While runoff volume from a particular area in the drainage basin may be high, if this runoff reaches the Red River either before or after flood conditions are present, it does not cause damage. [Using an impoundment upstream of Emerson, Manitoba as an example] …the routed hydrograph [could] fall before the timing interval and does not contribute as significantly to the flood peak at Emerson. Construction of an impoundment within this subarea could lag the peak of the routed hydrograph and actually increase rather than decrease, the peak flood at Emerson. However, if the impoundments can hold the floodwater for a [longer] period of time beyond the critical flooding period at Emerson, then these impoundments could serve to reduce flooding level at Emerson (McCombs-Knutson Associates, Inc., 1984, pp. 13-14).

Drainage and Flooding

There are calls to restore wetlands and to regulate drainage following each major flood in the Red River Basin (see Appendix A to this chapter). Some believe such drainage contributes to flood flows, but the issue is whether or not drainage and/or storage contribute to flood crests, the most damaging, highest water part of a flood. Science suggests that ***distributed storage***, micro-storage, and retention can work to reduce flood crests in small watersheds (Apfelbaum et al. 2004, Tiner 1984). However, because of runoff timing and basin scale issues, the same generalization may not be true for major watersheds (IJC 2000, Columbia Missourian 2011, Appendix A to Chapter 7).

The gist of the debate can be demonstrated with two hydrographs, one for a small watershed and one for a watershed the size of the Red River Basin. Retention/storage in natural or constructed reservoirs can substantially change the flood hydrograph in smaller watersheds (Figure 7.1). Enough water, as a percentage of overall flood flow in a small basin, can be retained upstream to flatten out the hydrograph and reduce the flood crest, both timing and scare are at work to lower flood flows.

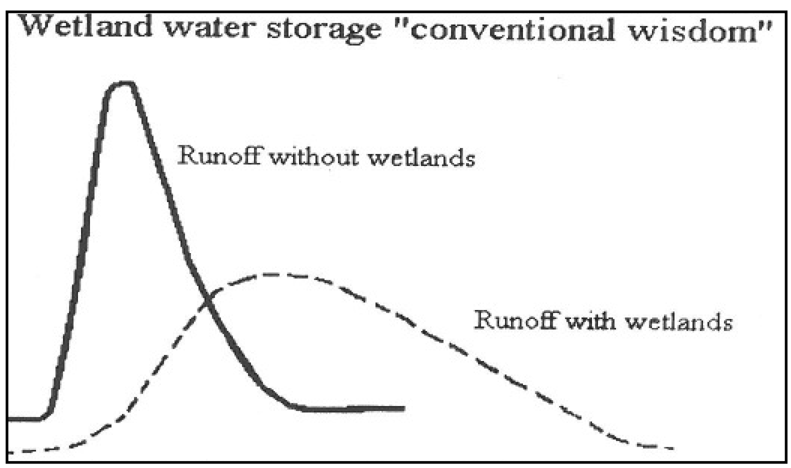


Figure 7-1
Optimal Timing and Adequate Scale of Retention Flatten Out the Flood Hydrograph in a Small Watershed
SOURCE: CAST. 1994 p. 23.

In large watersheds this may or may not be the case. Whether or not retention actually reduces the flood crest and not just the overall flood flow depends on timing and scale (Figure 7.2). The Red River Basin Flood Damage Reduction Work Group has a series of technical papers on this subject (see, for example, Anderson and Kean 2004). They conclude that peak flows could be reduced "using multiple types of FDR [flood damage reduction] measures in a strategic manner (p. 2)." The key is strategic operation to effectively manage what they refer to as "early," "middle," and "late" runoff areas (Anderson and Kean 2004).

The issue of scale refers to the relationship between the total volume of floodwaters and the potential volume that could be retained. The Red River Basin is notoriously flat, with little room for developing large-volume storage reservoirs. The reservoirs upstream of Fargo, for example, hold about 10 percent of the flood flow of a flood the size of 2009. If they are strategically operated so the 10 percent would come off the top of the flood crest, that would indeed reduce maximum flood levels. On the other hand, if they merely reduce overall flood flow, especially before or after the crest, they do little to reduce damages during the flood crest.

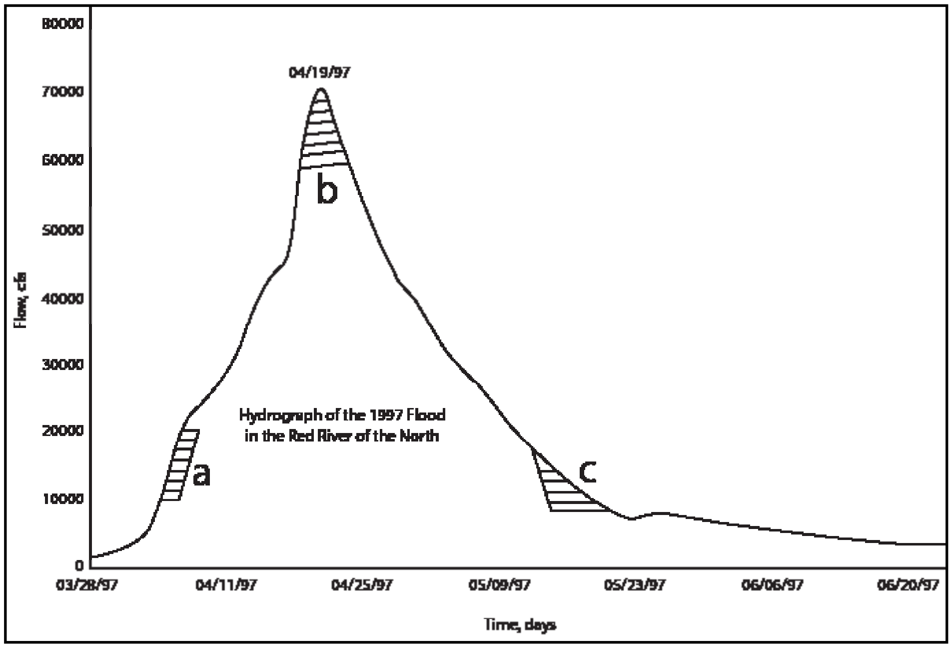


Figure 7-2
Runoff Timing and Scale are Crucial to Reducing Flood Crests in Large Watersheds During Low Frequency Events
[a. reduction out of rising limb; b. reduction of crest; c. reduction after crest]

Reservoirs are typically drawn down in anticipation of spring floods and allowed to fill during the flood. The small volume retained, relative to the total flood flow, may as well have come from the rising edge of the hydrograph (area "a" in Figure 7.2) as from the peak of the crest (area "b") or after the crest has passed (area "c"). It would only be through expert retention management (timing) that the peak would be reduced substantially.

This scale issue (and to some extent, timing) is why restoration of wetlands, or other micro- or distributed-storage methods, may not help to reduce flood crests in low frequency/high volume floods. There is just too little capacity and too much water—it's the proverbial "drop in the bucket." It's analogous to trying to reduce major city traffic congestion by keeping 5 percent of the cars off the road between 6 am and 9 am. This is complicated by antecedent conditions where higher than average precipitation results in full depressions with no room to retain runoff (referred to as ***bounce*** in the literature).

The "waffle plan" (EERC 2005) is a widely promoted distributed storage plan, but it suffers from both timing and scale issues, as well as management, implementation, and financial problems (see text box). The widespread flooding and washing out of rural roads during the floods of 1997, 2009, and 2011 also prove to be a weakness of the "waffle plan."

This is not to deny the many social values of wetlands in the Red River Basin, nor to deny the benefits of retention in smaller watersheds, as depicted in the text box. The issue is extending the relationships to major, low-frequency flooding, the type that causes widespread damages.

The US Army Corps of Engineers (USACE) also examined another upstream storage plan. This plan, referred to as the "waffle plan," utilizes farmland to retain water until the flood threat is over. Calculations by the USACE determined the "waffle plan" would require 3 feet of water to be stored over 1,120 to 2,150 square miles of farmland. It would require a "well-coordinated operating plan with defined timed storage requirements" and maintenance system in order to be effective in flood reduction (LeFever et al. 1999, p. 49).

Not only are there questionable hydrologic issues, with using restored wetlands to store floodwaters, there are also economic issues. A study in the Maple River watershed, a tributary of the Red River, concluded the benefit/cost ratios of wetland restoration to reduce flood damage were in the range of 0.2 to 0.7 (Schultz and Leitch 2003). A b/c ratio of 1.0 is needed to just break even.

"Special Wetland Funding to Reduce Flooding;…." (Farm Forum, p. 23, May 27, 2011)

Huron--$10 million will be available to help eligible landowners in three states reduce flooding, restore wetlands…in the Red River…Basin…. Landowners…are eligible for this special funding…that emphasizes WRP's (Wetlands Reserve Program) ability to mitigate flood damage by retaining higher levels of flood water within easement areas.

Considerable disagreement exists among professionals on the flood control value of upstream distributed or micro retention projects in the Red River Basin during major floods. That disagreement is evidence that there is uncertainty. As long as two groups of reasonable, informed people can not agree, then the issue is either (1) intractable, (2) ideological, or (3) lacks sufficient definitive, objective research. Drainage/retention in the Red River Basin seems to be a continuing controversy because of (2) and (3). Further sound research is needed.

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Appendix A to Chapter 7

The following two letters to the editor represent opposite opinions as to the role of wetlands in reducing flood damages.

The following letter to the editor was sent to *Minnesota Outdoor News*.

Editor:

You closed your October 8 (2010) editorial by asking "Does anyone doubt that rampant wetland drainage across this part of the country has amplified flood events?" In fact, yes, I do doubt it, as do many folks that have taken more than a superficial look at the role of mini-storage in large flood events. Yes, mini-storage (when seasonally available) may attenuate the flood peak in high frequency, smaller flood events. But, the same does not hold for the infrequent, large events, the type that causes widespread property damage.

You first have to understand a flood hydrograph, a depiction of how much water flows past a certain point over a period of time. When a major flood occurs, water may be out of the river banks (into "flood stage") for many days, even weeks. For example, in 2009 the Red River overtopped its banks in Fargo about March 21st and stayed above flood stage until well into April. During that time over 700,000 acre feet (my rough estimate) of water moved through Fargo-Moorhead. [actually 1.4 million af, US ACE]

There are three factors to consider regarding wetlands' role in flood water storage. The first is timing, when would the water stored have reached the mainstem in the absence of retention: not at all, prior to flood peak, at flood peak (March 27 to 29 in Fargo in 2009), or after flood peak? Think about what happens as snow starts to melt in the upper reaches of a watershed. It melts, runs into low areas, and fills up depressions. When the depressions (i.e., wetlands) are filled, they overtop and the water continues on to the next depression, or to a tributary and eventually to the mainstem of the river. Wetlands are the first to fill, capturing potential flood waters that represent the early portions of a flood hydrograph as waters are rising. Only through some miracle would the water captured by a wetland actually reduce the flood peak. However, that is what most proponents of micro-storage assume: storage only comes into play at the peak of the hydrograph.

Think about it like traffic congestion in the city and we hold back all the commuters who leave their homes at 6 am and get to work at 7 am, does that reduce congestion at 8 am? It reduces the total volume of traffic, but does nothing to reduce the peak and the peak is what causes the damage.

A second factor is antecedent conditions, or how much water was in the wetland (and the soil) before meltwater runoff. Wetlands and many closed-basin lakes in the Red River Valley of Minnesota have been overflowing for several years. A full, or overflowing, wetland cannot hold any spring runoff. In fact, a full wetland is about as helpful as a parking lot in retaining water. When it is wet, wetlands are likely to be full! When it is dry, wetlands have some capacity to capture runoff, but then we don't need it!

Finally, it is clear from the simple ratio of the cumulative capacity of the watershed's wetlands to hold water compared to the volume of water in a low frequency flood, it's only a drop in the bucket! There just isn't enough micro-storage to capture and hold the huge volume of water in a serious flood. And, given the timing argument, holding back a percentage of the flow will only help if it is the correct percentage during peak flow.

I will concede that if wetlands had remotely-controlled outlet control structures and hydrologists could accurately predict spring melt temperatures, ***runoff volumes***, and the shape of the flood hydrograph, then a management plan could be developed to capture water in wetlands when it would do the most good in reducing the flood peak.

I think wetlands are wonderful and serve society in numerous ways. However, it is naïve and hydrologically misleading to argue unconditionally that wetland drainage contributes to flood damages during low frequency flooding. Always ask: How do you know that? How, exactly, does that work? before blindly following the crowd! The greatest flood on record in the Red River Valley occurred in 1826, long before any wetlands were drained or any fields had tile drainage.

Jay A. Leitch
Moorhead, Minn.

The following appeared in the *Winnipeg Free Press,* February 28, 2011, p. A12.

Leave the wetlands wet

By: Bob Grant

Forecasters are calling for Manitoba's second massive flood in the last 15 years. Anxiety is high as people brace for the worst. Water pouring over land is indeed one of Mother Nature's most destructive forces. And while conditions and precipitation have put us in this position, when do we start thinking about next time?

With flooding expected across much of our province, there is always a strong call for more drainage. The problem is, some of that drainage work ends up not only draining our wetlands, but contributing to more intensive downstream flooding. When wetlands are drained, that water needs to go somewhere; usually negatively impacting our neighbours and others downstream.

No matter how bad the flooding situation is this year, the science is clear -- wetland drainage will only make our next flood event worse.

Wetlands help reduce flooding by acting as sponges; holding water, then slowly releasing it back onto the land. Wetland drainage not only removes water from the wetlands, it also removes the water from the surrounding lands that filled those wetlands during spring runoff and storm events. On average, for every acre of wetland drained, an additional five acres of surrounding area is added to downstream flows.

Flooding causes major damage and costs all of us in infrastructure repair and compensation expenses. The costs to repair the damage done in a flood year will only increase if we keep draining wetlands.

It is estimated wetlands provide more than $400 million in flood-prevention benefits in southwest Manitoba alone.

These benefits transform into flood-fighting costs as wetlands are drained -- costs such as building and maintaining replacement water retention areas, more or higher dikes, levees and diversions, and floodway construction. Then there are the extra costs associated with additional flood damage, which could have been prevented. Manitobans pay for all these expenditures through our taxes.

Ducks Unlimited Canada's (DUC) most recent research in the Broughton's Creek watershed in southwestern Manitoba estimates wetland drainage has increased total runoff (total volume of water draining downstream) by 62 per cent and peak discharge (high water flows) by approximately 37 per cent.

DUC's research suggests if we continue to drain the remaining wetlands from the Broughton's Creek watershed, total runoff will almost triple in volume and peak discharge will more than double. Given the impact flooding has had on agriculture, infrastructure and human life these last few years alone, we cannot afford to continue down this path. The flood-mitigation benefits of wetlands alone demand we take responsibility to protect what wetlands remain and restore what we can.

We should learn from others -- while we still can. Over the last number of years, flooding has been no stranger to the state of Iowa.

Environmental experts have said in the news many of their flood events could, in fact, be considered acts of man rather than nature, as man has removed the natural features and water-absorbing benefits from the land.

Iowa's Water & Land Legacy website states less than 10 per cent of that state's original wetlands remain and they have lost about 200,000 hectares of wetlands that could otherwise mitigate damage from future flooding.

Researchers have also linked the damaging 1993 and 1995 floods in the Mississippi River Valley to wetland drainage.

Wetland drainage is a major environmental and economic issue all Manitobans should be concerned about. Wetland drainage contributes to flooding and impacts our taxes and our lives. We can't afford to lose anymore wetlands.

Stopping wetland loss is an important solution to preventing even greater flooding problems in the future. Manitoba needs a wetland policy that protects wetlands so they can protect all of us.

Manitoba is headed into an election this fall and Manitobans need to make wetlands an election issue. Talk to your local candidates and tell them why wetlands are important for reducing flooding and to you. We need to act now before others look to Manitoba as a lesson to be learned.

Bob Grant is manager of operations Ducks Unlimited Canada in Manitoba.

Chapter 8
The "Not Enough" Problem

Introduction

Though water is used in a variety of ways in the Red River Basin, the focus of this chapter is primarily on water supplies for communities, farms, and industries. Broad questions of adequacy or inadequacy in terms of changing values and perspectives will be addressed, rather than "water budget" statistics.

The Red River Basin is thought by some to be an area with adequate supplies of water, an understandable perception given the large acreages which had to be drained before they could be farmed and the frequency and magnitude of flooding in the basin. However, residents may be faced with water shortages as well as flooding. Floods, which can be catastrophic events, garner newspaper headlines and television coverage. "In contrast, water shortages (gradual events) have generated little interest, except in the immediate vicinity where they occur. Shortages rather than surplus of water in the long term may be the more severe handicap for the area" (Carlyle 1984).

Red River Basin Commission

The opposite of flooding, periods of low flow also occur in the Red River.

Indeed, the variable nature of the basin's water resources is such that problems at both ends of the supply spectrum can occur within a span of only a few months. Floods and drought can even occur simultaneously in different areas of the basin.

Water Use and Rights

Water use may be either consumptive or nonconsumptive. Consumptive use means the water is used up and is not available to other users in the immediate area in the current time period. Consumptive use is measured as the difference between the amount of water withdrawn from a source and the amount returned to the source in the same time period. Examples of consumptive uses are evaporation; direct consumption by humans, animals, and plants; and incorporation of water into the products of industry or into food processing. Surface water that moves into the ground may also be termed "consumed." Severe pollution is also consumptive use of water, since the water is unavailable to other users without investments in cleanup.

Nonconsumptive uses involve either using nondiverted water in a way that does not reduce the supply (e.g., hydropower), or using diverted water and returning it to the source without reducing the supply. Maintaining water levels for fisheries and water-based recreation is an example of a nondiverted, nonconsumptive use. Diversion of water for cooling purposes in the generation of electricity is an example of a diverted, yet nonconsumptive water use.

Water Use Accounting

An area's water resources are used for a variety of purposes, ranging from human and livestock consumption, to industrial uses, to boating and fishing (Figure 8-1). Categories of water use in the Red River Basin include municipal and industrial (M&I), self-supplied industrial, rural domestic, livestock, irrigation, outdoor recreation, and fish and wildlife. The water use accounting systems of Minnesota, North Dakota, and Manitoba are not uniform in either the manner that uses are recorded or in the time periods reported. These differences make it all but impossible to directly compare water use statistics among the three areas.

For the irrigators and other users of large quantities of water, such as industry and power generation, use is expressed in af. A city's right to withdraw water from a surface or ground water source may be expressed in af per year, but its water plant is likely described in millions of gallons per day (mgd) capacity.

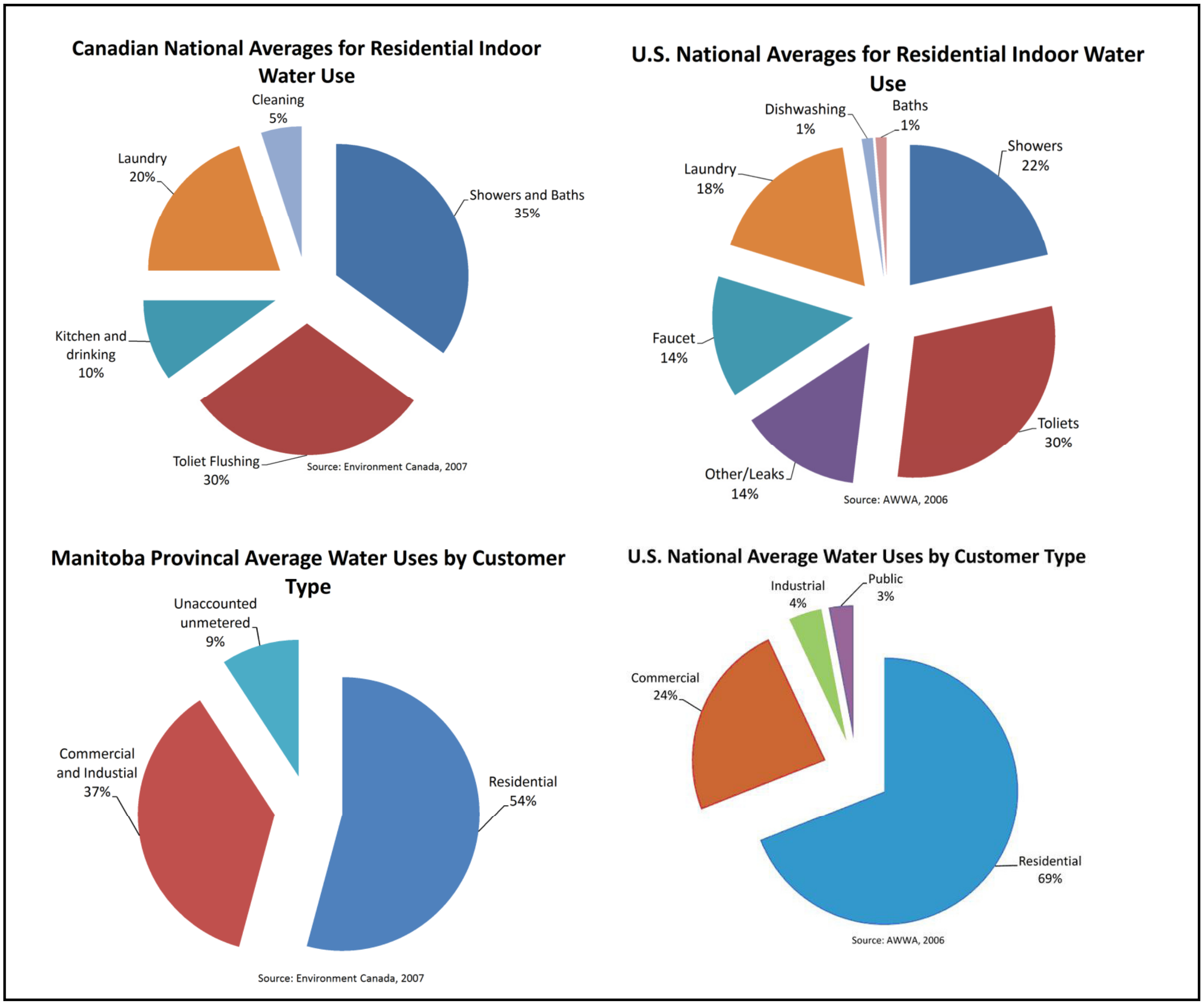


Figure 8-1
Water use in the Red River Basin
SOURCE: Red River Basin Water Conservation for Residential, Municipal, Commercial, and Industrial Needs - March 2010, p. 76, 78.

The users' costs for municipal and domestic water are generally modest in the basin, compared to other parts of the US or Canada.

Water Rights Accounting

Water rights are granted on the basis of ***Prior Appropriation Doctrine*** (i.e., western water law) in Manitoba and North Dakota. The first user of water for a "beneficial use" acquires a continued right to use that amount of water. Beneficial use is the use of water for a purpose consistent with the best interests of the people of the state or province. However, water rights are assigned according to the ***Riparian Doctrine*** (i.e., eastern water law) in Minnesota. Owners of land next to lakes and streams or above aquifers have rights to use the water by virtue of land ownership. Water rights issues will likely become more important in the years to come, as more users seek to use the relatively finite resource.

Water Supply

The combined surface/ground water supply of the Red River Basin is of vital interest to residents but, by almost any standard, insignificant in terms of global water resources. In all, there is over 325 million cubic miles of water on earth, covering about 80 percent of the earth's surface. About 1 percent of the water on earth is accessible freshwater. Another 2 percent consists of freshwater found in glaciers, freshwater present in deep aquifers, or freshwater that is otherwise inaccessible. The remaining 97 percent of the world's water is saltwater (Table 8-1).

A basin's total water resource is adequate or inadequate in terms of its ability to meet demands from both a quantity and quality standpoint. The supply/demand relationship is never static because demands made upon it change over time, both upward and downward.

Water fluctuations in the Red River Basin occur as the result of increases or decreases in precipitation, the timing and amount of runoff, the ability or inability to store water for future use, ground water recharge rates, upstream water uses, and a host of other factors. Extended periods of drought can effectively reduce water available, sometimes dramatically. Conversely, periods of above average precipitation, such as 1993 to the present, can enhance the amount of available water.

Table 8-1.
Earth's Freshwater Resources

Source	Volume (Cubic Miles)	Percent of Total
Ice caps, glaciers, and permanent snow	5,773,000	68.6
Ground water – fresh	2,526,000	30.1
Ground ice and permafrost	71,970	0.86
Freshwater lakes	21,830	0.26
Soil moisture	3,959	0.05
Atmosphere	3,095	0.04
Swamp water	2,752	0.03
Rivers	509	0.006
Biological water	269	0.003

Source: Igor Shiklomanov. 1993. "World Fresh Water Resources." In Peter H.Gleick (ed.) Water in Crisis: A Guide to the World's Fresh Water Resources. Oxford University Press. New York, NY.

A water shortage, in the physical sense, implies there is not enough water to meet all current requirements. However, requirements are based on economics, so a supply shortage in the economic sense implies the price is too low, since more water is demanded than is available at the price. Similarly, with excess or surplus water, there is either too much water around (e.g., flooding) or more water than the present water users need. Excess supply in economic terms means too much water is being provided at too high a price, or made available by Mother Nature, since some is going unused.

Generally speaking, ground water resources in areas of the basin beyond the valley are adequate, given today's water use patterns, in terms of both quantity and quality. However, there are areas where groundwater withdrawal is greater than groundwater recharge, a situation that is unsustainable. With some treatment, the basin's surface water resources are generally of acceptable quality for domestic use by humans and for livestock consumption. However, neither ground water nor surface water is uniformly available to basin residents. Some residents withdraw water from surface or ground water sources directly, while others depend on systems that transport water to where it is needed.

A fairly extensive area in the central part of the valley lacks locally available ground water, both in quantity and quality, for the requirements of rural residents. Residents of some of these areas have dealt with their water requirements largely through the formation of rural water systems.

The Bois de Sioux River, 2005.

Surface water resources are generally adequate to meet present requirements, but long-term drought conditions or development of high-water-use industry could place the basin's water supply infrastructure under stress. Ethanol production from corn in the basin has raised concerns about water use (USA Today 2006). There are currently two ethanol plants in the basin, one near Fergus Falls, MN, and the other near Casselton, ND. The Casselton plant uses recycled wastewater from the City of Fargo. Although it is difficult to generalize due to manufacturing processes and changing technology, a corn-based ethanol plant uses roughly three gallons of water for every gallon of ethanol produced. Thus, a 100-million gallon/year plant will use 300 million gallons of water each year (Aden 2007).

In its early years, Winnipeg used water from the Assiniboine River until its quality decreased. Then Winnipeg turned to artesian wells for a few years, only to discover the water was hard and its quantity inadequate. In 1919, water users in Winnipeg began using water from the Shoal Lake Aqueduct, a 156 km long concrete tube that delivers about 80 million gallons of water per day to several reservoirs near the city. (Siamandas 2011).

Cities that draw water directly from the Red River or one of its tributaries include Fargo, Grand Forks, Grafton, Drayton, and Pembina in North Dakota; Fergus Falls, Moorhead, Oslo, and East Grand Forks in Minnesota; and Emerson, Morris, Altona, Morden, Carman, and others in Manitoba.

Water Demand

The adequacy of the basin's water resources hinges on several factors. Most important, and sometimes most misunderstood, is demand. Water demand in the physical sense is the amount of water that people use. However, demand has a more rigorous economic meaning as an expression of the water requirements of a particular group at various prices. The amount of water demanded at various prices makes up a schedule called "demand." Demand is different than needs, use, requirements, or wants, in that demand includes a factor for how much the consumer is willing to pay for each unit.

Generally, water has been treated as a nearly free good, with only a nominal charge for quality adjustments and delivery. Consumers and local development promoters equate demand with how much water will be necessary to fill all users' requirements at the prevailing nominal price and rates of use. Although water is increasingly being treated like a market good in many other parts of the country, most basin residents still treat it as a free resource that should be available to them whenever they need it. This philosophy contributes to both real and imagined water shortages.

Water Demand Factors

Several factors influence the amount of water used, not the least of which is the perception by some that the supply of water is virtually infinite. Accustomed as they are to seeing their water needs met fully and promptly, users are inclined to assume that water supply is essentially unlimited. This is evident when comparing average water use per capita in areas with adequate water and in areas with less than adequate water. For example, water use in the US is about 200 gallons per day per capita. Water use in Jordan, one of the world's driest countries, is about 100 gallons per capita per day, while daily per capita water use in water-rich Canada is over 1,100 gallons (van der Leeden et al. 1991).

In one sense, water supply and water demand are two sides of the same coin in that the forces working to reduce available water are often the same forces responsible for increasing water requirements. Decreased summertime precipitation not only reduces the amounts of water at given locations, but it also increases the demands at those same locations. Demands made upon a city's water treatment plant for increased water to maintain green lawns may coincide exactly with reduced flows at the city's water treatment plant intake point. And inevitably, demand for increased amounts of irrigation water will occur as precipitation decreases. A case in point is the increase in permit applications for irrigation in North Dakota between 1989 and 1990. In 1989, 88 applications were filed for the irrigation of about 17,000 acres. In 1990, under continued drought conditions, the number of applications increased to 136 for 25,000 acres of irrigation (Krenz, 1990). The number of irrigation applications during the current wet cycle (1993-present) has declined.

Influence of Population Change

Changes in human population strongly influence the amount of water used. While water use fees, per capita use rates, conservation practices, and other relevant factors remain constant, increases in population result in proportionate increases in water use. Decreases in population do the opposite. Projecting what might or might not happen with respect to future population is an inexact science. Nevertheless, it is necessary to generate educated estimates of what future demands might be.


Red River Basin Commission

Demands on our water resources are growing.

Historic growth patterns, whether gentle or rapid, can serve as the basis for making projections of future demand trends. Such projections, particularly when done for a time period extending several decades into the future, often prove to be speculative. On the other hand, shorter range projections based on state-of-the-art techniques frequently prove to be reliable. Unforeseen or unexpected circumstances can raise havoc with population projections. Typically, projections are based on past trends and economic conditions that affect growth patterns. Historic growth, demographic characteristics, employment/unemployment rates, industrial mix, land use, personal income, and other parameters are examined. Major unexpected events, such as rapid population changes, the introduction or loss of a major industry, or even a war, can cause community and regional water use projections which would have been in the "ballpark" to be considerably off. Complicating matters for those making projections about future water demands is the fact that, because supply and demand are dynamic, attempts to measure that relationship produce a reflection of conditions which are changing even as they are being measured.

Dealing with Supply Issues

Despite the dynamic nature of the supply/demand relationship and the imprecise character of projections, municipalities and others must make decisions about how to manage future water requirements. Approaches will vary from area to area, based on water availability, costs of water delivery, water quality, costs of treatment, conservation practices, water politics, and numerous other factors.

The American Southwest is an example of an area where population growth has triggered increases in water use severely stressing local sources. The Central Arizona Project relies upon water imported from the Colorado River to satisfy needs where demand has outstripped supply. Growth along the Front Range of the Rocky Mountains in Colorado has surged dramatically over the last few decades, precipitating the need to look beyond the immediate area as locally available water sources are exhausted. Southern California has coveted the water resources of northern California and the Columbia River Basin for decades, because local water sources together with imported water do not meet the additional needs engendered by steady population growth. Finding uncommitted raw water supplies for most areas where rapid growth is occurring is a mounting problem.

US Army Corps of Engineers

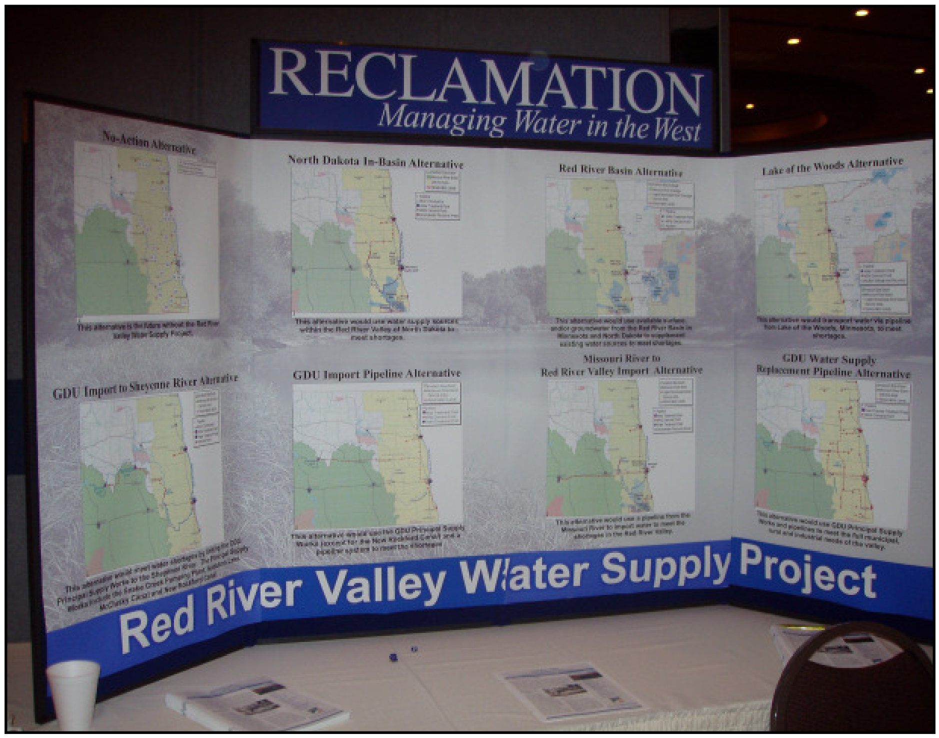
Otter Tail River and Orwell Dam.

Basin Supply Augmentation

Though the water supply problems in the Red River Basin are modest compared to those noted earlier, both overall and per capita water uses are increasing slowly. Indications are that current growth rates, coupled with periods of prolonged drought, could place stress on the water supply network in the United States portion of the basin.

A study addressing M&I water concerns of United States basin communities reported, "the combined water requirements of Fargo, Moorhead, Grand Forks, East Grand Forks, and West Fargo have the potential to increase from a maximum daily demand of about 80 cfs in 1990 to near 140 cfs by the year 2040" (NDSE 1990).

Drought-related water supply problems encountered in Manitoba's portion of the Red River Basin during the 1980s served as the catalyst for a joint undertaking by the Canadian federal government, the Manitoba provincial government, the Pembina Valley Development Corporation, and the Lower Red River Valley Water Commission to develop a strategy for meeting the long-term water requirements of a large area west of the Red River in Manitoba. The group's preferred option, based on public support, economic, and environmental considerations, was to "supply Red River corridor demands from the Red River and the remaining demands from the Assiniboine River via pipeline from Portage La Prairie" (PVCD 1993). While this project did not materialize, the survey served as the impetus for the formation of the Pembina Valley Water Cooperative, which treats and transports high-quality water to approximately 50,000 Manitobans (Rochon 2010).



Red River Basin Commission

US Bureau of Reclamation display on their Red River Valley Water Supply Project.

Water supply problems are commonly shared throughout the basin. In addressing such problems, consideration must be given to the consequences of actions taken in one part of the basin upon other parts of the basin. Withdrawals or diversion in one part of the basin affect water availability in other parts of the basin. The options available to water users for meeting needs now and in the future will vary throughout the basin and over time, but fall into three areas (1) reallocation of existing supplies, (2) augmentation of existing supplies, including conservation, and (3) finding substitutes for water in production and consumption. Greater efficiency in the current water supply system, reduced demand through conservation, and water importation are approaches typically implemented.

Efficiency Approaches

A first step in coping with municipal water demand is to determine whether or not greater efficiency of use is possible. Construction of new storage facilities, revised reservoir operating plans, reallocation of use from surface to ground water sources (or vice versa), water recycling and reuse, repair of leaky systems, or installation of new delivery systems can each contribute to improved efficiency.

Various land management practices (e.g., shelterbelts) implemented throughout a watershed can influence the amount of water stored in the soil profile and also the amount of water that ultimately reaches a stream or aquifer and becomes accessible to water users. Implementation of land treatment measures, however, is more practical as a long-term solution than as an emergency measure.

Conservation Approaches

The term "conservation" has different meanings for different people. For some it simply means wise use. For others it means limiting use through rate structure, priority of use, regulations, or other means to preclude the need to develop additional water supply facilities and to sustain environmental quality.

Substantial reductions in water use through conservation are possible, whether uses are large or small. For example, conversion of a flood or furrow irrigation system to a sprinkler system can dramatically reduce consumption and costs. "Flow-through" cooling mechanisms at coal-fired power plants can be converted to cooling towers, reducing diversion requirements and water use.

Conservation can affect several aspects of the municipal and industrial water supply requirements of basin communities as well. Conservation measures can lower water use to a point where there is no longer a need to develop supplies beyond present capacities. This translates into reduced expenditures for infrastructure and a reduced need for revenue. Reductions in the quantity of water needed to serve a community can likewise be translated into proportionate decreases in water and wastewater treatment. However, it is often in a community's best financial interests to sell more, rather than less, water.

Households can conserve water by developing a number of water-saving habits. Such household water conservation can be encouraged with incentives for appropriate behavior and disincentives (such as higher prices) for inappropriate behavior. However, changes in the price of water are usually so small relative to total household spending that they have little lasting impact.

Water conservation measures have yet to be widely implemented in the basin. This resistance may be due to the persistent, yet unfounded, belief that water supply is unlimited. An assured supply of water for human consumption is commonly thought of as a given. As long as there are no costs or penalties for not saving water, there is little incentive to conserve.

Red River Basin Commission

A dry dam, which only holds water during high-water periods.

Using increased fees to drive down water use is unpalatable to many in the basin since water charges have historically been very modest. As a consequence, citizens tend to expect that water should be furnished free or at a very low price. This tendency also exists with flood control and drainage projects. Modest price increases may be acceptable, but increases that exceed a user's sense of reasonableness are not.

As entrenched as these views may be, circumstances are changing the way basin residents view their use of water. There is growing acceptance of the idea that, contrary to popular belief, the basin's water supplies are indeed not without limits. Voluntary and mandatory lawn watering and car washing restrictions implemented by several communities on both sides of the border during recent years illustrate that reality. The necessity for implementing such measures is a reminder that the region's water supply is finite, while the numbers of users and uses are seemingly infinite.

Importation Approaches

Drought conditions, coupled with slowdowns in economic growth, cause community leaders and consumers to recognize that, if increased efficiency of use and demand management measures are not effective, new sources of supply may have to be identified. If no sources are locally available, importation from other areas within or outside the basin may be necessary. Legal and cost constraints may preclude importation of water, but it is an alternative worthy of consideration.

While it was never implemented, the Pembina Valley Water Task Force Status Report envisioned some part of the water needs for a large area west of the Red River main stem being met by a diversion from the Assiniboine River. Such a diversion would have been intrabasin (i.e., within the basin) since the Assiniboine is a tributary to the Red River.

A crack in the soil resulting from drought conditions.

On the other hand, diversion of Missouri River waters to the Hudson Bay drainage as proposed under the Garrison Diversion Project would be an interbasin (i.e., between basins) transfer. Much of the works are in place for this project, but concerns raised by various environmental groups, the state of Minnesota, the province of Manitoba, the government of Canada, and others have thus far impeded completion of the project. The *Garrison Reformulation Act of 1986* (PL 99-294) provides authority for diversion of 100 cfs of treated water for municipal and industrial purposes via North Dakota's Sheyenne River. The viability and acceptability of certain conveyance and treatment features are needed to effect the diversion. Water quality and biota transfer remain prominent concerns. Project proponents view the diversion of Missouri River water to the Hudson Bay watershed as the most viable source of an assured water supply for the Red River Basin. Opponents view the potential introduction of undesirable species and diseases and altered water quality as risks that outweigh the benefits.

Recent focus has been on developing a pipeline to transport Missouri River water to the east. Planning for the Red River Valley Water Supply Project (RRVWSP) is ongoing (Cook 2010). However, not everyone agrees the need for a pipeline is imminent (Watland 2008).

In the long run, each of the three mechanisms for providing water supplies in the basin—increased efficiency, conservation measures, and importation—will be used. In the longest run, substitutes for certain uses of water will be found. The extent that each is used will depend on local conditions and attitudes.

Difficult Decisions

How the basin decides to deal with the challenge of meeting its current and projected water needs is, of course, yet to be determined. The focus of this chapter has been on water for use by households, but decisions will be needed for a variety of other uses as well. The past decade has seen a big push for ethanol plants, which use large volumes of water. The options for competing users are sufficiently numerous as to make the choices difficult. Solutions will vary from one place in the basin to another, because perceptions and abilities differ as to how best to deal with what is likely the most perplexing water management issue of the 21st Century. When the current wet cycle ends, there will be renewed and heightened interest in finding more water from all sources.

It is important that citizens be involved in the decision-making process. Effective involvement means learning more about the physical nature of water resources, the human nature of water use, and the legal and political settings. It means taking time to attend meetings, to participate in the dialogue, and to share personal views with others. It means becoming informed and getting involved! It may even mean changing long-held perceptions and positions and treating water more like a market good.

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Chapter 9
The Management System

The Red River Basin is a complex hydrologic system, managed by a complex government system, influenced by a web of non-governmental organizations (NGOs). At times, during the spring snowmelt, the main stem of the Red River overtops its banks and spreads out for miles on both sides, looking far more like a lake than a river. It has also done the same thing as a consequence of record summer rainfall. And, as it has done on more than one occasion, it can approach or even reach no-flow conditions. Stated simply, it can run dry!

Tributary streams are, if anything, even more erratic. They show a wide range of constantly changing images, ranging from rapidly rising levels, to flood stage, to ebbing flows, to pattern-like displays of dry, shrinking bottom materials, and then back to some earlier form.

NIMBY (Not In My Back Yard) has been fortified with BANANA (Build Absolutely Nothing Anywhere Near Anything) making projects of all sorts, including water management, difficult to implement.

Recognizing and understanding all the natural and human forces which produce this changing imagery is a difficult task. Managing, or coordinating, such a system is equally challenging, especially in today's "BANANA" culture.

The Management Framework

The foundation upon which the basin's water management mechanism rests is a body of law created by local, state, provincial, and national governments to address water and related land resources. Added to that are the rules and regulations developed and used by dozens of governmental agencies to implement those laws. Zoning regulations, city ordinances, and a host of other actions by local governments affect how water resources are managed. International treaties, such as the *Boundary Waters Treaty of 1909*, set forth broad management parameters which protect parties agreeing to the terms of the treaty. To varying degrees, each of these precepts influence how water is managed in the basin. Some may be more important than others in the sense that they have greater or more sustained impacts, but all play a role.


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Local water managers tour basin water management projects.

There are about 1,500 government entities at all levels in the basin. When another several hundred special interest groups, government task forces and work groups, and other ***stakeholders*** are added to the mix, it becomes apparent why water management can pose a challenge. Some recent research on these ***institutions*** suggests changes may be in order to keep up with the times (Hearne and Kritsky 2010, Hearne 2007, Hearne and Torpen 2010).

Building Blocks

Water management in the Red River Basin is a matter of rules, regulations, and ordinances developed to implement laws. But it is more. It is an institutional framework within which decisions are made by numerous individuals, boards, and commissions that affect changes in the status quo as they pertain to water. It is a system that succeeds only when it correctly identifies and implements those actions which society deems acceptable or desirable, and for which it is willing to pay. Since substantial differences of opinion can exist about what is acceptable, desirable, or worth paying for, the system may seem inefficient and cumbersome, and it may seem that way more often than not. If it is so, it is the price paid for participating in the democratic process.

Ultimately, however else it may be characterized, water management is the sum of the management activities, goals and objectives, value systems, and special interests at work in the basin.

Water Management Measures

Water management can be defined in terms of the array of measures employed to bring about desired results, either prevention or protection (slmcleod 1999). These measures fall into two general categories: structural and nonstructural. Structural measures involve construction. Examples are dams, dikes, drainage canals, grade stabilization works, outfalls, floodwalls, and other practices designed to physically store, divert, or move water. Nonstructural measures seek to use or control water without the need for construction. Such measures have been broadly defined to include land use practices, flood warning systems, education, legal constraints such as floodplain zoning, and other regulations.

It has grown steadily more difficult, given the constraints of budgets, the requirements of environmental legislation, and the evolving and often conflicting desires of those affected, to implement "brick and mortar" structural programs. In the years preceding the beginning of the environmental movement, construction could begin when tests of engineering and narrowly defined economic feasibility had been met, when it had been determined that contemplated actions met appropriate legal criteria, and when a source of funding had been secured. Today, those projects would also have to meet stringent environmental and cultural preservation as well as broader economic criteria.

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Local water managers and engineers meet to discuss computer simulations (models) of various "what if" scenarios to determine ways to reduce flood damages.

At the same time, nonstructural programs, though they may be markedly less destructive to the environment, are not always the first choice either. Differences of opinion exist as to what constitutes sound environmental practice, and frequently there is disagreement over the questions of who is to benefit and who is to bear the costs. Differences of opinion such as these tend to polarize factions, and progress in implementing problem-solving measures is impeded. As a consequence, more and more water management programs are a combination of structural and nonstructural components acceptable through compromise.


Red River Basin Commission

Public meetings help gather the different views of the citizens.

Goals and Objectives

Success in managing water resources is measured in terms of the extent to which goals and objectives are met. Almost no one would argue with that assertion. But setting those goals and objectives is another matter entirely. Several factors come into play to complicate the process:

- *Goals and objectives are often broadly stated and/or ill-defined.* The vast majority of basin residents have not consciously thought about how they would like to see the basin's water resources managed. However, given the increasing levels of technical difficulty of water management, residents cannot be expected to be well informed about many of the technical aspects.

- *The attainment of one set of goals and objectives inevitably results in total or partial nonattainment of others.* An example of this dilemma can be found in the agricultural drainage/wetlands preservation controversy. Wetlands may be viewed by farmers as a nuisance or an economic liability. Some wetlands which are only temporarily wet but must be seeded after adjacent acres are seeded are a nuisance because the farmer must return at a later date. In the fall, it may be necessary to temporarily bypass those same acres when adjacent acres are harvested because the grain has not yet ripened. Some farmers see wetlands—be they temporary or permanent, large or small—as an economic liability because they lack capability to consistently produce income.

  On the other hand, from the viewpoint of groups or individuals who favor preservation, those same wetlands may provide habitat for waterfowl production and may, under some circumstances, trap nutrients, recharge ground water, and contribute to flood reduction. Moreover, proponents of preservation may believe such benefits have a higher value than any agricultural products produced as a result of drainage.

  The drainage/preservation dilemma is an example of just one set of goals and objectives on a collision course with another. Another example is upstream vs. downstream interests. This has surfaced recently as a result of discussions about the proposed Fargo-Moorhead diversion. Both upstream and downstream interests are concerned their flood situations will be worsened if the most popular diversion option were to be implemented without mitigating for **all** adverse effects.

  In almost every sector of water management, similar kinds of differences in goals and objectives can be found. Wherever they are found, the process of making appropriate choices about water management is complicated and requires political as well as technical solutions.

- *Goals and objectives are ever changing, never static.* Goals and objectives, whether local, state or provincial, or national, are ultimately a reflection of society, and are shaped by changing value systems and advances in technology and understanding.

Value Systems

Value systems, the sum of the things we believe and the basis for the goals and objectives we adopt, are themselves decision-based on technical "facts" determined as a part of several evaluation processes. The disciplines providing those facts are engineering, hydrology, geology, soil science, economics, and others. Technical information pertaining to specific fields of study remains an essential ingredient in the decision-making process, but it is not the sole ingredient.

But times have changed. Citizens as well as government leaders have come to believe decisions—whether the kind a water management agency has to make or the kind citizens make about their own affairs—involve not only technical facts but personal and group "values" as well. By insisting consideration of political values be an integral part of evaluation techniques, society is explicitly embracing the concept of water managers accommodating an assortment of perceptions that have little to do with engineering, hydrology, or economics and everything to do with how people feel or what they believe.

> WATER MANAGEMENT BELIEFS
>
> *Critical believers:* *individuals who base their beliefs/choices after considering all sides of an issue and are willing to change their position if faced with new information.*
>
> *Sophisticated believers:* *individuals who base their beliefs/choices on selected facts and other data that support one side of an issue, and are not willing to consider information contradictory to their beliefs.*
>
> *Vulgar believers:* *individuals who have little or no rational reason for their beliefs/choices but are extremely entrenched in one side of an issue and don't want to listen to any rational discussion.*

Value systems may reflect the beliefs of a single individual or a group of individuals. The opportunity for individuals to express themselves on natural resources issues is restricted only by conflicting schedules, a hesitancy to travel occasionally, and personal priorities. Undoubtedly, instances can be found where arguments of a single, persuasive individual have caused others to alter their positions, to adopt new points of view, and to embrace a project or program they could not earlier support. So, it is important that individuals stay involved. The value of personal views on a particular issue should not be underestimated. Individual involvement in the water management decision-making process is encouraged, because such involvement may provide the balancing influence needed for a thorough and full discussion of a particular issue.

Special Interest Groups

Notwithstanding the importance of individual involvement in the water management decision-making process, a growing number of individuals are choosing to participate not as individuals but as members of groups embracing particular points of view. Indeed, most people are represented to some extent by one special interest group or another. The farmer who is a member of a local grain or fuel cooperative, who pays dues to a farm organization, or who subscribes to the newsletter published by a marketing board is a member of a special interest group. The individual who belongs to a local fishing club or a statewide chamber of commerce is likewise a member of a special interest group. In fact, any group organized to influence the actions taken or contemplated by others—no matter what the specific area of interest might be—is a special interest group.

Red River Basin Commission

Public meeting allow all interest groups to be heard.

Some of these groups are general, such as farm or environmental groups, who may develop a special interest in a water issue. Others are formed specifically to promote or defeat a specific water project. Electronic social networking has vastly facilitated formation of these groups and instantaneous sharing of information (or misinformation!).

Players at the Local Level

Water projects and programs are implemented as the result of decisions being made somewhere within the collective, governmental framework established to manage our most precious natural resource. In some instances, that "somewhere" may be at the local level. Or, it may be at the state, provincial, or federal level. In fact, decisions may be needed, or politically side-stepped, at all levels.

Some agencies have authority to make decisions and the power to develop rules. Others may only have advisory powers to influence decisions. This is the case with special interest groups (e.g., Farm Bureau, Farmers Union, Ducks Unlimited, Audubon Society, commodity groups) and multi-agency task forces and work groups. Where the "buck stops" isn't always clear, either to the agency or to the regulated public. In fact, there are so many entities involved "passing the buck" may happen in particularly problematic situations.

Special interest groups and individuals may influence the decisions, and goals and objectives and value systems will come into play. But some board, commission, or individual must ultimately make a decision. On the local level, in the Red River Basin, that decision will frequently be made by a watershed district in Minnesota, a water resource district in North Dakota, or a conservation district in Manitoba. The ultimate decision point is largely a function of the scale of the issue.

Watershed Districts

On the Minnesota side of the Red River, local water management is the responsibility of watershed districts. Eleven districts (Figure 9-1), including the state's largest district, the Red Lake Watershed District, have been established in the basin under authority of the *Minnesota Watershed Act of 1955*. Typically named after the principal lake or stream in the watershed, these ***special purpose local units of government*** coordinate water management decisions in the watershed. They are governed by a board of managers appointed by the boards of county commissioners and are empowered to develop long-range plans, regulate activities affecting water resources, acquire property rights, and construct and finance improvement projects. An *ad valorem* (according to value) tax levy on each dollar of assessed value of all taxable real property within the district

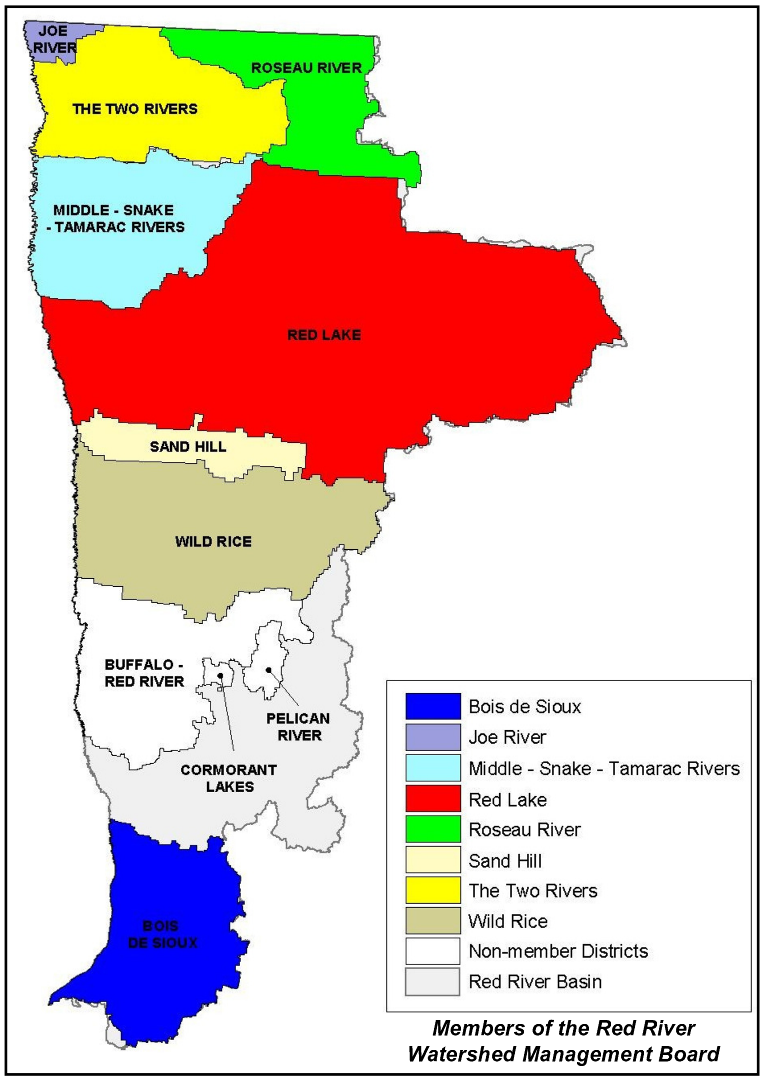

Figure 9-1
Watershed Districts (Minnesota).
SOURCE: RRWMB. 2011.

provides funds for general administrative expenses and for the construction and maintenance of projects (MAWD undated).

Legislation passed in 1976 made it possible for the watershed districts to form the Red River Watershed Management Board (RRWMB) for the purpose of instituting and financing flood damage reduction projects within the boundaries of member watershed districts. This legislation also allowed member watershed districts to levy an *ad valorem* tax. One-half of the tax collected is retained by each district for projects within the district, while the other half is transferred to the RRWMB for projects which provide benefits to the Red River main stem (TIC 1990).

Red River Basin Commission

The jurisdiction of the RRWMB is limited to that of its member districts, but it does have the power to cooperate with authorities in North Dakota and Manitoba and to enter into contracts, compacts, and other agreements necessary to ensure integration of its works and projects. The RRWMB participates financially in floodwater retention projects in the Red River Valley. Additional projects are actively being considered by the board.

Soil and Water Conservation Districts

Another local entity involved both directly and indirectly in water management activities on the Minnesota side of the river is the county soil and water conservation district (SWCD). SWCDs are local units of government responsible for managing and directing a myriad of conservation programs. Unlike watershed districts, whose borders generally conform to watershed boundaries, SWCD boundaries are usually those of the county for which they are named.

Each SWCD is governed by a five-member board of supervisors, elected at large within the district by eligible voters. Districts receive state money through the Minnesota Board of Water and Soil Resources (BWSR) to administer numerous conservation programs, such as the Erosion Control and Water Quality Management Cost-Share Program and the RIM (Reinvest in Minnesota) Program. RIM is a state conservation program created to improve water quality, stop soil erosion, increase fish and wildlife habitat, and reduce flooding (Thul 1990).

Water Resource Districts

In North Dakota, the principal water management entity at the local level is the water resource district (WRD). The earliest beginnings of water resource districts can be traced to county drain boards, which were authorized in 1895. Legislative action in 1935 made it possible for farmers to form water conservation districts. These districts were, in turn, renamed "water conservation and flood control" districts in 1957. In 1973, the legislature decided that all land in the state should be contained within a water conservation and flood control district. At this time, the name was changed to "water management district" (NDSWC 1987).

A comprehensive reform of the state's water management laws took place in 1981, expanding the powers and authorities of the water management districts. Among other things, the legislature eliminated legal drain boards, transferred the powers and authorities of legal drain boards to water management districts, and changed the name of legal drains to assessment drains (NDSWC 1987). In light of the increased responsibilities given the districts, the legislature again changed the name, this time to "water resource district."

Boards of water managers, appointed to staggered, three-year terms by the county commission, are responsible for water management activities within the WRDs (Figure 9-2). Boards may, at the discretion of the county commissioners, have three or five managers. County commissioners are prohibited from serving on a WRD board. Districts with numerous water management issues meet as often as twice monthly, employ staff, and maintain offices. Other less active districts meet less frequently, operate without staff, and do not maintain an office (NDSWC 1987).

WRDs engage in a wide range of management activities, financing their operations in one or more of the following ways:

- General district-wide mill levy;
- Special assessments against property benefited by a project or activity;
- User fees imposed and collected for the services provided by a project;
- Revenue bonds; or
- State or federal cost-sharing, or both (NDSWC 1987).

Most WRDs in the North Dakota portion of the Red River Basin were established along county boundaries. Exceptions to the rule are North Cass, Rush River, Maple River, and Southeast Cass—all of which are in Cass County.

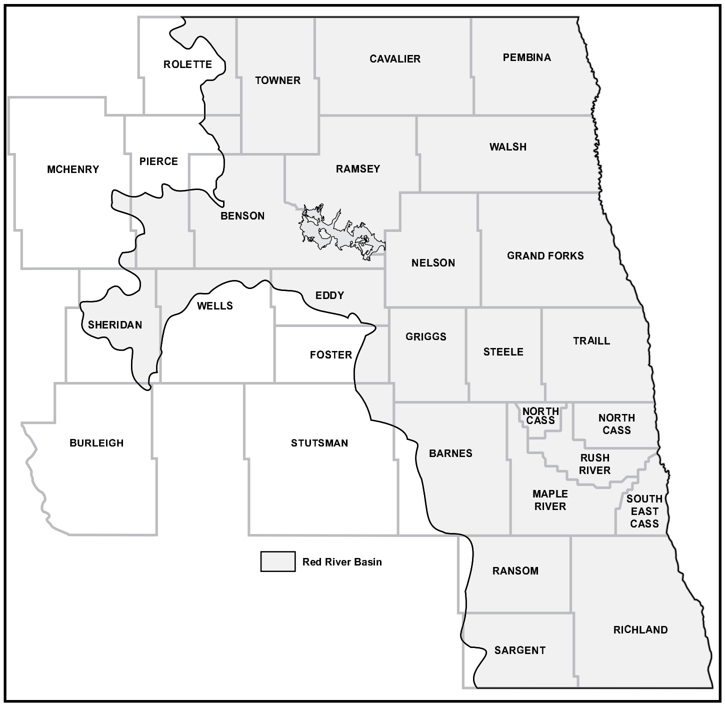

Figure 9-2
Water Resource Districts (North Dakota)
SOURCE: NDSWC 2012.

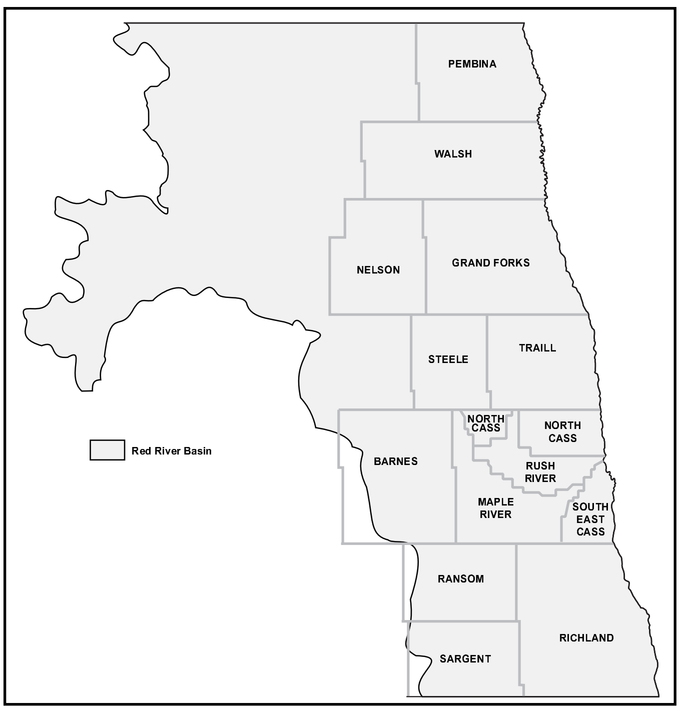

Figure 9-3
Red River Joint Water Resource District (North Dakota)
SOURCE: NDSWC 2012.

Recognizing that effective management often requires several WRDs to work together, the legislature enacted a "joint exercise of powers" statute for WRDs in 1975. The Red River Joint Water Resource District (RRJWRD) was the first such board created under this authority. Created in 1979, the RRJWRD consists of 14 members, representing 11 counties (Figure 9-3). Their main purpose is to reduce flood damage through use of flood protection projects such as retention dams. Each district, as approved by its county commission, has agreed to allocate funds based on the portion of their district that is in the Red River watershed.

These funds are used to provide cost-share for important retention projects in the valley, normally at a rate of 50 percent of the non-federal, non-state share. When considering whether or not the RRJWRD will provide cost-share for a project, it examines whether or not the project will provide flood damage reduction benefits in more than one district. They also work with other entities, such as the Red River Basin Commission, in efforts to reduce flood damage. To date, the RRJWRD has cost-shared in construction of 25 projects and 30 studies (RRJWRD undated). The board cost-shares as well with the North Dakota State Water Commission in maintaining a joint office in Fargo.

Several additional joint powers boards have been formed to deal with water problems in particular sections of the Red River Basin (Figure 9-4). The boundaries of joint powers boards frequently overlap. A county may belong to one or more joint powers boards. Some boards, such as the Devils Lake Joint Water Resources Board, are formed to address a broad array of issues and problems affecting several counties. Others are formed to address single issues or problems and may include only two or three counties. Several of the joint powers boards in the basin continue to exist solely to deal with operation and maintenance of projects or programs implemented under their authority (NDSWC 1987).

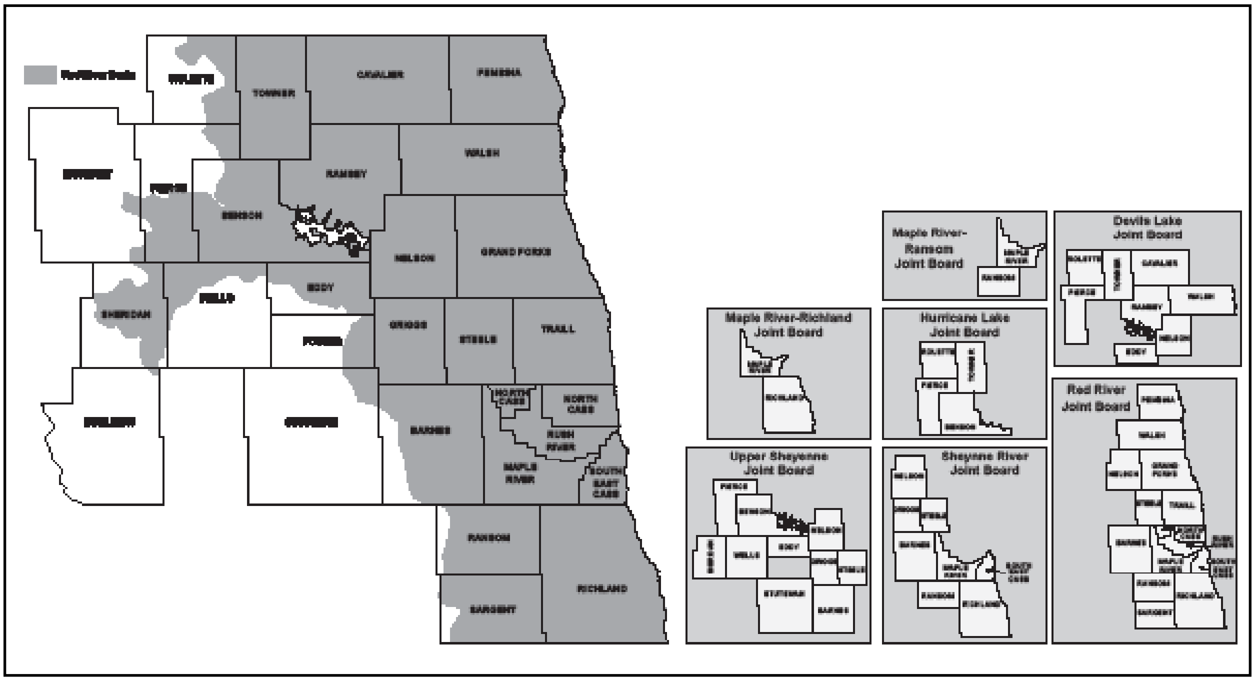

Figure 9-4
Joint Water Resource Boards (North Dakota)
SOURCE: NDSWC 2013.

Conservation Districts

Conservation districts in Manitoba are responsible for local water management. Like the watershed boards in Minnesota, the borders of conservation districts are generally the boundaries of the drainage basin of the major river of the area. A conservation district is an organization of local people cooperating to manage the natural resources and solve the resource management problems in their area (CDA 1986).

Manitoba's approach to dealing with resource problems is based on the premise that to solve one resource management problem, it is necessary to consider all other resources. Conservation districts provide people on the local level with a mechanism to organize and cooperate in managing their resources.

Each district is a corporate body and is governed by boards of local representatives. Special property tax levies are the source of a portion of a district's funds, but a majority of funds are provided by the province in the form of grants. The board may also accept funds from individuals or organizations. Special projects may be funded through agencies such as Ducks Unlimited or under federal-provincial agreements such as Agri-food.

Conservation districts routinely deal with soil conservation and management, conservation demonstrations/experiments, water management and conservation, and a host of other activities. Water-related programs are an important part of district activities. When a district is formed, the responsibility for managing and maintaining the drainage system is transferred from the municipalities to the district. Activities include maintenance of existing drains, reconstruction of drains, and new construction of drains. Managing the district's water resources may also involve stabilization of riverbanks and shorelines, construction of dams and other structures for a variety of purposes, and the sale of water.

Manitoba's first conservation district was formed in 1972 (CDA 1986). Of the 18 districts in the province today, five, the Pembina Valley, Seine-Rat River, Cooks Creek, LaSalle Redboine, and East Interlake Conservation Districts are entirely in the Red River Basin and a portion of the Turtle Mountain CD lies within the Red River Basin (Figure 9-5).

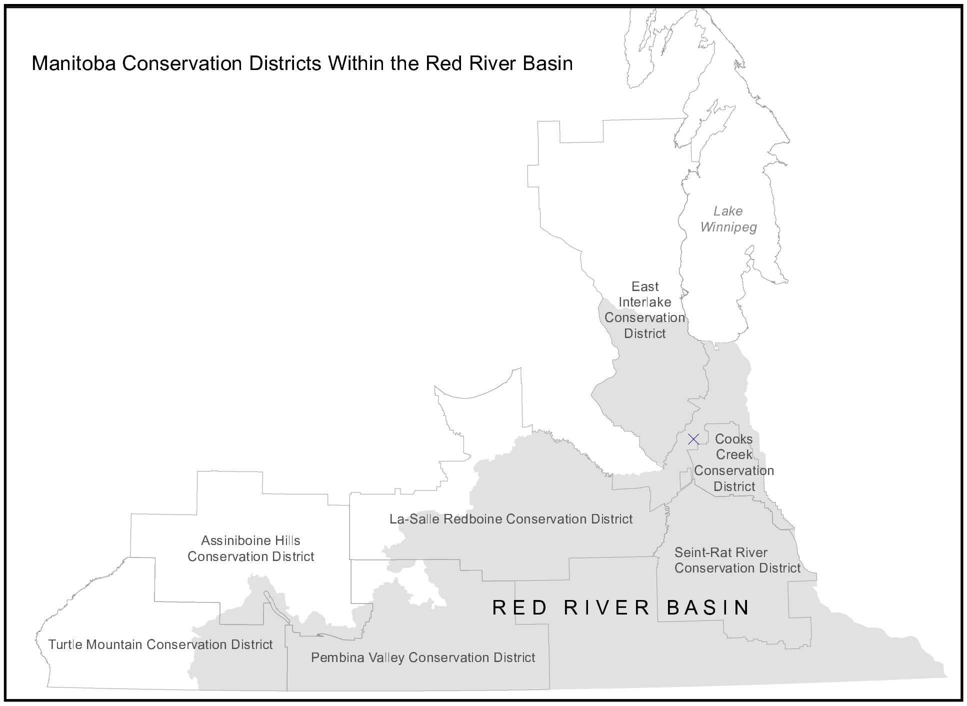

Figure 9-5
Conservation Districts (Manitoba)
Source: Manitoba Conservation Districts Association 2012.

Players at the State/Provincial Level

In most cases, the states and provinces have ultimate authority over water resources. According to the *US Constitution*, states and the federal government are equal partners. Local governments, as described above, are constitutional subordinates of the state.

Interstate/Cross-Border

Water doesn't follow many borders, and many borders don't follow water. This introduces a set of water management issues that must be dealt with by interstate or cross-border agreements. Minnesota's border, for example, consists of 60 percent water, resulting in shared management choices with the state's neighbors. (Lokkesmoe and Leitch 2011).

Minnesota

The Minnesota Department of Natural Resources (DNR) is a key state water management agency. DNR serves Minnesotans through six distinct but related divisions: Forestry, Lands and Minerals, Fish and Wildlife, Enforcement, Parks and Trails, and Ecological and Water Resources. While many of the programs administered by DNR are either directly or indirectly related to water and related land resources, overall responsibility for water management is assigned to the Division of Ecological and Water Resources.

DNR Division of Ecological and Water Resources: The Division of Ecological and Water Resources directs numerous programs affecting citizens of the Red River Valley. Five major regulatory programs, for example, are administered by the division, including:

- Protected waters and wetlands;
- Dam safety;

- Floodplain management;
- Shoreland management; and
- Surface and ground-water appropriation.

The DNR functions through four regions, with Region 1 serving the Red River watershed in Minnesota. Region 1 offices are in Bemidji.

In addition to its regulatory functions, the division is involved in many nonregulatory programs, such as instream flow protection, ground-water atlases, and regional aquifer studies. The division administers the Floodwater Retention Assistance Program. This program made cost-sharing funds available to the Red River Watershed Management Board to help establish a Water Resource Engineering/Planning Program. It also helped pay for costs associated with several floodwater protection projects. The Floodwater Retention Assistance Program was the predecessor to the Flood Damage Reduction Program enacted during the late 1970s and early 1980s. The Flood Damage Reduction Program expanded the types of projects that could be funded and enlarged the program to statewide coverage.

Another important nonregulatory program is the Statewide Water Allocation and Management Program. Among other things, this program is designed to provide a comprehensive assessment of the availability of the state's water and to define the value of water to Minnesota.

Minnesota Pollution Control Agency (MPCA): This Minnesota state agency has broad regulatory powers related to surface and ground water quality, solid waste disposal, disposal of wastes or surplus water in wells or sumps, municipal waste treatment systems, and cleanups of accidental spills. It is also actively involved with gathering data concerning water quality and establishing nondegradation standards for water quality. MPCA administers the Clean Water Partnership Program established in 1987 to control ***nonpoint sources*** of pollution and protect surface and ground water resources. In addition to Minnesota programs, MPCA administers a number of federal programs, including the federal Clean Lakes Program, Section 205(j)(3) of the *Clean Water Act*, the federal Nonpoint Source Management Program, and the *Water Quality Act*.

Red River Basin Commission

Nutrient workshop.

Department of Health: This state agency is charged with ensuring that public drinking water meets safe drinking water standards. It also administers the state well code.

Geological Survey: Minnesota's Geological Survey, which is part of the University of Minnesota, is responsible for investigation and mapping of the state's geology. It routinely cooperates with local watershed districts and soil and water conservation districts in defining geological parameters used in solving resource problems. It also has responsibility for maintaining geological and stratigraphic information on all wells drilled by licensed well drillers in the state.

Board of Water and Soil Resources (BWSR): This state agency assists local units of government in natural resources management. The 17-member board is made up of three county commissioners, three soil and water conservation district supervisors, three watershed district representatives, three citizen members, and five nonvoting members. One of these represents the University of Minnesota, and four represent other state agencies. BWSR is responsible for review and approval of county comprehensive water plans.

Red River Basin Commission

Multiple agencies work together to manage basin land and water resources.

Environmental Quality Board (EQB): This is Minnesota's principal forum for discussing environmental issues. The current 15-member board is composed of a chairperson and five citizen members appointed by the governor; the commissioners of the state departments of Agriculture, Health, Natural Resources, Public Service, and Transportation; the commissioner of the Pollution Control Agency; the chair of the Board of Water and Soil Resources; and the directors of the Office of Strategic and Long Range Planning and the Office of Waste Management.

EQB provides the public with an accessible forum for debating and discussing environmental policies and decisions of state government; it provides the mechanism for coordinating actions of major state agencies and the impact of their decisions on the environment; and it provides the governor and legislature with a tool for working on those environmental issues and problems not addressed by one of the state's other environmental agencies.

On-going activities of EQB established in statute and supported by staff include: administration and implementation of environmental review, power plant siting and transmission line routing, pipeline routing, critical areas, genetic engineering regulation, water policy, nuclear waste disposal policy, and sustainable development programs.

North Dakota

The State Water Commission, the Office of the State Engineer, and the State Department of Health are North Dakota's principal water management agencies.

State Water Commission (SWC): The SWC, created in 1937 as the State Water Conservation Commission, consists of the governor, who serves as chair, the Commissioner of Agriculture, and seven other members appointed by the governor to provide regional representation. Appointed members serve overlapping, six-year terms. The divisions of Administration, Atmospheric Resources, Planning and Education, Water Appropriation, and Water Development direct a variety of programs, including enforcement and inspection, construction and maintenance, data collection, aquifer identification and monitoring, engineering feasibility studies, technical assistance to water resource district boards, quantification of water rights, inventory of ground water and surface water resources, State Water Plan updating and maintenance, and information/education.

State Engineer: The State Engineer, originally appointed by the governor, is now appointed by the SWC and serves as its secretary and chief engineer. Created in 1905, the Office of the State Engineer regulates, administers, and allocates the state's water resources. The State Engineer is also responsible for maintaining original survey notes, drainage control, dike and dam safety, and floodplain management.

State Department of Health (NDSDH): Acting through its divisions of Municipal Facilities and Water Quality, the NDSDH plays an important role in managing the water resources of the Red River Basin. The Municipal Facilities Division consists of three primary programs designed to assist municipalities and other political subdivisions in the maintenance of public health and safety: (1) public water supply or drinking water, (2) operator training and certification and facility inspection, and (3) construction grants/ state revolving fund.

The Water Quality Division also administers a number of programs, including surface water monitoring, nonpoint source pollution management, ground water protection, wellhead protection, underground injection control, pollutant discharge elimination system permits, feed lots, and septic tanks.

South Dakota

In South Dakota, conservation districts, organized by county, function under the South Dakota State Department of Environment and Natural Resources and have primary responsibility for drainage permits. Water development districts (WDDs) are political subdivisions of the state composed of multiple counties or portions of counties and charged by the state with promoting conservation, development, and proper management of water resources according to district priorities. WDDs provide technical, organizational and financial assistance to prospective and existing projects. Not all geographic areas of South Dakota are part of a WDD. In the South Dakota portion of the Red River Basin, Marshall County is included in the James River WDD, and Roberts County is currently not a part of a WDD.

Manitoba

Primary water management responsibility on the provincial level rests with Manitoba Water Stewardship.

Manitoba Water Stewardship (MWS): MWS has been granted broad water management authority. While MWS was formerly a stand-alone department, as of early 2012, the functions of MWS are now housed under two separate departments. The environmental functions (i.e., water quality) now fit with Manitoba Conservation, which has been renamed Manitoba Conservation and Water Stewardship, while the activities related to flooding are now under Manitoba Infrastructure and Transportation (Winnipeg Free Press 2012).

MWS is responsible for many acts and regulations. One of these is the *Water Resources Act*. Under the provisions of this act, MWS constructs and operates water control works on designated provincial waterways. Another important piece of legislation is the *Water Rights Act*, which establishes the branch's role in the use and control of surface water and ground water as well as addressing drainage. Powers granted by the act include administration of a priority-of-use program, the licensing of water users, setting fees, and regulation of drainage activities. Examples of other powers and duties of MWS include:

- Overseeing the drilling of all water wells through licensing of well-drilling contractors,
- Regulating the use of water and land for hydroelectric power development,
- Operating provincially owned water control structures for water supply and flood control, and
- Providing professional, technical, and financial support to rural municipalities and conservation districts. (Whitney 1990).

Manitoba Water Services Board: The Manitoba Water Services Board was created in 1972 "to assist in the provision of water and sewage facilities to the residents of rural Manitoba." It is composed of representatives of the Departments of Environment and Municipal Affairs and two citizen members. Objectives include:

- Obtaining supplies of potable water for domestic and other uses within the province and selling water to municipalities and water districts;

- Acquiring or constructing, and operating and maintaining plants and works needed to provide adequate water supplies;
- Acquiring or constructing the necessary distribution features; and
- Acquiring or constructing the operation and maintenance works for the collection and treatment of sewage (Manitoba Water Services Board 1989).

Players at the Federal Level (United States)

The influence of the federal government on water management activities in the United States portion of the basin is growing. The more important agencies responsible for administering numerous federal programs in the basin include the Natural Resource Conservation Service, Fish and Wildlife Service, Geological Survey, Army Corps of Engineers, National Park Service, Environmental Protection Agency, and Department of Homeland Security.

Natural Resource Conservation Service

The Natural Resource Conservation Service (NRCS) is a technical agency of the US Department of Agriculture. Providing both technical assistance and matching funds, NRCS has cooperated with local and state agencies on both the North Dakota and Minnesota sides of the river in implementing several flood damage reduction measures and conservation practices. Local NRCS and Farm Service Agency (FSA) offices, with technical services provided by soil and water conservation districts, administer federal conservation programs such as:

- ***Watershed Protection and Flood Prevention Act of 1954* (Public Law 83-566)**. Assist urban and rural communities in protecting, improving, and developing water and land resources of watersheds of up to 250,000 acres.
- **Acreage Conservation Reserve Program**. Designed to assist in the conversion of cropland to various conservation uses.
- **Conservation Reserve Program.** Involves payment to farmers who agree to discontinue growing crops on highly erodible land for a period of ten years and to plant it to grass or trees or both.

Red River Basin Commission

Agriculture is of vital importance in the Red River Basin.

- **Agricultural Conservation Program**. Provides cost-sharing to carry out conservation and environmental protection practices on agricultural land.
- **Federal Waterbank Program**. Authorizes lease contracts with landowners to protect qualifying wetlands and adjacent uplands.

Fish and Wildlife Service

The Fish and Wildlife Service (FWS) administers two habitat preservation programs which impact directly on an area's water resources. The first program involves fee title purchases of land for waterfowl management purposes. A second program involves leasing certain valuable habitat acres. Landowners agree not to drain, tile, or fill wetlands. They may hay, graze, or farm wetlands under lease when they are dry from natural causes.

FWS documents and reports potential wetlands preservation violations to responsible agencies such as North Dakota SWC, Minnesota DNR, Army Corps of Engineers, Agricultural Stabilization and Conservation Service, and others. FWS has been active in monitoring implementation of the "Swampbuster" provisions of the 1985 and 1990 Farm Bills.

To prevent loss of or damage to wildlife resources, the *Fish and Wildlife Coordination Act* requires consultation with FWS and the State Game and Fish Department to impound, divert, channelize, or otherwise control or modify waters of any stream or water body. The act also authorizes federal water resource agencies to acquire lands or interests in connection with water use projects specifically for mitigation and enhancement of fish and wildlife, and provides for management of such lands by FWS or the State Game and Fish Department.

Wildlife habitat.

US Geological Survey

The US Geological Survey (USGS) provides technical services and assists local units of government in identifying and resolving water problems. USGS conducts regional aquifer studies and maintains a network of streamflow and lake level gages. The agency's data collection and management services are used at all levels of government in making water management decisions.

Army Corps of Engineers

The US Army Corps of Engineers (USACE) has broad authorities pertaining to dredge and fill activities, streambank protection, snagging and clearing, and other flood control measures. Under Section 10 of the *Rivers and Harbors Act*, it is necessary to secure a permit from USACE prior to initiating works or placing structures in waters classified as navigable. Under Section 404 of the *Clean Water Act*, a permit is needed for all projects involving sidecasting dredged material from drainage projects or other filling activities (Crist 1990).

Several types of assistance are available to local units of government under the agency's Continuing Authorities (Small Projects) Program, including:

- **Section 14, Emergency Streambank Protection Program.** Provides 25 percent cost-share to local governments to protect streambanks and other erosion-prone structures such as highways, public works, hospitals, schools, bridge approaches, and other nonprofit public facilities.
- **Section 22, 1974 Water Resources Development Act.** Authorizes USACE to cooperate with states in preparing comprehensive plans for water resource development, utilization, and conservation.
- **Section 205, Small Flood Control Projects Program.** Provides 25 percent cost-share to implement structural (levees, channels, or dams) and non-structural (floodproofing or floodplain evacuation) measures.
- **Section 208, Clearing and Snagging Program.** Provides 25 percent cost-share to remove debris (trees and snags, etc.) from streams and rivers to aid in flood control.
- **Floodplain Management Services Program**. Provides technical assistance and guidance on floodplain and flood issues including assistance in interpreting flood data, development of data on the frequency and extent of flood events, and assistance in developing flood evacuation plans (Crist 1990).

National Park Service

The National Park Service (NPS) makes grants to local units of government to fund outdoor recreation projects. These 50 percent matching funds are administered by Minnesota DNR and North Dakota Parks and Recreation Department.

Environmental Protection Agency

The Environmental Protection Agency (EPA) is charged with mounting a coordinated attack on environmental problems of air and water pollution, management of solid and hazardous wastes under Superfund, regulation of pesticides, toxic substances, and some aspects of radiation and noise. Functions include setting and enforcing environmental standards; conducting research on causes, effects, and control of environmental problems; and assisting state and local governments.

Department of Homeland Security

The Department of Homeland Security (DHS) was formed in March 2003 in response to the terrorist attacks of September 11, 2001. Two agencies within the department have some responsibility for managing water resources: the Coast Guard and the Federal Emergency Management Administration.

The United States Coast Guard is one of the five armed forces of the United States and the only military organization within DHS. The Coast Guard regulates boating activities on navigable waterways of the United States, which includes the Red River of the North. Operators of certain types of commercial watercraft on the Red River must be licensed by the Coast Guard.

Federal Emergency Management Administration (FEMA) improves capabilities to prepare for, protect against, respond to, recover from, and mitigate all hazards, including flooding. FEMA administers the National Flood Insurance Program (NFIP) and identifies flood plains. They also produce the digital flood insurance rate map (DFIRM) used to determine if structures are in designated flood plains.

Red River Basin Commission

The Coast Guard and FEMA spend time in the Red River Basin during flood events.

Players at the Federal Level (Canada)

The federal entity in Canada with the broadest water management responsibilities is Environment Canada. Established as a department of the government by an Act of Parliament in 1971, it was given the responsibility for preserving and enhancing the quality of the environment by promoting harmony between citizens and their environment.

With respect to water resources, Environment Canada has a clear mandate to preserve and enhance the quality of the natural environment, including water, land, and air. It likewise has significant authority in the areas of renewable resources and migratory birds and wildlife, and is responsible for enforcement of rules and regulations arising from the advice of the International Joint Commission (see following section) related to boundary water disputes between the United States and Canada.

Environment Canada's Water Science and Technology Directorate develops strategies and implements federal policy based on scientific study and extensive data collection and analysis programs. Areas of study include aquatic ecosystem impacts, management and protection, green technologies, and water quality monitoring and surveillance (Environment Canada, Science and Technology Branch, 2012).

Fisheries and Oceans Canada (DFO) and its Special Operating Agency, the Canadian Coast Guard, deliver programs and services that support sustainable use and development of Canada's waterways and aquatic resources. DFO is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social, and economic interests in oceans and fresh waters. Its guiding legislation includes the *Oceans Act*, which charges the Minister with leading oceans management and providing coast guard and hydrographic services on behalf of the Government of Canada, and the *Fisheries Act*, which confers responsibility to the Minister for the management of fisheries, habitat, and aquaculture. The department is also one of the three responsible authorities under the *Species at Risk Act* (Fisheries and Oceans Canada 2012).

The Agri-Environment Services Branch (AESB) is another federal program serving the interests of soil and water. AESB is an integration of the Prairie Farm Rehabilitation Administration (PFRA), National Land and Water Information Service, and Agri-Enviornmental Policy Bureau (Agriculture and Agri-Food Canada 2011). PFRA was created in 1935 to help drought-stricken farmers in the prairie provinces. AESB has now taken over the responsibility of providing services in a number of water and related land areas through field offices located throughout Canada, including one in Manitoba. AESB's mission is to bring[ing] an integrated expertise and innovative environmental solutions to the agriculture and agri-food sector (Agriculture and Agri-Food Canada 2011). AESB's goals include "improve[ing] the sector's on-farm environmental performance, accelerate[ing] development and adoption of innovative risk-mitigation technologies and strategies, and increase[ing] the sector's leadership capacity on environmental issues" (Andrew 2010).

Red River Basin Commission

Lake Winnipeg water quality is a top priority.

Non-Government Organizations (NGOs)

Many general and special interest NGOs are involved with water management in the Red River watershed, including the Red River Basin Commission (RRBC), the International Water Institute, River Keepers, Red River Coalition. NGOs, like government, operate on all levels from local, to statewide, to national, to international (slmcleod 1999).

Red River Basin Commission (RRBC)

A series of informal meetings among basin leaders from both sides of the International Boundary in late 1995 provided the impetus for the formation of the Red River Basin Board. This not-for-profit corporation is chartered in North Dakota, Minnesota, South Dakota, and the Province of Manitoba. Activated in mid-1997, it is a locally driven mechanism dedicated to the development of a basin-wide water management plan and to providing a mechanism for resolving inter-jurisdictional disputes. It is the first such organization to undertake a comprehensive planning effort for the entire basin.

Its goals are to:

- Foster increased involvement by local governmental officials and rank-and-file residents in the water management decision-making process;
- Promote cooperation and coordination;
- Create a central location in the basin for data access;
- Build consensus by forging a set of guiding principles to help basin leaders make the hard choices they must from time to time make;
- Develop an information-education program that contributes to making informed recommendations;
- Monitor planning and implementing activities ongoing in the basin; and
- Sponsor locally-led forums to discuss and seek consensus on water-related issues.

The RRBC Board of Directors is comprised of 41 individuals from the following jurisdictions:

- 12 from Manitoba, with four representatives from rural municipalities; two mayor's representatives, one each from Winnipeg and Selkirk; one from a water cooperative; one environmental organization representative; three appointed by the Premier, and one elected at-large from Manitoba delegates to the RRBC's Annual Summit Conference;
- 12 each from Minnesota and North Dakota, with two representatives from the counties, three mayors, two from watersheds/water resource districts, three appointed by each Governor, one representing environmental organizations, and one elected at-large from the state's delegates to RRBC's Annual Summit Conference;
- Two members from South Dakota, including a governor's appointee and one elected at-large from the state's delegates to RRBC's Annual Summit Conference; and
- One member each from the First Nations in Minnesota, North Dakota, and Manitoba.

Red River Basin Commission

A panel of local government leaders at an RRBC Annual Land & Water International Summit Conference.

Other NGOs

There are scores of other NGOs in the Red River Basin that either address water management as their principal focus, or enter the water management fray when issues important to them arise. This proliferation of NGOs is both an expression of discouragement with the progress of government as well as an indication of the importance of water management. It is also a reflection of the diverseness of values and opinions that exists when dealing with complex water issues.

International Management

Because the Red River of the North flows from one country into another, it is an international river. As such, it is subject to the terms of the *Boundary Waters Treaty of 1909*. The Boundary Waters Treaty provided for creation and maintenance of an International Joint Commission (IJC) composed of three members from the United States and three from Canada. The International Red River Board was formed in 2001 by merging the International Souris-Red Rivers Engineering Board and the International Red River Pollution Board. Its activities focus on factors affecting the Red River's water quality, water quantity, levels and aquatic ecological integrity (IJC 2011).

The treaty stipulated that, except for uses, obstructions, or diversions authorized prior to the January 11, 1909, signing date, further use, obstructions, or diversions affecting the natural level of water on either side of the boundary were to be permitted only if approved by the IJC. The treaty further stipulated that such waters were not to be polluted on either side to the injury of health or property on the other side.

Under terms of the treaty, questions or matters of difference between the United States and Canada can be referred to the IJC whenever either government so desires. The Garrison Diversion Project in North Dakota has been on the agenda of the IJC for several years. That body continues to study and deliberate over a variety of aspects of the project (49 PICAR 1987), including interbasin transfers of Missouri River waters and Devils Lake flooding.

Management is Dynamic

This brief overview of the water management system only touches the surface of its complexity. While formal government structures rarely change, government agencies change more frequently. Elected government officials change on a regular, periodic basis, and many must learn about water management "on-the-job" or "on-the-fly." Rules and regulations governing water management are subject to change with each change of elected officials. Visions and issues important to special interests and NGOs also change over time and as leadership changes. Add these dynamics to the multi-layered water management system and it becomes almost overwhelming to the ordinary basin resident.

There is some interest in simplifying management systems to enhance efficiency and effectiveness. "In order to enhance protection from future flooding, in either the US or Canada, we suggest a 'whole watershed' approach that recognizes the river as an hydrological system, not just a river to be managed in segments" (slmcleod 1999).

However, existing entities are reluctant to give up their authority or autonomy, some for good reason.

Red River Basin Commission

The river winds its way north.

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Chapter 10

Case Study: Devils Lake—A Closed Basin

Introduction

It is generally recognized by basin residents that flooding has an adverse impact on the economy. Unseeded cropland, damaged buildings and roads, floodproofing expenses, flood insurance premiums, and a variety of other factors are stark reminders of how floods exact an economic toll. At the same time, it is also widely acknowledged that reducing the severity and frequency of flooding has an opposite, positive economic effect.

What is less well-known is the role that water supply plays in various other aspects of the basin's economy. Water supply problems in the basin are usually short-term and localized. As a consequence, residents have only limited experience with this flip side of the "too much" problem. In fact, water supply shortages are considered a nonissue by most people…most of the time. History has conditioned them to expect water to be available for use when needed…because it always has been. Fleeting concerns engendered by intermittent periods of extended drought quickly subside with the return of more "normal" conditions. At such times, water supplies are generally adequate on a basin-wide basis…and generally taken for granted.

History has also affected the views of basin residents on costs. Not only do they expect assured supplies, they expect the cost of that water to be low, or at least modest. Some will argue that water is far from inexpensive when the "true costs" of making it available are considered, but virtually all will agree that an assured supply of low cost water is a component of infrastructure typically taken for granted in this area.

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Flooded road.

This perception about the availability and cost of water is pervasive in that it extends to all water uses throughout the basin. It also explains in part the reduced awareness citizens have about how water availability impacts their personal economic lives and the basin's economy. This chapter is dedicated to increasing citizen awareness and understanding of that relationship.

A case study approach, examining the dynamic water levels on North Dakota's Devils Lake, provides an opportunity to study the consequences associated with a lake that was, until 1993, "going dry." The recent low in 1993 was 18 feet higher than the low in 1940. Since 1993, Devils Lake has quadrupled in size and risen over 30 feet. The next section on "dry" Devils Lake was written for the 1993 printing of this book. The following section on "wet" Devils Lake describes the impact of the current wet cycle on the lake.

The Devils Lake Subbasin—DRY Years

The Devils Lake watershed is a hydrologic subdivision of the Red River Basin in North Dakota (Figure 10-1). It is quite probable that a significant segment of the basin's population is unaware that such a hydrologic relationship exists.

Nonresidents typically think of the Devils Lake watershed as being adjacent to, but separate from, the Red River Basin. This misperception stems largely from the fact that it has probably been some 1,200 years since an actual transfer of water between the two basins occurred (Bluemle 1981, Bluemle 1991).

At the end of the last glaciation period, the area occupied by present day Devils Lake was covered by a glacial lake estimated to be approximately three times larger. It is believed that glacial Lake Minnewaukan, as it is called, spilled into the Sheyenne River—a major Red River tributary—when its surface elevation reached approximately 1,453 feet msl (Bluemle 1981a). It has spilled over to the Sheyenne River several times in the past 10,000 years.

So long as the lake's elevation was maintained at about 1,450 feet msl through a combination of glacial meltwater flowing in from the retreating ice sheet to the north, precipitation, and snow meltwater, the lake drained to the south down the ancestral Sheyenne River. It ceased to contribute to the Sheyenne when the amount of water flowing into the basin became less than the water going out via subsurface outflow and losses to evaporation (NDSWC 1968).

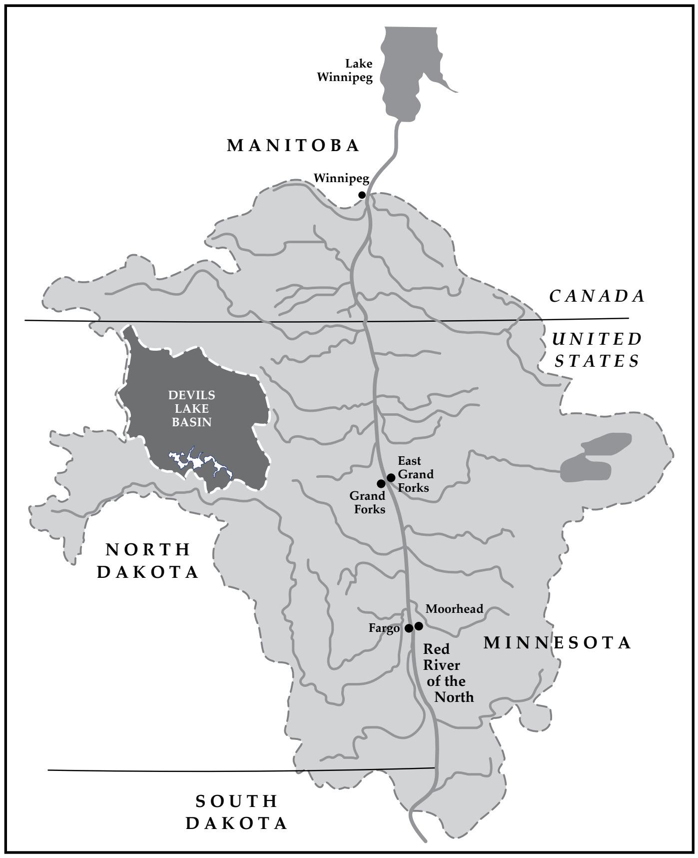

Figure 10-1
Location of Devils Lake Subbasin
SOURCE: NDSWC 2011.

The circumstances under which water would again flow naturally from the Devils Lake watershed to the Sheyenne River can be imagined, but the probability is sufficiently remote as to warrant neither calculation nor concern.[1] What might be termed an "unnatural" transfer is possible, however, should society determine it is desirable to do so.

Physical Characteristics (in 1993)

Devils Lake is the largest natural body of water in North Dakota. Lakes Sakakawea and Oahe, located on the Missouri River to the west, are larger, but they are man-made. Devils Lake is shallow and saline, but at higher elevations maintained during the most recent wet cycle, it is capable of sustaining a thriving fishery.

[1] How shortsighted we can be and how quickly things can change are clear. The concern about high water in Devils Lake in 2012 is far more serious than was the concern about low water in the early 1990s.

The Devils Lake watershed, in northeastern North Dakota, is a ***closed basin***, normally a noncontributing portion of the Red River Basin (Figure 10-1). Its 3,810-square-mile surface area (NDSWC et al. 1990) is about 8 percent of the Red River Basin's total area.

The eastern, western, and northern boundaries of the basin are poorly defined with low divides. The southern boundary of the watershed is a series of recessional moraines situated between Devils Lake and the Sheyenne River (Wiche 1986). Topography prevents surface water from leaving the watershed, and Devils Lake itself serves as the ultimate collection point for most, but not all, runoff. About 1,300 square miles, primarily in the northern portion, are either noncontributing or only partially contributing to Devils Lake. Intermittent connections with adjacent watersheds may occur during high water.

The amount of water reaching Devils Lake in any given year is determined by a complicated set of circumstances involving general climatic factors, soil moisture conditions, and the availability of surface water storage in wetlands and in a group of lakes located north of Devils Lake. The Sweetwater Group, which includes Sweetwater Lake, Morrison Lake, Cavanaugh Lake, Dry Lake, Mike's Lake, Chain Lake, Lac Aux Mortes (Lake Alice), and Lake Irvine, constitutes a first link in the Devils Lake chain (NDSWC et al. 1990). At times, during wetter cycles, the lakes are connected, discharging via a series of small coulees. Under average runoff conditions, however, these lakes are shallow, often marshy or nearly dry. Discharges from these lakes occur through Big Coulee or via a man-made outlet from Dry Lake known as Channel A.

The main chain of lakes, which includes West Bay Devils Lake, Devils Lake, East Bay Devils Lake, East Devils Lake, West Stump Lake, and East Stump Lake, is situated south of the city of Devils Lake on a west-northwest/east-southeast axis (Figure 10-2).

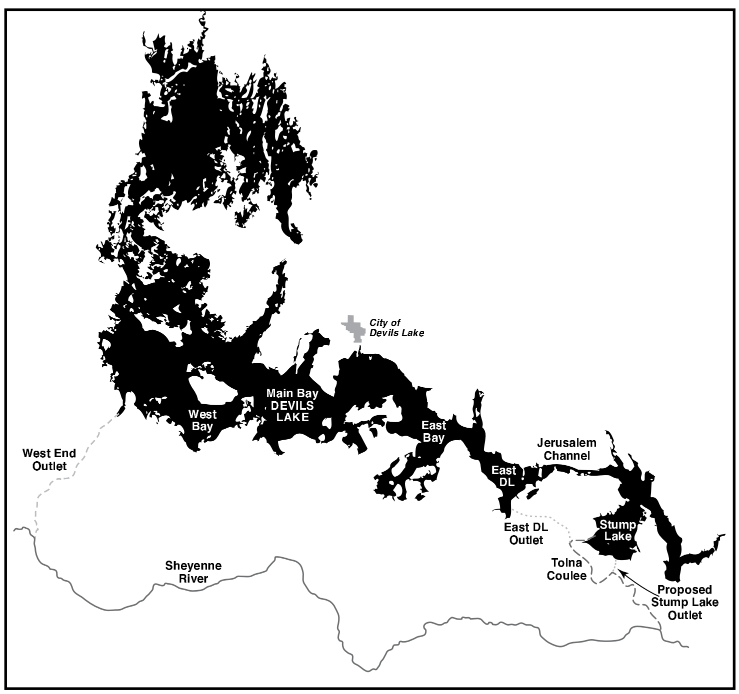

Figure 10-2
The Devils Lake Main Chain Complex
SOURCE: NDSWC 2012.

Records indicate that water levels of Devils Lake have fluctuated from 1,438 feet msl in 1867 to 1,400.9 msl in 1940.

Surface areas of the lake have varied from a high of about 140 square miles in 1867 to about 10 square miles in 1940. At elevation 1,428.9 msl (the maximum elevation achieved before the most recent decline began in 1987), Devils Lake covered approximately 53,200 acres (83.2 square miles) and contained nearly 850,000 af of water (Sando 1991). At its spill elevation, the lake covers 407 square miles.

By early 1990, Devils Lake had receded from its most recent high at elevation 1,428.9 msl to 1,424.7 msl. The volume lost between these two elevations was approximately 225,000 af (NDSWC et al. 1990). Runoff into Devils Lake in the spring of 1991 was virtually nonexistent. Even heavy rains in the summer of 1991 triggered only short-term, far-below-average flows into the lake. If the drought conditions of the past two to four years persist, the lake will continue to decline, and that decline is expected to continue to exert a negative impact on the area's economy.

The Problem

The Devils Lake problem starts with the physical issue of water which leads to an economic issue of the community impacts.

Hydrologic

Fluctuating lake level elevations are the rule rather than the exception for Devils Lake. A substantial body of research based on the analysis of sediment samples and on other factors such as vegetative growth points to a history of fluctuation over a period of several thousand years prior to the time when record keeping began (Arnow 1955, Arnow 1957, Bluemle 1981, Bluemle 1991, Callender 1968).


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A farmstead in the Devils Lake Basin that has been abandoned due to flooding.

Sporadic recording of lake level changes occurred between 1867 and 1901 when the US Geological Survey established a gage at Devils Lake. Gaging records, coupled with the authenticated pre-gage data, attest to the lake's continuing habit of fluctuation.

Declining lake levels increase the concentrations of ***total dissolved solids*** (TDS), and the volume of dissolved oxygen (DO) available to meet the biological oxygen demand (BOD) decreases. As TDS concentrations rise, fish become increasingly stressed and less tolerant to low DO conditions. Historically, conditions exist for partial to total fish kills when the water level falls below 1,422 msl (NDSWC et al. 1990).

Economic

Prehistoric lake fluctuations undoubtedly influenced the nature and extent of the area's flora and fauna, and more recent fluctuations have impacted directly on a variety of human activities. But it is only since Devils Lake has become a nationally recognized sport fishery that the importance of stabilizing the level of Devils Lake has been realized beyond basin boundaries. Stocked by the North Dakota State Game and Fish Department, northern pike, walleye, yellow perch, and white bass are important components of the existing fishery.

Creel census data collected during the summer of 1988 and the winter of 1988-1989 were the basis for the State Game and Fish Department's estimates that anglers spent $27 million to fish Devils Lake during the 1988-1989 fishing season. When the "recreation and tourism" multiplier contained in the Input/Output Economic Model developed at North Dakota State University is applied to the $27 million, the gross business volume generated by fishermen is over $90 million. That level of business activity translates into almost 1,400 jobs for the area (NDSWC et al. 1990).

Substantial public and private investments are at risk as a consequence of declining lake levels and the resulting diminished fishery. Public investments include an estimated $3.5 million in parks and lake access facilities on Devils Lake. Current plans call for additional public developments of about $2 million (NDSWC et al. 1990).

The State Game and Fish Department has invested approximately $4 million in the Devils Lake fishery in stocking, manpower, development, and research through 1992 (NDSWC et al. 1990). These are sportsman-financed investments placed at risk by declining lake levels.

Substantial private developments on about nine miles of the Devils Lake shoreline are conservatively estimated at $20 million, according to the Ramsey County Director of Tax Equalization. Other planned developments have been placed on hold by investors fearful of how a continuing decline in lake levels may impact not only on the fishery but on the existing shoreline.

Elusive Solutions

Devils Lake, as has been shown, has a history of extreme fluctuation. Conditions can change rapidly from those which threaten the fishery because of low water levels to those which pose a flood threat to shoreline property. As a consequence, it is generally accepted that a management plan which deals with both declining and rising lake levels is needed.

The *Devils Lake Stabilization Study* was a cooperative, multi-agency effort. The study was designed to compare numerous actions thought to have some potential for preventing the loss of the highly valued fishery and recreation opportunities currently provided by the lake. North Dakota agencies participating in this effort included the SWC, State Engineer, State Game and Fish Department, Garrison Diversion Conservancy District, and NDSDHCL. The US Bureau of Reclamation, USACE, and USGS also participated.

Alternatives considered were those that could be implemented quickly and at a minimal cost to provide short-term relief, and those that involved major construction projects capable of providing long-term solutions.

Short-term Alternatives to Low Water

Several alternatives using surface and ground-water sources were evaluated. Surface water sources were found to be inadequate during drought periods, and ground water was judged to be insufficient to significantly contribute to the level of Devils Lake without jeopardizing the supplies of existing water users.

One short-term alternative involved isolating portions of the lake by constructing a weir (control structure) and using natural inflows to maintain a viable, down-sized pool. Yet another would necessitate sacrificing East Bay and East Devils Lake by pumping the water that remains in these back into Main Bay. Needless to say, neither of these alternatives is desirable, but if conditions develop which are conducive to a major fish kill, they do represent two ways of potentially retaining a sport fishery in one portion of the lake.

Long-term Alternatives to Low Water

Three major scenarios—selected from a total of 28—for supplementing Devils Lake waters were considered. One involved diverting Sheyenne River water from a point southwest of Devils Lake. Another involved bringing in untreated Missouri River water, and a third would divert treated Missouri River water to Devils Lake by using features of the Garrison Diversion Project. The treated waters would meet the biota transfer requirements imposed by the government of Canada.


Red River Basin Commission

Devils Lake Basin.

Alternative 28, as it was called, was deemed to be the most practical. Under this alternative, 200 cfs (70,000 af) of treated Missouri River water would be diverted to Devils Lake via a 22-mile long pipeline. A biota control treatment plant would be located on the New Rockford Canal. The pipeline to Devils Lake would begin at the treatment plant and cross the Sheyenne River. A turnout facility would be built at the Sheyenne River crossing to make possible delivery of water to the Sheyenne River for conveyance to Fargo, Grand Forks, and surrounding communities in order to satisfy their long-term municipal and industrial water demands.

Alternative 28 was estimated to cost $76 million, with annual operation and maintenance costs of $3.8 million. It has several advantages over other proposals, including the fact that it is a "closed system" which minimizes the loss of treated water. It also involves minimal environmental impacts, and implementing the plan does not involve the conversion of large areas of land from current uses to other uses. The Sheyenne River would not be used for conveyance to West Bay, and a West Bay inlet enhances the potential for natural reproduction of sport fish.

Further Study Requirements

Concrete pipe sections for the East Devils Lake outlet.

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Agencies involved in the Devils Lake Stabilization study recognized that more detailed investigations were needed on preferred alternatives before implementation was possible. In March 1991, Congress authorized the Secretary of the Army to conduct a study for the purposes of providing plans "for the development, utilization, and conservation of water and related land resources" in the Devils Lake Basin. In April, the State Engineer appointed a special Devils Lake task force to assist the State Water Commission in developing a conceptual water management plan for the basin. This report, completed in October 1991, was used by USACE in its Devils Lake Basin reconnaissance level study and began an ongoing process to improve water management in the Devils Lake Basin.

The USACE completed its study in February 1992. The reconnaissance study was needed to determine the existence of a federal interest and to demonstrate, among other things, that at least one inlet/outlet plan is technically feasible, economically justified, environmentally acceptable, and supported by a nonfederal sponsor.

Solutions and Implementation Obstacles

The nationally recognized fishery of Devils Lake was under siege by Mother Nature. The economic well-being of a region was in jeopardy unless precipitation levels increased or unless some means could be found to supplement flows into the lake. It is well-established that nature is unpredictable. Though it would take some time, even under a return to normal precipitation levels, economic disaster might be averted if that "return to normal" has already begun. That does not seem to be the situation, however, and in any case, the "problem" of keeping lake levels stable remains.

To meet the immediate and long-term needs to provide a supplemental water supply for Devils Lake and then to maintain a desirable lake level within acceptable ranges, Alternative 28 or another alternative was needed. Implementation, however, requires time. Feasibility studies do not lend themselves to haste. Social acceptance is a prerequisite, and support from virtually every governmental and special interest downstream of the project must be secured. Canadian concerns about biota transfer must be addressed to their complete satisfaction.

Water management decisions made in the Devils Lake Basin are carefully scrutinized by others because, quite simply, the Devils Lake Basin is a part of a larger hydrologic unit. Solving the water supply problems in the Devils Lake Basin when solutions will impact elsewhere in the drainage of the Red River Basin is no longer the exclusive domain of its citizens. That reality does not mean that problems are beyond solution. It means, instead, that we live during a time in history when our business is often someone else's business as well.

The Devils Lake Subbasin—WET years

When *A River Runs North* was first published in 1993, Devils Lake water levels had fallen to a point that placed the survival of the Lake's multi-million dollar sport fishery in jeopardy. That same year, record summer precipitation caused Devils Lake to rise five feet in six months. *A River Runs North* authors noted that a long-term plan to address the naturally fluctuating water levels in Devils Lake would be needed. Congressional action in 1991 set the USACE on a course of developing a plan that would stabilize the situation at Devils Lake. Subsequent flooding over successive years has rendered that effort secondary in importance. All energy has been diverted to addressing the emergency flooding problems facing area residents.

Flood Background

Devils Lake is a terminal lake in a periodically hydrologically connected subbasin of the Red River of the North Basin. The lake has risen for nearly two decades, including the five-foot jump in 1997 (Figure 10-3). Since 1993, the Devils Lake region has been included in numerous Presidential Flood Disaster Declarations. Dr. John Bluemle, North Dakota State Geologist, suggests Devils Lake has overflowed naturally into the Sheyenne River about ten times in the last 10,000 years.

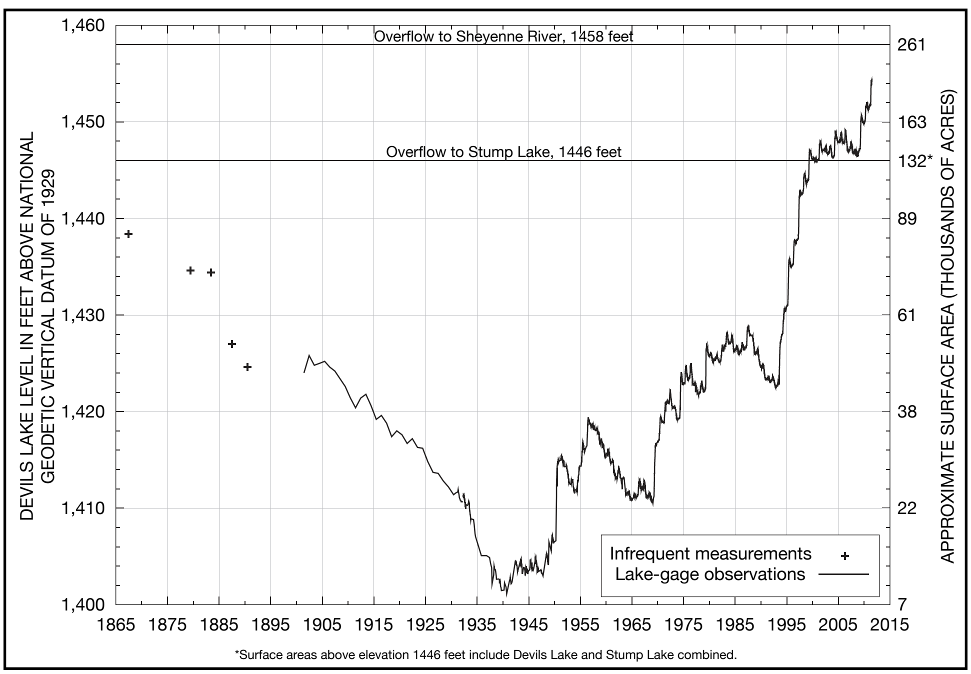

Figure 10-3
Water Surface Elevation, Devils Lake, North Dakota
SOURCE: NDSWC Flood Facts, NDSWC 2011.

The lake has increased by about 120,000 acres between 1993 and June 2011 (Figure 10-3). Hundreds of year-round and seasonal homes have already been moved or destroyed, miles of highways have been raised, some several times, or, in some cases, abandoned. Businesses have closed and tens of thousands of acres of agricultural land has been lost to the lake. Estimates place the economic loss into the hundreds of millions. Social and environmental impacts of this flood have reached devastating proportions. Professional water managers suggest it could get worse.

The governor, congressional delegation, SWC, and local political leaders have adopted a three-pronged approach to addressing the flood problem—improved water management in the watershed, continued infrastructure protection around the lake, and outlets to the Sheyenne River.

Red River Basin Commission

Devils Lake flooding.

The USACE's most recent effort to develop an outlet from Devils Lake came in 2003 when they completed an Environmental Impact Statement for that alternative. The cost of the Corps' outlet alternative was $186 million—causing the state to pursue an outlet project on its own.

In August 2005, construction on a state-sponsored emergency Devils Lake outlet was completed. The outlet was originally built with an operational capacity of 100 cfs. However, in June 2010, the state completed a major expansion to the outlet, increasing its capacity to 250 cfs. The west-end outlet consists of two pump stations, a rock filter, approximately four miles of pipeline, and ten miles of open channel.

The state's more recently completed East Devils Lake outlet is approximately 5.5 miles long, from the southeast corner of East Devils Lake to Tolna Coulee. At the intake, one 50 cfs and four 75 cfs pumps will move up to 350 cfs of Devils Lake floodwater.

The west and east Devils Lake outlets will have a combined operating capacity of 600 cfs. Together, the two outlet projects will be able to remove up to 200,000 af of water from Devils Lake during the seven-month operating season if they are operated at or near capacity. That amount of water, in addition to evaporation, could keep up with average (1993-2010) lake inflows of 247,000 af (NDSWC 2011).

A project such as the Devils Lake Emergency Outlet, unless properly designed, constructed, and operated, can impact downstream areas receiving the water and spawn many concerns. Public hearings for the Environmental Impact Statement process identified many concerns to be addressed. Areas of concern include:

- impacts on water quality in Devils Lake and downstream,
- potential added downstream flood risks,
- erosion and negative impacts to aquatic ecosystems,
- impacts on local and downstream recreation,
- effects on agriculture in the basin and downstream,
- concerns of Minnesota and Manitoba,
- infrastructure impacts, and
- questions about funding sources.

As this edition is being written, Devils Lake is at a record high of 1,454.4 feet msl, up from 1,422.4 in October 1992. At 1,454.4 feet msl, the lake covers 333 square miles. The lake will naturally spill over through Tolna Coulee to the Sheyenne River at 1,558 feet msl, as it has several times since the glaciers last retreated.

Red River Basin Commission

The Recipe For Sustained Growth

The Devils Lake case study has demonstrated that additional growth, or even sustaining current levels of economic activity, requires ever more creative solutions. While once quick physical fixes were all that was necessary, fixes may now require extensive structural measures and even more intricate social and political coalitions. And, one decade's fix may be 180 degrees off from the required fix a decade or two later.

As investments are made and growth occurs, the risk of adverse impacts from Mother Nature are increased. When an area becomes more developed, there is less room left to buffer the effects of flood or drought. This is true throughout the Devils Lake Basin. As development reaches its extensive (all space is filled up) and intensive (each space is filled full) margins, it becomes more and more sensitive to changes in the quantity and quality of water. These quality and quantity shifts are far more difficult and expensive to manage than when development was less intensive.

For example, a glass of water half full (not fully developed) can withstand some jolting around without spilling. However, a glass full to the brim needs to be handled with much more care to prevent spilling. Development in the basin is getting nearer to the "brim," much more sensitive to what once were considered normal water patterns and extremely sensitive to the abnormal events.

The recipe for ongoing growth includes one part technical know-how, one part economic feasibility, and one very large part political coalition. Each of these parts is becoming more complex in the Devils Lake Basin, as is the procedure for mixing them.

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Chapter 11
Divergent Perspectives

Introduction

This book is dedicated to helping residents of the Red River Basin better appreciate the nature and extent of the area's water resources and to provide insight into how those resources are managed. The intent has been to portray as clearly and objectively as possible the area's water problems without taking positions or influencing readers' views on the issues.

The necessity for water management in the Red River Basin dates back to the early years of the Selkirk Settlement, when intrepid pioneers first began dealing with the problem of wet lands or when they watched as their primitive farms were inundated by floodwaters.

Water management was mostly a private matter then, with individuals doing what they could to manage their specific problems. Because they possessed limited capability to deal with a major spring or summer flood, for example, their water management initiatives were likely modest in scope, restricted to their own land, and accomplished without controversy.

Water management has grown infinitely more complicated. Today, with the technology and equipment basin residents have at their disposal, water management activities undertaken in one part of the basin can have dramatic impacts on other parts. As a consequence, the decision-making process must accommodate the views of individuals, governmental agencies, and others throughout the basin.

Flooding continues to be a major concern to many. Water supply for domestic use and water quality are of growing concern as well. Dealing with these and other issues is a difficult task. Solutions are elusive and often costly. The processes to be followed in sorting through alternatives and determining costs are cumbersome and time-consuming but essential in order to protect the environment and identify efficient solutions.

To assess the current state of affairs regarding water management in the basin, about 40 professional water managers and private citizens throughout the basin were surveyed. They included individuals who regularly attended Red River Water Resources Council meetings and others known to have an interest in water management. The opinions of these experienced and respected individuals may help clarify the nature and extent of current issues, the probable nature of future problems, the adequacy of current approaches, and steps which might be taken to improve how water management activities are conducted. Responses are not listed in any particular order, and order does not imply priority of importance.

Notice as you read the comments that some conflict with others, some represent "outdated" thinking, some are "path-breaking," and almost all require the recipe for sustained growth from Chapter 10 to accomplish explicit or implicit objectives.

What do you believe is the single most important unresolved water management issue in the hasin today?

"Provision of a good quality, dependable water supply for all basin residents."

"The way land is used in the basin. Most so-called 'water' problems are the result of misused land."

"Water quality deterioration. Sediment and agricultural chemicals, in particular, have reduced water quality over time. The present protection activities seem aimed at maintaining current quality rather than restoring water quality to pre-settlement conditions."

"Supplemental water to the Sheyenne and Red Rivers for domestic, rural, irrigation, and industrial development."

"Flooding remains the single most important unresolved problem, but the problem of inadequate water supply is becoming increasingly significant."

"We do not have a clear view of the relationship between the price of water and water use. All water use projections seem to be based upon water purchased at prices below water cost."


Red River Basin Commission

"The supply of an adequate quantity of high quality water to meet the needs for continued economic growth, including stabilization of the water level and quality of Devils Lake."

"The inability to obtain a stable month-to-month, year-to-year source of water. This could be accomplished through interbasin transfer from the Missouri River."

"Controlling the spring runoff with retention structures that can hold the water for use during the dry periods."

What do you believe must happen before the issue you identified can be resolved?

"As is happening in Fargo-Moorhead, people must be faced with a water shortage before they realize the importance water plays in their lives."

"A greater realization by politicians, particularly those representing urban areas, that the provision of water supplies in rural areas will generate economic development, which will ultimately benefit all Manitobans."

"We must develop a way to compensate landowners for retaining water on their lands. If compensated fairly, landowners will not suffer financially or emotionally."

"The biota transfer issue and other political problems associated with diversion of Missouri River water to the Red River Basin must be resolved."

"There should be no illusions about the ultimate success of flood damage reduction measures in the basin. A combination of measures, including small retention structures, snagging and clearing projects, land use practices, floodplain zoning, floodplain insurance, etc., can significantly reduce flood damages. However, without additional major tributary storage—which residents have shown a reluctance to support—flooding will continue for the foreseeable future."

"Controlled drainage, together with diking around smaller cities and a system of diking and diversion of the rivers around Fargo and Grand Forks, are needed to effectively deal with basin flooding."

"Public education regarding legislation and water quality. Consumers and lawmakers should recognize the long-range impacts of 'rushing' into regulations."

"Water resource managers must recognize the interface between water quality and quantity and develop a unified approach to systematically solving problems."

"The general public will have to prioritize long-term environmental/aesthetic values above short-term ones."

"Identification and recognition of the suitability of land for various uses, the risks of various land uses, and the responsibilities of land stewardship."

"[What is needed is] a comprehensive inventory and description of the total hydrologic system within the basin, including documentation of all existing structural modifications to facilitate land drainage, reduce flood damages, conserve or supply water, and treat wastes."

"Education on the true and complete costs of water, its value, and acknowledgment of it as a limited resource."

When you look ahead, do you see new, equally challenging issues and problems? If so, what are they?

"The need to diversify Manitoba agriculture through the provision of reliable supplies of water for irrigation. The need to give greater protection to the quality of our water supply sources, particularly ground water."

"A complete debate over what is commonly referred to as 'North Dakota Water Policy,' which says that 'North Dakota has plenty of water; it simply needs to be moved to areas that are short of water.' The sources of money for this transportation need to be identified to determine who (the user or average taxpayer) is actually willing or able to pay."

Recreation opportunites.

"The quantity of water needed to sustain continued growth in the basin will continue to increase, particularly if Minnesota decides to reserve water for instream flows on the Red River main stem."

"The use of ground water for irrigation and domestic purposes and the conflicts that might arise."

"Water conservation issues, watershed control, water user permits, regulation of water treatment sludge, and raw water quality."

"The heightened interest and concern for the environment, the failing infrastructure, and the lack of a single 'most important' problem area are all issues that will create a growing challenge in the future."

"Resolving agricultural pollution issues in favor of both the environment and sustainable economic/agricultural development."

"The 'new' challenging issue is an old one: changing the perceptions we have of private property rights by introducing the recognition of land suitability, risks of various uses, and stewardship responsibilities."

"We are really 'hung up' right now on the 'free water' mentality. Once we're over that hump, there will be other more pressing environmental and social issues to address."

"A major challenge will be development of an integrated, coordinated basin planning approach to water management in the Red River Basin that encompasses strong public input; recognizes the uniqueness and limitations of each watershed; and involves all resource owners, managers, and users working together as a planning team."

"The issue of allocation versus the riparian rights appropriation of water."

If you could make changes in the institutional arrangements currently in place in the basin, what would those changes be?

"The allocation of water resources based on a sophisticated formula established nationally."

"Speaking relative to the Manitoba situation, a single agency which deals with both water quantity and water quality would be of benefit. There are currently three major agencies. Multi-year, rather than annual, budgeting would also be of great value."

"Watershed districts could place more emphasis on upstream dams for flood control and water retention than on cleaning out already deep ditches, which create all the more flooding for people downstream."

"I believe that the whole Red River Basin should be organized into watershed districts on the order of the watershed districts in Minnesota. There should be members from the watershed boards on an international board that meets regularly to discuss water problems and solutions."

Red River Basin Commission

Gimli, MB

"A more equitable method of assessing the costs of drainage projects should be devised. Benefits received should be the basis."

"Reduce the role of North Dakota state government and increase the role of local governments in water policy matters, especially in decisions about payment for water-related public works projects. This would make the cost of the water more apparent to the user. Current institutional arrangements disguise the costs, with water appearing less expensive than it really is."

"The institutions currently in place are capable of dealing with water issues, but communications between those who manage water and those who are impacted could be improved. Much more emphasis should be placed on information/education initiatives, which increase public awareness about the critical role water plays in everyone's lives."

Red River Basin Commission

"Get funding for the Corps of Engineers so it can become active in diking and diversion, or else give the money to some other agency that will get the job done. A 10-year minimum timetable to complete a project is too long."

"All natural resource decisions should be made by units of government specializing in those fields. Politics should be removed from the decision-making process by having only appointed officials (with the county making the appointments) pursuing solutions to problems. The state role should be advisory both in a technical and administrative sense. Financial incentives from the state are necessary as a contribution to the general welfare."

"I do not believe institutional arrangements need to be changed."

"Coordination of state and federal groups to avoid duplication of efforts."

"Water resource policy development in the Red River Basin is complicated by the large number of interest groups, the wide range of concerns, the international aspect, and conflicting water policies. Federal, state, and local partnerships are the only way to cooperatively work toward a common goal. A new institutional arrangement such as a TVA (Tennessee Valley Authority) could help overcome existing constraints and policy limitations. The Souris-Red-Rainy River Basins Commission was the right idea, but it lacked sufficient funds."

What are your concerns, if any, with respect to the basin's ability to meet future water demands in terms of both quantity and quality?

"Our inability to sit down and come to a solution and then to work at it. Studies have been done and then completely forgotten."

"Ground-water development, an area that has considerable potential to meet quantity needs, should be pursued. Our quality standards are too low and should be based on ecosystem health, not just human health."

"Water resource management must consider the relationship between surface and ground water resources."

"Future demands (50 years) can only be met economically by importation from the Assiniboine Basin. The development of large reservoirs on Red River tributaries [in Manitoba], particularly for irrigation, is not cost-effective."

"Complacency! The historic availability of both adequate surface and ground water in most of the geographic area has led to minimal planning to meet future needs. The public has not universally supported this type of activity. Governmental units that have moved ahead, however, have not been severely criticized or restricted. Crossing political boundaries has not been effective because of the extreme differences in statutes and governance. The public's attitude reflects the historic involvement of government."

"Without appropriate pricing of water, the quantity demanded will be 'artificially' high and 'shortages' will occur. Because state government does not appear interested in using differential pricing to determine demand, it may be that no amount of increased supply will be adequate."

“The basin needs an assured water supply, such as a diversion from the Missouri River, to address both quantity and quality problems. Continued growth of the major cities and industry will be stymied by the lack of adequate quantities of high quality water.”

“We have more runoff water going down the rivers every spring than Grand Forks, Fargo-Moorhead, and other communities along the Red River can ever use in the near future. The diversion around West Fargo is one of the stupidest examples of what can happen when selfishness rules over common sense. The money spent on the canal should have been used to build the Kindred Dam for water conservation and flood control.”

“Drainage of too many wetlands, which recharge aquifers like the Moorhead Aquifer. When wells must be drilled deeper, it is a sign that the land is responding to man’s overindulgence.”

“The recent drought years have demonstrated that there are several areas in the basin where supplies of good quality water are limited during extreme climatic conditions. The perception that water can continue to be overused and abused in the way it has been in recent decades must be changed. Water must be viewed as a scarce and finite commodity that has real value, and it has to be managed accordingly.”

Do you have any suggestions as to what might be done to improve water management in the basin?

“Create a basin-wide water management board with representatives from North Dakota, Minnesota, and Manitoba. This board could develop consensus on basin needs and seek solutions, perhaps through the formation of a basin-wide plan which would prioritize needs.”

“Decision makers should redirect their efforts from an endless search for more water to the appropriate pricing of existing water.”

“Begin soon the construction of a pipeline to carry Missouri River water to eastern North Dakota. If Fargo doesn’t want the project, Grand Forks needs to ‘go it alone.’ Other interested, interconnecting cities could join in supporting Grand Forks in this effort.”

“Continue programs that facilitate interrelationships within governmental structure and foster maximum communication between all players. Currently, cooperation is restricted to the sharing of information, education, and methodology. However, cooperative efforts could be expanded to developing guidelines and criteria, and eventually to joint finance and construction activity.

“I believe that government agency staff must become more accepting of public involvement as a way of helping them do their jobs better. Too often, the public involvement process is treated as simply another hurdle to be ‘jumped’ on the way to getting the job done. On the other hand, the basin resident has to strive for a more global view rather than his or her own self-interest. The common good must be our common goal.”

“Focus first on the rivers, wetlands, and lakes. Control flooding, restore and protect wetlands, and improve water quality. Prioritize problems and pool resources to resolve problems in a systematic manner.”

“Require a quarter-mile buffer strip along river corridors where agricultural and industrial development are prohibited. Impose pollution tax on all activities which tend to degrade the resource. Use tax funds for cleanup and incentives not to pollute. Promote low chemical agriculture and lawn care.”

“Mandate efficiency criteria (e.g., benefit-cost analysis or total net benefit maximization) as a precondition to project approval. Clearly limit state and federal cost-sharing to state and federal benefit shares.”

Red River Basin Commission

"More and larger water retention structures with control gates that can hold the water until it is needed. In some cases, levees along the rivers would help."

Red River Basin Commission

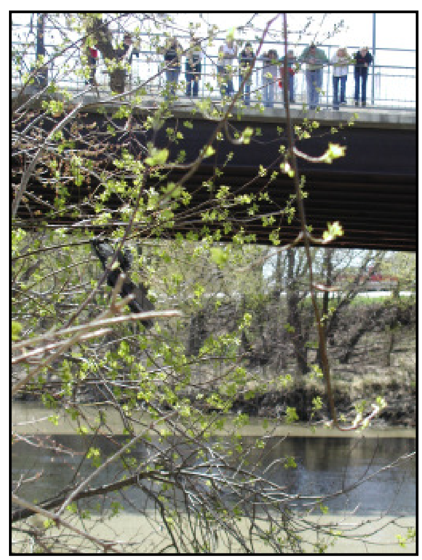
Sheyenne River Basin.

"A long-term, water management strategy needs to be created to support economic development within the basin. The traditional water management approach, one of reacting to and dealing with problems as they arise, must be replaced by a new approach that stresses anticipation and prevention of problems."

Do you have any suggestions as to how communications between the various levels of government and residents of the basin might be improved?

"Holding meetings where township, county, and city officials, and basin residents confer and offer their viewpoints on how best to address problems for the betterment of all concerned."

"The actions of various levels of government and organized interest groups must be integrated with the needs and aspirations of the people who live within the basin through strong local involvement in a coordinated resource management planning process. Seminars on items of mutual concern between various levels of government would promote understanding and foster good will. Open house meetings to discuss specific issues would improve two-way communication with the public."



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"Improved communications is a two-way street. Far more resources must be dedicated to the information/education programs of the various water sector agencies at all levels. Perhaps more important is the provision of 'opportunity' for citizens to interface with government on an array of wide-ranging issues. Wise water management is in everyone's best interests, but far too few people participate—many because they are indifferent and others because they don't know how."

"Continued periodic meetings between the two states and province."

"Communication, to be effective, must be followed up by action to maintain the credibility of the communication."

"Perhaps a start would be a seminar on the relationship between the price of water and the quantity demanded of water."

Do you have any observations you would like to offer on any aspect of water resources management in the basin?

"Existing water management interest groups are all very good people working to the best of their abilities to help solve various water resource problems. They should be commended on their fortitude and resilience in dealing with the day-to-day frustrations that result because of policies and program limitations."

"More emphasis should be placed on institutional, societal, and legal change, and less on engineering."

"I like what I have seen over the last decade in the area of public participation, although more has to be done. Education is the key in my view. Education at all levels: elected officials, public servants, and basin residents. A greater understanding of how the basin works and of the trade-offs involved to achieve goals is needed."

Red River Basin Commission

Elementary school children participate in annual water festivals held in the Basin.

"In the past, several water management plans have been implemented without the benefit of a clearly defined, long-term management strategy for the basin. Water management projects to combat major flooding or to mitigate the effects of prolonged droughts have been undertaken on a reactionary basis rather than with foresight to prevent their consequences in the first place. What is needed now is a basin-planning framework within which all water-related decisions of the various governments can be made."

A Parting Thought

The mixture of responses to the several questions raised in this chapter suggests that even among those responsible for managing the basin's water resources, disagreement exists as to how to best address emerging water management issues. Problems such as flooding, water supply, water quality, and a shortage of water-oriented outdoor recreation opportunities are already on the scene. Issues emerge when we disagree about how to deal with the problems. In any case, making wise choices in the years that lie ahead is essential, and the probability of that happening is enhanced by the active participation of citizens in the water management decision-making process.

Play a role, if you will, in shaping the future of "the river that runs north," and be a part, if you dare, in the kind of governance that can occur only at the local level.

Red River Basin Commission

Enjoying the natural resources.

Epilogue

It might have happened! The wet cycle may have ended the fall of 2011. Precipitation in the upper Red River watershed for 2011 was 24 inches, or 23 percent above normal. Most of 2011's precipitation came by August, followed by four dry months and a dry start to 2012. This spared residents of the Red River Valley from a spring flood in 2012. In fact, the River barely got out of its banks that spring. Annual precipitation in 2012 was just 14.5 inches, or 25 percent below normal. Although this was a relief from the wet cycle of 1993 to August 2011, talk of 'drought' began. The flow in the River during the second half of 2012 was much lower than most people could remember. As of December 2012, the chance of a major spring flood in 2013 was less than 10 percent.

Housing buyouts continued along, and on, both sides of the Red River. Efforts continued in earnest to design, authorize, and fund a Red River diversion around Fargo-Moorhead. Some resistance to a diversion is coming from upstream/downstream residents who may be adversely impacted and those who see the cost as excessive in light of all the flood protection improvements that have already been made. While buyouts and talks about flood water diversion are ongoing, talk of a pipeline to bring Missouri River water to eastern North Dakota is again at the forefront as dry conditions prevail. Is the Red River Basin going straight from 'too much' to 'too little'? Predictably, the last word on water management in the Red River Basin will never be written—there will always be another cycle and another chapter.

As we end this book, folks in the Red River Valley are hoping for a return to 'normal', no more major floods and adequate, but not excess, precipitation. But, HOLD THE PRESSES!! Just as this book was going to print a spring flood forecast came out saying there could be a new flood of record in spring 2013! What happened?

- Late spring snows in the upper basin totaling around 60 inches, many daily snowfall records were broke, and April 2013 was the fourth snowiest on record;

- Much colder than average spring temperatures, with the first 50-degree day coming on April 26, 9 days later than the previous record, the first 25 days of April were the coldest on record, and April was the fourth coldest on record, just 0.8 degrees warmer than the coldest April ever; and

- Winter snowpack lasted until the end of April.

Fargo mobilized for a new flood of record, in the 43′ range. They prepared over 1.5 million sandbags and began constructing seven miles of temporary clay dikes. The governor had 4,000 National Guard personnel ready to assist. Moorhead waited and watched for the deterministic crest prediction, which came toward the end of April. It was 38′ and many folks breathed a big sigh of relief that it was not over 40′. The actual crest occurred late on April 30, at 33.32′, number 12 in the record book for Fargo-Moorhead.

The flood of 2013 did not materialize in the upper watershed because

- Weeks of freezing nights and barely thawing days slowed the runoff;

- Extremely dry soil and depressional storage conditions allowed almost half of the snowmelt to infiltrate the soil or fill dry depressions, and

- Expected average rainfall during snowmelt did not occur.

Needless to say, people in the Red River watershed can never quite be sure when the next big flood will come, or not. The area's weather records only go back to 1881, just 132 years of observations of a wide-swinging, mid-continental climate. We will continue to put extreme weather events into the record book.

Glossary

Acre-Foot (af): Volume of water equal to an area one acre in size and one foot deep, or 43,560 cubic feet.

Ambient Temperature: Air temperature of the surrounding environment.

Aquifer: Water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water.

Atmospheric Water: Water that is stored in the atmosphere.

Basin (watershed, catchment): Region drained by a river and all its tributaries.

Bois de Sioux River: Drains 1,429 square miles and forms the boundary between the Dakotas and Minnesota. Headwater is in Lake Traverse and joins the Otter Tail River at Breckenridge, Minnesota, to form the Red River.

Bonanza Farms: Extremely large, successful farms, created from the sale of land by the Northern Pacific Railroad, that emerged during the second half of the 1800s. Over time, they became less profitable and, by the 1920s, largely disappeared.

Bounce: The lowering of water in a wetland to allow room to retain runoff. For example, a 2-foot bounce in a 5-acre wetland could potentially hold up to 10 acre feet of runoff.

Channel Capacity: Storage volume within stream or below flood stage. See also ***river cross section***.

Closed Basin: A basin draining to some depression or pond within its own area from which water is lost only by evaporation or percolation. A basin without a surface outlet for precipitation falling precipitation.

Confluence: Place at which a stream flows into another. Also, the place where two streams of equal size unite.

Conservation Pool: The specified amount of a reservoir's capacity dedicated to water storage, used to meet water needs, including municipal, domestic, agricultural, industrial, and recreational.

Cretaceous Rocks: Fine-grained sediments, mostly silt and clay, deposited on the floor of the large, shallow sea covering the Red River Basin during the Cretaceous Period (about 100 million years ago).

Cubic Feet Per Second (cfs): Rate at which water flows past a measuring station.

Discharge: The runoff rate or flow, usually given in cubic feet per second.

Distributed Storage: Storage of runoff in numerous, scattered, small ***reservoirs***, depressions, or ***wetlands***.

Drawn Down: The practice of releasing water from reservoirs to provide room for expected excess runoff.

Evapotranspiration (ET): The movement of water into the atmosphere from soil and water bodies (evaporation) and plants (transpiration).

Flood Crest (flood peak): The point in a flood when the water is deepest and the flow (cfs) is at its maximum at the point of measurement.

Flood Duration: The length of time water is above flood stage.

Flood Peak: See *flood crest*.

Flood Plain: The year-specific flood plain is the extent of land that is inundated with each frequency of flood. See also ***river cross-section***.

Flood Stage: The stage at which overflow of the natural stream banks begins to cause damage in the reach in which the elevation is measured.

Floodway: Land immediately adjacent to rivers and streams that regularly becomes inundated by channel overflow. See also ***river cross-section***.

Flooding: When surface water levels in lakes, streams, and rivers exceed the norm and spill over onto surrounding lands.

Gaging Station: Point at which measurements are made. Can be either mechanical and automatic or manually collected and recorded by an individual.

Glacial Drift/Till: Any boulders, gravel, sand, or clay transported by a glacier and deposited, after melting of the ice, as a mixture (heterogeneous).

Ground Water: Generally the water below the ground water table, also called the zone of saturation.

Historical Flood: Floods based on evidence other than gages and modern hydrologic records.

Hydrograph: A two-dimensional graphical representation of stage, flow, velocity, or other characteristics of water at a given point as a function of time. The vertical axis depicts the volume of stream flow expressed as cfs (or other units) and/or the river stage in distance above flood stage of another benchmark (e.g., msl). The horizontal axis depicts time, usually in 24-hour increments or less, since floods generally occur over a period of several days.

Hydrologic cycle: Flow of water through the physical environment over time.

Hydrology: Science dealing with the properties, distribution, and circulation of water.

Infiltration: (1) Entry of surface water into the ground or soil surface. (2) Movement of water through small openings in the earth as it seeps downward to the ground water.

Institutions: Rules, norms, and structures that guide social behavior (Hearne 2007).

International Joint Commission: A six-member body established by the 1909 Boundary Waters Treaty to prevent or resolve disputes related to waters flowing across the international border.

Invasive Species: A species not native to the ecosystem whose introduction does or is likely to cause economic or environmental harm or harm to human health.

Lacustrine: Of, relating to, or formed in lakes, or growing or living in lakes.

Lacustrine Plain: A flat area at low elevation produced by or formed in a lake or lakes.

Lake Agassiz: A lake that existed approximately 10,000 years ago, due to the melting of glacial ice.

LiDAR: Light Detection and Ranging is an integration of airborne laser and global position system (GIS) technology. Laser pulses are directed at the earth's surface (early spring or late fall) from equipment aboard an aircraft flying at a predetermined grid over an area of interest. The laser reflections are recorded and the range is calculated from the instrument's orientation in space and the time required for the laser's light reflection to travel back to the aircraft.

Main Stem (mainstem): The principal or dominant branch of a drainage basin. The Red River is the main stem of the Red River drainage basin.

Mean Sea Level (msl): Average height of the sea taken over all tidal stages over a 19-year period. Used as a set point to compare height of land.

Meandering Stream: A stream having a sinuous (winding) flow path with a series of meander bends.

Métis: People of mixed North American Indian-European descent.

Mid-continental Climate: Weather patterns in the interior of large continents are more likely to show seasonal extremes, such as wide swings in temperature or precipitation.

Moraine: An accumulation of soil or rock carried and deposited by a glacier.

Nonpoint Source: A contributing factor to water pollution that cannot be traced to a specific spot, such as agricultural fertilizer runoff or construction sediment, as opposed to point source pollution, which is a specific location where pollutants are discharged.

Non-Structural Measures: Include mechanisms to modify the severity of flooding through runoff-retarding land stewardship, enhanced flood prediction and warning systems, disaster preparedness, and flood plain awareness and zoning.

Otter Tail River: The upper reaches (about 160 miles) of the Red River, usually referred to as a tributary of the Red River. The source of the Otter Tail River is a small lake near the southwest corner of Clearwater County, Minnesota, about 13 miles west of Lake Itasca, the head of the Mississippi River.

Overland Flow: Runoff not contained in a stream's floodplain, but rather spread out and flowing over generally flat land downslope toward a natural channel.

Prior Appropriation Doctrine: Water rights determined by priority of beneficial use, generally meaning the first person to use water or divert water for a beneficial use or purpose can acquire individual rights to the water. Generally used in western states.

Recharge: Process by which water is added to the aquifer, usually through infiltration.

Recorded Flood: Floods that have systematic hydrologic data. Historic floods are based on other forms of information, such as first-hand accounts or tree ring data.

Red River Basin: Central portion of the Hudson Bay drainage system, which includes parts of Manitoba, Saskatchewan, North and South Dakota, and Minnesota. Estimated total drainage area is approximately 64,126 square miles.

Red River Valley: Term applied to the valley of the Bois de Sioux rather than that of the Otter Tail and extends from Lake Traverse north to Lake Winnipeg. The valley is a plain (see lacustrine plain) 30 to 50 miles wide and 315 miles long. The entire drainage basin is approximately 149,000 square miles.

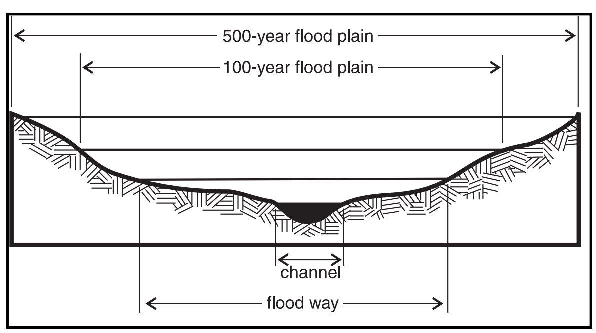
Reservoir: A holding area, natural or artificial, used to store, regulate, or control water.

Riparian: Areas immediately adjacent to a river, stream, or lake.

Riparian Doctrine: Reasonable use of water based on ownership of riparian land. Generally used in eastern states.

River Channel: The entrenched part of a stream occupied either temporarily or permanently by flowing water.

River Cross-Section: A profile of where the river flows at various river stages. Depicts the normal channel, the floodway, and flood plains. Cross-section flood stage characteristics may be changed by upstream structural measures.



River Cross-Section

Runoff: The movement of water from land to the ocean, chiefly in the form of rivers, lakes, and streams. Runoff consists of precipitation that neither evaporates, transpires, nor penetrates the surface to become ground water.

Runoff Volume: Volumetric total given in acre feet or cubic meters.

Rural Municipality: A rural municipality in Canada is roughly equivalent to a county in the US**.**

Slope: Ratio of rise (vertical) to run (horizontal) distance from a datum point.

Special Purpose Local Unit of Government: A local unit of government organized for a special or single purpose, like school districts, water districts, or park districts.

Stakeholder: A person or group who affects or can be affected by an organization's actions. Someone with an interest in specific actions of others or government.

Structural Measures: May include dams, dikes, levees and flood walls, channel modifications, diversions, floodproofing and pumping systems. Meant to reduce the severity, frequency, duration or geographic extent of flooding by physically altering the flow of water.

Subbasin: A component of a drainage basin, which is naturally smaller than the next larger classification.

Surface Water: Water found on the surface of the earth, for example, lakes, rivers, streams or wetlands.

Timing: Determination of the timing of flows in a river and its tributaries for purposes of studying peak flow or flood stages.

Total Dissolved Solids: Any particle smaller than 1.2 mm is considered a dissolved solid. The concentration or total amount is one common measure of water quality. 1,500 g/m^3 (grams per cubic meter) is considered the upper limit for fresh water. Brackish waters have values up to 5,000 g/m^3. Above 5,000 g/m^3 is classified as saline.

Township: A local government unit that is 6 miles by 6 miles square.

Tributary: A stream or river flowing into a larger stream or river.

Vadose Water: Water that exists in the pore spaces of rock or soil, between the ground surface and the water table.

Waffle Plan: A plan to temporarily retain runoff within rural land sections bounded by roads. From above, these 1 mile by 1 mile sections resemble a waffle or checkerboard.

Watershed (basin, catchment): The whole catchment area of a single river system. All surface waters drain to the principal river.

Water Table: The boundary between the zones of aeration and saturation.

Wet Land: Land where the soils at or near the surface are sufficiently wet to prohibit or greatly restrict normal tillage practices and inhibit or prevent agricultural crop growth. Land not falling within the legal definition of wetland.

Wetland: It's complicated! (1) There are "jurisdictional" wetlands that are covered by wetland regulations. Generally, these are lands where there is water at or near the surface for some portion of the growing season, there is an abundance of wetland plants, and the soils are hydric. (2) Wetlands from a layperson's perspective are also called swamps, sloughs, bogs, small lakes, and frequently have a combination of open water, emergent plants (such as cattail), and wetland-related wildlife (such as ducks and muskrats).

Zone of Aeration: Region below the Earth's surface that is marked by the presence of both air and water within pore spaces in the ground.

Zone of Saturation: Region below the Earth's surface where pore spaces in the ground are totally filled with water.

Some definitions taken from *http://www.waterencyclopedia.com* and *http://ks.water.usgs.gov/waterwatch/flood/definition.html.*