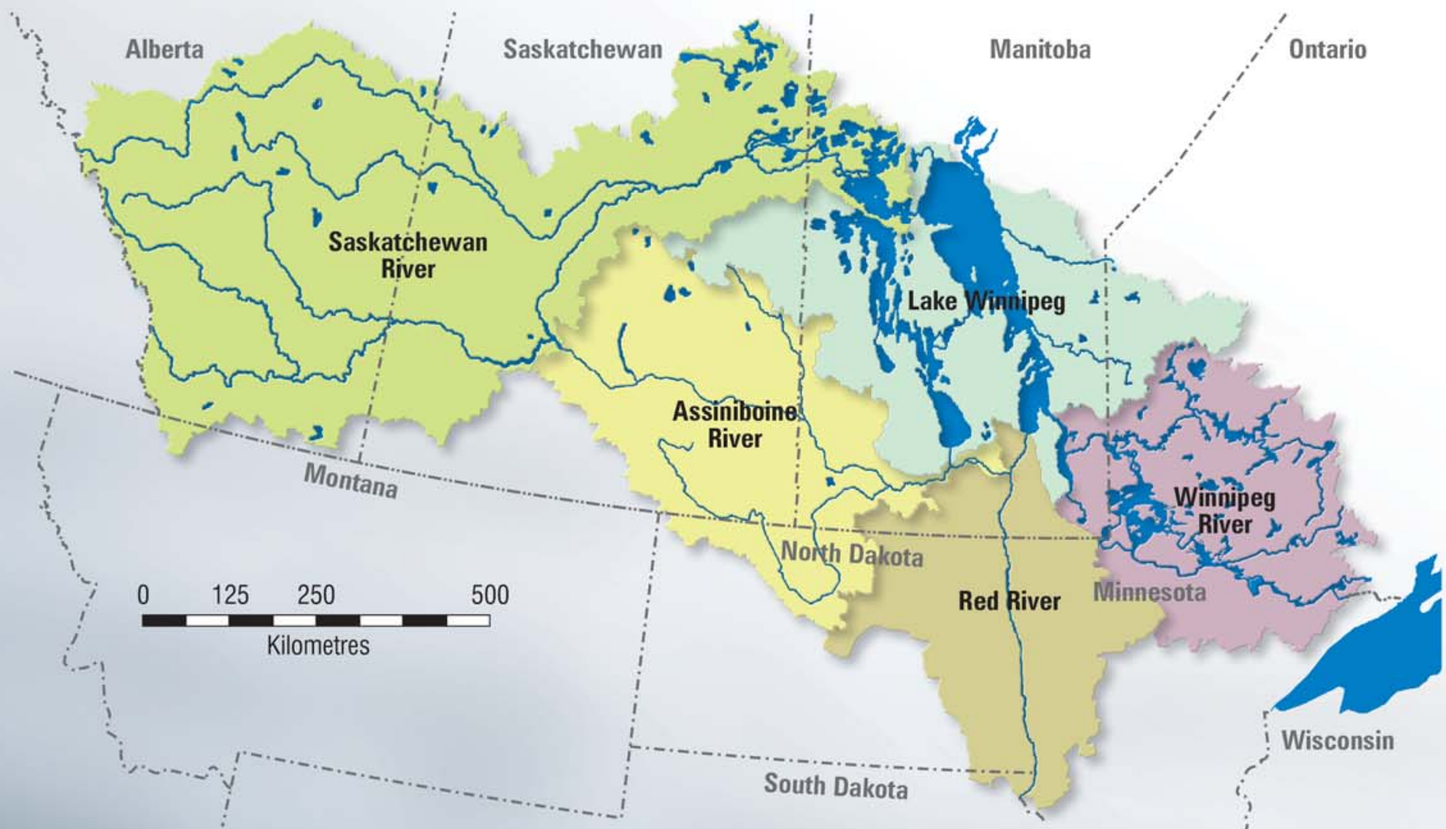
# CHAPTER ELEVEN
## LAKE WINNIPEG

***Figure 11.1.*** *Lake Winnipeg Basin*



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*Lake Winnipeg is made up of remnants of glacial Lake Agassiz, a lake that covered much of Manitoba and parts of other provinces and American states from about 13 000 years ago until about 8000 years ago. The northern basin of Lake Winnipeg became hydrologically detached from Lake Agassiz about 7700 years ago. The original course of the Saskatchewan River bypassed Lake Winnipeg. Instead, the river flowed toward the Nelson River and entered the receding Lake Agassiz through the Minago River.*

## Sub-basin Summary

**Characteristics**
- boreal plain to boreal shield
- world's 11th largest lake
- area – 23 750 $km^2$
- length – 436 km
- gross drainage area – 1 025 900 $km^2$

**Hydrology**
- reliable inflow
- average level – 217.4 m
- both inflow and outflow regulated
- regulated range in water level is smaller than natural range

**Water Quality**
- fair

**Biodiversity**
- healthy, but with problems

**Key Issues**
- eutrophication
- effects of lake regulation on water quality
- invasive species
- climate change
- natural shoreline erosion

At least 2500 years ago, the river breached a till barrier between what is now Cross Bay and Cedar Lake, and began flowing to Lake Winnipeg.[1] The lake drains northward to Hudson Bay through the Nelson River. Water levels are controlled by a bedrock narrows at Jenpeg, now the site of a hydroelectric dam.[2]

Lake Winnipeg is the 11th largest body of freshwater (measured by surface area) in the world, with a surface area of 23 750 $km^2$. The lakebed is flat and shallow with an average depth of 9.7 m in the south basin and 16 m in the larger north basin. Strong currents in the narrows between the north and south basins near Black Island have removed bottom sediments, creating the lake's maximum depth of over 60 m. It is 436 km in length and varies in width from a minimum of 2.5 km at the narrows up to 40 kilometres in the south basin, and as wide as 111 km in the north basin. The shoreline length is 1760 km. The total volume of water in the lake is small compared with its surface area. On average, the water is exchanged in the lake every three to five years. The equivalent time for Lake Superior is 191 years and for Okanagan Lake, 53 years.

The rebounding of the earth's surface due to the loss of the Laurentide ice sheet – about one kilometre thick at Lake Winnipeg – continues to occur across the whole lake. With the rebound hinged to the northeast of Lake Winnipeg, the north end of the Lake is rebounding more quickly than the south. The effect on the south basin is to increase water levels at a rate of about 200 mm each century, leading to shoreline erosion.

The length of the lake means there are significant climate variations from one end to the other. At the south end, the mean annual temperature is about 1.9°C, while toward the north end it is 0.5°C. Similarly, precipitation varies from an annual mean of 589 mm toward the south end to 483 mm toward the north end.

Water flowing into and through Lake Winnipeg serves over six million people in its drainage basin. There are a number of communities on or near the lake, including 11 First Nations communities.

## THE LAKE WINNIPEG WATERSHED

The watershed encompasses 953 000 km$^2$ and extends from within 20 km of Lake Superior to the headwaters of the Saskatchewan River in the Rocky Mountains, and thus includes parts of four provinces and four states. (Figure 11.1) It is the second largest watershed in Canada after the Mackenzie River Basin. Lake Winnipeg's drainage basin to surface area ratio, at 40:1, is the largest of any of the great lakes of the world. This large catchment area raises concern that the loadings of nutrients, contaminants and sediments entering the lake through natural processes and human activities may be greater than the lake's natural capacity to process these materials.

Approximately 65 million hectares of agricultural land is found within the basin – 55 million of that within Canada. More than half is under crop production. At the same time, the Canadian portion of the watershed supports 17 million livestock, made up of approximately equal numbers of cattle and pigs and a few hundred thousand sheep.

**Water Sources**

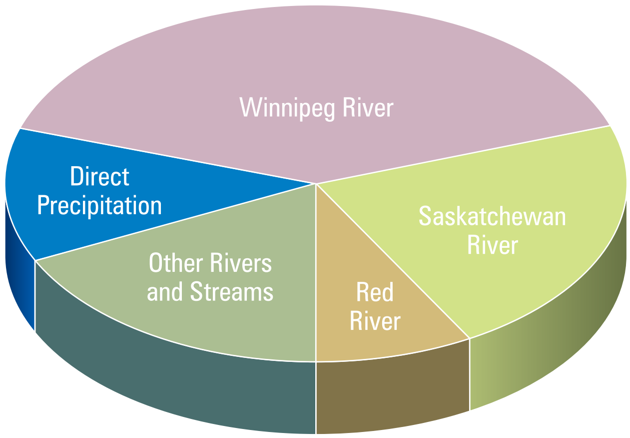


**Figure 11.2.** Sources of Water Entering Lake Winnipeg.

Major inflows to the lake arrive via the Winnipeg River, the Saskatchewan River and the Red River, as well as from a number of smaller rivers. Their proportions of the total inflow to the lake are shown in Figure 11.2. Approximately 45 percent of the annual inflow to Lake Winnipeg occurs during the April to July period.

Lake Winnipeg is bounded on the west by the boreal plain ecozone and on the east by the boreal shield. To the east of the lake, and for much of the lake bottom, the terrain is underlain with the hummocky and undulating bedrock of the Precambrian Shield. The dominant landcover is dense coniferous boreal forest of spruce and balsam fir; wetlands cover about 25 percent of the landscape. To the west of the lake, the flat interlake plain is underlain by sedimentary limestone. Moving from north to south, the closed boreal forest gives way to farmland.[3]

Under the lake itself, Lake Agassiz clays are up to 50 m deep in the southern basin and over 100 m deep in the northern basin. More recent sediment deposits rarely exceed 10 m in depth.[4]

## LAKE CHARACTERISTICS

The water chemistry of the lake reflects the diverse geology of this huge basin and the similarly diverse human activities prevalent, not only in the Saskatchewan basin, but also in the basins of the Red River and the Winnipeg River. The Winnipeg River largely drains the Precambrian Shield to the southeast of the lake. The Saskatchewan River, both north and south branches, rises on the eastern edges of the Rocky Mountains but then flows through the prairie landscape and agricultural lands until within a few hundred kilometres of its mouth, just below Grand Rapids. The Red River and its tributaries, like the Assiniboine River, flow through prairie landscapes almost exclusively. The size of the inflows to the lake is such that the water renewal time for the south basin is about 0.4 to 0.8 years, while the renewal time for the entire lake is 2.9 to 4.3 years. The short renewal time and the shallow depth of the south basin mean that its waters are well mixed.

During the 20th century, water transparency generally increased in the north basin. This is attributed to the damming of the Saskatchewan River and the consequent removal of sediment from the Saskatchewan River inflows. Meanwhile, in the south basin, water transparency has steadily declined. Phosphorus, nitrogen and carbon concentrations have increased. Zooplankton abundance has multiplied. The north basin algal species have adjusted and more blue-green algae are now in evidence. Phosphorus retention in the lake, as a percentage of the annual loading, has tripled since 1973.

Lake Winnipeg is operated as a reservoir for generating hydroelectric energy at dams along the Nelson River, which drains Lake Winnipeg into Hudson Bay. This has the effect of stabilizing lake elevations and altering typical outflows by decreasing outflow during spring and summer and increasing outflow during fall and winter. The total range of water levels on the lake is also limited to less than half the natural and historical range. The current licensed range of Lake Winnipeg is 216.8 m to 218 m above sea level, while before regulation fluctuations were from approximately 216.3 m to 218.9 m – almost a metre and a half greater. The licensed range can be exceeded during very high or very low flow periods. The upper level was exceeded as recently as 2005.

## HISTORICAL AND CURRENT RESIDENTS

Archaeological evidence indicates that native North Americans were resident in areas surrounding the lake approximately 8000 years ago. The Cree moved into the Lake Winnipeg basin about 2000 years ago, followed by the Ojibway in the 1700s. The first permanent European settlers on the shores of Lake Winnipeg were the Icelanders who arrived in 1875. The Icelanders were followed by Ukrainian, German, Hungarian, and Polish immigrants. (Although the land granted to Lord Selkirk in 1811 by the Hudson’s Bay Company included part of the western shore of Lake Winnipeg, the Selkirk colonists settled primarily at the junction of the Red and Assiniboine rivers. The Hudson’s Bay Company repurchased the land in the 1830s from Selkirk’s estate.)

The combined permanent population of the communities around the lake is more than 23 000. In addition, there are over 10 000 cottages or seasonal residences rimming the south basin of the lake. The population is increasing in communities such as Gimli and Winnipeg Beach, which are considered good seasonal residential or holiday areas and good communities for retirement.

## LAKE WINNIPEG AND THE ECONOMY

The lake has a significant influence on provincial and regional economies. Commercial fishing has been a major industry on the lake for over 125 years. The harvest typically exceeds six million kilograms a year, which makes it the largest freshwater commercial fishery in Canada, west of the Great Lakes. Walleye and whitefish are the dominant species harvested but sauger and goldeye are also an important part of the

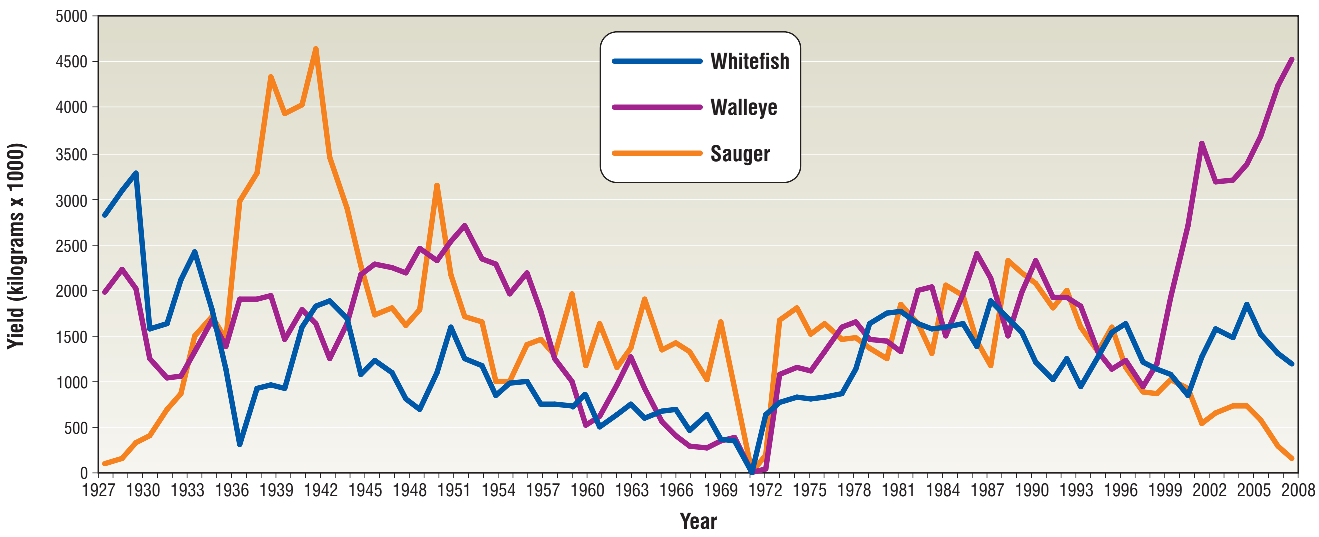


**Figure 11.3.** Commercial Fisheries Yield from Lake Winnipeg (Manitoba Water Stewardship).

harvest. Indeed, Lake Winnipeg's walleye harvest is the largest in North America. Annual returns are in the order of $20 million and support the livelihoods of approximately 1000 commercial fishers, 80 percent of whom are of First Nations or Métis ancestry.[5] In addition, the fishery is a major source of income to those employed in packing, processing or transporting the fish. A plot of the commercial yield from Lake Winnipeg is shown in Figure 11.3.

Subsistence fishing is an important source of food for those living in fishing communities. Fishing is also important to the traditional life of First Nations people.

Significant income is generated from recreation and tourism around the south basin of the lake. There are eight provincial parks. Grand Beach and Winnipeg Beach are two of the busiest, often with a combined half a million visits per year. Fifteen harbours provide berthing for commercial and recreational craft. The largest, Gimli, has a capacity of 220 boats. Recreation and tourism expenditures are in the range of $110 million a year. Recreational fishing on the Red and Winnipeg rivers, close to Lake Winnipeg, is estimated at about $17 million of direct expenditures per year.

Manitoba Hydro's use of Lake Winnipeg as a reservoir helps the crown corporation to generate several hundred million dollars in energy export sales each year. Regulation of flows out of the lake assists Manitoba Hydro to optimize power generation in the large hydroelectric generating stations downstream on the Nelson River.

## CHALLENGES AND SOLUTIONS FOR LAKE WINNIPEG

From a water quality perspective, Lake Winnipeg is in crisis. Nutrient loading and invasive species are particular challenges, although the lake is vulnerable to other water quality threats.

### Nutrients

Phosphorus and nitrogen inputs to Lake Winnipeg have been climbing, resulting in significant algal blooms in both basins. In fact, the lake is identified as the most eutrophic of the world's major lakes. The environmental consequence of this situation is major, and deterioration of the lake's condition can be expected to have a similar effect on local and downstream economies.

The impacts of eutrophication can include:

- Changes to the water quality in the lake
- Changes in the numbers and types of organisms in the lake
- Reduction in dissolved oxygen leading to fish kills and reductions in other species
- Release of toxins harmful to either or both aquatic species and human health.

Nutrient inflow concentrations have been examined, with the following findings:

- A significant increase in median concentrations of total phosphorus and total nitrogen in the Red River at Selkirk for the period 1978 to 1999 inclusive. In addition, the annual flows to Lake Winnipeg from the Red River during the last decade have been the highest in almost 90 years of record.
- A significant increase in median concentrations of total phosphorus for the period 1972 to1999 inclusive for the Winnipeg River measured at Pointe du Bois.
- No significant trend in total phosphorus concentrations in the Saskatchewan River below Grand Rapids for the period 1973 to 1997 inclusive.[6]

The increased inflow of nutrients is linked to human activities, including use of household cleaning products, run-off from urban residential and commercial properties, municipal sewage, particularly from communities where tertiary treatment is not implemented, livestock manure, use of commercial or synthetic fertilizers, and other land management practices, such as drainage, which hasten the flow of water off the land. The decrease of wetlands on the agricultural landscape also leads to faster run-off from snowmelt and rainfall, and, consequentially, greater movement of soil and nutrients off the landscape. Wetland restoration can play a role in reducing nutrient runoff. The occurrence, intensity and extent of algal blooms may be exacerbated by climate change. Higher air temperatures will lead to greater warming of the lake, while increased evaporation will cause changes in the concentrations of nutrients in the water.

Blooms of blue-green algae clog fishing nets and water intakes, and the related toxins are harmful or fatal to various life forms in the lake. Effects of the algal blooms include changes in fish species and quantities of species available for harvesting, and reduced species diversity.

Interaction of three factors contributes to the rapid pace of eutrophication of Lake Winnipeg:

- Excessive inputs of phosphorus, coming from the watershed
- Regulation of the lake as a reservoir, which holds back water during the most productive growing periods
- Lower sediment loads in the Saskatchewan River due to impoundments. This means clearer water and more light penetration, and consequent greater algal growth.

Phosphorus loadings to Lake Winnipeg are shown in Figure 11.4. Phosphorus and nitrogen loadings to the lake originate from point sources, such as the city of Winnipeg wastewater outflows (and countless other wastewater treatment facilities, whether municipal or

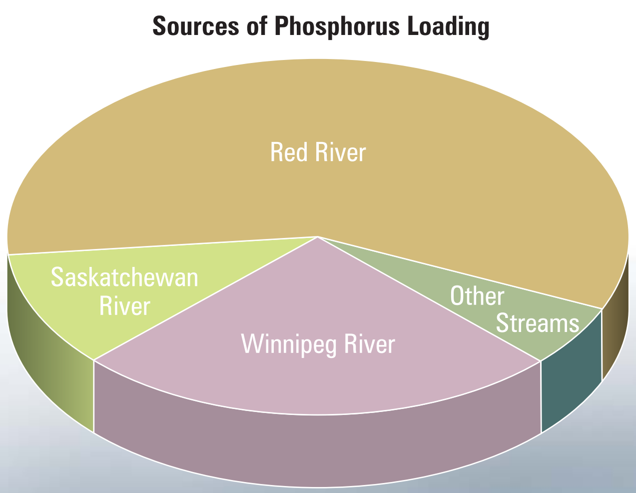


**Figure 11.4.** Sources of Phosphorus Loading to Lake Winnipeg.[8]

industrial), and non-point sources, such as run-off from all soils, but particularly from agricultural lands. Fifty-three percent of the phosphorous entering the lake is from non-Manitoba sources. The city of Winnipeg on average contributes seven percent of the phosphorus loading to Lake Winnipeg. The contribution from agricultural land in Manitoba is estimated to be 5% of the nitrogen load and 15% of the phosphorus load to Lake Winnipeg.[7]

There is debate about how to bring Lake Winnipeg closer to natural conditions, in terms of its ecological state. Both nitrogen and phosphorus are required for accelerated eutrophication to occur. However, the ratio of nitrogen to phosphorus is quite important. The phosphorus content of commercial fertilizers has thrown the natural ratio out of balance. The simplest way to restore the appropriate ratio is to reduce the runoff of phosphorus from the landscape and from communities. Measures that reduce nitrogen in runoff serve to limit ammonia toxicity, particularly in tributary streams. In reducing nitrogen, the importance of the ratio must be considered or extra high rates of algal growth will continue.

Regulation of lake levels and outflows from the lake may result in enhanced algal growth and accumulation of that biomass. As a consequence, nitrogen and phosphorus are accumulating in the sediments of the lake and lower concentrations are leaving the lake via the Nelson River. This may mean that even when nutrient inflows to the lake are reduced, there will still be a reservoir of nutrients bound to sediments available to support rapid algal growth.

## Invasive Species

The spread of invasive species can cause habitat change, competition for food, and even local extinction of indigenous species.[9] A number of species introduced into the lake are having considerable impact on habitat and/or indigenous fish species on the lake. A few key examples are:

- **Rainbow smelt** – this is a small fish first documented in Lake Winnipeg in 1990. It apparently arrived from northwestern Ontario via the Winnipeg River. It is a voracious predator that multiplies rapidly and competes with native species, such as the emerald shiner, for food. It has become the most abundant bait fish in the north basin of Lake Winnipeg. It is also a primary food choice for the walleye population and tends to be linked to the seven-year high walleye harvests from the lake. Its effects are 1) to put competitive pressure on the emerald shiner, and 2) to cause palatability and spoilage issues related to walleye and sauger catches.
- **Asian carp tapeworm** – has recently been found in emerald shiners in Lake Winnipeg. In other locations, effects have been severe on other fishes higher in the food chain as it is spread by ingestion. Thus, the walleye and sauger populations may be threatened by this parasite's entry to the lake.
- **Common carp** – this species is, of course, not a new invasive. It has been observed in southern Manitoba waters for over a century. The carp tends to stir up bottom sediments causing turbidity issues. It can slowly cause small islands in marshes to disappear over time, such as in Netley Marsh at the south end of the lake, as it causes sediments to be eroded and carried away. The carp is also a heavy feeder on vegetation in marshes, destroying habitat for other species.
- **White bass** – a species introduced into North Dakota in 1953 that had moved downstream to Lake Winnipeg as early as 1963. It is in competition with pike, walleye and sauger for emerald shiners and zooplankton.
- ***Eubosmina coregoni*** – is a zooplankton first identified in Lake Winnipeg in 1999. It is of Eurasian origin and has quickly become the most abundant zooplankton in the north basin of the lake. It appears to be replacing native species, thus affecting the overall ecology of the lake.
- **Hybrid cattail** – an invasive from Europe began to hybridize with the North American cattails nearly two centuries ago. The hybrid is described as more robust and a better competitor than either its native or imported parent. It invades wetlands and ponds, reduces biodiversity, and displaces species more desirable for wildlife habitat. This has

happened in the Netley Marsh at the south end of Lake Winnipeg, significantly reducing the productivity and diversity of the marsh.

There are a number of well-known invasives that have not yet arrived in Lake Winnipeg but which threaten to if preventative measures are not put in place:

- **Rusty crayfish** – a bigger, more robust crayfish than the native species, which has been found in Lake of the Woods, the upper Winnipeg River and in Falcon Lake (2007). It has come to the basin from Ohio and tends to be spread by bait bucket release. Should the rusty crayfish make it to Lake Winnipeg, it can be expected to replace the native crayfish and damage the commercial fishery as it eats fish caught in nets and can cause huge damage to the netted fish in a very short time.
- **Zebra mussel** – is moving towards Lake Winnipeg from the Great Lakes and the Mississippi River, where it has caused billions of dollars in damage by clogging infrastructure and reducing the recreational value of waterways. It has a significant effect on aquatic ecosystems.
- **Viral hemoragic septicaemia** – a virus which has been found in the states to the southeast of Manitoba. When it has become established in native fish populations it has been disastrous to those populations.

Most of the invasive species that affect Lake Winnipeg negatively have arrived from the southeast and not from the Saskatchewan River basin or via the Saskatchewan River. Nonetheless, this does not mean watershed planners and managers should not pay due attention to control or removal of invasive species within the Saskatchewan River basin. Some may cause issues within the individual sub-basins. Others may migrate to Lake Winnipeg and cause issues there.

One example is grass carp. This species has been introduced into the drainage ditches in Alberta to control aquatic plants. The fish introduced have been genetically modified to eliminate the possibility of reproducing, which reduces the risk to other ecosystems. This is not to say the risk has been entirely eliminated.

Another concern is, of course, that Lake Winnipeg may become a source of invasive species that then begin to migrate upstream into the Saskatchewan River basin. While downstream migration of an invasive species is of primary concern, species that are moved for use as bait fish, for example, can quickly establish themselves in an entirely new watershed. Whether movement is upstream or downstream thus becomes almost irrelevant. All sub-basins need to be cognizant of threats posed to them or by them when it comes to invasive species, and must manage their portion of the basin accordingly.

## Other Vulnerabilities

Additional challenges to the health of Lake Winnipeg, though still in need of quantification include:

- Persistent organic pollutants – which include DDT, PAHs, PCBs and dioxins that can last in biological organisms for quite some time. Some may disrupt normal functioning of organisms (endocrine disruptors). The Saskatchewan and Red river basins are largely agricultural, and pesticides used in agricultural production will find their way to the lake during the spring runoff or during summer rainstorms. The Red River Flood of 1997 resulted in significant inputs of persistent organic pollutants to the south basin of the lake.
- Pharmaceuticals and personal care products – which include antibiotics and other pharmaceuticals and disinfectants. Some are endocrine disruptors and can result in impacts on organism development and reproduction. Another concern is the enhancement of antibiotic-resistant bacteria.
- One species of snail and five species of fish in Lake Winnipeg are designated either as endangered, threatened, or of special concern.
- Wetland habitat is substantially reduced due to the control of lake levels within a reduced range.
- The cumulative effects of landscape change and climate changes on water supply to Lake Winnipeg.

## Lake Winnipeg Action Plan

Several programs are aimed at improving scientific understanding of Lake Winnipeg and to reducing nutrient loadings to the lake. In 2003 Manitoba announced a plan to reduce nitrogen and phosphorous loads to Lake Winnipeg to pre-1970s levels. The plan is aimed at protecting riparian growth along the Red and Assiniboine rivers, ensuring appropriate fertilizer application, introducing new effluent regulations, reducing shoreline erosion on Lake Winnipeg, and engaging other jurisdictions in Lake Winnipeg nutrient management. As a federal contribution to meeting the challenges to the sustainability of Lake Winnipeg ecosystems, recent federal budgets have allocated $18 million to a Lake Winnipeg Basin Initiative. Through federal-provincial mechanisms, federal funding will be directed to reduction of harmful algae blooms, improved recreational water quality, restoration of the ecological integrity of Lake Winnipeg, and a sustainable fishery. Federal funding will support research information and monitoring, and facilitate governance and stewardship.

## ENDNOTES

[1] McMartin, I. 1996. "Lake Agassiz Beaches and Reconstruction of Lower Lake Levels in the Shield Margin Area, Northwest of Lake Winnipeg." in *Lake Winnipeg Project: Cruise report and Scientific Results*. Todd, B.J., C.F.M. Lewis, and L.H. Thorleifson, editors. Geological Survey of Canada Open File 3113. Ottawa, ON.

[2] Lewis, C.F.M., D.L. Forbes, B.J. Todd, E Nielsen, L.H. Thorleifson, P.J. Henderson, I. McMartin, T.W. Anderson, R.N. Betcher, W.M. Buhay, S.M. Burbridge, C.J. Schroëder-Adams, J.W. King, K. Moran, C. Gibson, C.A. Jarrett, H.J. King, W.L. Lockhart, W.M. Last, G.L.D. Matile, J. Risberg, C.G. Rodrigues, A.M. Telka, and R.E. Vance 2001. "Uplift-driven Expansion Delayed by Middle Holocene Desiccation in Lake Winnipeg, Manitoba, Canada." *Geology* 29:8 743-746.

[3] Agriculture and Agri-Food Canada and Environment Canada 1996. *A National Ecological Framework for Canada*. Ottawa, ON.

[4] Todd, B.J., C.F.M. Lewis, and L.H. Thorleifson 1996. *Lake Winnipeg Project: Cruise report and Scientific Results*. Geological Survey of Canada Open File 3113. Ottawa, ON.

[5] Lake Winnipeg Stewardship Board 2006. Reducing Nutrient Loading to Lake Winnipeg and its Watershed: Our Collective Responsibility and Commitment to Action. Report to the Minister of Water Stewardship. Winnipeg, MB.

[6] Manitoba Conservation 2001. Long-term Trends in Total Nitrogen and Total Phosphorus Concentrations in Manitoba Streams. Report No. 2001-0. Winnipeg, MB.

[7] Lake Winnipeg Stewardship Board 2006. *supra.*

[8] Lake Winnipeg Implementation Committee 2007. *Restoring the Health of Lake Winnipeg*. Lake Winnipeg Implementation Committee. Winnipeg, MB.

[9] Personal Communication – Wendy Ralley, Water Quality Specialist, Manitoba Water Stewardship.