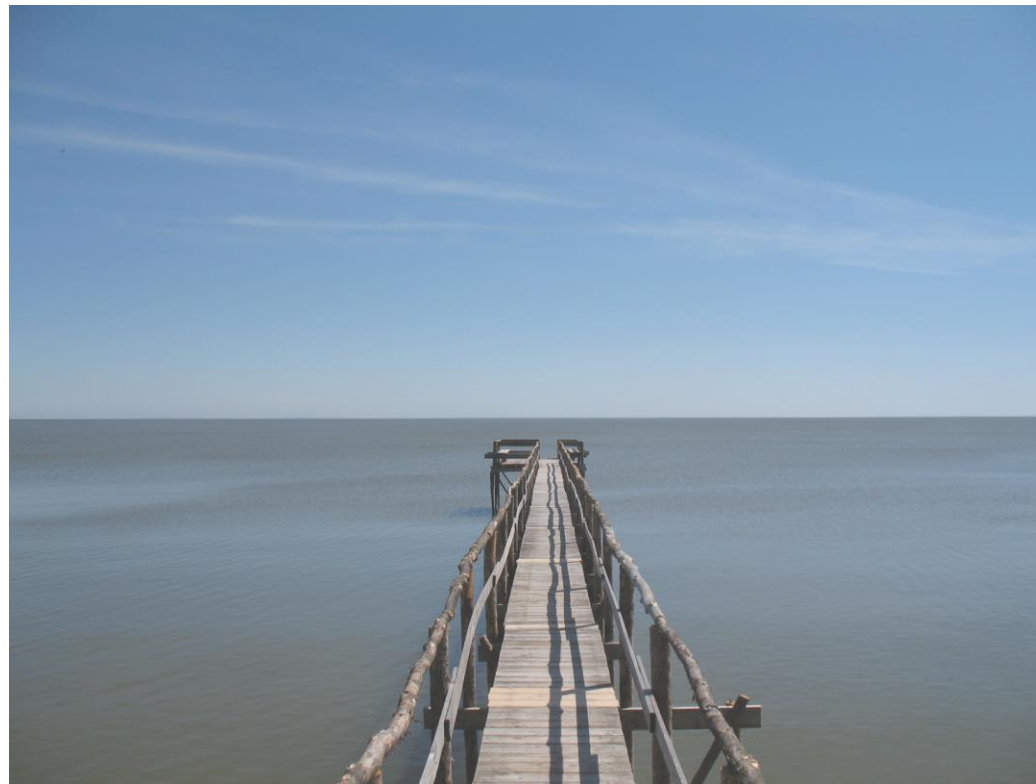
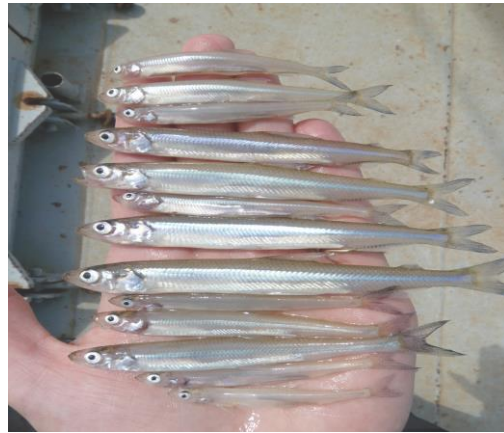


LAKE WINNIPEG: NUTRIENTS AND LOADS

A STATUS REPORT



Lake Winnipeg: Nutrients and Loads

Phosphorus Concentrations in Lake Winnipeg

The south basin of Lake Winnipeg is rich in phosphorus and is considered hypereutrophic with total phosphorus (TP) concentrations almost 3 times higher in the south basin (0.104 mg/L) as compared to the north basin (0.039 mg/L) of the lake. There is no apparent increasing or decreasing trends in total phosphorus and recent concentrations are within the range

of variability observed for the 1999 to 2016 period. Phosphorus concentrations in the north basin of Lake Winnipeg appear to be below the long-term average in recent years. Total phosphorus concentrations in the south basin are approximately two times higher than total phosphorus objective of 0.05 mg/L.

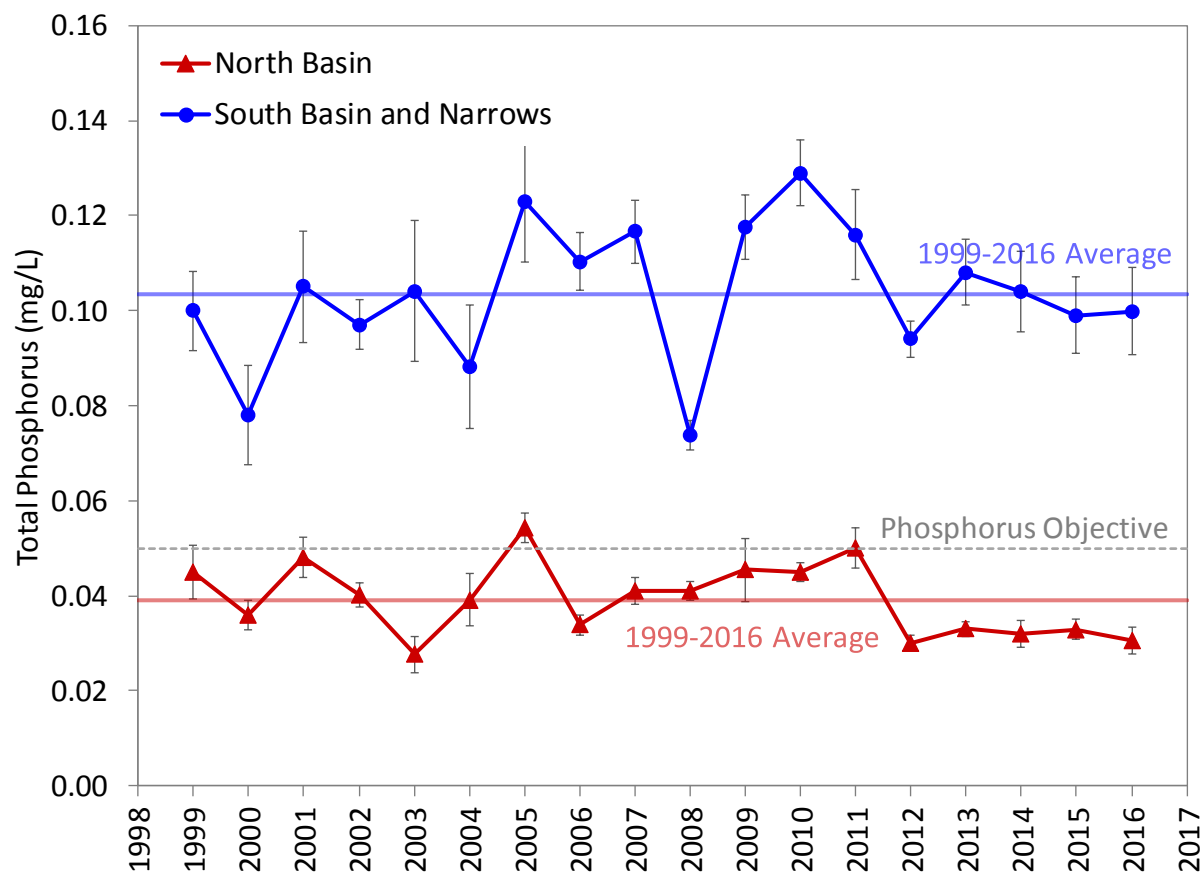


Figure 1. Total phosphorus concentrations in the north and south basins of Lake Winnipeg, 1999 to 2016.

Nitrogen Concentrations in Lake Winnipeg

Lake Winnipeg is also rich in total nitrogen with higher concentrations in the south basin (0.85 mg/L) as compared to the north basin (0.63 mg/L) of the lake (Figure 2). The large between year variability in nitrogen may be driven by a number of factors in Lake Winnipeg including nitrogen fixation and denitrification processes, nitrogen loading from tributary rivers,

internal loading and wind-induced resuspension. From 1999 to 2016, there are no clear trends in total nitrogen in the Lake Winnipeg although nitrogen concentrations since 2012 have remained below the long-term average and annual nitrogen concentrations in both basins have generally followed the same temporal pattern since 2012.

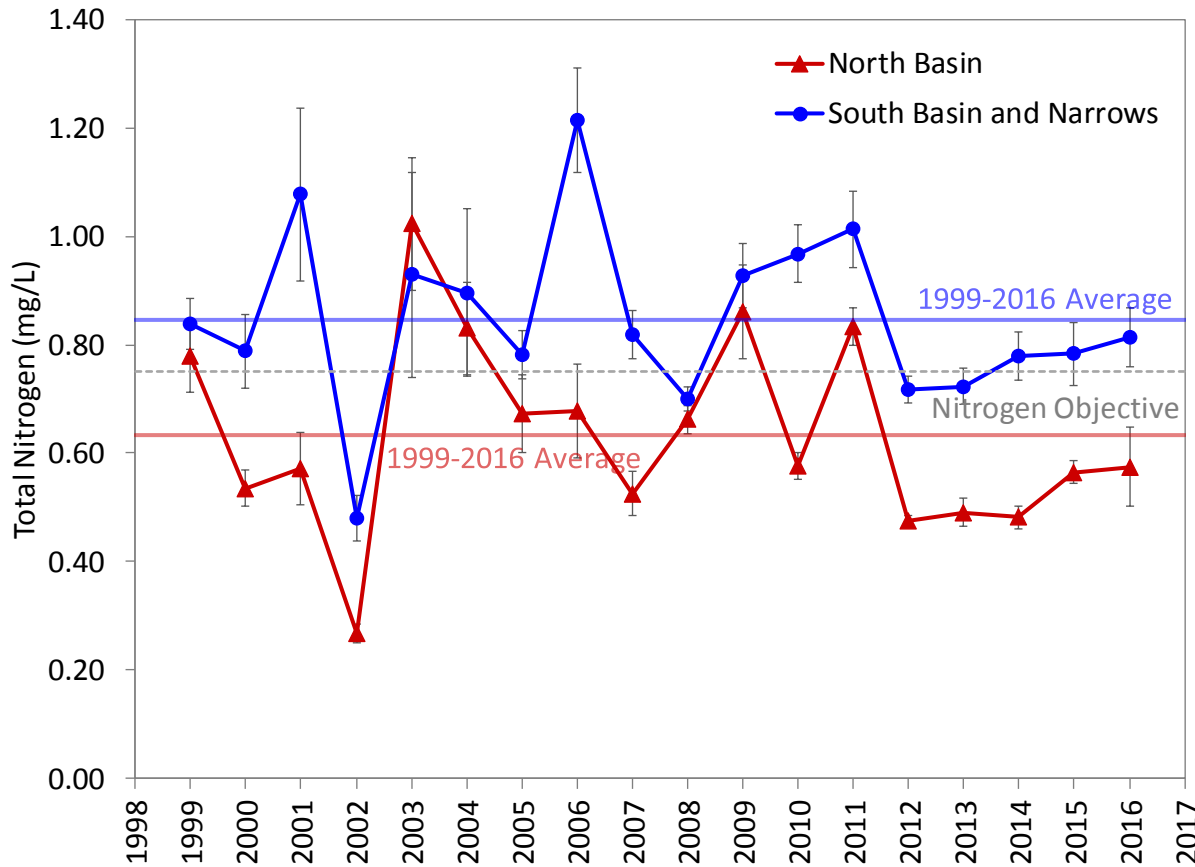


Figure 2. Total nitrogen concentrations in the north and south basins of Lake Winnipeg, 1999 to 2016.

Nutrient Loads to Lake Winnipeg

Most nutrients reach Lake Winnipeg through four major river basins - the Red River, Winnipeg River, Saskatchewan River and Dauphin River (Figure 3). The Red River Basin drains the fertile soils of the Red River Valley region, an area that is dominated by annual crop agriculture and prone to major flood events. The Red River is the single largest nutrient source to Lake Winnipeg accounting for almost 70 percent of the total phosphorus and 35 percent of the total nitrogen load despite the fact that it only

accounts for about 17 percent of the total inflow to the lake on average. Although the Winnipeg River contributes almost half of the flows to Lake Winnipeg, nutrient loads from the river are comparatively lower because of the relatively low nutrient concentrations in the river. Atmospheric deposition and nitrogen fixation also comprise a significant part of the nutrient load to Lake Winnipeg given the large surface area and prevalence of nitrogen fixing cyanobacteria blooms in the lake.

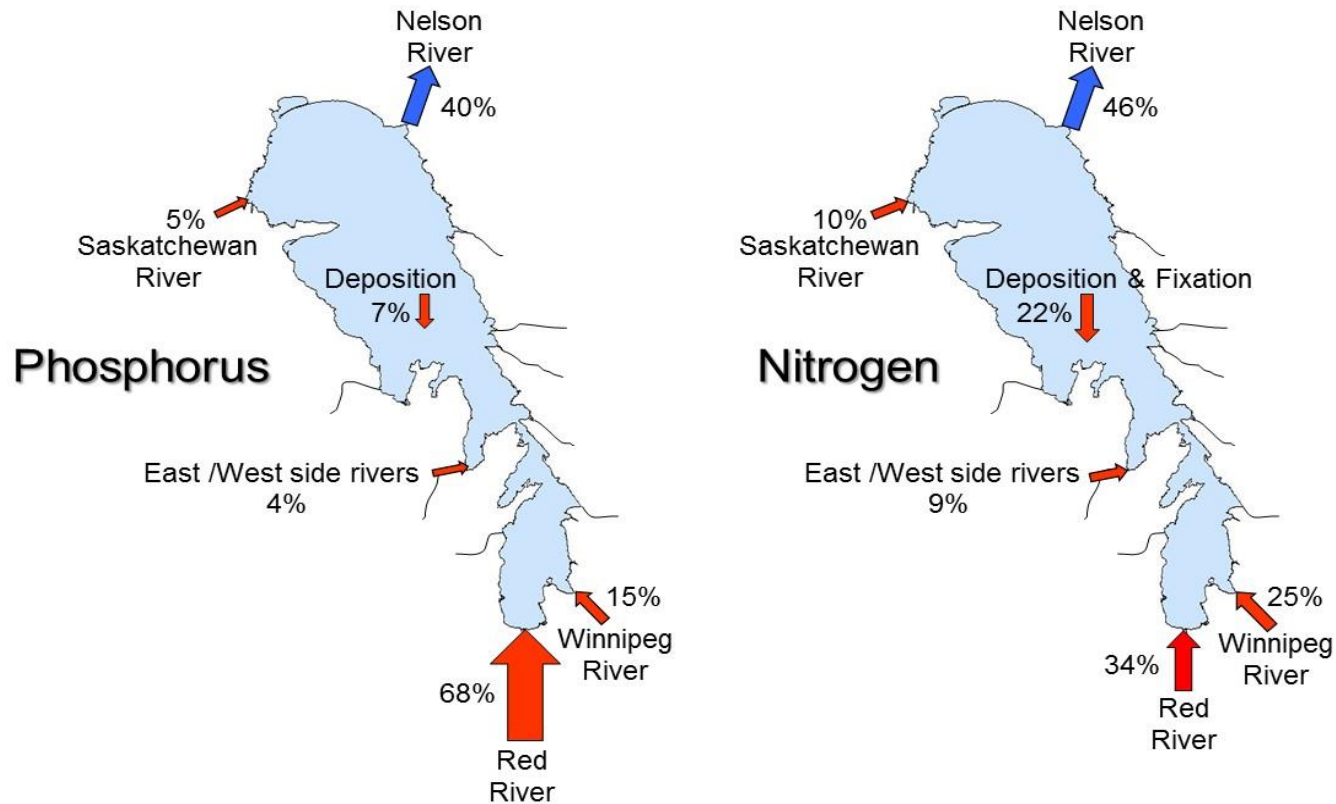


Figure 3. Average percent phosphorus and nitrogen loading contribution to Lake Winnipeg (from Environment Canada and Manitoba Water Stewardship 2011).

Red River – Phosphorus Loads

Since the early 1990s, a wet cycle has persisted in the Red River Basin, and flows have increased with more water and nutrients transported to Lake Winnipeg compared to the historic record. Between 1994 and 2016, the Red River was the single largest contributor of phosphorus to Lake Winnipeg, contributing more than 5,000 tonnes of phosphorus per year on average (Figure 4). Total phosphorus loads ranged from approximately 1,300 tonnes to 8,100 tonnes of phosphorus per year for the period of

record and generally followed patterns in streamflow with the highest loads transported in wet years (1997) and the lowest loads in dry years (2012). In 2016, the total phosphorus load in the Red River was 4,780 tonnes or 7 percent below the long-term average. The phosphorus loads in the Red River have generally been at or below the long-term average in most recent years.

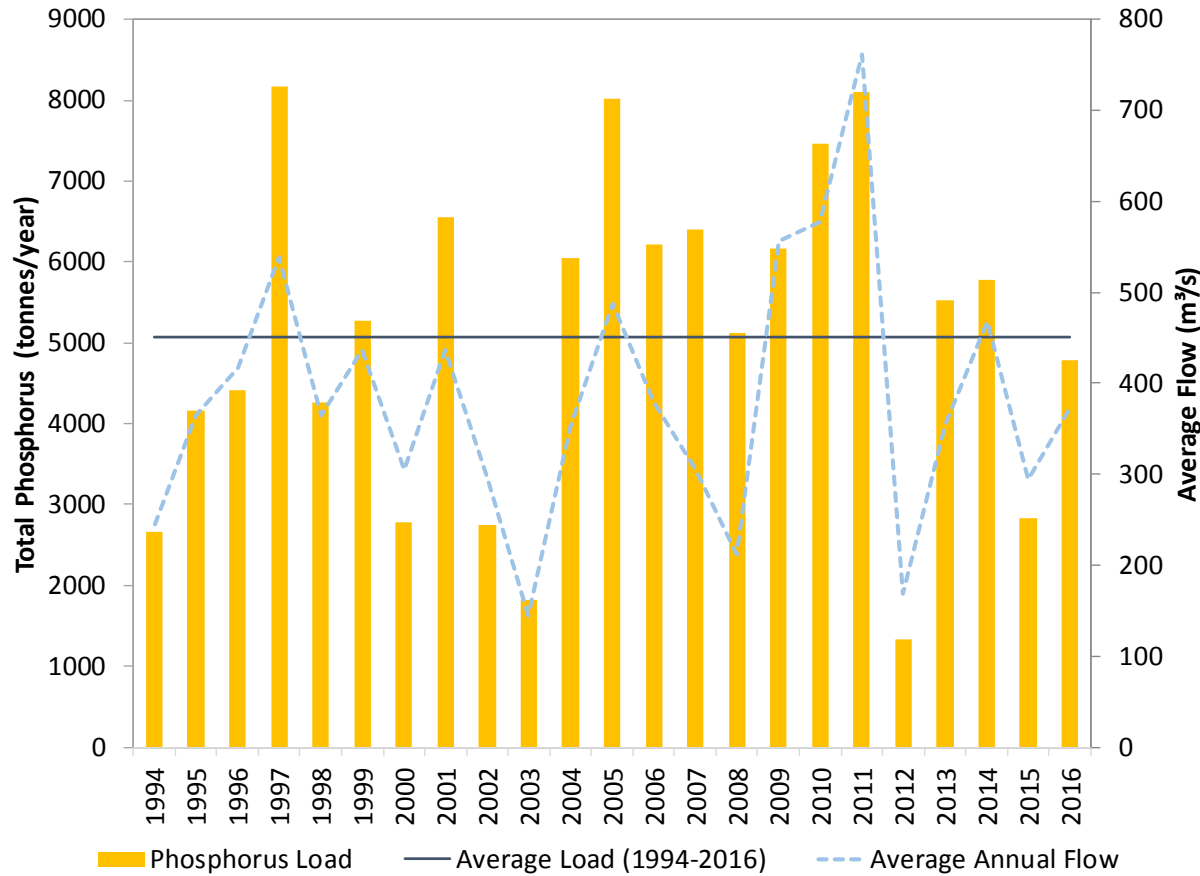


Figure 4. Annual total phosphorus loads (t/yr) and flows in the Red River (at Selkirk), 1994 to 2016.

Red River – Nitrogen Loads

The Red River was also the single largest contributor of nitrogen to Lake Winnipeg, contributing more than 31,000 tonnes of nitrogen per year on average (Figure 5). Total nitrogen loads ranged from approximately 11,000 tonnes to nearly 64,000 tonnes of nitrogen per year for the period of record and generally followed patterns in streamflow with the highest

loads transported in wet years (1997) and lowest loads in dry years (2012). In 2016, the total nitrogen load in the Red River was just over 31,000 tonnes, at the long-term average. Similar to phosphorus loads, nitrogen loads in the Red River have generally been at or below the long-term average in most recent years.

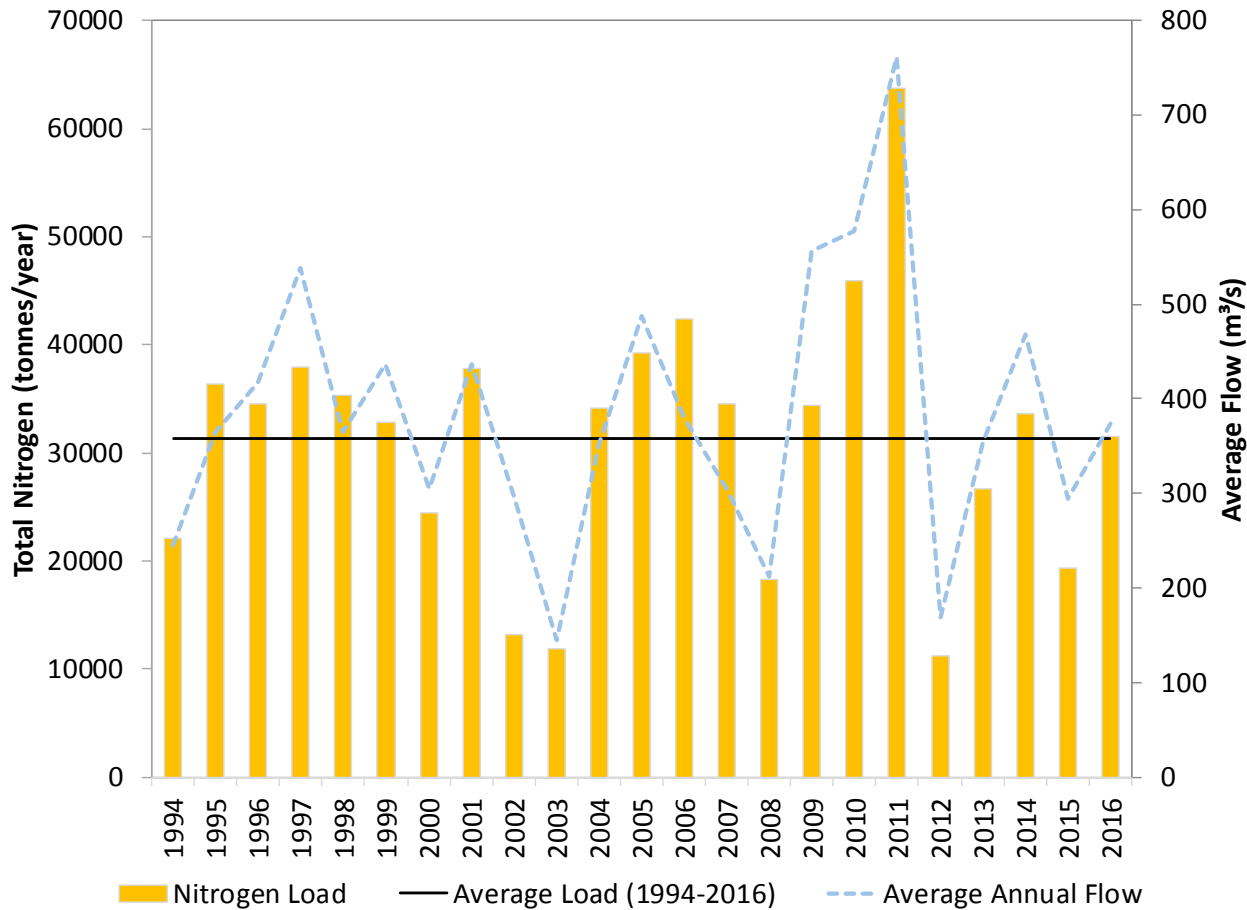


Figure 5. Annual total nitrogen loads (t/yr) and flows in the Red River (at Selkirk), 1994 to 2016.

Winnipeg River – Phosphorus Loads

The Winnipeg River is the second largest source of phosphorus to Lake Winnipeg contributing nearly 1,000 tonnes of phosphorus per year on average or approximately 15 percent of the total phosphorus load to Lake Winnipeg (Figure 6). Total phosphorus loads ranged from approximately 450 tonnes to just over 1,400 tonnes of phosphorus per year for the period

of record and generally followed patterns in streamflow. In 2016, the total phosphorus load in the Winnipeg River was approximately 1,300 tonnes, 24 percent above the long-term average. Total phosphorus loads in the Winnipeg River have remained relatively stable with loads fluctuating around the long-term average.

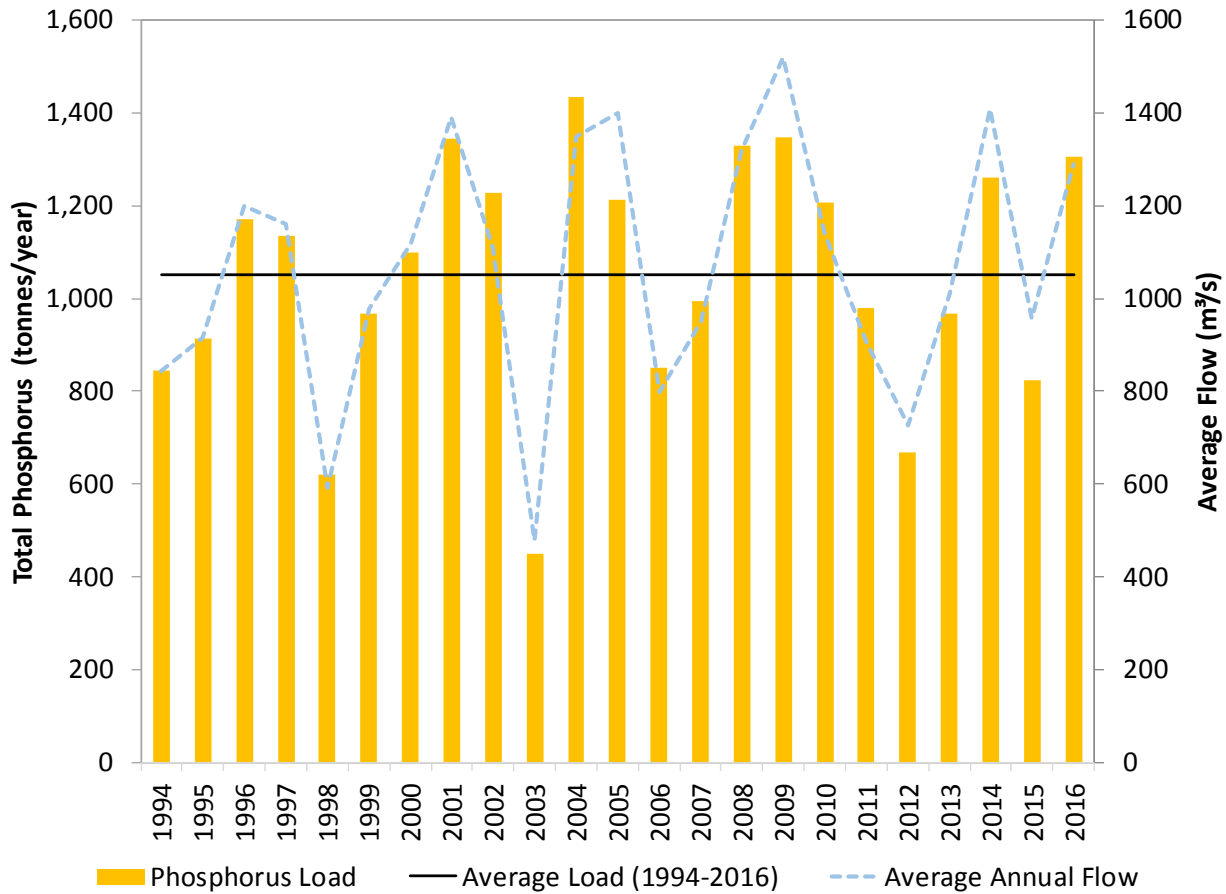


Figure 6. Annual total phosphorus loads (t/yr) and flows in the Winnipeg River (at Pine Falls), 1994 to 2016.

Winnipeg River – Nitrogen Loads

The Winnipeg River is the second largest source of nitrogen to Lake Winnipeg, contributing just over 20,000 tonnes of nitrogen per year on average or approximately 25 percent of the total nitrogen load to Lake Winnipeg (Figure 7). Total nitrogen loads ranged from approximately 13,000 tonnes to just over 33,000 tonnes of nitrogen per year for the

period of record and generally followed patterns in streamflow. In 2016, the total nitrogen load in the Winnipeg River was approximately 24,500 tonnes, about 20 percent above the long-term average. With the exception of 2016, total nitrogen loads in the Winnipeg River have been at or below average in recent years.

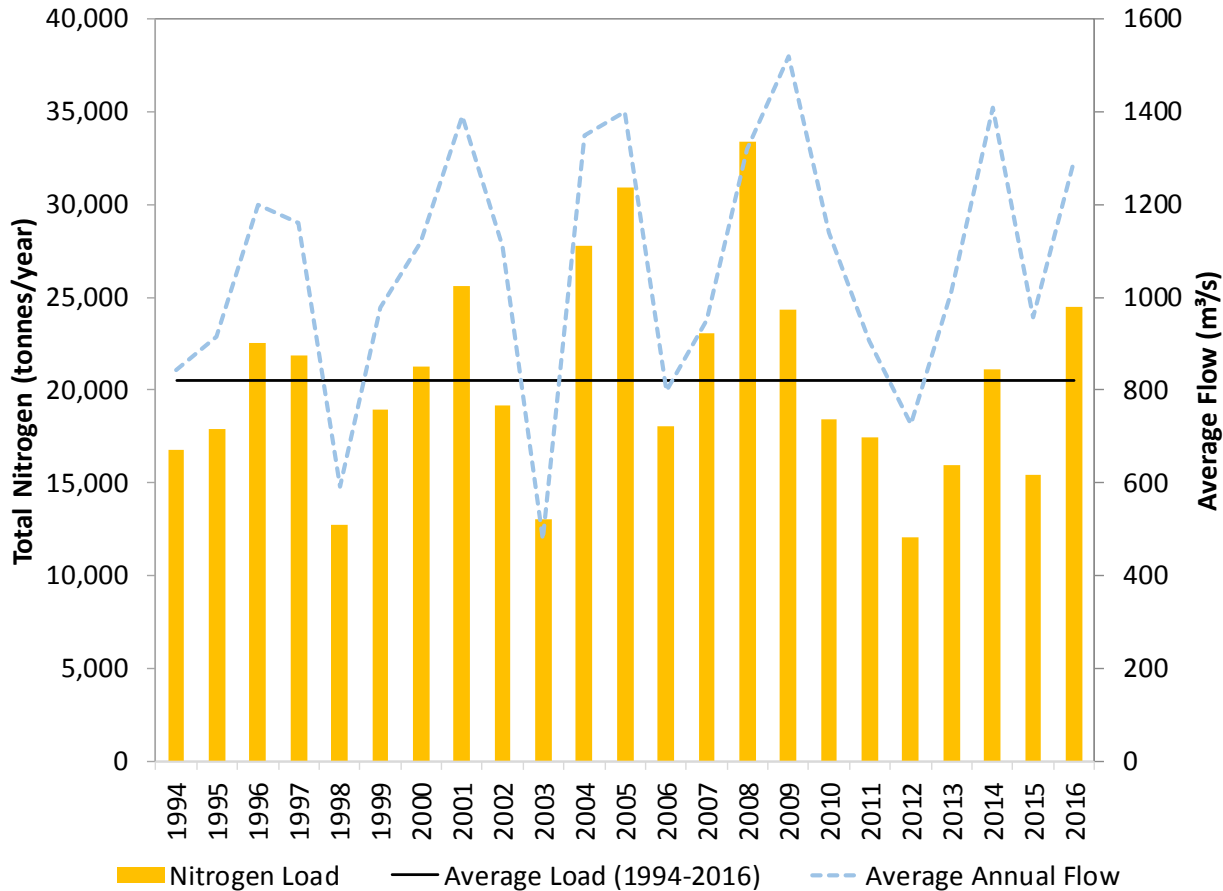


Figure 7. Annual total nitrogen loads (t/yr) and flows in the Winnipeg River (at Pine Falls), 1994 to 2016.

Saskatchewan River – Phosphorus Loads

The Saskatchewan River comprises about 5 percent of the total phosphorus load to Lake Winnipeg and contributes approximately 400 tonnes of phosphorus per year on average (Figure 8). There is high inter-annual variability in total phosphorus, with annual loads ranging from approximately 90 tonnes to just over 800 tonnes of phosphorus per year for the period of record. Phosphorus loads generally followed patterns in

streamflow with the highest loads transported in wet years (2011) and lowest loads in dry years (2001). In 2016, the total phosphorus load in the Saskatchewan River was approximately 670 tonnes, or 68 percent above the long-term average. Flows have increased significantly on the Saskatchewan River since 2005 and phosphorus loads have generally been well above average in the most recent period of record.

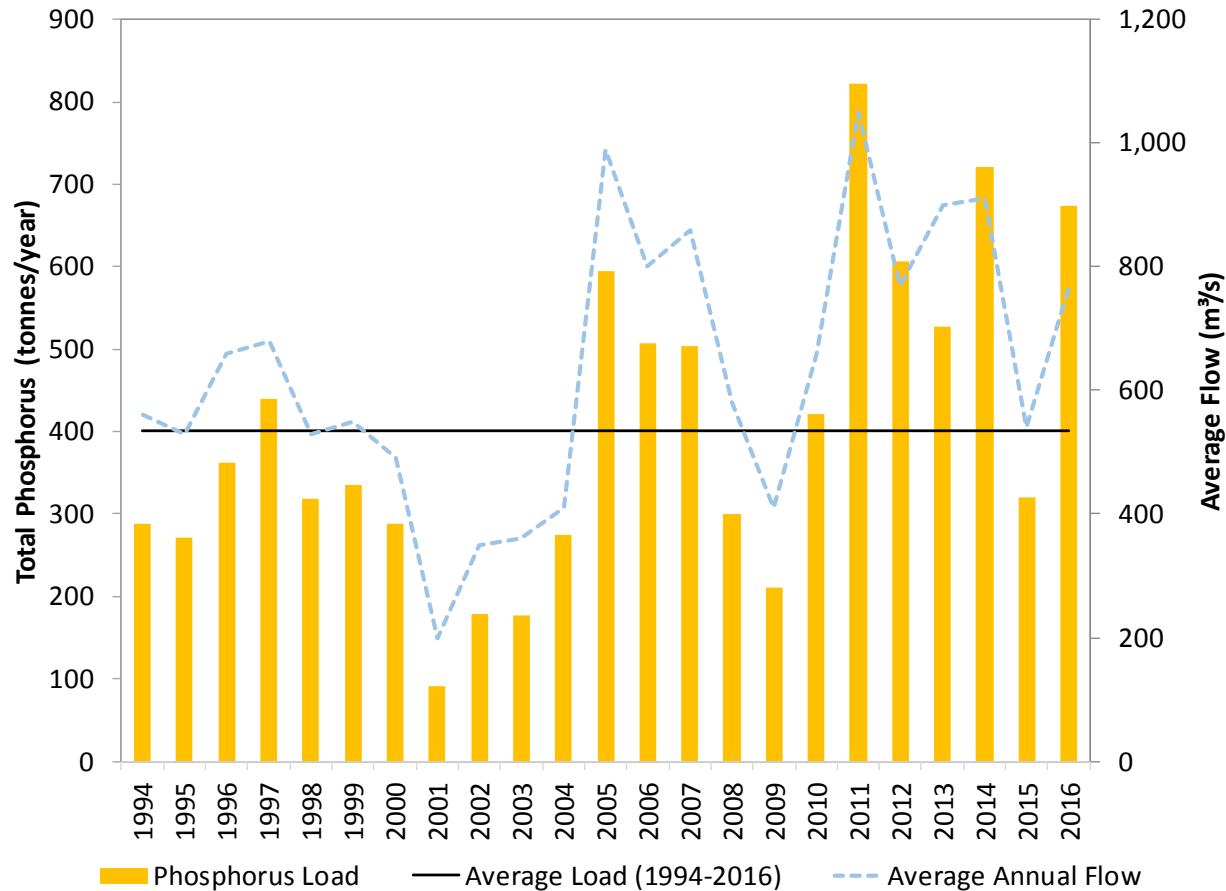


Figure 8. Annual total phosphorus loads (t/yr) and flows in the Saskatchewan River (at Grand Rapids), 1994 to 2016.

Saskatchewan River – Nitrogen Loads

The Saskatchewan River comprises about 10 percent of the total nitrogen load to Lake Winnipeg and contributes almost 11,000 tonnes of nitrogen per year on average (Figure 9). There is high inter-annual variability in total nitrogen, with annual loads ranging from approximately 3,000 tonnes to just over 20,000 tonnes of nitrogen per year for the period of record. Nitrogen loads generally followed patterns in streamflow with the highest

loads transported in wet years (2011, 2014) and lowest loads in dry years (2001). In 2016, the total nitrogen load in the Saskatchewan River was approximately 14,000 tonnes, or 31 percent above the long-term average. Flows have increased significantly on the Saskatchewan River since 2005 and similar to total phosphorus loads, total nitrogen loads have generally been well above average in the most recent period of record.

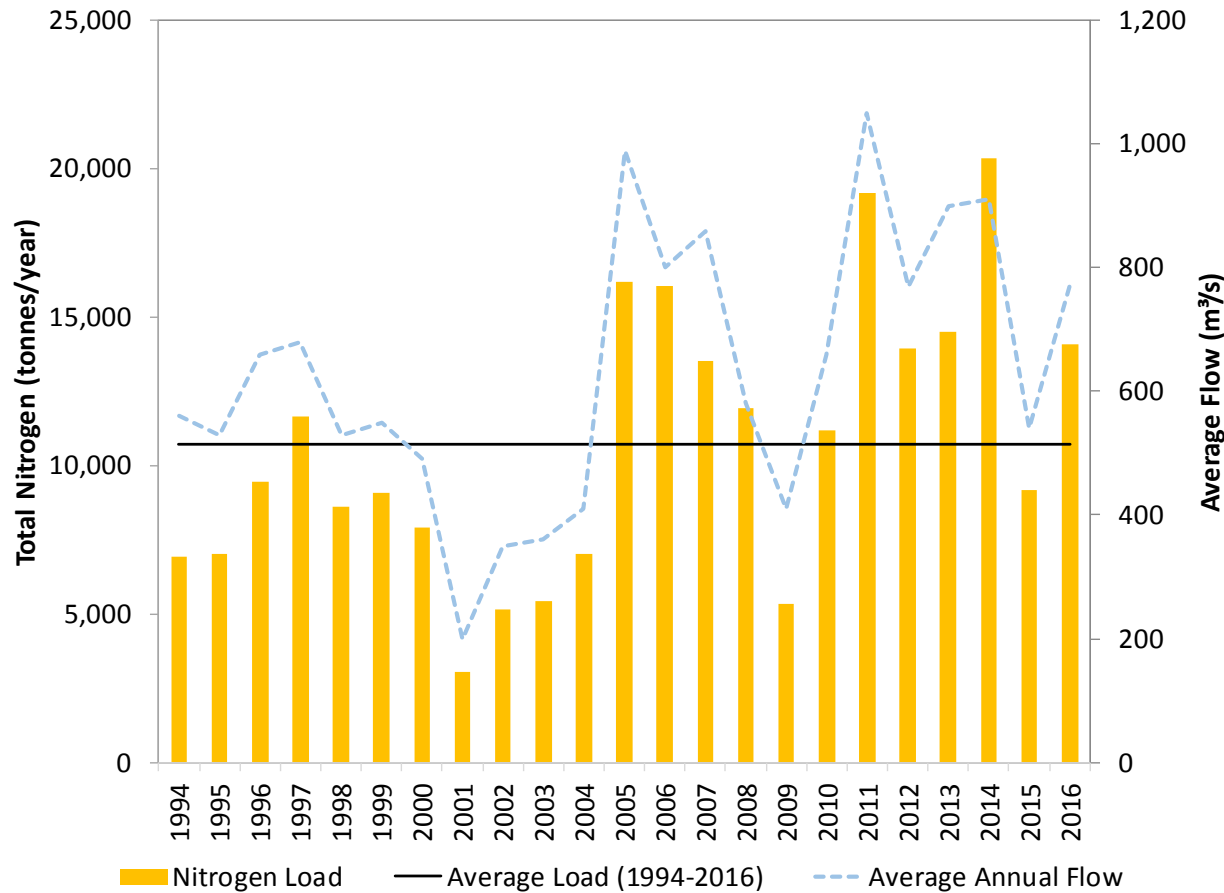


Figure 9. Annual total nitrogen loads (t/yr) and flows in the Saskatchewan River (at Grand Rapids), 1994 to 2016.

Dauphin River – Phosphorus Loads

The Dauphin River comprises a very small fraction of the total phosphorus load to Lake Winnipeg, contributing approximately 83 tonnes of phosphorus per year on average (Figure 10). There is high inter-annual variability in total phosphorus, with annual loads ranging from approximately 15 tonnes to nearly 250 tonnes of phosphorus per year for the period of record. Phosphorus loads generally followed patterns in

streamflow with the highest loads transported in wet years (2011) and lowest loads in dry years (2002-2004). In 2016, the total phosphorus load in the Dauphin River was just over 100 tonnes, or 26 percent above the long-term average. Flows have remained high on the Dauphin River since 2011 and phosphorus loads have generally been well above average in the most recent period of record.

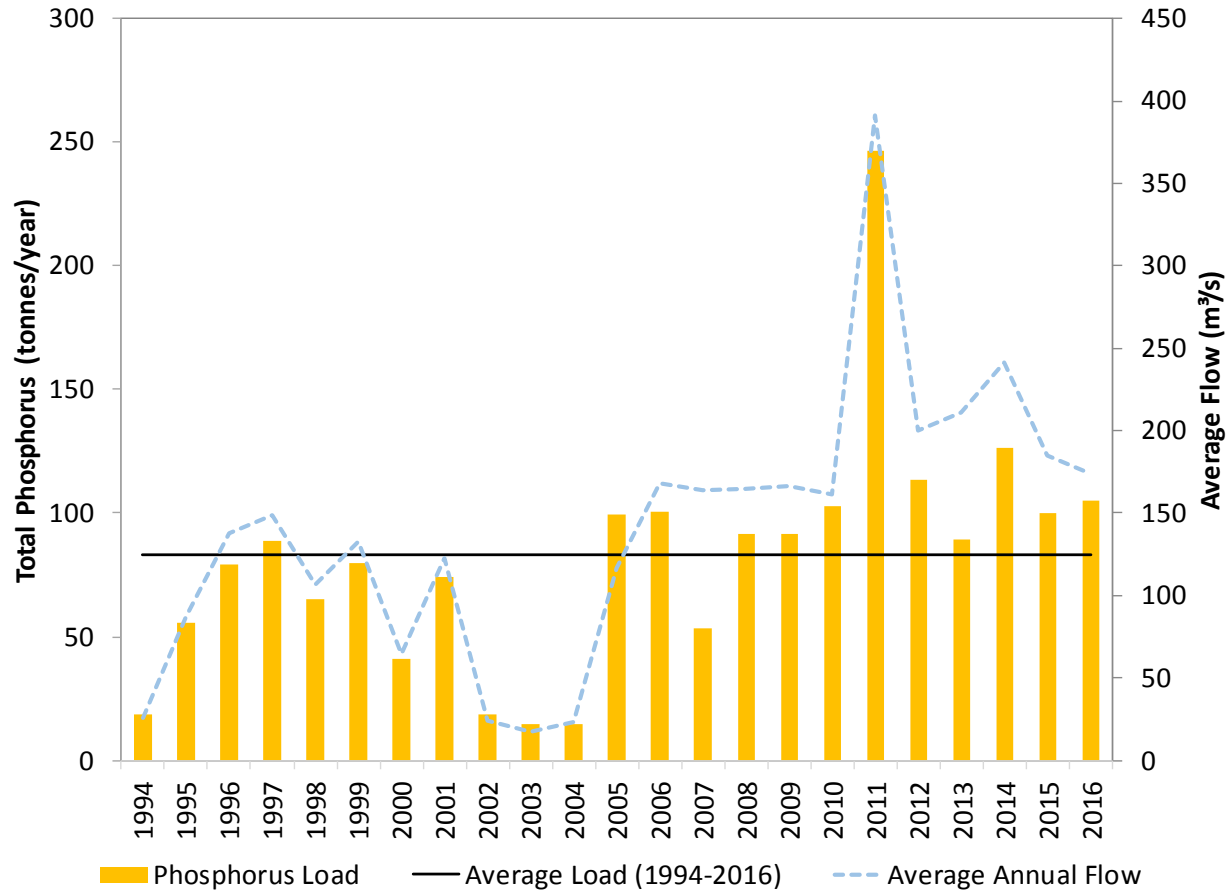


Figure 10. Annual total phosphorus loads (t/yr) and flows in the Dauphin River, 1994 to 2016.

Dauphin River – Nitrogen Loads

The Dauphin River comprises a very small fraction of the total nitrogen load to Lake Winnipeg, contributing approximately 5,500 tonnes of nitrogen per year on average (Figure 11). As with phosphorus, there is high inter-annual variability in total nitrogen, with annual loads ranging from approximately 900 tonnes to just over 13,000 tonnes of nitrogen per year for the period of record. Nitrogen loads generally followed patterns in

streamflow with the highest loads transported in wet years (2011) and lowest loads in dry years (2002-2004). In 2016, the total nitrogen load in the Dauphin River was just over 6,000 tonnes, or 11 percent above the long-term average. Flows have remained high on the Dauphin River since 2011 and nitrogen loads have generally been above average in the most recent period of record.

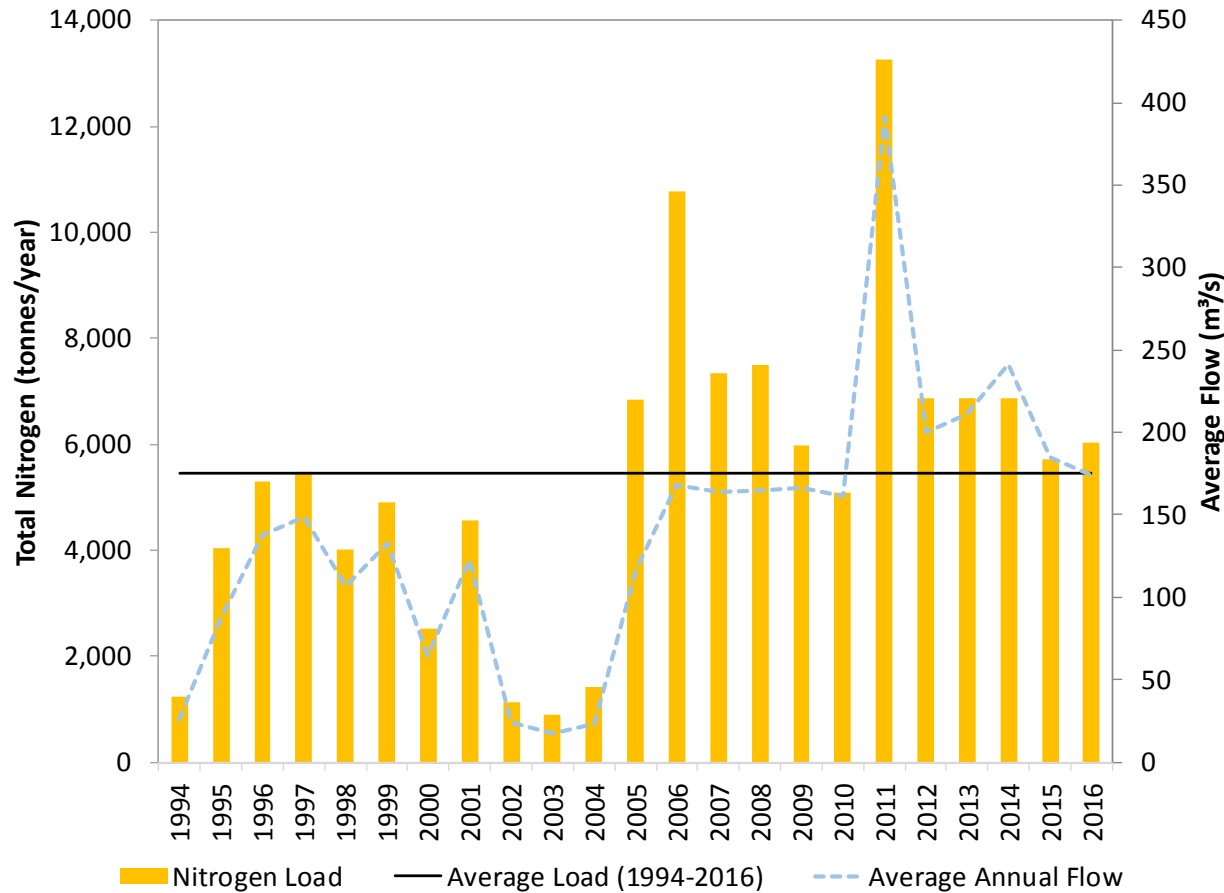


Figure 11. Annual total nitrogen loads (t/yr) and flows in the Dauphin River, 1994 to 2016.

References

Environment Canada and Manitoba Water Stewardship. 2011. State of Lake Winnipeg: 1999 to 2017. 209 pp.
https://gov.mb.ca/waterstewardship/water_quality/state_lk_winnipeg_report/index.html

Methods

All nutrient loads calculated per the 2011 State of Lake Winnipeg report (Environment Canada and Water Stewardship 2011) with water quality data from Sustainable Development and flow data from Water Survey of Canada.

Total phosphorus concentrations measured by Sustainable Development from April 2001 through March 2009 in Lake Winnipeg and its tributaries have been adjusted to account for a change in laboratory analysis technique. Concentrations measured during this period were approximately 12 per cent higher than those observed with the laboratory technique used in 2000 and in 2009 through the present.

Cover Photos: Water Science and Watershed Management Branch