# Chapter 7 – Climate Change and Source Protection

Consideration of climate change is important within the context of the *water budget*, as well as other components of *drinking water* source protection. Some of the eastern Ontario source protection regions/areas have prepared climate change reports for their specific jurisdictions: Cataraqui (Watt, 2009) (see **Appendix 'L-13'**), Mississippi-Rideau (Oblak, 2009) and Trent Conservation (Trent Conservation Coalition, 2009). The reports summarize a number of other climate change reports and studies, and present some potential water quantity and water quality *impacts* due to climate change, as well as some mitigation and adaptation considerations.

This chapter intends to provide a further summary of the above noted work. Section 7.1 provides a short summary of previous studies, Section 7.2 provides a listing of potential *impacts* on water quantity in the CSPA, Section 7.3 provides a listing of potential *impacts* on water quality in the CSPA, Section 7.4 provides potential *impacts* on the delineations of *vulnerable areas*, Section 7.5 provides some information on *monitoring* of climate change variables and Section 7.6 provides some possible mitigation and adaptation solutions.

It must be noted that there is a high uncertainty associated with climate change around the globe. It is very clear that our c*limate* is changing, but which aspects of our c*limate*, and how much they may change in the future, it is very unclear. None of the potential *impacts* presented here are definitive.

## 7.1 Research to Date for Southeastern Ontario

Climate change *impacts* occur on a regional *scale* (eastern Ontario, eastern North America) rather than by city or town. Much of the research done to date, and the reports that discuss climate change, are structured in this way and look at areas as large as eastern Ontario, or eastern Canada and the northeastern United States. In fact, there is minimal research specific to southeastern Ontario with regards to climate change. However, most of the studies do come to the same general conclusions about potential climate change in our area.

The United Nations Intergovernmental Panel on Climate Change (IPCC, 2007a, 2007b) reports summarize potential climate change across the globe, looking at both global variability, as well as smaller areas such as eastern North America. The reports synthesize results from 21 global Climate change *models*. For our area, the reports predict:

- an increase in temperature, specifically winter minimum temperatures and summer maximum temperatures
- more winter *precipitation*, with changes in summer *precipitation* being less certain
- small increases in *runoff* (may not be statistically significant)
- more frequent heavy *precipitation* events.

The specific *impacts* of these changes are interpreted to be:

- increased temperature resulting in increased potential *evapotranspiration* (actual *evapotranspiration* may not change over the summer months unless there is water available to evaporate, such as in lakes and *wetlands*), which could mean less water for *runoff* to *streams* (and storage in lakes) or *recharge* to groundwater
- increased temperature means more *precipitation* will fall as rain than snow, which means less snowpack in the winter and earlier spring *freshets* in *streams*
- more frequent heavy *precipitation* may mean more flooding and more *erosion* of *streams*.

It has also been seen, since the IPCC report was published, that the predictions it contains are actually occurring faster than expected (Richardson et al., 2009; UNEP, 2009).

Also in 2007, the Ontario Ministry of Natural Resources (MNR) produced a report and mapping considering “Climate Change in Ontario” (Colombo et al., 2007). They used Canadian data provided by Natural Resources Canada. Specifically, this study looked at the relative change in temperature and *precipitation* for three 30 year periods (2011-2040, 2041-2070, 2071-2100), compared to the 1971-2000 period. It must be noted that the 1971-2000 period happens to be one of the wettest periods in recent history (Hogg, 2007) based on the analyses of c*limate* data conducted by Mekis and Hogg (1999). The MNR study predicts:

- a *precipitation* decrease from zero to ten per cent in most areas of the CSPA, though some areas show an increase of zero to ten per cent (neither of these represent a statistically significant change)
- a temperature increase of a few degrees, more in the winter months than summer months.

The specific *impacts* of these potential changes are the same as noted for the IPCC predictions.

In addition to the IPCC and MNR studies, numerous other studies and reports have been completed that provide similar predictions and conclusions. Some of these other reports include predictions such as:

- a decrease in the number of cold events
- an increase in the number of warm events
- an increase in night time temperatures
- a decrease in snow depth in many areas, but an increase in eastern Ontario
- an increase in the number of days of *precipitation*, specifically rain
- a decrease in length of dry spells
- less ice cover on the Great Lakes (thinner and shorter ice-in season) and
- a drop in Great Lake levels (predicted one metre for Lake Ontario).

Some of the predictions presented are contradictory, which reflects the large uncertainties associated with climate change *models*. This must be taken into account when considering potential climate change, there is not enough information to predict the results with absolute certainty.

## 7.2 Potential Impacts on Water Quantity

The potential *impacts* of climate change to water quantity vary greatly, depending on what c*limate* variables actually change. Watt (2009) provides more detailed information on potential *impacts* to water quantity, but the following provides a summary.

If climate change produces a decrease in *precipitation* and an increase in temperature, then we can expect that potential *evapotranspiration* will also increase (during the summer months, potential evapotranspiration is typically higher than the amount of water available for evapotranspiration, so the term actual evapotranspiration is used instead). However, during the summer months, actual evapotranspiration may not increase, as there will still be minimal water available for evapotranspiration, other than in lakes and *wetlands*, where water levels may fall faster due to losses via evapotranspiration. Higher temperatures during the fall, winter and spring may increase actual evapotranspiration in these seasons, as more water is available for evapotranspiration. In general, this change could mean:

- less water available for surface storage (lakes and *wetlands*), flow augmentation and consequently less supply for *drinking water*
- further, the demand is expected to increase, given the longer warm and dry periods
- lower lake levels in summer, *wetlands* dry up, possible constraints to recreational *activities* (boating, swimming), possible constraints to transportation/shipping
- less water recharging into the ground, lower groundwater levels, dry wells, dry groundwater fed *streams*/lakes
- more rain versus snow, earlier *freshet*, less water to ground during snow melt, but more during traditional winter periods.

If instead we see an increase in *precipitation* and an increase in temperature, we would expect to have much the same *impacts* as above, but could see even higher *evapotranspiration*, as there will be more water available to allow actual *evapotranspiration* to be closer to potential *evapotranspiration*.

If heavy *precipitation* events become more frequent, but the annual *precipitation* does not increase, we can expect more flooding potential due to heavy *precipitation*. But, we would then also expect longer periods of dry weather, with streamflows falling very low or drying up altogether, as well as lower groundwater levels, since heavy *precipitation* typically results in more *runoff* and less *recharge* into the ground.

## 7.3 Potential Impacts on Water Quality

Similar to water quantity, the *impacts* to water quality due to climate change will also vary depending on what actually changes.

If we see higher temperatures we can expect:

- warmer winters, possibly allowing the overwintering of pests/invasive species (CCSP, 2008; UNEP, 2009)
- warmer winters/waters may also allow new pests to migrate (CCSP, 2008; UNEP, 2009), causing fouling of intakes similar to current zebra mussel problems
- warmer winter temperatures could mean less snow and ice, leading to less salt and sand application. However, more freezing rain may develop, meaning more salt and sand needed
- less snow may mean less toxic *runoff* into *surface water* as snow melts
- reduced streamflows, with the same amount of *contaminant*, means an increase in *contaminant* concentration, potentially leading to effects not normally experienced
- warmer *surface water*, which will foster more (and earlier) algal growth, leading to more frequent fouling of intakes and require increased treatment at water treatment plants
- higher temperatures, more sunny days, and increased *nutrient runoff* into *surface waters* have the potential to increase the initial appearance of and increase the existing extent of Cyanobacteria (blue-green algae) blooms, some of which could be toxic to fish and/or other organisms (Davis et al, 2009, Dupuis and Hann, 2009, Wagner and Adrian, 2009). However, some other research has seen that with multiple parameters changing due to climate change, not just temperature, these changes may cancel out increased drivers of cyanobacteria growth (Howard and Easthope, 2002, Feuchtmayr et al, 2009).

If we see higher *precipitation*, or more intense *precipitation*, more *contaminants* may be washed off the surface and into the water. A link has been found between heavy *precipitation* and water-borne disease outbreaks (CCSP, 2008). We would also expect to see more *erosion* due to heavy *precipitation*, which could also increase the loading of *sediment*-bound *contaminants* into *streams* and the groundwater.

## 7.4 Potential Impacts to Vulnerable Area Delineations

Climate change may also mean changes to the extent of the *vulnerable areas* that are described in Chapters 5 and 6. The following are some interpretations of the potential *impacts* to *vulnerable areas*:

#### Significant Groundwater Recharge Areas (SGRAs)

- SGRAs are based on the composition of the soil and rock, so the identification of the areas will probably not change
- the vulnerability of the SGRAs may increase due to increased *precipitation*, as noted for WHPAs below.

**Wellhead Protection Areas (WHPAs)**

- more *precipitation* may mean more *impact* due to *transport pathways*, which will increase the vulnerability of the WHPAs
- Less *recharge* may mean less water available in the existing WHPA, so the area of influence must increase to maintain supply, therefore the WHPA will be larger. Less *recharge* may mean overall flow rates are lower, therefore WHPAs will be larger.

**Intake Protection Zones (IPZs)**

- more frequent heavy *precipitation* may mean the potential for more *contaminants* washed into the water, which could result in the need to increase vulnerability of the zones due to increased hydrological or hydrogeological condition of the *transport pathways*
- more frequent heavy *precipitation* could also mean increased streamflow, which would increase the size of some IPZs
- higher temperature may mean lower water levels due to increased *evapotranspiration*, which could expose some intakes to the surface, or surface *impacts*
- warmer temperatures resulting in a shorter ice cover period may make additional *activities* subject to consideration (for example: increased shipping), and given that winds are generally stronger in the winter, this would require an increase in the size of wind-derived IPZs.

## 7.5 Considerations for Monitoring Climate Change

Most authors agree that the current *monitoring* of c*limate* is not properly suited to capturing the right data or locations to properly identify what variables might change, and how they might change. Basically, more *monitoring* is needed, as identified by a number of sources. Specific recommendations on *monitoring* are not appropriate for this document, but it should be conducted through partnerships between all levels of government (federal, provincial, municipal), as well as scientific/research organizations such as conservation authorities and universities.

In particular, some of the variables that should be monitored include: *precipitation* (rain, snow), *evapotranspiration*, solar radiation, water and air temperature, and water use, among others.

In addition, consideration should be given to the changes in the data that have taken place due to development, and climate change since *monitoring* began, as well as the changes that will continue (Milly et al., 2008). The CRCA has prepared a document for Conservation Ontario (Watt, 2010) that details potential improvements to the existing *monitoring* networks in the CSPA to improve climate change *monitoring*, as well as adaptation *monitoring*.

## 7.6 Mitigation / Adaptation to Climate Change

The *climate* is changing. Knowing this is important so that aside from efforts to correct the causes, we can try to mitigate the effects and prepare to adapt to the changes. Some of the mitigation/adaptation measures we should consider include:

- water conservation measures to ensure that reduction in water storage can be accommodated via reduced use
- promoting water conservation and reuse methods such as rainwater harvesting and grey water systems
- *monitoring* of groundwater levels, *groundwater recharge* and *discharge*, groundwater movement, streamflow (particularly low flows), *precipitation*, evaporation, and solar radiation, to name a few. These types of *monitoring* data will help to identify what variables are changing, and how they are changing, allowing for mitigation and/or adaptation. *Modeling* requirements, and results, are made much more useful by having actual data for *model calibration* and *validation* (Silberstein, 2006). As he states, “we cannot manage what we do not measure.”
- the Climate Change Science Program (CCSP, 2008) also recommends continued analysis of existing data by multiple independent experts to improve our confidence in detecting past changes
- research on *groundwater recharge* and the movement of water in fractured *bedrock geology* will help to identify where the *source water* is coming from, as well as how to maintain the supply with respect to climate change, research will also help to identify when changes to the landscape, and c*limate* variables, could influence both *recharge* and movement
- delineating *recharge areas* (both existing and future due to climate change) with respect to wells so that these areas can be protected and the volume of *recharge* can be maintained
- protecting the *recharge areas* to minimize possible *contamination* of the groundwater that is the source for the wells
- reducing climate change by minimizing greenhouse gas emissions and changing other problem *activities* that may also be contributing to climate change.