Qu'Appelle Nutrient Mass Balance Reports (2013-2020)

Summary

- The quality of water in the Qu'Appelle River and the watershed's lakes and creeks holds significant cultural, environmental and resource importance to Saskatchewan. There is a corresponding desire to understand factors affecting water quality and to measure responses from various management initiatives.
- An ongoing concern relates to the abundance of algae in Qu'Appelle watershed's lakes, notably large algal blooms. Conditions are set for algal blooms to occur when there is an abundance of available nutrients; however, nutrients are not the only factor that determine whether algal blooms occur.
- Similar to other prairie ecosystems with naturally rich soils, the Qu'Appelle Watershed is a naturally nutrient-rich system.
- To gain a better understanding of nutrients and nutrient sources in the watershed, a nutrient mass balance study was initiated in 2013.
- Findings from the 2013-2016 study are summarized in the first Qu'Appelle Nutrient Mass Balance report (2018).
- In 2023, the Water Security Agency (WSA) released its second Qu'Appelle Nutrient Mass Balance report.
- The 2023 report was focused on understanding nutrient levels in the mid-reach of the Qu'Appelle River between Buffalo Pound and the outlet of Katepwa Lake.
- The goal of the 2023 report was to understand nutrient changes in the river following Regina's 2017 wastewater treatment plant upgrade.
- The reports identify key load sources for nutrients and highlight some significant steps taken to reduce phosphorus and nitrogen loads entering Pasqua Lake. It also provides important scientific information on the formation of algal blooms.
- The 2013-2015 and 2018-2020 study periods had very different streamflow patterns, representing very wet (2013-2015) and very dry (2018-2020) conditions in the watershed. These studies improve our understanding of how nutrients move through the watershed in these very different conditions.
- WSA will continue to gather and evaluate information to inform decisions regarding options to manage nutrient inputs in the Qu'Appelle Watershed. WSA's work includes regulating sewage effluents, moving forward with the Agricultural Water Management Strategy, and continuing collaborative work with researchers, local watershed authorities and municipalities.

Key Findings

- The dry conditions in the watershed during 2018-2020 were a major contrast to the wet conditions of 2013-2015. Inflows from tributaries to the Qu'Appelle River were less important contributors of flow and nutrients to the river, while releases from Buffalo Pound Lake (primarily originating at Lake Diefenbaker) increased in importance.
- Last Mountain Lake functioned differently between the two periods. In 2013-2015 it had high water levels due to the wet conditions and contributed roughly a third of the streamflow in the Qu'Appelle River at its outlet at Craven. In 2018-2020 water levels in Last Mountain Lake were low and it was a net recipient water from the Qu'Appelle River. During this dry period roughly a third of Qu'Appelle River streamflow at Lumsden was diverted into Last Mountain Lake.
- Total nutrient loads at nearly all sites from 2018 to 2020 were much lower than those measured in 2013-2015 because of the much lower streamflow volumes.
- Total nutrient loads in the Regina wastewater treatment plant effluent were reduced by 41 per cent for phosphorus and 75 per cent for nitrogen in 2018-2020 compared to those in 2013-2015.
- Total phosphorus concentrations in the inflow to Pasqua Lake declined by 35 per cent in 2018-2020 compared to 2013-2015. However, despite the significant reduction in nitrogen load (75 per cent), total nitrogen concentration was similar between the two periods.
- The lack of reduction in nitrogen concentration at the inflow to Pasqua Lake is because of different streamflow conditions (wet versus dry conditions). During the wet conditions in 2013-2015 more watershed flow was available to dilute nitrogen originating in the wastewater effluent. In 2018-2020 the dilution was much less.
- For both studies, the Calling Lakes (Pasqua to Katepwa) received more nutrients at the inflow to Pasqua Lake than they released at the outflow from Katepwa Lake. The retention of nutrients in lakes is common and was an expected finding.
- For nutrients from non-point sources the differentiation between natural load and that proportion derived from agricultural activities is not easy to quantify. The prairie landscape naturally contributes comparatively high levels of nutrients to the river, particularly during periods with high runoff volumes.
- The reports provide an assessment of nutrient concentrations and loads along the Qu'Appelle River and its tributaries. The reports cannot assess whether the observed nutrient levels are above acceptable levels as these have not yet been defined for the Qu'Appelle River. The 2018-2020 study demonstrates the differences in nutrient concentrations that arise from changes in streamflow. This complicates the setting of nutrient targets, but greatly adds to our understanding of nutrient dynamics in the Qu'Appelle River watershed.

1. **Why is WSA interested in nutrients within the Qu'Appelle Watershed?**

   The Qu'Appelle Watershed is an important watershed in the province. Regina and many other cities and communities are located within the watershed. The watershed is important for cultural, environmental and economic reasons. The watershed is a managed system, with augmented flows from Lake Diefenbaker and multiple water control structures, at or near lake outlets, along the length of the river.

2. **Have there always been algal blooms on the Qu'Appelle lakes?**

   Yes. Multiple sources have confirmed the presence of algal blooms in the Qu'Appelle Lakes. This includes historic mention of blooms by European explorers in the mid 1850's and a comment in the federal fisheries inspector's diary from the 1890's about "green scum" present on the Qu'Appelle lakes.

   Scientific reconstruction of the number of algae present in the lakes over time has been done by evaluating algal remains in the sediment at the bottom of the lakes, with older periods represented by deeper sediment layers. This study confirmed the historic and natural high algal content of these lakes. It also found increased total algae in the furthest upstream lake, Pasqua, which was attributed to human activities in the watershed. To address these changes, there have been more stringent controls placed on nutrients from wastewater treatment plants.

3. **Why are nutrients important to the formation of algal blooms?**

   Nutrients are an essential building block for all organisms, including algae that live in lakes. Various scientific studies have found that certain nutrients, notably phosphorus and nitrogen, can indicate the amount and type of algae present. Generally, this means that when more nutrients are present there are more algae present.

   There are other factors critical to the growth of algae including the physical nature of the lake and other organisms present in the lake. Lakes naturally have different amounts of algae, which is often linked to the geographical features of that area. Nutrients do not always limit algal growth or algal bloom formation; however, understanding their dynamics is an important component to understanding algal growth.

4. **Have nutrient levels in the Qu'Appelle River and its lakes changed over time?**

   Nutrient concentrations in the Lower Qu'Appelle lakes are known to have increased from historical background levels up to the mid to late 1970's because of various human activities in the watershed, including from wastewater effluent. The upgrade of Regina's wastewater treatment plant in the mid to late 1970's decreased the nutrient load to the Lower Qu'Appelle lakes. The nutrient load from the city of Regina has further decreased with the recent (2017) upgrade to the wastewater treatment plant.

5. **What is meant by "nutrient mass balance"?**

   This study measured both the concentration and the load of nutrients in the Qu'Appelle River. Load is a measure of the mass of nutrients transported over a given time. Load is calculated from concentration and flow. A mass balance approach looks at how nutrient load changes through time and space to better understand sources and sinks (losses) of nutrients transferred within the watershed.

6. **What is the difference between nutrient loads and nutrient concentrations? Which are more important for understanding algal blooms?**

   Nutrient concentration represents the amount of nutrient in a certain volume of water. For example, the mass (e.g., milligram) of a nutrient in water (e.g., litre). Nutrient loads refer to the total mass of nutrient (e.g., tonne) transported at a specific place over a given period (e.g., year). Both measures are important for understanding nutrient dynamics and algal blooms.

   Concentration governs the amount of nutrient available for algal growth. Nutrient loads provide information on the total mass of nutrients that move over a certain timeframe. Over longer timescales, loads help determine concentrations.

7. **What are the sources of nutrients to the watershed?**

   Sources of nutrients to the watershed can be divided into point and non-point sources. Point sources are discrete additions of nutrients, such as would be found at the end of a pipe, for example effluent from a wastewater treatment plant. Non-point sources are contributions from a diffused area.

   This study did not undertake assessment to understand different types of non-point sources but rather assumed that non-point sources represent the total load minus those from point sources.

8. **Do all nutrients that enter the Qu'Appelle River stay within the water of the Qu'Appelle watershed?**

   No. Ecosystems, through a variety of processes, remove nutrients from water. This includes burial and in the case of nitrogen, removal through a process called denitrification.

9. **What are non-point sources of nutrients?**

   Non-point sources of nutrients include all those nutrients from diffuse sources. This includes overland flow, which in the Qu'Appelle watershed, naturally contains higher level of nutrients. These are derived from soils and dead plants. Nutrients also can be added within the river channel; for example, through bed or bank erosion. Other sources of non-point nutrients include atmospheric depositions and those arising from a variety of human activities in the watershed, including various land-use activities such as developments and agricultural activities.

10. **Why does streamflow volume affect nutrient concentrations in the river?**

    Streamflow affects nutrient concentrations in the river in several way but notably because streams bring nutrients into the river and in-river processes can retain nutrients. Also, when streamflow is higher there is greater dilution of any point sources.

11. **If upgrades to Regina's wastewater treatment plant removed such a large amount of nitrogen, why did nitrogen concentrations at the inflow to Pasqua Lake remain at similar levels?**

    During the wet period the higher stream flows provided greater dilution of the effluent from the wastewater treatment plant, whereas during the dry period there was less dilution. If the river flows had remained the same before and after the wastewater treatment plant upgrades, there would have been a reduction in concentration.

12. **What does the report say about the contribution of agricultural activities to nutrients in the Qu'Appelle River?**

    The study did not specifically evaluate agricultural nutrient contributions. Water entering the Qu'Appelle River through its tributaries flows over a landscape where agriculture is the dominant land use. However, the prairie landscape would naturally contribute comparatively high amounts nutrients, more so during periods of high flow, to the river relative to other geographic areas. The difference between the natural load and an agriculturally contributed load is not simple to evaluate and was not done in the study.

13. What are some of the ways that the WSA engages with stakeholders within the Qu'Appelle Watershed?

The Water Security Agency supported the creation of watershed plans, supports ongoing implementation of these plans and is engaged in a technical manner with stakeholder groups in the Qu'Appelle Watershed. The province regulates wastewater treatment systems and has been instrumental in the upgrades and assessment of effects to understand the influence of these activities on the watershed. The provincial Agricultural Water Management Strategy is administered by the WSA, which is working to balance the benefits with the impacts related to agricultural drainage.

14. What are the next steps to inform management of water quality in the Qu'Appelle?

WSA continues to monitor nutrient concentrations and loads at a subset of sites from Wascana Creek to the outflow of Katepwa Lake. It is also undertaking long-term monitoring of nutrient concentrations in the Qu'Appelle Valley lakes to understand how nutrient concentrations change over time.

The WSA is also collaborating with university researchers to address specific questions related to nutrient dynamics in the Qu'Appelle Watershed. These studies will improve understanding of achievable nutrient reductions and the expected effect of nutrient reductions on size and formation of algal blooms.

15. Do the reports indicate that the observed nutrient levels are above acceptable levels?

No, that is not the focus of this report. The report assesses nutrient concentrations and loads along the Qu'Appelle River and its tributaries. The Qu'Appelle River, including lakes along the river, are known to be naturally nutrient rich, or in more technical terms, hypereutrophic. While this report does not explore "acceptable levels", it is the intention of ongoing studies to set nutrient objectives in part on the information from this report and WSA's ongoing water quality monitoring program of those lakes.

16. Do the reports indicate that the water quality of the Qu'Appelle system is bad?

No, this was not the intention of this study. Water quality encompasses a large range of variables associated with water, with nutrients being one of them. This report was focused on understanding nutrient sources to the Qu'Appelle Watershed as part of a larger study of updating notional nutrient objectives in the downstream Qu'Appelle lakes. The provincial government undertakes water quality monitoring of provincial beaches within the Qu'Appelle Watershed to ensure the safety for recreational activities.

17. Is the province controlling nutrients to reduce algae blooms which can be problematic under extreme conditions?

Yes, the provincial government issue permits to limit the discharge of point source nutrients within the Qu'Appelle Watershed. These permits, notably the current nutrient targets for Regina's wastewater treatment plant, are amongst the most stringent on the prairies. The provincial government also undertakes various programs to promote and subsidise implementation of beneficial management practices to reduce non-point nutrient loading from human landscape activities.

18. Does the report show that it isn't safe to use water in the Qu'Appelle system?

The intention of the report was to quantify nutrients to better understand the sources, not to evaluate the safety of water within the Qu'Appelle system. Safety for human activities, aquatic life and water suitability for other uses are evaluated/regulated by other monitoring.

19. How low do the nutrients have to go to stop algal blooms?

All lakes have algae growing in them, and at times algae become more abundant. Some algal blooms are clearly visible because they form surface scums, whereas other algal blooms are less visibly apparent because they occur within the water column. This difference is largely a function of the types of algae that are blooming. For example, there is typically a large spring bloom of algae that occurs within the water column of the Qu'Appelle lakes.

These algae form an important part of the food web in the lakes and the productive nature of the lakes is important for the lakes' fisheries. Algal blooms, including summer and autumn blooms with surface scums, are a natural condition of the Qu'Appelle lakes. Lakes with nutrient levels much lower than is practically achievable in the Qu'Appelle system experience these types of blooms. Reducing nutrients may, however, reduce the size and severity of the blooms.

20. Will reductions in phosphorus concentrations in the inflow to Pasqua Lake make a difference to algal blooms in the Calling Lakes?

Lower phosphorus concentrations at the inflow to Pasqua Lake observed during the 2018-2020 study, combined with the longer retention times of water in the Calling Lakes, may cause decreases in lake phosphorus concentrations. WSA's long-term monitoring suggests that this is occurring. However, phosphorus concentrations remain high enough to support algal blooms.

21. Will the reductions in nitrogen loading from Regina's wastewater treatment plant improve nitrogen concentrations and algal blooms in the Qu'Appelle Lakes?

Over the long term, this reduction in nitrogen is anticipated to result in lower nitrogen concentrations in the lakes. This may result in a change in the algal species, including to species that are able to generate their own nitrogen supply from air through a process called nitrogen fixation. The Regina's wastewater treatment plant upgrades also changed the dominant inorganic nitrogen form from ammonium to nitrate. This shift can also affect which algal species become dominant, although this effect will be most pronounced closer to Regina.

22. Do industrial water withdrawals make the nutrient load worse?

Any water withdrawals remove nutrients along with water from lakes and rivers. This removal of nutrients generally has a small effect on nutrient concentrations.

23. What is a "good" nutrient level for the Qu'Appelle?

Nutrient levels vary along the length of the Qu'Appelle River and in lakes within the watershed. Generally, nutrients are at hypereutrophic levels (i.e., naturally nutrient rich). The nutrient rich nature of the lakes makes them productive, including a productive fishery. One of the consequences of high nutrient levels, however, is that blue-green algae (cyanobacteria) blooms occur with greater size and frequency. There is no ideal nutrient level for the Qu'Appelle lakes, although the longer-term goal is to reduce the amount of nutrients added to the Qu'Appelle from human activities.