# CHAPTER 9
# Water Safety

# 9.0 Water Safety: Key Findings

## Climate change projections and exposure pathways

- Within York Region, climate forecasts a likely increase in extreme precipitation, and a very likely increase in warmer temperatures. This can have significant impacts on drinking water and recreational waters
- Storms are expected to become more frequent, bringing higher amounts of precipitation that may stress local water systems
- The relationship between waterborne illness with climate change is complex with many factors impacting disease risk (e.g., sequence of weather events, time-lag effects, environmental factors, exposure), making it challenging to link York Region waterborne cases to climate change
- Temperature, rainfall, humidity and water turbidity were found to impact *Escherichia coli* concentrations in public beaches, but results varied greatly from month to month
- York Region sources drinking water mostly from Lake Ontario (90%) followed by Lake Simcoe (3%) and groundwater (7%)
- Local agriculture and urban surface run-off are the largest human sources impacting local rivers, lakes and groundwater systems
- Existing floodplains and significant groundwater recharge areas within York Region may be more impacted by heavy precipitation events
- Impacts of drought on groundwater sources have been assessed in York Region, and are unlikely to impact supply in the next 10 years

## Population sensitivity

- There has been a declining trend in the number of private well submissions in recent years. Individuals using private wells that are dug, or in significant groundwater recharge areas, are more vulnerable to flooding and heavy precipitation events
- Food and waterborne illnesses may also indirectly relate to behaviour activity such as greater outdoor activity (e.g., visiting beaches) and hygiene practices during summer months (e.g., barbeques)

## Adaptive capacity

- York Region Public Health, Regional Environmental Services, local municipalities and the Ministry of the Environment, Conservation and Parks are involved in monitoring and regulating drinking water within the Region
- There is an increasing number of York Region residents being serviced by municipal drinking water, reducing the number of residents relying on private wells and small drinking water systems
- Using a “One Water” perspective, York Region recognizes the need for protection throughout the water cycle, and the necessity to consider climate change impacts as part of the evaluation of future municipal water and wastewater needs
- Current projection models used for wastewater systems focus on 25-year storm events, but future models can consider other scenarios relating to expected climate change impacts

## Health impacts

- Recent research has assessed how various weather conditions (air temperature, precipitation, flooding and droughts) have contributed to cases of enteric diseases

Recent trends:

- Most enteric diseases illustrate a seasonal trend, peaking during the summer months or early fall in York Region. The highest numbers of cases for enteric diseases are for *Campylobacter* enteritis and Salmonellosis

Numerous studies highlight the impacts weather variables can have on food- and waterborne illnesses.[4,92,140,163,164,165,166,167] With heavier rainfall events, increased air temperatures and a longer growing season expected for York Region, it is necessary to consider how future climate conditions may impact the incidence of food- and waterborne illnesses.

This chapter provides an overview of the various ways climate change may impact human health through water in York Region, including:

- Recent trends and patterns of enteric diseases in York Region
- Potential climate change exposure pathways relating to drinking water (municipal, small drinking water systems and private wells) and adaptive capacity
- Potential climate change impacts relating to recreational water (focused on beaches) and adaptive capacity

After discussing food- and waterborne illnesses trends in York Region (Section 9.1), subsequent sections review the potential exposure routes and the adaptive capacity for water safety (Section 9.2) and food safety and security (Chapter 10) respectively. Impacts relating to municipal water and wastewater systems are examined at a high level, but more information can be found in the 2016 Water and Wastewater Master Plan[98] and the Assessing and Mitigating Municipal Climate Risks and Vulnerabilities in York Region, Ontario report. [168] Food and water security are also discussed with a focus on food security.

## 9.1 FOOD- AND WATERBORNE ILLNESSES

Food- and waterborne illnesses can be caused by food and water contaminated with pathogens including bacteria, parasites, viruses and fungi, as well as the toxins they produce. Illnesses most commonly highlighted in climate change research include bacterial pathogens (e.g., vibrio, campylobacteria, listeria, salmonella, shigella, and *Escherichia coli*), parasites (e.g., cryptosporidia, giardia) and viruses (e.g., norovirus).[140,163] Many of these food- and waterborne illnesses are enteric diseases that result in gastrointestinal symptoms such as diarrhea, abdominal cramps, nausea and vomiting.[140,163] Enteric diseases can also be caused by other factors, such as person-to-person contact or exposure to animal sources through direct contact or consumption.

**Recent research highlights the association between weather factors and food- and waterborne illnesses.** Studies have assessed how various climatic variables (e.g., air temperature, precipitation, flooding and droughts) have contributed to cases of enteric diseases. In a systematic review, Levy et al.[164] found a high confidence level association between bacterial causes of diarrheal diseases with increased temperatures. They also found a moderate level association between heavy rainfall and diarrheal diseases and a low association with drought and diarrheal diseases.

**Higher temperatures have been associated with an increased number of pathogens on food products.** [4] In Montreal, Allard et al.[165] found the incidence of *Campylobacter* was two times

higher in the summer than in winter, and the risk of campylobacteriosis increased 0.8% with every 1°C rise in temperature above 10°C. The incidence of salmonellosis is also correlated to ambient temperature. The rate in which S*almonella* bacteria growth doubles on raw chicken increases from one hour to 22 minutes when the temperature increased from 21°C to 32°C.[140] A study of 10 European countries found there was a 5% to 10% increase in cases of salmonellosis for every 1°C increase in temperature above a 6°C threshold.[166] However, this association could be due to changes in human behaviour (e.g., increases in picnics or barbecues during the summer) rather than increased amounts and spreading of *Salmonella* in the environment.

**Weather impacts to food- and waterborne illnesses can be complicated depending on the sequence of weather conditions and lag time between a weather event and when cases arise.** Heavy rainfall after a dry period is associated with an increased incidence of diarrhea. This is likely due to the impacts on recreational water from pathogens becoming concentrated in reduced water levels during drought, which are then dispersed with heavy rain.[164] Chhetri et al.[92] found a significant increase in laboratory-confirmed cases of cryptosporidiosis and giardiasis in the Metro Vancouver population four-to-six weeks after extreme precipitation events, particularly after long dry spells.

Similarly, Galway et al.[167] highlighted how seasonal trends in diarrheal diseases in British Columbia can vary based on weather and ecosystem factors of local watersheds. For example, communities with snowmelt-dominated hydroclimates showed an earlier peak for rates of diarrheal diseases in the spring, while rain-dominated hydroclimates would peak later in the summer and fall.[167]

While research has shown an association between weather factors and food- and waterborne illnesses, pathogen survival and presence in the environment is a complex process based on many contributing factors. These factors include the animal and human populations that can carry pathogens, conditions that favour the growth and survival of pathogens, transportation and movement of pathogens and susceptibility and behaviour of human populations.[4,5] Similarly, the movement of contaminants in the environment depends on the environmental fate and transport through the soil, water and land that can impact water and food safety. With climate change expected to increase food- and waterborne illness risk globally, there is also the potential for pathogens to be introduced to the local environment through greater movement of individuals and goods, nationally and internationally.[140]

**While enteric illnesses can be a result of food, water and other sources of contamination, enteric disease cases for York Region are discussed as a whole.** More information on enteric diseases of public health significance is available on the York Region website, which includes the annual reports and monthly diseases of Public Health significance reports. Table 9.1 provides an overview of select enteric diseases and the potential climate factors identified in literature that can contribute to the risk of exposure.

**Table 9.1. Summary of select enteric diseases in York Region and potential climate factors.**

| Enteric diseases identified in climate change research | Number of cases in York Region in 2018 | Rate of cases in York Region in 2018 (per 100,000) | Potential climate factors noted in research[v] |
|---|---|---|---|
| *Campylobacter* enteritis | 324 | 27.0 | **Food-related impacts:**<br>**Rising air temperatures and moisture**: Pathogens have favourable growth conditions in warm and humid conditions. Mould growth can be higher in warm and humid conditions, during production and after harvesting.<br><br>Seasonal peak in enteric cases during summer months may be related to climate or to greater outdoor activity.<br><br>Norovirus peaks during the winter months. Warmer winters may be associated with fewer cases, but this is still not clear.<br><br>**Longer growing season:** An extended growing season for food crops can impact the timing of pathogen transmission.<br><br>**Extreme weather events (flooding):** Flooding can contaminate water sources, which are used during the production, harvesting or processing of food.<br><br>Norovirus cases are also associated with flooding events that can increase risk of transmission.<br><br>**Water-related impacts:**<br>**Rising air and water temperatures:** Increased temperatures may contribute to an increased risk of pathogens present in drinking and recreational waters. Rising water temperatures will increase the seasonal window and create favourable conditions for algal blooms.<br><br>**Heavy rainfall and flooding:** Increased risk of contamination from pathogens into recreational and drinking water systems. Impacts will depend on the capacity and vulnerabilities of municipal systems, private wells and recreational water in specific areas. Lack of access to clean water can increase the risk of food- and waterborne illnesses. |
| Salmonellosis | 214 | 17.8 | |
| Norovirus | Most enteric outbreaks in York Region relate to norovirus. | | |
| Verotoxin-producing *Escherichia coli* | 18 | 1.5 | |
| Giardiasis | 80 | 6.7 | |
| Cryptosporidiosis | 36 | 3.0 | |

### 9.1.1 Trends in cases and incidence from 2000 to 2015 in York Region

**The largest numbers of cases in York Region for enteric diseases are from *Campylobacter* enteritis and Salmonellosis.** *Campylobacter* enteritis is a bacterial infection of the intestines and

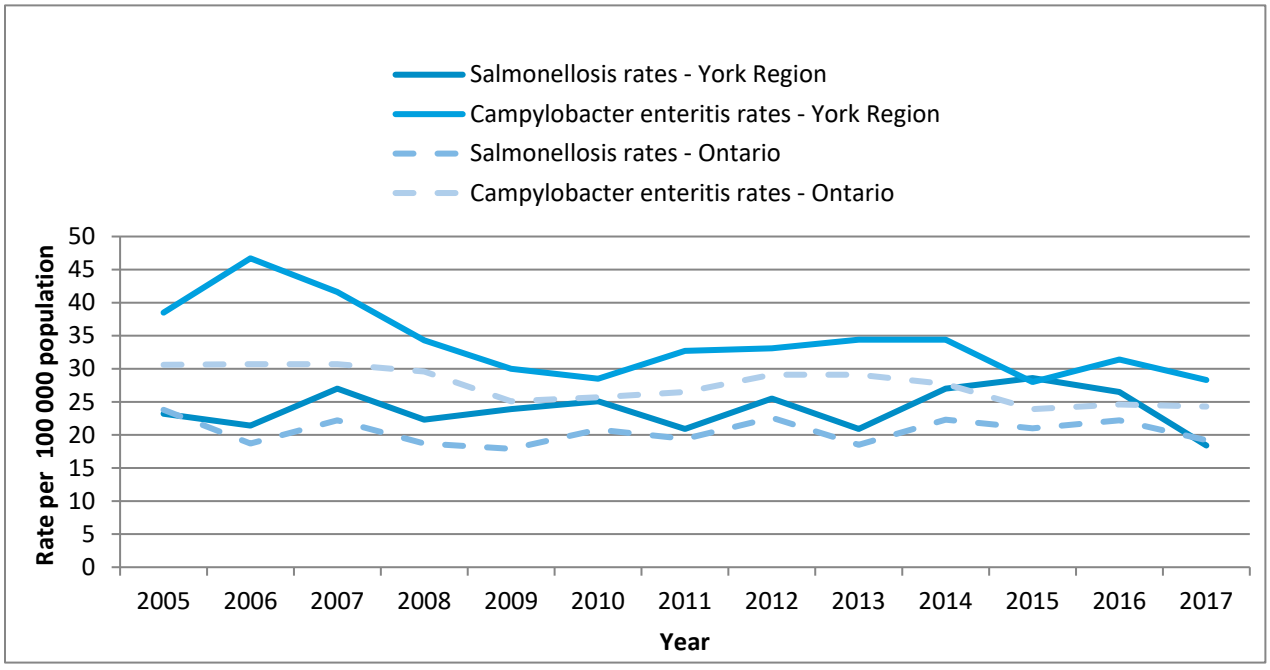
[v] Climate drivers from United States climate change and health assessment and Health Canada assessment. [4,5] Note: These potential climate factors are not specific to enteric diseases in this table or cases in York Region. These factors are based on research studies examining how climate conditions may contribute to food- and waterborne illness exposure and risk.

is the most commonly reported cause of gastroenteritis worldwide.[146] It is caused by contaminated food, such as uncooked or undercooked meat (especially poultry), and in some cases through contaminated water or by contact with infected animals. The incidence rate of *Campylobacter* in York Region decreased between 2000 and 2009 and has not varied much since this time.[146] The rates of *Campylobacter* enteritis in York Region were generally higher than Ontario incidence rates between 2005 and 2017 (Figure 9.1).[169]

Salmonellosis is caused by a bacterial infection from contaminated food or water, contact with infected animals or by person-to-person via the fecal-oral route. The incidence rate of salmonellosis varied slightly from year to year, with no clear trend between 2000 and 2015.[146] A slight decline was observed for 2017 and 2018, with the incidence rate of salmonellosis in York Region similar to Ontario.[170]

**Although less common, other enteric diseases can pose serious health impacts to infected individuals.** For instance, certain strains of *Escherichia coli* produce toxins (e.g., verotoxins) that can cause serious illness, such as hemolytic uremic syndrome (HUS). The incidence of verotoxin-producing *E. coli* (VTEC) infections in York Region decreased from 2000 to 2017. The incidence rates in York Region between 2000 and 2017 were similar to Ontario, aside from outbreaks in York Region in 2011 and 2012.[146] In York Region 6% to 7% of VTEC cases resulted in HUS in children below age 10, with HUS more rarely observed for those 10 year of age and older.[146] However, with better laboratory detection methods for VTEC introduced in 2018, more cases of VTEC are being detected and reported.

**Figure 9.1. Rates of salmonellosis and *Campylobacter* enteritis in York Region and Ontario from 2005 to 2017.**

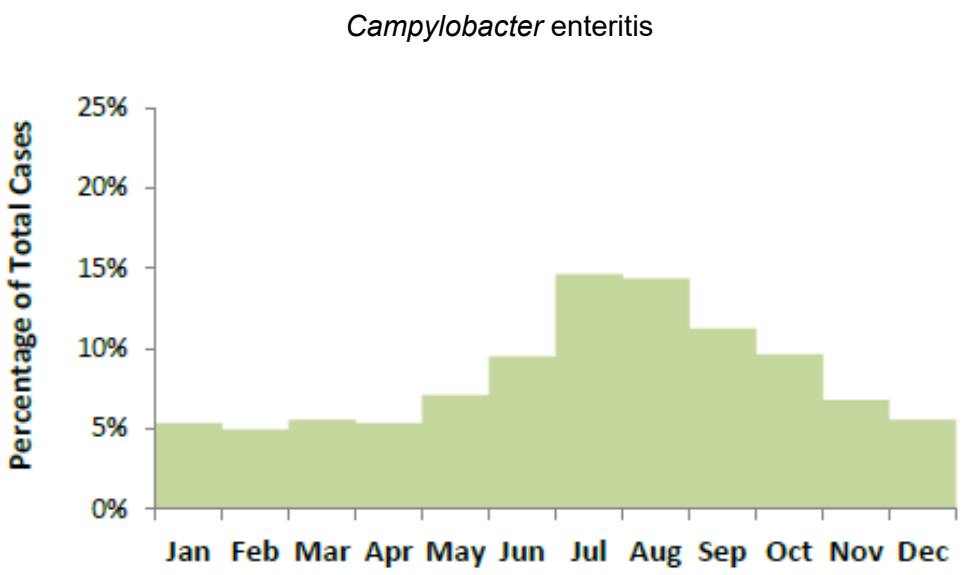



Data Source: Ontario Agency for Health Protection and Promotion (Public Health Ontario). Infectious disease trends in Ontario: Campylobacter enteritis and salmonellosis [data file]. Toronto: Queen's Printer for Ontario; 2018.

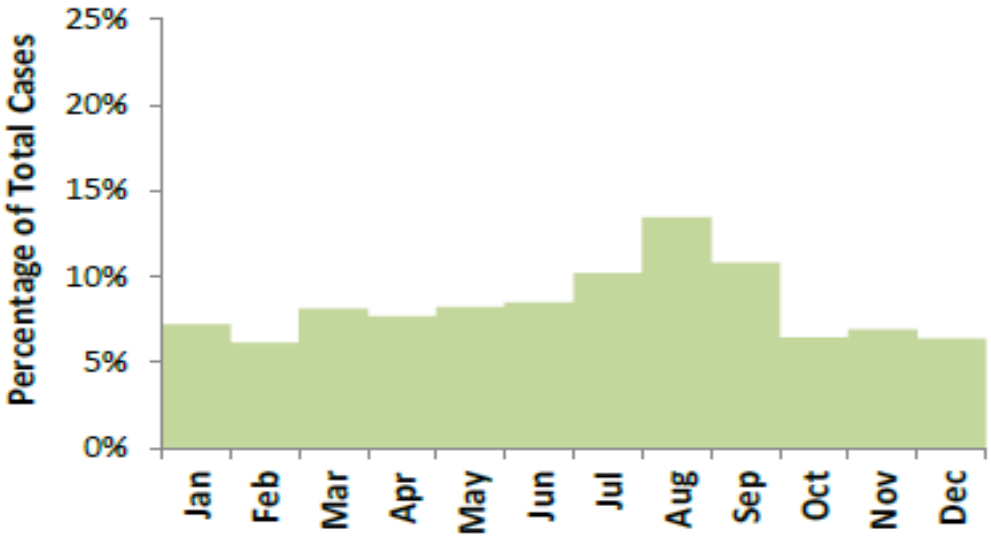
**Environmental factors have also played a potential role in enteric diseases.** Many of the cases reported in Ontario relate to environmental factors linked to food outbreaks, contaminated drinking water or contaminated recreational waters. Exposure to contaminated recreational water was noted as a risk factor for cryptosporidiosis between 2011 and 2015 and accounted for 36% of reported cases in York Region. Additionally, research highlights how livestock contact can also be a factor. This may explain why incidence rates of cryptosporidiosis in more rural areas (East Gwillimbury, Georgina, and King) were 1.8 times higher than in urban communities in York Region.[146]

**Food- and waterborne illnesses show a seasonal trend.** When reviewing food- and waterborne illness cases and incidence rates in York Region from 2000 to 2015, most enteric diseases illustrate a seasonal trend peaking during the summer months or early fall (Figure 9.2). This can be attributed to several behavioural factors such as increased outdoor summer activity, community events and festivals and recreational swimming. This seasonal trend aligns with increases of bacteria levels found in food products during this time period such as *Campylobacter* in chickens or peak shedding of VTEC from cattle livestock.[146] For giardiasis, a seasonal trend is observed, with a peak in September among cases who did not report travel during their possible exposure window.[146] Giardia parasites are commonly found in untreated water from rivers and lakes and are commonly transmitted to humans through recreational water. As a result, the increase in recreational swimming activities and associated exposures during the summer months corresponds with the seasonal trend and the local peak number of giardiasis cases.

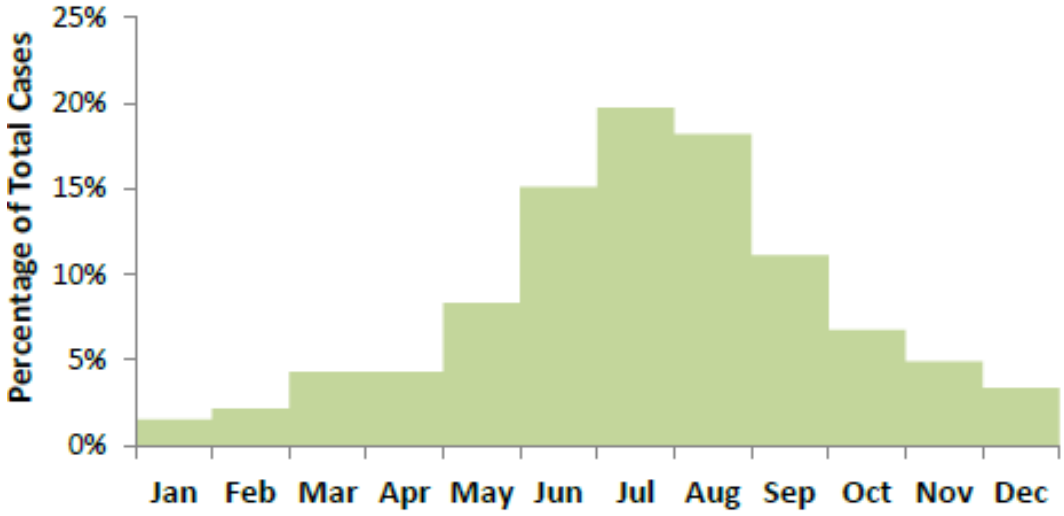
**Figure 9.2. Percentage of total cases for each enteric disease by month in York Region from 2000 to 2015.**



Salmonellosis




Verotoxin-producing *E. coli*




*Source:* The Regional Municipality of York. Reportable diseases in York Region 2000 to 2015 [Internet]. Newmarket: The Regional Municipality of York; 2016. Figure 2.2.3. Campylobacter enteritis; p.16. Figure 2.7.3. Salmonellosis;p.29. Figure 2.7.2 Salmonellosis; p. 29. Available from: https://www.york.ca/wps/wcm/connect/yorkpublic/c1dd6685-e886-45b5-ad4e-6808b5285e3c/Reportable_Diseases_in_York_Region_2000-2015.PDF?MOD=AJPERES

### 9.1.2 Enteric outbreaks in York Region

**Enteric outbreaks reported in institutions and the community associated with norovirus were reported more frequently between December and February**.[146] An institutional enteric outbreak investigation is initiated when two or more individuals experiencing symptoms within a

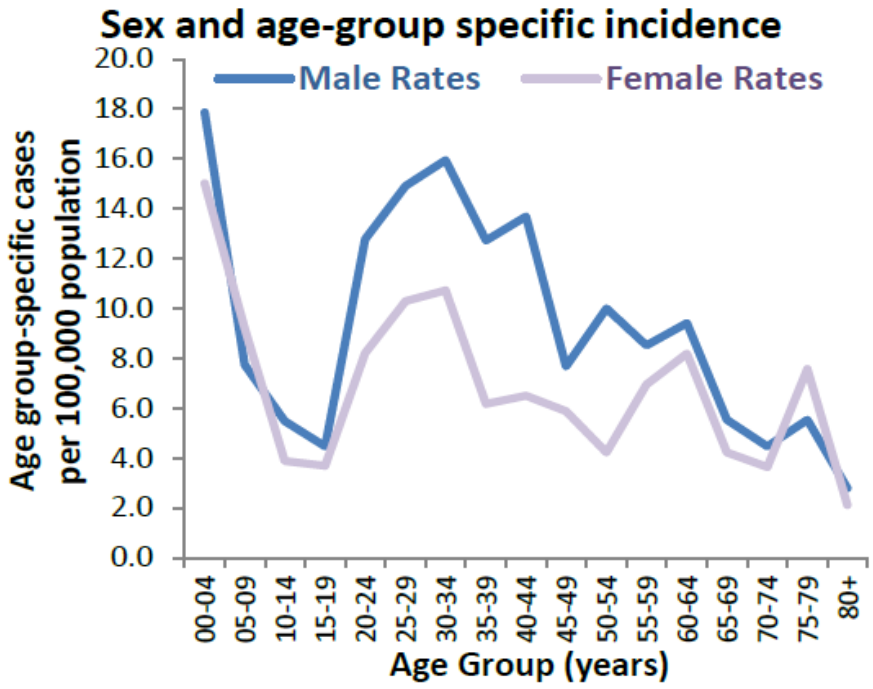
48-hour period; whereas a community outbreak investigation[w] occurs when two or more epidemiologically-linked individuals develop acute gastrointestinal illness. Each year, York Region Public Health investigates approximately 100 institutional enteric outbreaks, most often in the winter. Between 2008 and 2015, norovirus was responsible for the majority of enteric disease outbreaks in York Region. It caused 88% of the 169 institutional outbreaks (e.g., hospitals, long-term care homes, retirement homes or childcare centres) and 65% of the 34 community outbreaks.[146] *Salmonella* was responsible for 12% of community outbreaks.[146] This is consistent with data from the United States indicating most acute gastrointestinal illnesses are caused by norovirus, followed by bacterial pathogens such as *Salmonella.*[140]

## Vulnerable populations

Demographic factors such as age and gender were found to have a greater impact for certain enteric diseases in York Region cases (Figure 9.3). Consistent with the literature, more cases of certain enteric diseases were reported among seniors (e.g., listeriosis) and children (e.g., salmonellosis). Young adults were largely impacted by giardiasis. Trends in gender differences were also observed, with listeriosis having relatively more female cases and giardiasis having more male cases.

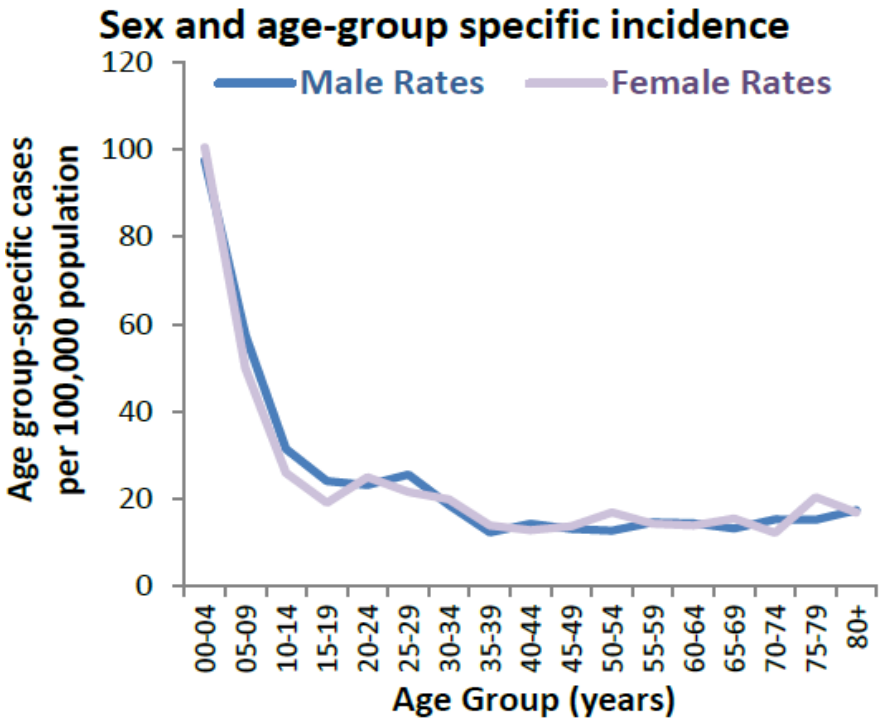
**Figure 9.3. Age distribution of enteric disease cases in York Region from 2000 to 2015.**

**Salmonellosis**

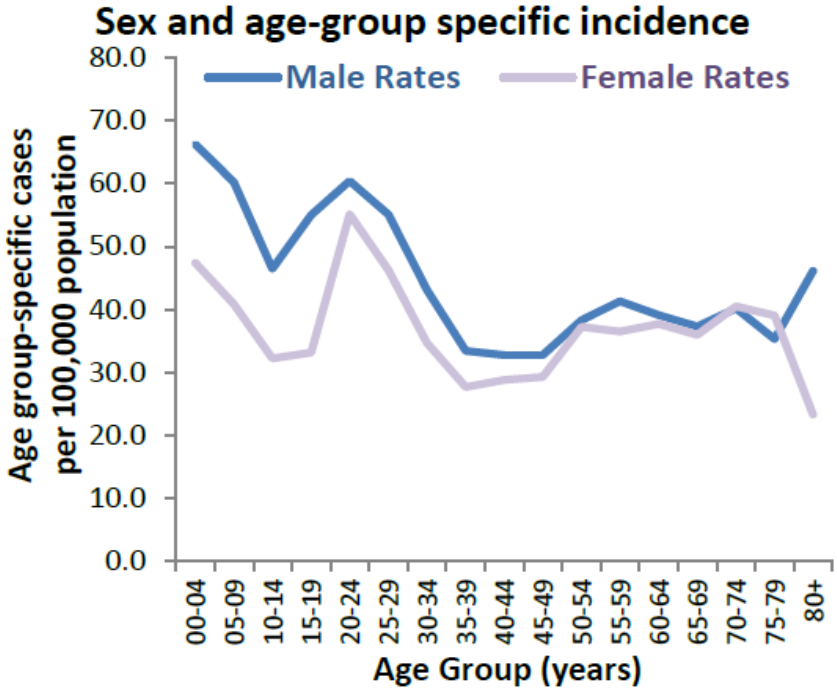



[w] There is no standardized case definition of a community outbreak, and are locally defined depending on multiple factors such as place, person and timing of cases.

**Giardiasis**




***Campylobacter* enteritis**




Source: The Regional Municipality of York. Reportable diseases in York Region 2000 to 2015 [Internet]. Newmarket: The Regional Municipality of York; 2016. Figure 2.5.2. Giardiasis;p.23. Figure 2.7.2 Salmonellosis; p. 29. Figure 2.2.2. Campylobacter enteritis;p.16. Available from: https://www.york.ca/wps/wcm/connect/yorkpublic/c1dd6685-e886-45b5-ad4e-6808b5285e3c/Reportable_Diseases_in_York_Region_2000-2015.PDF?MOD=AJPERES

Children are one of the most vulnerable groups for food- and waterborne illnesses due to a combination of factors such as immature immune systems, poorer hand hygiene and increased exposure when compared to adults. For example, they have higher consumption rates relative to body weight and are more likely to be exposed through play and contact with pathogen sources (e.g., in recreational beach water). Shigellosis, salmonella, cryptosporidiosis and VTEC were shown to have higher incidence rates among children under the age of 10, which can be attributed to a developing abdomen, poor hand hygiene and close personal contact in schools and child care centres.[146]

Seniors are also vulnerable to foodborne illnesses and their complications. In the U.S., children (1 to 4 years of age) and older adults (80 years of age and older) make up more than 25% of hospitalizations for gastroenteritis each. However, older adults account for 85% of deaths.[171] As the population of older adults grows, the public health and economic burden of enteric diseases will likely increase. Climate change may exacerbate this burden without public health interventions.

Other populations that may be vulnerable to food- and waterborne illnesses or may be at a higher risk of exposure to pathogens causing these infections include: [4,140,163]

- Individuals who are active outdoors and with outdoor activities such as barbecuing
- Frequent recreational water users (e.g., lakes, rivers, swimming pools)
- Individuals who get drinking water from a private water system
- Farm workers and individuals who are in contact with animals and livestock
- Individuals who travel to areas with a higher risk of exposure to food- and waterborne pathogens
- Pregnant women
- Individuals with pre-existing health conditions and/or those who are immune-compromised

See Chapter 4 for more information on vulnerable populations in York Region. The following sections will discuss the potential exposure pathways in which climate change can impact water, and current York Region activities that address these issues.

## 9.2 Water Safety

The public can be exposed to waterborne illnesses through many direct and indirect routes including direct skin contact and ingestion of contaminated drinking water, recreational water sources or seafood harvested from contaminated water sources. Climate change is expected to influence multiple pathways where water systems can potentially increase the risk of waterborne illnesses:[163]

- Rise in temperatures, increased evaporation and drought conditions may impact the quantity of drinking water supplies and reduce the dilution of pathogens and contaminants in water
- Rise in water temperatures can contribute to the growth of algae and the production of toxins, which can impact recreational and drinking water and contaminate fish species
- Heavy rainfall resulting in urban and agricultural run-off can increase nutrients, sediment and pollutants, which can impact drinking water sources, such as lakes and private well systems, and recreational waters
- Extreme weather events and storm surges can damage or impact water treatment activities

**Waterborne illnesses and risk to human health will depend on many factors.** Exposure of local populations, personal hygiene practices, prevention measures such as public health practices and interventions, water and wastewater treatment and local environmental conditions contribute to the risk of waterborne illnesses. Although many potential pathways have been identified, estimating future climate change impacts can be difficult due to limitations in current research and modelling required.[163]

The United States' recent Climate Change and Health Assessment[5] noted there is strong evidence climate change will impact water treatment infrastructure through flooding and impacts to surface waters. In a systematic review, Sterk et al.[172] found the concentrations of *Campylobacter* increased in rivers downstream of combined sewage system overflows during periods of heavy rainfall. Heavy precipitation can increase levels of pathogens, such as cryptosporidium and giardia, by reducing water treatment efficacy due to increased water turbidity, increased run-off into the water systems and resuspension of infectious cysts and oocytes from sediments.[92]

### Climate conditions expected in York Region

**In York Region, climate forecasts predict a likely increase in extreme precipitation and a very likely increase in warmer temperatures.** Fausto et al.[10] found that 1-day and 5-day maximum precipitation amounts are likely to increase from 39.3 mm to 50.9 mm and 61.4 mm to 78.4 mm respectively by the 2050s.[10] It is important to note these estimates reflect average numbers across York Region and extreme precipitation events can lead to higher localized precipitation during an event. Storms are also expected to become more frequent in York Region, bringing higher amounts of precipitation that may stress local water systems.[10]

Temperatures are very likely to increase in York Region by the 2050s with maximum temperatures in summer months increasing by approximately 4˚C and an increase in days with temperatures above 25˚C.[10] These forecasted changes in climate can have significant impacts on drinking water and recreational waters in York Region.

## 9.2.1 DRINKING WATER AND WASTEWATER

Drinking water and wastewater issues involve multiple Regional and provincial stakeholders, each responsible for various aspects of drinking water safety in the Region.

The most common types of drinking water and wastewater treatment systems managed or supported by York Region include:

- Municipal drinking water and wastewater systems operated by York Region
- Local distribution and collection systems operated by each of the nine local municipalities in York Region
- Small drinking water systems (SDWS) and those under the jurisdiction of the Ministry of Health (MOH) and York Region Public Health
- Private wells

Private sewage systems under Part 8 of the Ontario Building Code are no longer managed by York Region Public Health. In 1999, the approval authority for private sewage systems was transferred to the jurisdiction of the local municipalities' building departments. Climate change impacts on private sewage systems are not discussed in detail in this chapter. Nevertheless, the discussion on adaptive capacity and vulnerabilities for smaller drinking water systems and private wells will cover factors relevant to private sewage systems impacts, including protecting groundwater supplies or identifying shallow aquifer groundwater.

This section is not intended to be a comprehensive analysis of water and wastewater infrastructure vulnerabilities to climate change. Rather, it provides a climate change and health perspective on these issues using available information on existing assessments, operations and programs within the Region. More information about York Region's municipal water systems can be found on the York Region Water and Wastewater webpage, which includes Annual Water Quality Reports and the 2016 Water and Wastewater Master Plan. Water systems regulated and monitored by MECP are not further discussed in this report.

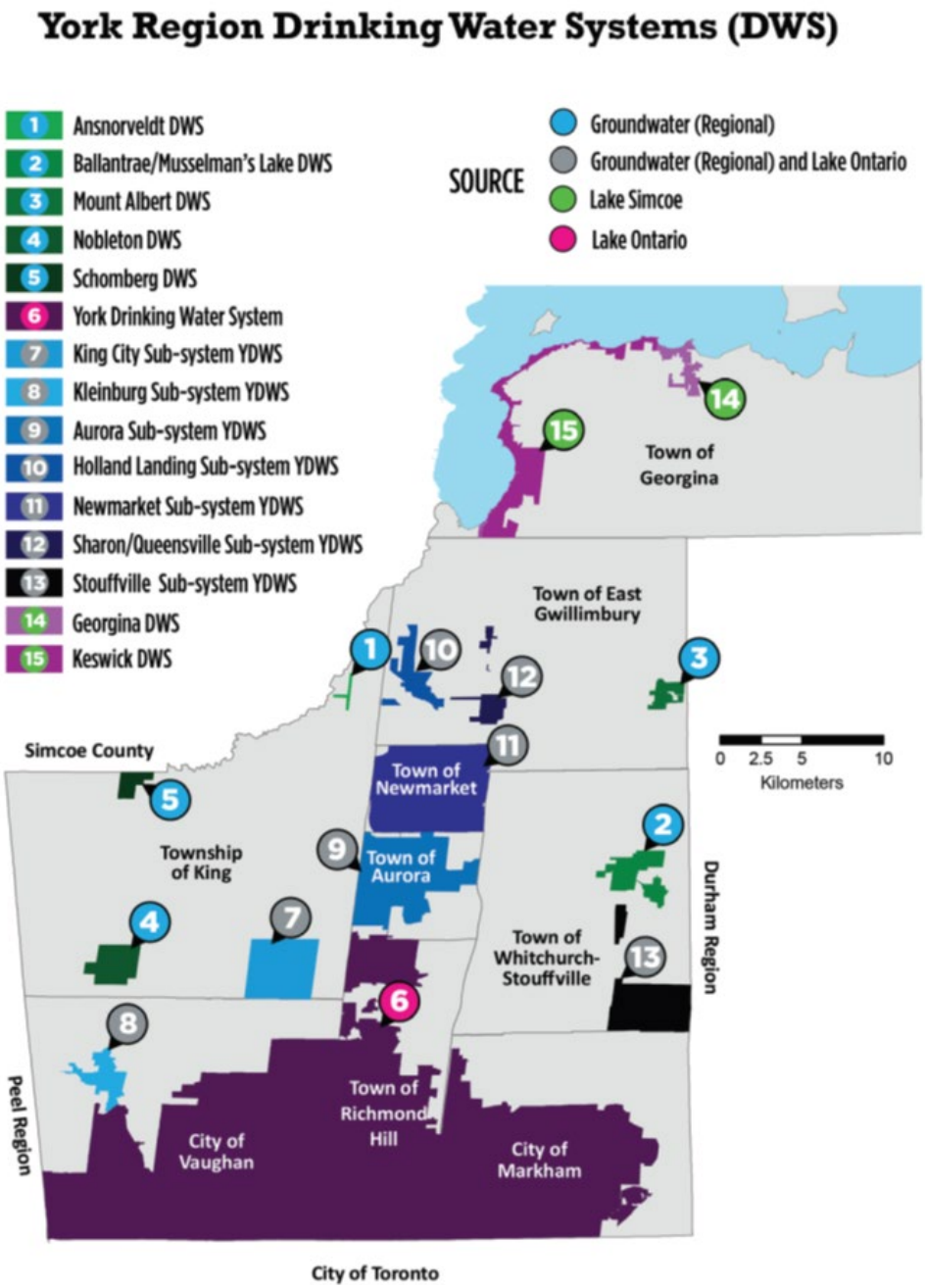
### 9.2.1.1 Municipal drinking water and wastewater systems

#### Overview of current systems and sources

Approximately 90% of York Region's water comes from Lake Ontario, which supplies all of Markham, Richmond Hill and Vaughan. Lake Simcoe supplies approximately 3% of York Region's water supply, primarily to the Town of Georgina.[173] The remaining 7% of source water is derived from groundwater wells in King Township, the Town of East Gwillimbury, and the Town of

Whitchurch-Stouffville.[173] Certain municipalities, such as the Town of Newmarket and Town of Aurora, use a blend of groundwater and water from Lake Ontario water (Figure 9.4).[173]

**Figure 9.4. York Region municipal drinking water systems.**




Source: The Regional Municipality of York, Environmental Services Department. Drinking Water Systems Report 2016 [Internet].Newmarket: The Regional Municipality of York; 2016. York Region Drinking Water Systems (DWS); p. 11. Available from: https://www.york.ca/wps/wcm/connect/yorkpublic/62103308-1634-4ff1-a153-7ffed2c2f22b/2016_Annual_Drinking_Water_Report.pdf?MOD=AJPERES

The majority of groundwater production wells used for municipal drinking water are north of the southern three municipalities (Vaughan, Richmond Hill and Markham). The Oak Ridges Moraine geology also acts as an important source for groundwater recharge.[173] Certain groundwater areas where shallow wells exist are more likely to be more impacted by heavy rainfall and have been identified as significant groundwater recharge areas (SGRA).

**Agriculture and urban areas are one of the leading human factors impacting local water systems.** Agricultural practices can impact local water systems through run-off into local rivers and lakes, or contamination of groundwater with pesticides, fertilizers and animal waste. Agriculture is the second largest land use around the Lake Simcoe watershed (37% of the area).[174] Additionally, certain areas in York Region such as the Town of Whitchurch-Stouffville, have high livestock densities.[174] As part of source water protection plans, agricultural activities are managed to reduce or eliminate impacts to local municipal water sources.[174]

Urban and suburban land also impact local water systems by increasing surface run-off into lakes and rivers and reducing water captured to recharge groundwater sources. Certain areas around Georgina, such as Keswick and Sutton, have more impervious sources that can contribute to run-off into Lake Simcoe. Municipalities in the north such as Newmarket can also contribute to surface run-off, impacting local streams and rivers connected to the Lake Simcoe watershed.[174] Land uses in urban areas can pose a risk to water systems following extreme weather events. Groundwater recharge is managed by Conservation Authorities, with an extra focus on the central portions of York Region that surround municipal wells.

## Potential climate change impacts

### Impacts of storms and surface run-off

York Region conducted an assessment of water and wastewater system requirements to better prepare for future heavy rainfall events. As part of the 2016 Water and Wastewater Master Plan[98], York Region rainfall data was used to model a 25-year storm[x] to provide a more accurate projection of rainfall impacts on wastewater flow rates. While the review assessed the current capacity of wastewater systems, it was based on current conditions, and climate change impacts will likely increase the frequency of extreme storm events. As a result, additional adjustments to the model will likely be required as severe weather events increase in frequency.

The assessment also identified possible impacts in York Region such as:

- the potential for algae blooms in Lake Simcoe
- increases in infiltration and inflow needs resulting in system backups and discharge of untreated sewage
- flooding impacts on facilities and pipe infrastructure
- extreme weather events damaging infrastructure.[173]

[x] A 25-year storm refers to a storm event that is only anticipated once every 25 years.

The literature recognizes challenges to water infrastructure, particularly from combined sewage overflows. However, York Region does not have combined sewers and relies on a separate sewer and stormwater system. York Region experiences issues with infiltration and inflow, where wastewater is infiltrated by other water sources, such as groundwater and stormwater. This can contribute to household basement flooding.[173] Basement flooding has been associated adverse health impacts from mental health stressors and indoor air quality issues relating to mould and dampness.[5]

### Impacts relating to water supply

Certain impacts, such as a rise in water usage from increased temperatures, are not seen to have a significant impact on water supply quantities in York Region.[173] To assess impacts to groundwater sources in York Region, modelling was conducted as part of the Source Water Protection work to meet the *Clean Water Act*. Modelling predicted municipal water availability from four wells may decrease during a 10-year drought, but would not be below sustainable levels. The model was also able to provide recommended adjustments to prevent or mitigate that risk.[106] While these estimates provide an understanding of groundwater impacts that may result from climate change, it is also possible that climate change could increase overall water demand.[173]

## Adaptive capacity and resiliency of municipal drinking water systems

### Current activities

York Region provides drinking water to its nine local municipalities by operating and maintaining three water treatment plants, 45 water storage facilities, 40 production wells and close to 350 kilometres of transmission mains. The Region treats wastewater via seven water resource recovery facilities and one lagoon system (co-ownership of the Dufferin Creek Plant with Durham Region), 21 sewage pumping stations and approximately 330 kilometres of sewer mains.[173] York Region is currently using the Building Adaptive and Resilient Communities Tool developed by the International Council for Local Environmental Initiatives (ICLEI) Canada. This tool follows a five milestone framework to support adaptation planning and building resiliency of water and wastewater systems.[173]

In 2016, 99.87% of all tests conducted on water quality samples across York Region met the regulated standards.[173] Additionally, 25 of the 18,489 tests performed indicated a water quality parameter had fallen outside of the normal operating range.[173] However, none of these events posed a threat to public health or required corrective actions from the MECP or the Region's Medical Officer of Health.[173]

**Source water protection also plays an important role in water quality.** Using a "One Water[y]" perspective, York Region recognizes the need for protection throughout the water cycle and to consider climate change impacts in evaluating of future water and wastewater needs. Developing climate change adaptation and mitigation strategies are part of the Made-In-York One Water Action Plan.[98]

[y] "One Water" refers to a concept of efficiently using water from every source, which encourages conservation and reducing the burden on local water sources, while maintaining safe drinking water.

The 2016 Water and Wastewater Master Plan also includes an objective for creating a more resilient water and wastewater treatment plan to be able to service the anticipated population and employment growth that are expected to increase for York Region by approximately 50% in 2041.[173] As part of the Master Plan update, the Region completed a Climate Change White Paper, which includes a pilot study of wastewater impacts in a local municipality.[98] The Master Plan also recommends incorporating climate change considerations into the risk management framework for water and wastewater infrastructure. The Plan highlights how the increased demand for quantity cannot be met by using one water source alone (Lake Simcoe, Lake Ontario or groundwater).[98]

**York Region's Long-term Water Conservation Strategy and multi-barrier approach support water safety and supply.** York Region has a proven record of water conservation and efficiency programming spanning more than a decade. The Long-Term Water Conservation Strategy[175] expands on existing Regional plans, strategies and programs and sets the stage for innovative and jurisdiction-led water conservation and efficiency programming for the next 40 years. York Region's Water for Tomorrow program includes education and programs for residents, water-saving incentives for businesses, fusion gardening, inflow and infiltration reduction and student water conservation programs.

Following the Walkerton tragedy, a multi-barrier approach has been the standard to ensure that preventive and corrective actions are taken to protect drinking water quality. Many of the measures in the approach are likely to address concerns and adaptive capacity of existing services to the anticipated impacts of climate change. The multi-barrier approach currently used by York Region includes:

- **Measures for source water protection:** Source Water Protection is a program legislated by the Province of Ontario to protect municipal drinking water sources from contamination or overuse. York Region protects drinking water sources by conducting a groundwater monitoring program, conducting studies to better understand and manage municipal groundwater supplies, preparing water source protection plans, reviewing all development applications to make sure that drinking water sources are protected and helping businesses implement risk management measures
- **Operator training:** York Region continues to develop and participate in top quality operator training. These training priorities ensure staff is equipped to competently and efficiently manage drinking water systems in compliance with applicable rules and best practices
- **Drinking Water Quality Management Standard:** The Region implements this statutory management standard that protects public health through consistent practices for managing and operating water systems and by identifying and mitigating risks. It is also a tool for identifying and resolving inefficiencies. The Integrated Management System implements continual improvement efforts to proactively manage risks to drinking water systems. York Region Environmental Services' Integrated Management System also includes International Organization for Standardization (ISO) 14001 and ISO 9001 certification and Ontario's Drinking Water Quality Management Standard

In addition to the multi-barrier approach, recent infrastructure investments, such as the York Durham Sewage System Forcemain Twinning Project, will also help support adaptation to future climate change impacts and reduce the risk of spills from storm events.[176]

#### 9.2.1.2 Small drinking water systems and private wells

Besides municipal drinking water systems, residents may also receive their water through smaller systems that supply drinking water to a specific property or building. In general, these smaller systems are SDWSs or private wells.

Significant improvements to drinking water regulations were established after the Walkerton crisis of 2000, which have improved the drinking water quality for smaller systems**.** Nonetheless, it is still important to note the potential impacts of climate change on these systems through heavy rainfall events, flooding and increased temperatures. For example, in 2005 the Holland Marsh (a local area vulnerable to flooding in York Region) had to prepare for potential drinking water advisories for local private wells and SDWSs in the area following a flooding event.

**How climate change is expected to impact these smaller water systems remains unclear.** Multiple variables need to be considered such as the source of water, type and condition of well, treatment level, sources of contamination, local hydrology factors and behaviours of water users. As these drinking water systems are more localized and smaller scale, climate change could have various impacts including:

- Heavy rainfall and flooding events impacting local groundwater (particularly shallow aquifers or dug wells) and surface water source quality
- Extreme weather events resulting in power outages that could impact treatment for SDWSs and private wells
- Warmer conditions that can influence the growth and survival of pathogens

##### Small drinking water systems

In 2018, there were just over 300 SDWSs regulated by the MOH. These systems obtained drinking water from Lake Simcoe or a groundwater well with treatment using filters, UV and/or chlorine. Facilities using SDWS are diverse and include recreational facilities, resorts, restaurants, campgrounds and parks. As of 2018, the majority of SDWS were within the municipalities of Georgina, East Gwillimbury, King Township and Whitchurch-Stouffville. There are less than 20 SDWS within Richmond Hill, Markham, and Vaughan due to protected lands within the Greenbelt and Oak Ridges Moraine. Two facilities presently use treated lake surface water as their source, mainly from Lake Simcoe. Twenty-nine facilities also fall within a floodplain.

**The risks for each SDWS vary in terms of populations served, location of the facility, sources of drinking water and treatment operations**. In past years, the most common adverse water quality incidents were related to treatment operation malfunctions such as ultraviolet lights not working and power outages. From a climate change perspective, SDWS with surface water or shallow groundwater sources, and water treatment options without back-up generators for power outages, can be cause for concern. However, risks to drinking water are reduced through existing regulations requiring SDWS to have sufficient water treatment in place.

There are challenges with available data relating to SDWS, such as inconsistencies in reported incidents between SDWS. There are also challenges with interpreting existing data with respect to climate change vulnerabilities. Currently, reporting is completed through separate datasets [risk categorization tool - RCat[z], and Laboratory Results Management Application[aa]], making data analysis and assessment more challenging.

### Private wells

A number of York Region residents get their drinking water from private wells. According to provincial records, there are more than 40,000 private wells in York Region, but not all are used for drinking water. Private well testing is done voluntarily by property owners and public health recommends two-to-three tests per year and testing following a heavy rainfall event. York Region Public Health provides water sample bottles, forms and information to local residents who own private wells. Sample bottles are available for pick up and drop off at several locations. Samples are sent to Public Health Ontario laboratories to be tested for bacteria. Test results are received by telephone, mail or can be picked up directly from the Public Health Ontario laboratories. It is the owner's responsibility to maintain and monitor their well.

Table 9.2. summarizes private well testing in York Region from 2014 to 2018. Within the five-year period approximately 12% of all private well water testing results showed significant bacterial contamination.[177] In addition, 2% to 3% of all sample water results were deemed unsafe to drink due to fecal contamination.[177]

**As private well testing is voluntary, it is difficult to know how many private wells are used for drinking water.** There is also a general declining trend in the number of well water submissions. This may be a result of residents choosing not to submit samples or a growing number of properties being connected to municipal drinking water systems. In addition, limitations in the data create challenges in interpretation due to a variety of factors:

- The number of samples does not necessarily correspond to the number of private wells tested. Multiple submissions can be made by one private well owner
- Certain geographic areas within York Region have fewer sample submissions compared to other areas
- Follow up on adverse drinking water results does not obtain sufficient information to assess the risk relevant to climate conditions
- Although recommended, sample submissions may not be taken after heavy rainfall events

As such, current data collected is not a useful measure of potential climate change impacts due to many confounding factors. Future planning can consider data collection on well water testing following heavy rainfall events, or conducting risk assessments that incorporate climate factors for adverse results.

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[z] The risk categorization tool is approved by the Ministry of Health and designed for site specific risk assessments of SDWS.

[aa] Laboratory Results Management Application is an electronic database for SDWS water sampling test results, notifications or adverse water quality incidents.

**Table 9.2. Summary of private wells sampled in York Region from 2014 to 2018 – WTISEN.**[bb]

| | Samples Processed | No significant evidence of bacterial contamination | % | Significant evidence of bacterial contamination | % | Unsafe to drink, evidence of fecal contamination | % |
|---|---|---|---|---|---|---|---|
| 2014 | 3,667 | 2,918 | 80% | 478 | 13% | 69 | 2% |
| 2015 | 3,694 | 2,939 | 80% | 460 | 12% | 93 | 3% |
| 2016 | 3,800 | 3,113 | 82% | 427 | 11% | 63 | 2% |
| 2017 | 3,396 | 2,699 | 79% | 400 | 12% | 89 | 3% |
| 2018 | 2,902 | 2,318 | 80% | 389 | 13% | 59 | 2% |

Source: Water Testing Information System Electronic Notification (WTISEN) [data file]. Toronto: Ministry of Health and Long-Term Care; 2019.

**Wells located within floodplains may be at higher risk of treatment process disruption following heavy precipitation events.** Of all private wells in the Region, approximately 2,600 are located within a floodplain and 1,500 are located in significant groundwater recharge areas. These areas may be more vulnerable to heavy rainfall events.

Drilled wells that are properly constructed and maintained are likely to be protected from impacts due to heavy precipitation and flooding, unless the flood water rises above the well cap. However, dug wells are more vulnerable to contamination as they obtain water from shallower aquifers, which are more susceptible to climate impacts such as heavy rainfall and flooding. Ontario's Regulation 903[178] requires all well types to be constructed under specified direction. Drilled wells are inherently more protected as dug wells do not have to follow the same standard. Drought conditions may also affect groundwater systems by impacting the supply of water in shallow wells, which can lead to water treatment challenges.

In total, there are 32 dug wells across York Region; however, it is not clear if all of them are in operation. While no dug wells were located within a floodplain, 13 are located within significant groundwater recharge areas.

**While uncertainty remains regarding the impacts of climate change on private wells in York Region, it is important to note existing regulations and legislation help protect local drinking water.** Recognizing the emerging issues stemming from climate change, the recent OPHS revisions now include climate change adaptation as part of the Safe Drinking Water and Fluoride Monitoring Protocol, 2019.[179] Preventative measures were also developed as part of the *Safe Drinking Water Act*, and include monitoring, risk assessment and management of incidents to help reduce or eliminate the potential risk from waterborne illnesses.

[bb] Water Testing Information System Electronic Notification database. Note total will not add to 100% as other result categories are not included.

## 9.2.2. RECREATIONAL WATER

Exposure to recreational waters contaminated by algal blooms or pathogens has been associated with gastrointestinal infections.[4] With projected increases in temperatures and longer summer weather periods due to climate change, cyanobacteria blooms (blue-green algae) may become a more significant issue. This may also increase the risk of exposure to toxins related to cyanobacteria, particularly microcystin-LR. Research including modelling studies, laboratory studies, field surveys and a review of historic and current freshwater lakes provide strong supportive evidence of the risk of algal blooms.[163] The only human cases of death involved dialysis patients in Brazil exposed intravenously to microcystins in water.[180] Microcystins have not been found in any municipal water systems in Ontario to date.

There are other issues that may arise as a result of increased outdoor activities during the warmer summer months, which could indirectly contribute to a higher risk of exposure from recreational water use. For instance, one splash pad located at the Toronto Zoo was associated with an enteric outbreak in 2007.[146]

### Public beach surveillance activities

**York Region Public Health monitors public beach water quality and developed a predictive beach model to inform beach advisories and closures.** In total, there are 14 public beaches monitored by York Region Public Health. There are 13 public beaches on Lake Simcoe and one at Musselman's Lake in Whitchurch-Stouffville. Water sampling is done annually beginning in mid-June and continues until the end of August. A minimum of five samples are collected from each beach once a week and tested for levels of *E. coli* bacteria. As bacteria can increase after heavy rainfall events, there is signage posted that warns swimmers not to swim for two days after a heavy rainfall. In more serious cases, a beach closure can be issued. Since 2006, there have been two temporary beach closures in York Region; one at Lake Wilcox in 2008 relating to the redevelopment of the land area, and a second at Glenwood Beach in 2011 due to weed and algae growth.

### Modelling the relationship between beach water and environmental factors

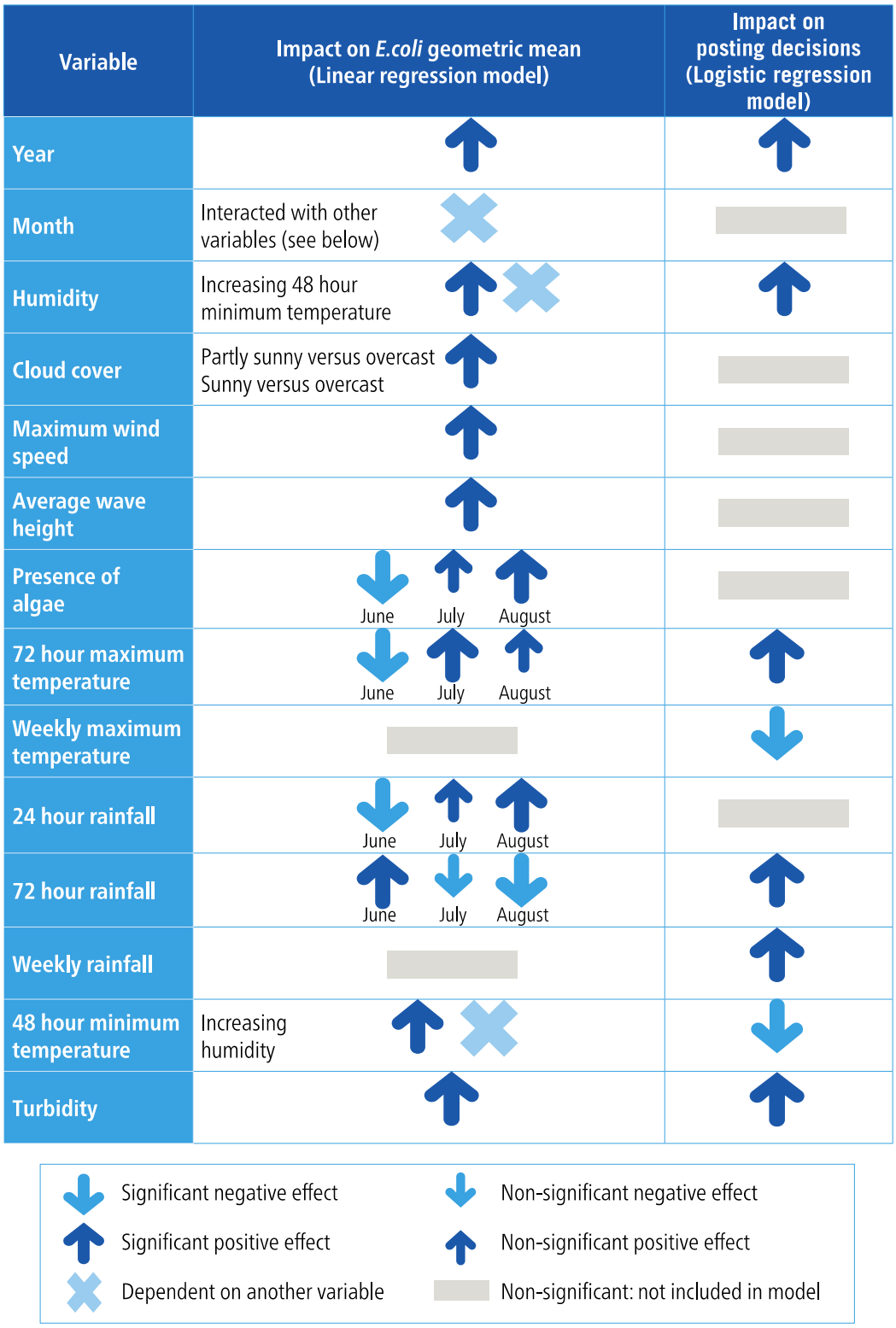
Multiple parameters can contribute to adverse water conditions in recreational beaches. These include the presence of animal sources of pathogens (e.g., waterfowl populations) and nearby farms, local geography, temperature, turbidity, wind conditions and rainfall. York Region Public Health developed predictive models for certain beaches to determine when to issue a beach post.

A recent York Region study examined factors that influenced *E. coli* geometric mean concentrations and posting decisions at York Region beaches during the 2013 to 2018 beach seasons by constructing statistical regression models.

**In both models, temperature, rainfall, humidity and water turbidity were found to have a statistically significant relationship with *E. coli* concentrations and posting decisions.**

However, in examining *E. coli* concentrations, many of these effects varied significantly by month (Figure 9.5). It was also noted that the majority of variation in the models occurred between samples, not between beaches. This reflects the difficulty in developing consistent predictive models for informing beach posting decisions.

**Figure 9.5. Results of statistical regression models examining the impact of climatic, hydrologic and anthropomorphic factors on the *E. coli* geometric mean and posting decisions at York Region beaches from 2013 to 2018, inclusive.**



### Potential climate change impacts on recreational beaches in York Region

The projected increase in heavy rainfall events, higher water temperatures and lower lake levels (due to increased evaporation) are expected to contribute to beach water contamination.[181] With the increase in rainfall events, there is also potential risk of run-off contributing to adverse water conditions.

With York Region expecting to have a rise in one- and five-day heavy rainfall events, there is potential for more run-off, flooding and storm events that could contribute to poor recreational water quality conditions. Beach contamination events for the Great Lakes Region of the United States generally occur when precipitation exceeds 5 cm to 6 cm.[11] Annual one-day maximum precipitation events are anticipated to increase from around 4 cm to 5 cm in York Region by the 2050s,[10] which may contribute to poorer beach quality days. Recent heavy rainfall events in York Region have also had an impact on bacteria counts measured the day after a heavy rainfall event. More information is needed to assess the potential linkages with heavy rainfall events and bacteria counts at beaches in York Region.

While climate change may increase exposure to pathogens and toxins, cases of waterborne illnesses will still depend on variables such as hygiene practices and the extent of beach use by local populations. There is limited information on potential sources of water contamination and how this may change with future population growth and land-use changes. There is also limited data on beach users in York Region to provide context on the number and demographics of people potentially impacted by beach water quality.

## 9.3 CONCLUSION

York Region takes a comprehensive approach to water safety through a multi-barrier approach to protect human health and the environment and complies with regulations and requirements in the *Safe Drinking Water Act* and Ontario Public Health Standards. York Region's water systems are ISO certified and follow an international standard management practice. This approach incorporates multiple layers of protection throughout the water cycle including source water protection, water and wastewater treatment, management of water systems and supportive policies.

York Region Public Health takes proactive measures to ensure the safety of residents who use public beaches, private wells and small drinking water systems. These measures include existing recreational beach monitoring activities, development of a predictive beach model to anticipate future impacts, promotion of private well water testing and education to reduce risk of exposure.

While climate drivers are expected to increase in York Region, such as extreme precipitation and warmer temperatures, there is limited information available to estimate the future health burden associated with climate change and water safety. Existing health data for York Region shows how some reportable enteric diseases such as Shigellosis were at higher rates than Ontario averages, but others such as cryptosporidiosis and giardiasis were lower. Consistent with other jurisdictions

and the research, there is a seasonal trend peaking in the summertime; however, it is not clear whether this peak relates to beach water activity, drinking water consumption or other exposure routes such as contaminated food.

While smaller water systems (e.g., private wells, SDWS) may be more susceptible to the impacts of climate change, it is not clear if future weather conditions will likely result in adverse drinking water quality conditions. It is important to note that more households and facilities are now linking to larger municipal water systems. This will play an important role in the reduction of private well water risks related to climate change. Nonetheless, more information is needed to assess the risk of climate change to smaller water systems.

Certain climate change impacts related to combined sewer overflows and drought conditions identified in the literature are not likely to pose challenges to water safety and security in York Region. Other areas identified as potential issues include algal blooms, vulnerability for dug well users, infiltration and inflow into sewer systems, flooding and extreme weather impacts on water treatment systems and impacts to beach water quality. With York Region expecting to have a rise in heavy rainfall events, there is a potential for more run-off, flooding and storm events contributing to poorer water quality conditions.

More information is needed to assess complex exposure pathways and to estimate health impacts. Currently, various datasets capture information that may be relevant to assessing exposure such as boil water advisories, drinking water advisories, adverse water quality incidents, bacterial counts and beach closures. More research is needed to interpret the results and to be able to associate the data with climate events such as flooding, water temperature and heavy rainfall.

While climate change may increase exposure to pathogens and toxins, potential cases of waterborne illness will still depend on other variables such as hygiene practices and beach use. There is limited information on potential sources of water contamination and how this may change due to future population growth and land-use changes.

Lastly, multiple challenges have been identified in assessing waterborne illnesses including underreporting and many potential sources for transmission of the diseases such as food, travel and contact in the environment. This makes it difficult to identify a definitive cause of infection for cases. York Region residents' activities outside the Region can also impact local health surveillance data. Current York Region initiatives and opportunities that support adaptation to climate change are summarized in Table 9.3.

**Table 9.3. Summary of water safety activities and adaptation planning opportunities.**

| | Ongoing and Completed Activities | Opportunities |
|---|---|---|
| **Population Health Assessment and Surveillance** | **Health Surveillance:**<br>Diseases of public health significance and outbreak case investigation and management as part of provincial requirements. | Explore potential data for other health endpoints, such as swimmers itch and conjunctivitis.<br><br>Explore ACES surveillance for potential climate change impacts on waterborne disease.<br><br>Consult agencies with research expertise (e.g., PHO, PHAC) on assessing relationship between health outcomes and weather patterns. |
| | **Environmental Monitoring:**<br>Beach monitoring at 14 public beaches for bacteria counts from mid-June to the end of August, with minimum five samples per beach once a week.<br><br>Private well water testing (voluntary and encouraged at least three times per year).<br><br>Monitoring of algal blooms and information shared from key stakeholders. | Explore available data and assessments from other jurisdictions (e.g., lake water quality and algal bloom monitoring).<br><br>Collect relevant data to determine which SDWS and private wells are most vulnerable to changes in weather conditions (e.g., MECP private well data).<br><br>Provide additional training to SDWS operators to ensure consistent reporting and potential impacts relating to weather conditions. |
| | | Consult private well owners (e.g., regarding groundwater use, use of dug wells, water quality testing following heavy rainfall events).<br><br>Survey beach users on how they prefer to receive beach posting information.<br><br>Explore beach use data with municipalities to assess potential population exposure. |

| | | |
|---|---|---|
| **Program and Policy** | Respond to complaints, inquiries and investigations as needed for private wells and SDWS (e.g., water main breaks, 24/7 response).<br><br>Issue boil water advisories and drinking water advisories, beach advisories and/or beach closures as needed.<br><br>Predictive beach modelling which used data collected from beach sampling to determine conditions at the beach.<br><br>Completion of SDWS workshops. | Assess potential weather linkages with results relating to poor water quality (e.g., adverse water quality incidents, boil water advisories, drinking water advisories and bacterial counts) and consider time-lag effects.<br><br>Determine suitable criteria for beach closures (e.g., % of time beach requires advisory).<br><br>Assess how heavy rainfall events can be incorporated into predictive beach modelling to inform beach closures.<br><br>Consider one-to-one SDWS operator/owner education opportunities. |
| **Health Promotion** | Existing webpage content on private well water testing and beach monitoring.<br><br>Safe water key messaging and social media included as part of emergency response (e.g., ice storms, flooding, power outages, etc.).<br><br>Completed Test Your Well campaign. | Consider evaluating beach sign effectiveness for public beach users.<br><br>Consider health promotion approaches and key messaging for testing well water on social media and other media channels following heavy rainfall events to ensure it is safe to drink.<br><br>Consider community events for future promotion activities related to private well use and recreational waters. |
| **Key Stakeholder Activities (outside of public health)** | Long-Term Water Conservation Program and source water protection initiatives.<br><br>2016 York Region Water and Wastewater Master Plan that provides an overview of needs for 2041, including population growth and climate change impacts.<br><br>York Region Environmental Services Inflow and Infiltration Reduction Strategy to ensure capacity and optimal operation of wastewater treatment facilities.<br><br>Assessment of water quantity impacts for local municipal groundwater sources.<br><br>Developed by-laws for water use restriction during drought or low water conditions.<br><br>**Emergency Preparedness and Response*:*** Development of a Public Notification Procedure by York Region Environmental Services during overflows, bypasses from wastewater treatment.<br><br>MECP monitoring and response to designated facilities and monitoring algal blooms. | Review relevant information on source water protection measures that may inform private well water and small drinking water systems in York Region, and beaches (e.g., promotional material to reduce run-off).<br><br>Future assessments may look at different storm conditions to determine water and wastewater infrastructure design, which could inform Public Health program and policy development.<br><br>Discuss potential opportunities to address health impacts on basement flooding with other departments such as Environmental Services. |