Grand River Source Protection Area

ASSESSMENT REPORT

Chapter 24: State of Climate Change Research in the Lake Erie Source Protection Region

Chapter 25: Consideration of Great Lakes Agreements

Version 10.1

July 29, 2025

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24.0 STATE OF CLIMATE CHANGE RESEARCH IN THE LAKE ERIE SOURCE PROTECTION REGION

Recent climate change studies focus on modeling a doubling of CO_2 in the atmosphere. Studies of the consequences of this climate change scenario specific to the Grand River watershed include Bellamy *et al.* (2002), de Loe and Berg (2006), de Loe *et al.* (2001) and Southam *et al.* (1999). As well, research on the broader Lake Erie basin give predictions on local scale impacts of climate change for the Grand River watershed, accounting for the meso-climatic influences of the Great Lakes.

Many recent studies have incorporated the changes already seen in the Great Lakes regional climate (such as Bruce *et al*., 2006; Chiotti and Lavender, 2008; Kunkel *et al*., 2009; Zhang *et al*., 2000). Research into climate change and water resources in the last decade are thought to be more reliable than previous studies (IPCC-TGICA, 2007). Recent studies have the advantage of analyzing observed changes as well as the availability of better modeling tools. Many recent studies agree that greater and more frequent extremes in temperature and precipitation are expected in the Lake Erie basin. More specifically, an annual average increase in both temperature and precipitation are the driving predictions for Ontario and the Lake Erie basin; both of which have the potential to dramatically impact water resources (Kling *et al*., 2003).

Annual average air temperature in the Lake Erie basin (including the Grand River watershed) is expected to increase only slightly; McBean and Motiee (2008) estimate 0.8^0C increase by 2050. The small increase, however, masks the intra-annual changes, as seasonal temperatures and diurnal temperatures are expected to fluctuate more dramatically (Cunderlik and Simonovic, 2004; Jyrkama and Sykes, 2007; Kunkel *et al.*, 2002). In particular, studies show much warmer winter temperatures will occur (Bruce *et al*., 2000; Cunderlik and Simonovic, 2004; Jyrkama and Sykes, 2007; Kunkel *et al*., 2002; Mortsch *et al*., 2000). Summer daily temperatures are projected to gradually increase towards 2030 and then a more rapid increase could have daily average summer temperatures 10^0C higher than the 1960-1990 average by 2100 (Kling *et al*., 2003).

For precipitation, the projected effects of a doubling of CO_2 are extensive. Annual total precipitation is predicted to increase over the next 50 years in the Great Lakes basin (McBean and Motiee, 2008); however net basin water supplies are projected to decrease due to greater evapotranspiration and runoff. The distribution of precipitation throughout the year will be altered, as Sharif and Burn (2006) estimate that only the months of January, March and October will have increased monthly precipitation. The other months may see a decrease in precipitation, including the months between April to September when water demand is the highest. The form of winter precipitation is expected to shift to rain instead of snowfall, as winter temperatures rise (Bruce *et al.*, 2000; Mortsch *et al.*, 2000). The extreme events for precipitation will be more intense and higher frequency (McBean and Motiee 2008), at the expense of the more gentle and persistent rainfall events (Mortsch *et al.*, 2000).

Warmer winter temperatures are predicted to be the most influential change for water resources in the Grand River watershed. Some of the changes predicted include more winter precipitation as rain, a smaller snowpack, higher evaporation from open water bodies that no longer freeze and an earlier and smaller spring freshet (Barnett *et al*., 2005; Bruce *et al*., 2000; Environment Canada, 2004; Jyrkama and Sykes, 2007; Mortsch *et al*., 2000). Soil moisture will start higher in the spring but drop lower in summer with anticipated higher evapotranspiration. This will lead to greater demand for water resources for irrigation and more frequent drought occurrence (Brklacich, 1990; McBean and Motiee, 2008). Precipitation trends show more intense storms, causing a decrease in infiltration and groundwater recharge (de Loe and Berg, 2006; McLaren and Sudicky, 1993), higher sediment and nutrient loading in the creeks due to greater erosion (McBean and Motiee 2008) and fewer number of days with rain or longer dry periods (Mortsch *et al.*, 2000). Net basin supplies are projected to decrease, following decreases in runoff, infiltration, higher surface water temperatures and greater evapotranspiration (Lofgren *et al.*, 2002; Mortsch *et al*., 2000) Overall, climate change is expected to shift the means in temperature, precipitation and evaporation which will lead to increased variability, more frequent and intense events (Francis and Hengeveld, 1998)) in de Loe *et al.*, 2001).

24.1 Potential Effects of Climate Change on Water Quantity and Quality

The predictions on climate change in the Grand River subwatersheds have implications to both water quality and quantity. In terms of water quality, the increased air temperature and greater occurrence of extreme precipitation events will lead to degraded water quality with lower dissolved oxygen rates and higher stream temperatures (Bruce *et al*., 2000; Chiotti and Lavender, 2008; Cunderlik and Simonovic, 2004). Higher sediment and nutrient loading are expected in the creeks due to greater erosion (McBean and Motiee, 2008), and coupled with increase in water temperature, will allow for an increase in nutrient concentrations and a rise in the number of cyanobacteria and algal blooms. The blooms will lead to more taste and odour problems in drinking water, a higher risk of water-borne diseases and increased treatment costs (Chiotti and Lavender, 2008; Hunter, 2003; de Loe and Berg, 2006). Decreases in runoff and baseflows from climate change are also important changes with respect to the dilution of sewage treatment effluent because less water will be available for waste assimilation (de Loe and Berg, 2006). The problem of reduced waste assimilation capacity is exacerbated by the projected increase in future populations in these areas and the ability of the system to meet wastewater discharge criteria (Bruce *et al*., 2000; Cunderlik and Simonovic, 2004).

In terms of water quantity, climate change is expected to shift the timing of seasonal events, including an earlier and lower spring freshet and changing levels in Lake Erie to rise and fall one month earlier on an annual basis, due to increased lake surface temperatures (Lenters, 2001; Lofgren *et al*., 2002; Millerd, 2006). The longer frost-free periods lead to increased potential evapotranspiration and an increase in drought occurrence (Environment Canada, 2004; McBean and Motiee, 2008), meaning that longer, drier and warmer growing seasons will lower soil moisture (more deficit) and increase the demand for irrigation (Brklacich, 1990; McBean and Motiee, 2008). Rainfall

is expected to fall with more intensity but on fewer days, leaving longer dry spells that may exacerbate seasonal water shortages during low flow periods (Mortsch *et al*., 2000). Projected reductions in groundwater recharge to drawdowns of 2 to 7metres will require wells to be drilled deeper, increasing costs to land owners and municipalities and could lead to rural domestic and urban water use conflicts (de Loe and Berg, 2006; McLaren and Sudicky, 1993). The reliability of water resources is compromised and unpredictability of the hydrologic cycle will demand more planning and adaptation by water managers (de Loe and Berg, 2006).

24.2 Potential Impacts of Climate Change on Lake Erie and Reservoir Levels

Impacts to Lake Erie will have important consequences with the changing climate. Anticipated changes in Lake levels are a function of the altered water balance of the basin including higher precipitation, a decrease in runoff, higher evapotranspiration and an increase in lake surface temperature (Jones *et al*., 2006; Lofgren, 2006; Millerd, 2006). Increasing water temperature in both summer and winter are projected for Lake Erie, causing large increases in evaporation especially in winter months as ice cover would minimize these losses. Net basin water supplies will be diminished (Mortsch, 2006), as any increases in precipitation are not expected to overcome the decreases in water due to evapotranspiration (Millerd, 2006). The reduction in winter ice formation on Lake Erie is expected to be considerable and perhaps non-existent in some years (Lofgren *et al*., 2002). Typically, Lake Erie would nearly freeze over in the months of January and February and limit the lake's influence on snowfall (Kunkel *et al*., 2009). As a consequence of open water in winter months, the lake-effect storm season off Lake Erie will be longer (Mortsch *et al*., 2000), however more of this precipitation will fall as rain due to a decrease in the frequency of air temperatures between optimal ranges for snow (−10 degrees Celsius to 0 degrees Celsius, (Kunkel *et al*., 2002). The seasonal variation in Lake Erie levels is also projected to increase, with low levels occurring more frequently, being most pronounced in the shallower western portion of Lake Erie (Lofgren *et al*., 2002; Mortsch *et al*., 2000; de Loe and Kreutzwiser, 2000). The decline in annual Lake Erie levels could as much as between 0.60 metres to 1.36 metres from the International Great Lakes Datum of 1985 of 174.18 metres, according to the results of 3 Canadian Global Climate Model(GCM) scenarios (Millerd, 2006; Mortsch *et al*., 2000). Jones *et al.* (2006) concluded that Lake Erie is possibly the most vulnerable of the Great Lakes to the effects of climate change, as they are the most southerly, shallowest and lowest volume and thus more susceptible to changes in thermal regime and lake levels. The consequences of Lake Erie level declines to the Lake Erie drinking water intakes would be costly if dredging or pipe extensions were required and, with less depth over the intake, raw water quality could be degraded.

Reservoirs in the Grand River watershed will be affected by climate change similar to the Great Lakes, just at a smaller scale. Winter ice cover is expected to be reduced, with some years without any cover at all, and consequently an increase in evaporation off the reservoirs and decrease in levels (de Loe and Berg, 2006; Lofgren et al., 2002). The operation of reservoirs will need to be modified, as flood risks will be less predictable in all seasons (Cunderlik and Simonovic, 2005). More frequent thaws in winter will cause snow-melt induced maximum flows to decrease while high-river flows

may be more frequent (Cunderlik and Simonovic, 2005). The greater flood risk in winter months will be at the expense of an earlier and lower spring freshet, which will also alter reservoir operations for low flow augmentation in summer months (Bruce et al., 2000; Mortsch et al., 2000). The decrease in ice cover may have an effect on the amount of erosion from the banks of the reservoirs and the amount of sediment build-up behind the dam structure.

24.3 Effect of Projected Climate Changes on Assessment Report Conclusions

Projected climate changes may affect the assessment report conclusions with respect to the groundwater and surface-sourced drinking water supplies in the Grand River watershed. There is uncertainty regarding the net quantitative and temporal impacts to the Grand River water budget as precipitation, evapotranspiration, runoff, recharge and water use rates change. A Tier Two Assessment was completed for the Grand River Watershed in 2009 (AquaResource 2009a, 2009b), which identified subwatersheds and groundwater assessment areas that contain municipal water supply systems that had an elevated (Moderate or Significant) potential for hydrologic stress from a surface water or groundwater perspective. The water quantity stress analysis indicates that eleven municipal water systems are in areas with moderate or significant potential for stress: Elora/Fergus in the Township of Wellington Centre; Rockwood and Hamilton Drive in the Township of Guelph/Eramosa; the City of Guelph system including the Eramosa intake; Elmira, West Montrose, Conestogo Plains, and the Integrated Urban System in the Regional Municipality of Waterloo; Lynden in the City of Hamilton; and Bright in the County of Oxford. The Ontario Ministry of Environment and Climate Change (MOECC) released a set of updated Technical Rules (MOECC, 2017), which included the previous requirement of Tier Three Assessments to be completed in subwatersheds that have a Moderate or Significant water quantity stress in areas that supply municipal drinking water. Tier 3 Water Budget and Risk Assessments were completed for the following municipal drinking water system study areas; the City of Guelph and the Township of Guelph / Eramosa, the Region of Waterloo, Whitemans Creek Tier 3, and Centre Wellington Tier 3. The purpose of the Tier 3 Assessments is to provide a measured assessment of current and future sustainability of municipal drinking water systems in light of municipal growth and development and climate change. Specific climate change scenarios have been included in the City of Guelph and the Township of Guelph / Eramosa Tier 3 and in the Centre Wellington Tier 3.

Changes in precipitation and flow regimes may also require revisions to reservoir operations to address water quality impacts upstream and downstream of these structures. The large reservoirs in the upper portions of the watershed are operated to augment downstream flows for water taking and wastewater assimilative capacity needs as well as flood management. Increasing nutrient loads and water temperatures have the potential to increase the occurrence of taste and odour problems in the riverine surface water intakes for the Guelph, Waterloo Region, Brantford and Ohsweken municipal water supplies. In addition to the potential for surface water quality problems, the Lake Erie intake for Dunnville, at a depth of 2.7 metres, is somewhat vulnerable to declining Lake Erie water levels.

25.0 CONSIDERATION OF GREAT LAKES AGREEMENTS

Under the Clean Water Act, the following Great Lakes agreements must be considered in the work undertaken in Assessment Reports:

- Canada-United States Great Lakes Water Quality Agreement (GLWQA)
- Canada – Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (COA)
- Great Lakes Charter
- Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement

The Great Lakes Water Quality Agreement and the Canada – Ontario Agreement generally deal with water quality concerns, while the Great Lakes Charter, the Great Lakes Charter Annex, and the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement provide principles for joint water resources management and water quantity and quality concerns in the Great Lakes Basin.

25.1 Grand River Watershed and Great Lakes Agreements

The Grand River watershed drains directly into Lake Erie and has the potential to contribute pollutants to the lake. These pollutants, including sediments and nutrients, as well as organic and inorganic contaminants, contribute to the overall water quality of the nearshore of Lake Erie, including, but not limited to the IPZ-1 and IPZ-2 of the Dunnville drinking water intake.

The GLWQA, first signed in 1972 and updated in 2012, is a commitment between the United States and Canada to protect, restore, and enhance water quality in the Great Lakes and prevent further pollution and degradation of the Great Lakes Basin ecosystem (Government of Canada & Government of the United States of America, 2012). To contribute to the achievement of water quality goals and objectives set under the GLWQA, Canadian and United States federal governments are addressing Areas of Concern (AOC) through Remedial Action Plans (RAP). No AOCs were identified in the Grand River watershed area in the GLWQA, and thus no RAPs are in place.

The federal governments of Canada and the United States have developed Lakewide Action and Management Plans (LAMPs), to support commitments under the GLWQA. The Lake Erie LAMP is an ecosystem-based strategy to protect and restore water quality in Lake Erie and the St. Clair-Detroit River System (ECCC & US EPA, 2021). Since its establishment in 2000, the Lake Erie LAMP has focused research and projects on nutrient management, biodiversity and habitat, emerging Issues, and monitoring.

The Lake Erie Binational Nutrient Management Strategy is an associated project which was developed in 2011. This strategy is a coordinated response from Canada and the United States that outlines nutrient management goals, objectives, targets, and actions to reduce excessive phosphorous loading and prevent further eutrophication of Lake Erie (Lake Erie LaMP, 2011). This strategy is an important foundation for future Great

lakes targets under the Clean Water Act. For the period 2003-2016, the Grand River contributed approximately 35% of the Total Phosphorus loading from major tributaries to the Eastern Basin of Lake Erie (Bocaniov et al., 2023). Reducing the load from the Grand River will be an important focus of long-term water quality objectives for Lake Erie.

As part of the Southern Grand River Rehabilitation Initiative under the Lake Erie Lake-wide Management Plan, targeted research and monitoring was undertaken in the lower Grand River to help identify areas of concern with respect to water quality and aquatic habitat. Intensive water quality monitoring in the summer and fall of 2003 and spring of 2004 at 15 sampling sites helped to characterize nutrient, dissolved oxygen and suspended sediment throughout the lower Grand River and tributaries. Important conclusions from this assessment show that the southern Grand River is nutrient-rich with high levels of phosphorus and nitrogen. Most of the samples analyzed for total phosphorus and nitrate do not meet the provincial or federal objectives. Preliminary trend analysis indicates that phosphorus concentrations are decreasing over the past 20 years while nitrate concentrations are increasing. Overall, the high nutrient and suspended sediment levels of the southern Grand River likely reflect the cumulative inputs from the watershed above Brantford.

The purpose of the 2021 COA is to restore, protect and conserve Great Lakes water quality and ecosystem health to support the vision of a healthy, prosperous, and sustainable region (MECP & ECCC, 2021). The work undertaken and described in this Assessment Report contributes to the achievement of Annex 6: Lakewide Management. This Annex includes commitments to identify and assess potential threats to the Great Lakes as a safe drinking water source and undertake early actions to manage risks. This includes commitments from the Government of Ontario to identify sensitive areas and mitigate risks to drinking water; provide available datasets to support the identification and assessment of drinking water issues and threats; and foster education and outreach opportunities on the protection of drinking water sources.

The 2005 Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement is a good faith agreement between the 8 U.S. Great Lakes States and the Provinces of Ontario and Quebec intended to implement the Great Lakes Charter and the 2001 Great Lakes Charter Annex. The Agreement sets out objectives for the signatories related to collaborative water resources management and the prevention of significant impacts related to diversions, withdrawals and losses of water from the Great Lakes basin (Government of Ontario, 2005). The agreement sets out conditions under which transfers of water from one Great Lake watershed into another (intra-basin transfer) can occur. The surface water intakes in the Grand River watershed are not considered to be intra-basin transfers since wastewater is discharged back into the Lake Erie watershed.