Grand River Source Protection Area

ASSESSMENT REPORT

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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^{0}C 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^{0}C 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 2-7m 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 (-10^0C to 0^0C, (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 0.60m-1.36m from the International Great Lakes Datum of 1985 of 174.18m, according to the results of 3 Canadian 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)~~Respecting the Great Lakes Basin Ecosystem (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 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). ~~In order to~~To contribute to the achievement of water quality goals and objectives set under the ~~Great Lakes Water Quality Agreement~~GLWQA, Canadian and United States~~U.S.~~ 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 ~~remedial action plans~~RAPs are in place.

~~Additionally, ~~T~~t~~he federal governments of Canada and the United States~~US~~ have developed Lakewide Action and Management Plans (LAMPs~~LaMP~~), to support commitments under the GLWQA. ~~in conjunction with the Province of Ontario and the States within the Great Lake watersheds. Lakewide Management Plans are broad plans to restore and protect water quality in each Great Lake (Environment Canada, 2005).~~ 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). ~~The Lake Erie LaMP, introduced in 2000, established an ecosystem vision for Lake Erie based on sustainable development and recognition of the multiple benefits of a healthy lake to society (United States Environmental Protection Agency, 2006).~~ Since its establishment in 2000, the Lake Erie LAMP~~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). ~~A bi-national nutrient management strategy is currently being developed that will "define the goals,~~

~~objectives, targets, indicators, priority watersheds, monitoring and research needed to limit further eutrophication and improve current conditions in Lake Erie" (United States Environmental Protection Agency, 2010).~~ This strategy ~~will be~~is an important foundation for future Great lakes targets under the Clean Water Act. ~~In particular,~~ For the period 2003-2016, the Grand River contributed~~s~~ approximately 35~~40~~% of the T~~t~~otal Phosphorus loading from major tributaries to the Eastern Basin of Lake Erie (Bocaniov et al., 2023~~Dolan and McGunagle, 2005~~). 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.

~~Goal 6 under Annex 3: Lake and Basin Sustainability under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (Environment Canada, 2004). The report addresses two key results identified under Goal 6 of Annex 3 by identifying and assessing the risks to drinking water sources in Lake Erie (Result 6.1), and developing knowledge and understanding of water quality and water quantity issues of concern to Lake Erie (Result 6.2).~~

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 (~~Ontario Ministry of Natural Resources~~Government of Ontario, 2005~~a~~). 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.

26.0 CONCLUSION

The Grand River Source Protection Area Assessment Report provides a summary of the results of technical studies undertaken to identify the threats to municipal drinking water sources in the Grand River watershed. Assessment Report findings have been used to develop policies for a Source Protection Plan to protect the sources of drinking water for the Southgate, Grand Valley, Amaranth, East Garafraxa, Shelburne, Wellington North, Mapleton, Centre Wellington, Guelph-Eramosa, City of Guelph, Waterloo Region, Perth East, Halton Hills, Oxford County, Brant County, City of Brantford, City of Hamilton, Six Nations and Haldimand County water supply drinking water systems in the Grand River watershed.

26.1 Watershed Characterization

The Grand River Source Protection Area is located in southwestern Ontario and covers an area of approximately 6,800 km^2 draining to Lake Erie. Much of the land of the watershed is used for agriculture. The main urban areas are the Cities of Guelph, Waterloo, Kitchener, Cambridge and Brantford. There are two First Nations bands: Six Nations of the Grand River and Mississaugas of the New Credit.

Residents in the Grand River watershed receive drinking water from both private and municipal supplies. Within the Grand River watershed there are 50 municipal systems and one First Nation system that provide water to 865,500 residents in the watershed (**Table 26-1**).

Table 26-1: Drinking water sources within the Grand River watershed

Region~~In:~~	~~**The communities of:**~~**Community**	**Drinking Water Source~~With:~~**
Grey County	Dundalk	Groundwater wells
Dufferin County	Waldemar, Grand Valley and Marsville, Shelburne	Groundwater wells
Wellington County	Arthur, Moorefield, Drayton, Centre Wellington, Hamilton Drive, Rockwood	Groundwater wells
City of Guelph	Guelph	Groundwater wells and Eramosa River surface water intake
Perth County	Milverton	Groundwater wells
Region of Waterloo	Waterloo, Kitchener, Cambridge, Elmira, St. Jacobs (Integrated Urban System), Hidden Valley, Wilmot Centre	Groundwater wells and Grand River surface water intake
	Ayr, Branchton Meadows, Roseville, Linwood, St. Clements, Wellesley, Foxboro Green, New Dundee, New Hamburg, Conestogo, Heidelberg, Maryhill,	Groundwater wells
Oxford County	Bright, Drumbo, Plattsville	Groundwater wells
Brant County	Paris, Brantford Airport, St. George and Mount Pleasant	Groundwater wells
City of Hamilton	Lynden	Groundwater wells

Region~~In:~~	~~The communities of:~~**Community**	**Drinking Water Source**~~With:~~
City of Brantford	Brantford, Cainsville	Grand River surface water intake
Haldimand County	Dunnville	Lake Erie surface water intake and Emergency Grand River Intake
Haldimand County	Caledonia and Cayuga	City of Hamilton Lake Ontario surface water intake in Halton-Hamilton SP Region
Haldimand County	Hagersville	Nanticoke Lake Erie surface water intake in Long Point Region SPA
~~First Nation~~	~~The communities of:~~	~~With:~~
Six Nations of the Grand River	Ohsweken and parts of the Reserve	Grand River surface water intake
Mississaugas of the New Credit	Parts of the Reserve	Nanticoke Lake Erie intake in Long Point Region SPA

The physiography of the Grand River watershed is dominated in the north and west by the Dundalk and Stratford Till Plains, in the centre and east by the Hillsburg and Waterloo Hills and the Horseshoe Moraines, and in the south by the Haldimand Clay Plain.

The Stratford Till Plain, which dominates in the northwest, is characterized by silty, clay-rich soils which are generally level and often poorly drained. Artificial drainage has made this a rich and productive agricultural region and, as a consequence, only a small portion of the land remains in woodlot, marsh or rough pasture.

The Horseshoe Moraine region consists of a series of moraines surrounding much of southwestern Ontario. The eastern leg of the horseshoe runs along the eastern boundary and through the central part of the Grand River watershed from the Town of Erin in the north, past Guelph and Cambridge to Paris and Brantford in the south. Some of this region is very hilly, often with steep irregular slopes and small enclosed basins. This region has large sand and gravel deposits with many extraction operations in southern Wellington County, southern Waterloo Region, and northern Brant County. This dynamic region provides extensive habitat including 5,000 hectares of wetlands. Approximately 30% of the moraine region is forested and fencerow vegetation is often well developed. The region hosts a number of cold-water watercourses that receive groundwater discharge including the Eramosa River and Mill Creek. Groundwater discharge also feeds the Grand River itself, between Cambridge and Brantford, providing a significant portion of the river's flow during summer months. The Waterloo Hills region, located in the centre of the watershed, is characterized by sand hills, gravel terraces and many swampy valleys. The soils of the hilly areas are rich and well drained.

The Haldimand Clay Plain south of the City of Brantford is characterized by heavy clay soils; much of the land is poorly drained and is used predominantly as livestock pasture and for soybean, corn and hay production. In this area, groundwater is generally obtained from the bedrock because sufficient quantities of water cannot be obtained from the overburden. Groundwater drawn from the bedrock aquifers in this area is often poor in quality as a result of naturally elevated concentrations of sulphur, salts and minerals in the water. For this reason, municipal and First Nations drinking water supplies have tended to be sourced from the Grand River or Lake Erie.

The geology of the Grand River watershed varies widely across the region. The entire watershed is underlain by carbonate bedrock formations which form north to south trending bands. Unconsolidated sediments, or overburden, deposited in relation to the movement of glaciers across the landscape over time overlay the bedrock formations. The overburden sediments are classified into three common groupings within the north, central and southern portions of the watershed. Overburden within the northern part of the watershed, are commonly tills and till-related materials. The central portion of the watershed contains a series of complex moraine systems, ice-contact, and outwash deposits, whereas the southern portion of the watershed is comprised of fine-grained glaciolacustrine, or clay-rich, sediment.

The majority of the population of the Grand River watershed relies on groundwater as a clean, safe, drinking water supply. In addition to providing a safe source of drinking water, groundwater is used in agriculture, commercial, and industrial applications. Groundwater also plays a pivotal role in sustaining sensitive natural features and aquatic habitats such as streams and wetlands. It has long been recognized that groundwater has a vital role in the hydrologic function of the watershed. Groundwater provides critical baseflow to many parts of the watershed, thereby supporting aquatic and wetland ecosystems.

The northern portion of the watershed contains primarily till deposits, which do not to contain extensive or significant aquifer units. Communities such as Dundalk, Grand Valley, Waldemar, Marsville, Fergus, Elora, Guelph-Eramosa, and the City of Guelph rely on groundwater obtained from the Guelph, Goat Island, and Gasport Formations for municipal supply. Communities in Wellington North, such as Arthur, Moorefield, and Drayton obtain municipal water from aquifer units located in the overburden.

The Waterloo Moraine is one of the largest moraines within the Grand River watershed. A number of aquifers situated within the moraine are used by the Region of Waterloo for drinking water supply. The moraine is situated within the west-central part of Waterloo Region in the central portion of the watershed.

Located in the southwest portion of the watershed, the Norfolk Sand Plain is a significant source of groundwater within the overburden sediments. Groundwater from the aquifers located within the sand plain is used as a drinking water resource, and also relied heavily upon for crop irrigation and to meet agricultural water needs. Groundwater from these shallow aquifers also provides critical baseflow to Whitemans Creek which supports cold-water fisheries. The chemical characteristics of groundwater within the Grand River watershed are derived from two sources: (1) the ambient chemistry, where the composition of the groundwater reflects its relative residence time in the aquifer and the nature of the substrate through which it flows, and (2) anthropogenic impacts to the quality of the groundwater through various land use activities such as road salting, fertilizer and manure applications to agricultural fields, and industrial chemical use. In the Grand River watershed, three distinctive land use activities have impacted groundwater quality: road salting, the application of manures/fertilizer, and the use of industrial chemicals.

Surface water quality in the Grand River is influenced by the geology and current land use. Surface water quality parameters of interest within the Grand River include: chloride, sodium and nitrates. Chloride concentrations reflect the influence of urban point and non-point sources but levels in the Grand River do not exceed the aesthetics guideline for drinking water supplies of 250 mg/L. Levels do, however, approach the guideline for the protection of aquatic life (150 mg/L) albeit occasionally, usually during the spring freshet. Nitrate levels above 10 mg/L, the drinking water quality guideline for treated water, may cause concern for municipal supplies. Research in the watershed indicated that shallow tile drainage may have an important role in the elevated nitrate concentrations seen in the upper central Grand River area. Progress to address data gaps identified in the Grand River watershed characterization report have been made and include; detailed Tier 3 water budget studies which contain updated local geologic and groundwater flow data determined through detailed field investigations and modeling.

26.2 Water Quantity Risk Assessment

Municipal water supply accounts for just over 57% of the consumptive water use in the Grand River watershed. Industrial and agricultural uses account for about 5% and 9% of the consumptive water use.

The surface water subwatershed stress assessment classifieds three subwatersheds as having a moderate potential for stress under existing conditions (Eramosa River Above Guelph, Whitemans Creek and McKenzie Creek).

The groundwater stress assessment classifieds three assessment areas as having a moderate potential for stress under existing conditions (Canagagigue Creek, Upper Speed, and Mill Creek), one additional assessment area as having a moderate potential for stress under future conditions (Irvine River), one assessment area as having a moderate potential for stress under drought conditions (Whiteman’s Creek), and one assessment area as having a significant potential for stress under existing conditions (Central Grand).

Tier 3 local water quantity risk assessments wereare required for ten municipal systems **(Table 26-2)**:

Table 26-2: Municipal systems requiring Tier 3 water quantity risk assessments

Assessment Area	Municipality	Water Supply System
Canagagigue	Waterloo Region	Elmira
Canagagigue	Waterloo Region	West Montrose
Canagagigue	Waterloo Region	Conestogo Plains
Upper Speed/Eramosa	City of Guelph	City of Guelph wells and Eramosa River intake
Upper Speed/Eramosa	Guelph-Eramosa	Rockwood wells
Upper Speed/Eramosa	Guelph-Eramosa	Hamilton Drive wells
Central Grand	Waterloo Region	Integrated Urban System wells
Irvine River	Centre Wellington	Fergus-Elora Integrated System wells
Whiteman’s Creek	Oxford County ~~County of Brant~~	Bright wells~~Bethel wells~~
Whiteman’s Creek	County of Brant	Bethel wells

26.2.1 Tier 3 Water Budget and Risk Assessments

Tier 3 Assessments aim to determine if a municipality is able to meet their current and future water demands. Specifically, Tier 3 Assessments estimate the likelihood that a municipal drinking water aquifer or surface water feature (i.e., river or lake) can sustain pumping at their future pumping rates, while accounting for the needs of other water uses such as coldwater streams, or other permitted water takers in the area. Tier 3 Assessments consider current and future municipal water demand, future land development plans, drought conditions, and other water uses as part of the evaluation.

Within the Grand River watershed, Tier 3 studies have been completed for municipal drinking water systems within the City of Guelph, Guelph/Eramosa Township (G-GET), Centre Wellington, Region of Waterloo, the Bethel Wellfield in the County of Brant, and the Bright Wellfield in Oxford County. Further information on the Region of Waterloo Tier 3 study can be found in Chapter 19. The results of the Whitemans Creek (Bethel and Bright Wellfields) Tier 3 study can be found in Chapter 20. The detailed results of the Centre Wellington Tier 3 study are discussed in Chapter 22. The G-GET Tier 3 study results will be incorporated into the assessment report through future updates.

Tier 3 Assessments were completed for the Town of Halton Hills and the Town of Orangeville. Although the Town of Halton Hills and the Town of Orangeville do not have wells located within the Grand River watershed, the Wellhead Protection Area for Quantity extends into the Grand River Source Protection Area.

Region of Waterloo Tier 3 Water Budget and Risk Assessment

The vulnerable areas in the Waterloo Tier 3 Assessment are represented by four Water Quantity Protection Areas (WHPA-Qs). The WHPA-Q1-A underlies the western portions of Kitchener and Waterloo and extends north to the town of Heidelberg, south to New Dundee, west to St. Agatha and east toward the Grand River. The WHPA-Q1B underlies the majority of the urban portion of Cambridge, and extends in a northwestward direction toward Guelph. The WHPA-Q1B extends into Guelph, as the northern model boundary condition for the Cambridge Model coincides with the pumped groundwater level elevations for the aquifers in Guelph. The WHPA-Q1C area is a small drawdown cone located around the Blair Road Wells (Wells G4 and G4A). The WHPA-Q1D area is represented by a 100 m buffer surrounding the Conestogo Plains Well Field (Wells C3 and C4). The consumptive water users and potential reductions to groundwater recharge within the WHPA-Q1s were not classified as Significant or Moderate water quantity threats, therefore no water quantity policies were developed within the WHPA-Qs.

Whitemans Creek Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Bright Wellfield in Oxford County and the Bethel Wellfield in the County of Brant. The WHPA-Q for the Bright Wellfield is a circle of 100 m radius around each production well, with a *low* risk level for water quantity impacts. The WHPA-Q for the Bethel Wellfield is a 6 km^2 area with a significant risk level for water quantity impacts. This finding was based on the production well's inability to meet future demand under drought conditions, and the potential for impacts to neighbouring shallow private wells and wetlands under worst-case conditions for water quantity impacts. Water quantity policies were developed for only the Bethel Wellfield as the WHPA-Q is classified with a significant risk level.

Centre Wellington Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Centre Wellington (Fergus and Elora) drinking water system. A WHPA-Q was delineated surrounding the Centre Wellington municipal wells and around other water takers in the portions of neighbouring townships of Woolwich, East Garafraxa, Mapleton, Guelph/Eramosa, Wellington North and Towns of Grand Valley and Erin. The Risk Assessment scenarios predicted that there was a Low Risk Level associated with groundwater level decline at the municipal wells, and groundwater discharge to coldwater streams and Provincially Significant Wetlands when considering the Future pumping rates (approximately representing future demands between 2031 and 2036). However, the current municipal well infrastructure cannot meet the Water Supply Master Plan's (WSMP) estimated average annual 2041 water demand estimate. This circumstance results in a Significant Risk Level designation for the WHPA-Q. The WSMP evaluated alternatives to meet the 2041 population demand and outlined a process whereby the municipality will locate and test new water supply wells. Consumptive water users include the permitted water demands (i.e., 9 municipal and 17 non-municipal takings) and non-permitted (e.g., domestic and agricultural) water demands (i.e., 2,715 non-municipal, non-permitted takings). Additionally, 4.3 km^2 of reduced groundwater recharge areas were also identified as Significant water quantity threats within the boundaries of the towns of Fergus and Elora.

Town of Orangeville Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Town of Orangeville. Although the Town of Orangeville in not located within the Grand River watershed, the WHPA-QA extends to portions of the Townships of Amaranth and East Garafraxa which are located within the Grand River watershed. Risk assessment scenarios resulted in a Significant Water Quantity Risk Level for WHPA-QA. Threats for the Orangeville WHPA-QA within the Grand River watershed included 44 consumptive water takings.

Town of Halton Hills Tier 3 Water Budget and Risk Assessment

A Tier 3 Assessment was completed for the Town of Halton Hills in the communities of Georgetown and Acton. Although the communities of Acton and Georgetown are not located within the Grand River watershed, the WHPA-Q surrounding the municipal supply wells in Acton includes a small portion of Grand River Watershed. Threats for the Halton Hills WHPA-Q within the Grand River watershed included 9 consumptive water takings.

26.3 Water Quality Risk Assessment

WHPAs are mapped for each municipal groundwater supply system based on a quantitative assessment of lateral groundwater flow in the vicinity of the municipal wellfield. A WHPA consists of four zones which are based on the time it takes for groundwater to travel from the water table surface to the municipal well. Using the calibrated groundwater flow models, capture zones in the Grand River watershed have been delineated through time of travel assessments using backward and forward particle tracking.

An aquifer vulnerability analysis is a physically-based evaluation of the geologic and hydrogeologic character of the sediments and bedrock overlying the municipal aquifer. The resulting calculations provide a rating of the intrinsic vulnerability for the aquifer of interest. Numerous approaches are available to estimate groundwater intrinsic vulnerability such as the Intrinsic Susceptibility Index (ISI), Aquifer Vulnerability Index (AVI), Surface to Well Advective Time (SWAT), Surface to Aquifer Advective Time (SAAT). To obtain the vulnerability score within a WHPA, a scoring matrix is applied which intersects the WHPA zones with the aquifer vulnerability classification. The presence of transport pathways are considered following the initial vulnerability assessment, and may result in a revision to the vulnerability assessment.

The Intake Protection Zone (IPZ) is the primary vulnerable area to be delineated to ensure the protection of the municipal surface water supply. For each drinking water system, an IPZ-1, IPZ-2 and IPZ-3 can be delineated. Surface water intakes are classified according to their location, with four different classifications (Types A, B, C, or D). Vulnerability scoring is based on the attributes of the intakes (e.g., length and depth), type of source water body, and the physical characteristics of the environment it is situated in.

In determining the potential impact of certain types of land use activities on municipal water quality, the percentage of managed lands and the livestock density in the surrounding area must be considered. Managed lands are those lands to which agricultural source material, commercial fertilizer, or non-agricultural source material are applied. Livestock density is a surrogate measure of the potential generation, storage, and application of agricultural source material within a given area, and is expressed in nutrient units generated per year, per acre. In addition, impervious surface area mapping is used in the scoring and assessment of threats related to road salt application.

In the Grand River watershed, drinking water threats within either WHPAs or IPZs of municipal drinking water systems were identified through the following:

- An activity prescribed by the Act as a Prescribed Drinking Water Threat;
- An activity identified by the Source Water Protection Committee as an activity that may be a threat and (in the opinion of the Director) a hazard assessment confirms that the activity is a threat;
- A condition that has resulted from past activities that could affect the quality of drinking water; or
- An activity associated with a drinking water Issue.

Enumerated significant water quality threats are summarized in each municipal chapter of the Assessment Report. All significant threats must be addressed in the Source Protection Plan. The LESPR SPC may choose to develop policies to address low or moderate drinking water threats.

~~26.4 Municipal Drinking Water Systems~~

~~In all, there are 50 municipal systems and one First Nations drinking water system. Of these, there are 49 groundwater municipal systems, including two integrated groundwater/inland river systems, three inland river systems, one Lake Erie intake. In addition, one pipeline system from Lake Ontario provides water to residents in the Grand River watershed. Municipal systems are owned and operated by upper, lower, and single tier municipalities. Municipal water demand within the watershed is estimated at approximately 86 million m^3/yr, and this volume services approximately 865,538 residents.~~

~~26.4.1 Dundalk – Township of Southgate~~

~~The Dundalk municipal water supply system consists of three bedrock wells (Wells D3, D4 and D5) and services a population of approximately 1,700 people. Wellhead Protection Areas are delineated for each well: a 100 m proximity zone and three time-related (2-year, 5-year and 25-~~

~~year) capture zones generated through a groundwater model. Final vulnerability scores include 10 in WHPA-A, 6 in WHPA-B, 2 in WHPA-C and 4 and 2 in WHPA-D.~~

~~The water quality threats assessment shows that three activities on three properties may be significant threats within the WHPA-A or WHPA-B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.2 Waldemar – Township of Amaranth~~

~~Three wells (PW1, PW2 and PW3) supply groundwater to the Waldemar Heights water supply system. The wells are completed in bedrock and draw water from the locally confined Guelph – Amabel aquifer. The municipal system supplies water to approximately 342 residents. Final vulnerability scores include 10 in WHPA-A, 10, 8 and 6 in WHPA-B, 2 in WHPA-C and 6 and 2 in WHPA-D. Adjustments were made to the vulnerability mapping to account for the transport pathway provided by the sand and gravel pit located on the eastern edge of WHPA-D.~~

~~The water quality threats assessment shows that 39 activities on 36 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.3 Grand Valley – Town of Grand Valley~~

~~The Grand Valley water supply system includes four wells (PW1, PW2, PW3 and PW5) that service a population of approximately 2,100 people.~~

~~Wells PW1 and PW2 are located east of the Grand River in the flood plain and obtain water from a confined limestone bedrock aquifer (Guelph-Gasport formation). Vulnerability scores are predominantly high to medium with high vulnerability mapped along bedrock outcrops along the Grand River valley and areas of thin overburden. Adjustments were made to the vulnerability mapping to account for potential transport pathways (concentrations of private wells and underground infrastructure within the village limits, aggregate operations). Well PW3is west of the Grand River. The bedrock in the area of PW3 is protected by over 24 m of fine-grained overburden. PW5 was drilled in March 2020 and is completed as a open hole in the Gasport formation. Final vulnerability scores include 10 in the WHPA-As, 10, 8 and 6 in the WHPA-Bs, 8, 6 and 2 in the WHPA-Cs and 6, 4 and 2 in WHPA-D.~~

~~The water quality threats assessment shows that 33 activities and 1 condition on 31 properties may be significant threats within WHPA-A, B and C. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.4 Marsville – Township of East Garafraxa~~

~~The Marsville water supply system includes two wells which service approximately 80-90 people. The wells, which tap the locally confined Guelph – Amabel aquifer, draw water from the upper weathered and competent middle portion of the bedrock aquifer. Because of the low pumping rate within a very productive aquifer, the pumped water is replenished to the aquifer within the 2-year capture zone and, therefore, no 5-year or 25-year zones have been delineated. Overburden in the vicinity of the Marsville well is approximately 62 m in thickness. Final vulnerability scores include 10 in WHPA-A and 6 in WHPA-B.~~

~~The water quality threats assessment shows that 10 activities on 8 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.5 Shelburne – Township of Melancthon~~

~~The Shelburne Water Supply System services a population of approximately 8,200 residents (2022) and consists of six bedrock supply wells (PW 1, 3, 5, 6, 7, and 8). Wells PW 1, 3, 5 and 6 are located within the Nottawasaga Valley Source Protection Area and Wells PW7 and PW8 are within the Grand River Source Protection Area. Final vulnerability scores for Shelburne wells PW7 and PW8 include a score of 10 in the WHPA-A, 8 and 6 in the WHPA-B, 6, 4 and 2 in the WHPA-C and 4 and 2 in the WHPA-D. The WHPAs from wells PW1, PW2, PW5 and PW6 overlap into the Grand River Source Protection Area.~~

~~The water quality threats assessment shows that there are 8 activities on 3 properties that may be significant drinking water threats within the WHPA-A. An Issues-based threat analysis was also completed through a review of water quality data collected from the municipal well. No Issues-based threats were identified within the WHPA.~~

~~26.4.6 Orangeville Water Supply~~

~~The Town of Orangeville is located in the headwaters of the Credit Valley River and in the Credit Valley Source Protection Area. Orangeville has 12 water supply wells in nine well fields that supply the town of approximately 29,000 people. The wells obtain water from a combination of overburden and bedrock aquifers (Burnside, 2010). Portions of WHPA-B, C and D for the Orangeville wells, with the exception of Well 10, cross into the Grand River Source Protection Area.~~

~~An Issues evaluation was also completed by reviewing water quality data collected from the municipal wells. Sodium and Chloride were both identified as Issues under Technical Rule 114. An Issue Contributing Area has been delineated the well field of Well 2A, Well 5/5A and Well 9A/9B for the Issue of chloride. Both a chloride and sodium Issue Contributing Area has been delineated for the well field for Wells 6 and 11 and is the 25 year time-of-travel.~~

~~The water quality threats assessment shows that 32 activities on 11 properties may be significant threats within WHPA-B, C and D or ICA.~~

~~26.4.7 Arthur – Township of Wellington North~~

~~Within the Township of Wellington North, the community of Arthur's municipal water supply system consists of 3 overburden wells (Wells 7B and 8A/8B). The municipal system supplies water to approximately 2,500 people within the community. All three wells are completed in the deep overburden aquifer at approximately 46 m below ground surface. The wells are located in an area of low vulnerability, which results in medium to low vulnerability scores in most of the wellhead protection areas, and an area of high vulnerability within the 100-metre area around the wells. Adjustments were made to the vulnerability mapping to account for the transport pathways (buried infrastructure within the WHPA-B).~~

~~The water quality threats assessment shows that 14 activities on 6 properties may be significant threats within WHPA-A and C. An Issues-based threats analysis was also completed through a~~

~~review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.8 Drayton – Township of Mapleton~~

~~Two municipal wells, completed in the Salina bedrock formation, supply approximately 1,550 people in the community of Drayton. Both wells are completed as open hole in the upper portion of the dolostone bedrock aquifer which is overlain by about 58m of fine-grained overburden. Because of the low vulnerability in the area, vulnerability scores are low to medium in most of the wellhead protection areas and high within the 100-metre area around the wells.~~

~~The water quality threats assessment shows that 18 activities on 7 properties may be significant threats within WHPA-A and B. An issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No issue-based threats were identified within the municipal groundwater system.~~

~~26.4.9 Moorefield – Township of Mapleton~~

~~The Moorefield Water Supply has two pumping wells and supplies approximately 550 people. Water in the wells comes from an extremely permeable portion of the dolomite bedrock aquifer at a depth of 82m. The aquifer is described as a confined aquifer with little to no leakage. The wells are located in an area of low vulnerability, which results in medium to low vulnerability scores in most of the wellhead protection areas, and an area of high vulnerability within the 100-metre area around the wells.~~

~~The water quality threats assessment shows that 9 activities on 3 properties may be significant threats within WHPA-A. An issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No issue-based threats were identified within the municipal groundwater system.~~

~~26.4.10 Township of Centre Wellington (Fergus-Elora)~~

~~Within the Township of Centre Wellington, the communities of Fergus and Elora are supplied by an integrated municipal groundwater system. Together, the water systems are referred to as the Centre Wellington Supply System which serves 20,600 (2018) residents in Fergus and Elora. The water supply system for Elora consists of three bedrock wells referred to as E1, E3 and E4. The water supply system for Fergus consists of six bedrock wells referred to as F1, F2, F4, F5, F6 and F7. Intrinsic vulnerability in the wellhead protection areas is low and moderate across much of the area with some high bands cutting across WHPA-As and WHPA-Bs. Vulnerability scoring in the Centre Wellington WHPAs is 10 in WHPA-As, 10, 8 and 6 in WHPA-Bs, 8, 6, 4 and 2 in WHPA-Cs and 6, 4 and 2 in WHPA-D's.~~

~~Since Well F2 is identified as groundwater under the direct influence of surface water (GUDI), a WHPA-E was delineated in addition to the WHPA-A to D. The WHPA-E has a vulnerability score of 6.3.~~

~~The water quality threats assessment shows that 1761 activities on 709 properties may be significant threats within WHPA-A, B, C and the ICAs for the Centre Wellington Supply System Wells. An issues-based threats analysis was completed through a review of water quality data collected from the municipal wells. The review identified chloride and trichoroethylene Issues for drinking water source F1 under Rule 114. Additionally, the review identified a chloride Issue for drinking water source E3 under Rule 114.~~

26.4.11 Rockwood – Township of Guelph/Eramosa

The water supply system for Rockwood includes two well fields, the Station Street Well Field (Well 1 and 2) and the Bernardi Well Field (Well 3 and 4) serving a population of 1,635 people. Rockwood Well 1 and Well 2 are constructed approximately 60 m bgs into the fractured Gasport bedrock aquifer. Rockwood Well 3 and Well 4 are constructed approximately 50 m bgs and 62 m bgs, respectively into the Gasport bedrock aquifer. Although the Rockwood Wells 1 and 2 are identified as groundwater under the direct influence of surface water (GUDI), there is no evidence of a connection or interaction with a surface water body that would decrease the time of travel of water to the well; therefore, no WHPA-E was delineated for these wells.

The wellhead protection areas are located in areas dominantly classified as medium to high intrinsic vulnerability. The vulnerability score for the Rockwood Wells is 10 in the WHPA-A, 10 and 8 in the WHPA-B,6 in the WHPA-C and mostly a score of 4 in the WHPA-D. Adjustments were made to the vulnerability mapping to account for the transport pathways.

The water quality threats assessment shows that 292 activities on 107 properties may be significant threats within WHPA-A, B and C. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. Sodium and chloride concentrations at Station Street Wells 1 and 2 are described a drinking water issue per Technical Rule 115.1 under Section 15(2) (f) of the *Clean Water Act, 2006.* Under this Technical Rule, an Issues Contributing Areas is not delineated.

26.4.12 Hamilton Drive – Township of Guelph/Eramosa

The community of Hamilton Drive has a serviced population of approximately 216 people and is supplied by two bedrock wells (Cross Creek and Huntington wells).The Cross Creek Well is an open hole in bedrock from 39.62 m to a depth of 99 m bgs within the Reformatory Quarry member of the Eramosa Formation. The Huntington Well is an open hole in bedrock from 12.5 to 71.9 m bgs within the Guelph and middle Gasport Formations. The wellhead protection areas are located in areas classified dominantly as medium intrinsic vulnerability with some low intrinsic vulnerability areas within the WHPA-C and WHPA-D zones. The vulnerability score for the Rockwood well WHPAs is 10 in the WHPA-A, 8 and 10 in the WHPA-B, and mixed 8, 6, 4 and 2 scores in the WHPA-C and mainly a score of 4 in the WHPA-D. Adjustments were made to the vulnerability mapping to account for the transport pathways.

The water quality threats assessment shows that 82 activities on 39 properties may be significant threats within WHPA-A, B and C. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.

26.4.13 Guelph Waterworks

The groundwater supply system includes 25 groundwater supply wells and one shallow groundwater collector system that serve a population of approximately 135,000. Currently 19 wells are in service, with four wells out of service due to quality and maintenance concerns. The majority of the wells draw water from deep confined bedrock formations, primarily the Gasport Formation (formerly the Amabel Formation) but to a lesser extent the Guelph, Eramosa and Goat Island Formations. At Arkell, which is located just outside the City, the groundwater supply is supplemented by an artificial recharge system. Surface water from the Eramosa River is used to recharge and enhance the flow of the Arkell Springs (Glen) Collection System.

Wellhead protection areas were delineated using the City's most current groundwater model that builds upon previous models and includes the most recent hydrogeological investigations undertaken by the City. A large portion of the City of Guelph's land area is contained within the WHPA-B (2-year) and most of the land area is contained within the WHPA-C (5-year).

Vulnerability in the wellhead protection area has been assessed using the Intrinsic Susceptibility Index (GwISI) method. Vulnerability scores are high (10 or 8) in the WHPA-A and portions of the WHPA-B, particularly along the Eramosa and Speed River valleys where overburden is thin. Vulnerability scores through the remainder of the WHPA-B are moderately high to moderate (8 or 6) and, in the WHPA-C, moderately high to low (6 or 4). Vulnerability scores were adjusted to account for transport pathways (buried infrastructure and pits and quarries).

The Glen Collector system, Arkell 1 well and the Carter wells are identified as groundwater under the direct influence of surface water (GUDI). A WHPA-E was delineated for the Carter wellfield in addition to the WHPA-A to D. The WHPA-E has a vulnerability score of 7.2. No WHPA-E was delineated for the Glen Collector system or the Arkell 1 well because these wells are influenced by the Eramosa River and the intake protection zones delineated for the Eramosa intake are relevant for these wells.

The Eramosa River intake that pumps water to the Arkell Recharge System is classified as a Type C intake. The Intake Protection Zone 1 (IPZ-1) is delineated as a 200 metre semi-circle centred on the intake and extending upstream. Where the delineated area abuts land, a setback of 120 m or the Conservation Authority Regulation Limit, whichever is greater, is applied. The IPZ-2 is based on the distance that water will travel at the 95th percentile flow in six hours and was determined in the Eramosa River using a series of dye tracer tests together with a hydraulic model of the river. The IPZ-3 is delineated by identifying all watercourses that supply water to the Arkell intake and applying a lateral setback equal to the greater of 120 m or the Conservation Authority Regulation Limit. The vulnerability score for the IPZ-1 is 10 and for the IPZ-2 is 7. The vulnerability score in the IPZ-3 is 5 for built-up areas, 3 for agricultural areas and 1 for natural areas.

An Issues evaluation was also completed by reviewing water quality data collected from the municipal wells. Nitrate was identified as an issue under Technical Rule 114 at the City of Guelph's Carter wells, while Trichloroethylene (TCE) was identified as an issue at the Membro, Edinburgh, Smallfield, Sacco and Emma wells. Issue Contributing Areas have been delineated for each well at which an Issue has been identified.

The water quality threats assessment shows that 1,830 activities on 1119 properties may be significant threats within WHPA-A, B C, and the Issue Contributing Areas. In addition, 24 conditions have been identified in the City of Guelph.

26.4.14 Region of Waterloo Integrated Urban System (IUS)

The Integrated Urban System (IUS) is a complex network of water sources, treatment, storage and delivery systems serving Cambridge, Kitchener, Waterloo, Elmira, New Hamburg, St. Agatha and St. Jacobs that serves a total population of approximately 517,030. The IUS system is comprised of 67 wells (from seven drinking water systems), completed in both overburden and bedrock, the Hidden Valley surface water intake on the Grand River, and an aquifer storage and recovery system (ASR). During periods of high demand treated surface water is introduced to the IUS in Kitchener and combined with treated water from a variety of groundwater sources. During the seasons of lower demand, treated surface water is injected via ASR wells for storage and pumped out for use during high demand periods.

~~The two FEFLOW groundwater flow models developed and refined during the Tier 3 Risk Assessment and a third ASR MODFLOW model, were utilized to develop updated WHPAs for the municipal supply wells in the Region. The Regional FEFLOW model encompasses the entire Region of Waterloo and was modified from a pre-existing groundwater flow model with a focus on the overburden groundwater flow systems. The Cambridge FEFLOW Model was developed during the Tier 3 Assessment and focussed on the bedrock stratigraphy in the Cambridge area. The model utilized to generate capture zones at each wellfield was chosen based on which best represented the local conditions. Capture zones for all wells besides the ASR wells were completed using steady-state model conditions. The WHPAs for the ASR wells were delineated using a MODFLOW model run in transient state to simulate the cyclical nature of water injection and withdrawal of this system. Vulnerability in each of the wellhead protection areas has been assessed using the Intrinsic Susceptibility Index (ISI) method for the applicable aquifer.~~

~~The following summarizes the vulnerability assessment, threats assessment and issues evaluation for each of the well fields that are part of the integrated urban system.~~

~~26.4.15 Waterloo Area Well Fields~~

~~Erb Street Well Field~~

~~The water supply for the Erb Street Wellfield was obtained from Production Wells W6A/W6B, W7 and W8. Well W6A has become problematic and a replacement well W6C has been constructed adjacent to W6A but has not yet been connected to the municipal system. All of the production wells are completed within the sand gravel Middle Waterloo Moraine Sands (AFB2) underlain by the Maryhill Till at screen depths ranging from 32 m to 56 m below ground surface. Final vulnerability scores include 10 in WHPA-As, 10, 8 and 6 in WHPA-Bs, 8, 6 and 4 in WHPA-Cs and 6, 4 and 2 in WHPA-Ds.~~

~~The water quality threats assessment shows that 17 activities on 7 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~William Street Well Field~~

~~The water supply for the William Street Well Field is obtained from Production Wells W1B, W1C and W2. All of the production wells are screened at depths ranging from 20 m to 34 m below ground surface with Pre-Catfish Creek Aquifer which is overlain intermittently by the Maryhill and Catfish Creek Tills. The overlying aquifers (AFB2 and AFB3) are consequently hydraulically connected to AFD1 in areas where the aquitards pinch out.~~

~~Final vulnerability scores include 10 in WHPA-A, 10, 8, 6 in WHPA-B, 6 and 4 in WHPA-C and 6, 4 and 2 in WHPA-D. Vulnerability scores were increased to account for transport pathways (several well clusters) within WHPA-A, B and C.~~

~~An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. TCE, sodium and chloride have been identified as Issues for the William Street production wells. The Issue Contributing Area for both TCE, sodium and chloride Issue is delineated as the 25-year capture zone.~~

~~The water quality threats assessment shows that 635 activities and 5 conditions on 526 properties may be significant threats within WHPA-A, B, and ICA.~~

~~Waterloo North Well Field~~

~~The water supply for the Waterloo North well field is obtained from Production Wells W5A and W10. The Region ceased full-time production at W5 in the mid to late 70s due to water quality concerns – mainly elevated TDS, hardness, iron and sulphate – and the well was physically disconnected from the IUS in 2000. A Class Environmental Assessment was completed in 2011 for the addition of a new well adjacent to the Laurel Tank (W25) to the Waterloo North Wellfield. An addendum to the Environmental Assessment was undertaken to limit construction of treatment facilities for only W25 (and not W5A) as demand did not warrant bringing W5A on line in the short term. Production well W5 is screened within the Pre-Catfish Aquifer at a depth of approximately 34 m BGS to 39 m BGS; W25 is screened at a depth of 75 m BGS to 78 m BGS Production well W10 is screened within Upper Waterloo Moraine Sands at a depth of approximately 9 m BGS to 18 m BGS. These two aquifer systems are separated by a confining aquitard corresponding to the Maryhill and Catfish Creek Tills.~~

~~Final vulnerability scores include 10 in WHPA-As, 10, 8 and 6 in WHPA-Bs, 8, 6 and 4 in WHPA-Cs and 6, 4 and 2 in WHPA-Ds.~~

~~Well W10 is classified as Groundwater under the direct influence of surface water (GUDI) with effective filtration. A WHPA-E was delineated for Well W10 in addition to the WHPA-A to D. The WHPA-E has a vulnerability score of 8.1.~~

~~The water quality threats assessment shows that 20 activities on 14 properties may be significant threats within WHPA-A, B and E. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.16 Kitchener Area Well Fields~~

~~Mannheim Well Field~~

~~Water supply for the Mannheim well field is obtained from the following well fields:~~

~~Mannheim East – Wells K21/K21A, K25 and K29 screened from 30 to 52 m bgs in AFB2;~~

~~Mannheim Peaking – Wells K91, K92, K93, and K94 screened from 54 to 75 m bgs in AFB2;~~

~~Mannheim West – Wells K23, K24 and K26 screened from 20 to 38 m bgs in AFB2;~~

~~Aquifer Storage and Recovery (ASR) wells – Wells ASR1, ASR2, ASR3, ASR4 and ASR5 (previously RCW1) screened from 52 to 80 m bgs in AFB2; and,~~

~~ASR Recovery Wells – Wells RCW2, RCW3 and RCW4 screened from 62 to 73 m bgs in AFB2.~~

~~The Mannheim wells are all constructed within the Middle Waterloo Moraine Sands (AFB2) and generally positioned just above the Maryhill Till. AFB2 is overlain by a discontinuous, fine-grained, aquitard unit (ATB2) throughout the Mannheim area. ATB2 is overlain by AFB1, which outcrops in various locations throughout Mannheim. It is of note that AFB1 and AFB2 are hydraulically connected in the vicinity of the Mannheim West Wellfield and modeled particle pathlines during the capture zone assessment indicated particles extended predominantly through both aquifers. This was the rationale for applying AFB1 as the aquifer for intrinsic vulnerability mapping.~~

~~The Peaking wells historically were primarily used in the summer months to meet peak water demands with either one of K91/K92 and K93/K94 pumping at any given time. The ASR wells were designed to inject treated water from the Grand River into the Middle Waterloo Moraine Sands (AFB2) during periods of low demand and then pump it out again when the water is needed, similar to the peaking wells. The ASR wells are capable of both pumping and injection whereas the RCW wells are only capable of pumping. The Mannheim wells contribute water to the IUS.~~

~~Final vulnerability scores include 10 in WHPA-A, 10, 8, 6 in WHPA-B, 8, 6 and 4 in WHPA-C and 6, 4 and 2 in WHPA-D. Vulnerability scores have been increased in the wellhead protection area to account for transport pathways: an aggregate operation within WHPA-C and D of wells K25 and K26 and clusters of wells, septic systems and underground services throughout the WHPA.~~

~~Well K23 is classified as GUDI with effective filtration. A WHPA-E was delineated for Well K23 in addition to the WHPA-A and B. The WHPA-E has a vulnerability score of 6.3.~~

~~Nitrate has been identified as an Issue for the K23, K24 and K26 wells. The Issue Contributing Area for well K24 and K26 has been delineated as the 25-year capture zone; the Issue Contributing Area for well K23 has been delineated as the 25-year capture zone plus the area of the WHPA-E zone for this well.~~

~~The water quality threats assessment shows that 630 activities on 379 properties may be significant threats within WHPA-A, B, C, D and E, or ICA.~~

~~Greenbrook Well Field~~

~~The water supply for the Greenbrook well field is obtained from production wells K1A, K2A, K4B, K5A, and K8 which are screened from approximately 33 to 50 m bgs. All of the production wells are completed within the Pre-Catfish Creek Aquifer (AFD1) and are overlain by an extensive aquitard unit comprised of the Maryhill and Catfish Creek Tills.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Vulnerability scores have been increased to account for transport pathways (several clusters of wells and underground services).~~

~~Greenbrook has been classified as a provisionally GUDI well field with effective filtration, due to the windows in the Maryhill Till identified near the production wells. As such, a WHPA-E zone has been delineated for the Greenbrook wellfield in addition to the WHPA-A to D. The vulnerability score of the WHPA-E is 8.1.~~

~~Chloride has been identified as an issue for the Greenbrook wells. The Issue Contributing Area has been delineated as the 25-year capture zone plus the area of the WHPA-E zone for this wellfield.~~

~~The water quality threats assessment shows that 480 activities on 383 properties, and 1 condition, may be significant threats within WHPA-A, B, C, D and E, or ICA.~~

~~Strange Street Well Field~~

~~The water supply for the Strange Street well field is obtained from production wells K10A, K11, K13A, K18 and K19. The production wells are screened at depths ranging from approximately 17 m to 38 m bgs within the Middle Waterloo Moraine Sands (AFB2). AFB1 is typically identified at~~

~~ground surface near the site and is often separated from AFB2 by the presence of a fine-grained aquitard unit. The production wells are screened below this aquitard unit, near the top of the Maryhill Till.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Vulnerability scores have been increased areas of WHPA-B and D to account for transport pathways (well and underground servicing clusters).~~

~~An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. Chloride has been identified as an Issue for the Strange Street wells. The Issue Contributing Area for the chloride issue is delineated as the 25-year capture zone for K10A.~~

~~The water quality threats assessment shows that 149 activities conditions on 108 properties may be significant threats within WHPA-A, B, C and D, or ICA.~~

~~Parkway Well Field~~

~~The water supply for the Parkway wellfield is obtained from production wells K31, K32 and K33. All of the production wells are screened across depths ranging from approximately 24 m to 34 m below ground surface within the Pre-Catfish Creek Aquifer (AFD1), which is overlain by an extensive confining to semi-confining aquitard unit consisting of the Maryhill and Catfish Creek Tills.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 4 and WHPA-D, 2. Vulnerability scores have been increased to account for transport pathways (several well and underground service pathways).~~

~~Sodium and chloride been identified as Issues for the Parkway wells. The Issue Contributing Area has been delineated as the 25-year capture zone for this well field.~~

~~The water quality threats assessment shows that 972 activities on 830 properties may be significant threats within WHPA-A, B, C, D and E.~~

~~Strasburg Well Field~~

~~The water supply for the Strasburg well field is obtained from production wells K34 and K36. K34 is pumped at a higher rate and more consistently than K36 The production wells are screened from approximately 28 to 50 m bgs within the Pre-Catfish Creek Aquifer (AFD1),, which is overlain by an extensive confining to semi-confining aquitard unit consisting of the Maryhill and Catfish Creek Tills.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 6 and 4, WHPA-D, 2.~~

~~The water quality threats assessment shows that 4 activities on 2 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats have been identified for this well field.~~

~~Pompeii Well Field~~

~~The water supply for the Pompeii/ well field is obtained from production wells K72, K73, K74 and K75. The Pompeii well field includes production wells K72, K73, K74 and K75. None of the wells are currently connected to the IUS; however, an update to the Updated Water Supply Master Plan included these wells in long-term water supply plans. All of the production wells are screened over depths ranging from approximately 9 m to 15 m below ground surface within the Pre-Catfish Creek Aquifer (AFD1) in the Grand River Valley. Many of the upper moraine units, including the Upper and Middle Waterloo Moraine Sands, have been eroded away by glaciofluvial processes in the Grand River Valley, resulting in the Pre-Catfish Creek Aquifer (AFD1) being present near ground surface; hence, despite their shallow depths, the wells at the Pompeii Wellfield are screened in the Pre-Catfish Creek Aquifer (AFD1).~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Pompeii Wellfield resulted in the identification of two gravel pits found adjacent to the Pompeii wells and several clusters of wells and underground services which warranted an increased ISI within WHPAs A through D.~~

~~The Pompeii well field has been classified as a GUDI well field with effective filtration. As such, a WHPA-E zone has been delineated for the well field in addition to the WHPA-A to D. The vulnerability score of the WHPA-E is 7.2.~~

~~The water quality threats assessment shows that 28 activities on 6 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats have been identified for this well field.~~

~~Woolner Well Field~~

~~The water supply for the Woolner well field is obtained from Production Wells K80, K81 and K82. The production wells are screened within the Pre-Catfish Creek Aquifer (AFD1) from approximately 6 m to 12 m below ground surface and are located in the Grand River Valley, where many of the upper moraine units, including the Pre-Catfish Creek Aquifer (AFD1), have been eroded away by glaciofluvial processes, resulting in the presence of the Pre-Catfish Creek Aquifer (AFD1) at or near the ground surface. Similar to the Pompeii wells, despite their shallow depths, the Woolner wells are also screened in the Pre-Catfish Creek Aquifer (AFD1).~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 4 and 2, WHPA-D, 6, 4 and 2. Vulnerability scores have been adjusted to account for transport pathways (an aggregate operation, closely spaced underground services and a cluster of wells).~~

~~Woolner has been classified as a GUDI well field. As such, a WHPA-E zone has been delineated for the well field in addition to the WHPA-A to D. The vulnerability score of the WHPA-E is 7.2.~~

~~The water quality threats assessment shows that 15 activities on 7 properties may be significant threats within WHPA-B. An issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No issue-based threats have been identified for this well field.~~

~~Wilmot Centre – Region of Waterloo~~

~~The water supply for the Wilmot Centre well field is obtained from Production Wells K50 and K51 Well K52 was recently constructed on the same property and is planned to be connected to the~~

~~supply system shortly. The three production wells are screened within the Middle Waterloo Moraine Sands (AFB2) at depths ranging from 30 m BGS to 40 m BGS. This aquifer behaves as a semi-confined aquifer system as it is overlain by clay till in the area immediately surrounding the wells~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8 and 6, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Wilmot Centre WHPA resulted in the identification of several well and septic system clusters, a length of road along Bleams Rd. with closely spaced utility services, and one aggregate licensed property within the WHPA-B through D, which warranted increases to the ISI.~~

~~Wilmot Centre has been classified as a GUDI well field. As such, a WHPA-E zone has been delineated for the well field in addition to the WHPA-A to D. The vulnerability score of the WHPA-E is 6.3. Nitrate has been identified as issue for the Wilmot Centre well field.~~

~~The water quality threats assessment shows that 158 activities on 84 properties may be significant threats within WHPA-A, B and the Nitrate Issue Contributing Area.~~

~~26.4.17 Cambridge Area Well Fields~~

~~Hespeler Well Field~~

~~The water supply for the Hespeler well field is obtained from production Wells H3, H3A, H4A, H5 and H5A. The production wells have screened depths ranging from approximately 31 m BGS to 121 m BGS in the bedrock of the Gasport Formation. Overburden was variable from well to well in this Wellfield, with the Waterloo Moraine Sands (AFB1/AFB2) identified at or near ground surface, followed by the Maryhill and/or Catfish Creek Tills, which directly overly bedrock. A portion of the WHPA-C and WHPA-D from the Hespeler Wellfield extends into The County of Wellington.~~

~~Final vulnerability scores include: WHPA-A-10, WHPA-B, 10 and 8, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Vulnerability scores have been increased to account for transport pathways (several clusters of wells and underground services).~~

~~Chloride has been identified as an Issue for wells H3, H3A and H4A. The Issue Contributing Area has been delineated as the 25-year capture zone for chloride.~~

~~The water quality threats assessment shows that 199 activities on 158 properties and 1 condition may be significant threats within WHPA-A, B and the Issue Contributing Area.~~

~~Pinebush Well Field~~

~~The water supply for the Pinebush well field is obtained from production well G5, G5A, P10A, P10B, P11, P17, P15/P15A, and P9 and P19. The production wells are open hole over depths of approximately 22 m BGS to 135 m BGS, within the Guelph, Eramosa, Goat Island and Gasport bedrock formations, with overlying overburden material consisting primarily of fine grained sediments. Portions of the WHPA-B through WHPA-D extend into The County of Wellington.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Vulnerability scores have been to account for transport pathways (clusters of wells, septic systems and underground services).~~

~~Well G5 has designated chloride and sodium Issues due to increasing impacts of de-icing salt on groundwater at this well. The Issue Contributing Area is delineated as the 25 year time-of-travel (WHPA-D) for supply well G5. The new and deeper well G5A has lower chloride and sodium impacts and does not have a designated Issue.~~

~~The water quality threats assessment shows that 448 activities on 289 properties, and 2 condition, may be significant threats within WHPA-A, B, C and the Issue Contributing Area.~~

~~Blair Road Well Field~~

~~The water supply for the Blair Road Wellfield is obtained from production well G4 and G4A. The production wells are open hole within the within the Guelph, Eramosa and Gasport bedrock formations from 31 m BGS to 83 m BGS with a thin layer of overburden outwash deposits directly overlying the bedrock.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 6 and 4, WHPA-D, 4 and 2. Analysis of the attributes of each potential transport pathway in the Blair Road WHPA identified a cluster of wells and underground services within WHPA-B and another cluster of wells and septic systems in WHPA-D which warranted increased ISI.~~

~~The Blair Road wells are classified as GUDI with effective filtration. The delineated WHPA-E focused on identifying the upstream points within Devil's Creek which, under bankfull or 2-year peak flow conditions, lie at the two-hour time of travel distance from the shallow overburden zone of influence for G4/G4A.~~

~~The water quality threats assessment shows that 21 activities on 9 properties, and 1 significant condition, may be a significant threat within WHPA-A, B and E. No water quality Issues or Issue-based threats have been identified.~~

~~Clemens Mill Well Field~~

~~The Clemens Mill well field consists of Production Wells G6, G16, G17, G18 and G19. The production wells are open hole within the Guelph, Eramosa Goat Island and Gasport bedrock formations from approximately 28 m BGS to 127 m BGS Portions of the WHPA-B through WHPA-D extend into The County of Wellington.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Vulnerability scores were increased to account for transport pathways (several clusters of wells and underground utility services).~~

~~The water quality threats assessment shows that 24 activities on 16 properties, and 1 condition, may be significant threats within WHPA-A and B. No water quality Issues or Issue-based threats have been identified.~~

~~Elgin Street Well Field~~

~~The water supply for the Elgin Street well field is obtained from production well G9. The production well is open hole from approximately 25 m to 78 m below ground surface within the Guelph and Eramosa bedrock formations, with sand and gravel deposits overlying bedrock in this area.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Elgin Street WHPA resulted in the identification of several well clusters, closely spaced septic systems~~

~~and numerous underground utility services found within the WHPA-B through D zones, which warranted an increased ISI.~~

~~Trichloroethylene (TCE), sodium and chloride have been identified as issues for wells G9. The corresponding Issue Contributing Area has been delineated as the 25-year capture zone for well G9.~~

~~The water quality threats assessment shows that 151 activities on 119 properties may be significant threats within WHPA-A, B, C and D.~~

~~Middleton Street Well Field~~

~~The water supply for the Middleton Street well field is obtained from Production Wells G1, G1A, G2, G3 and G14. The production wells are open hole within the Guelph, Eramosa and Gasport bedrock formations from approximately 29 m to 60 m below ground surface. This well field, located adjacent to the Grand River, is characterized by only a couple meters of outwash deposits overlying bedrock.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8, and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Middleton WHPA resulted in the identification of a few well clusters, septic system clusters and numerous underground service clusters within the WHPA-B through WHPA-D zones, which warranted an increased ISI.~~

~~Although the Middleton Street wells are classified as GUDI with effective filtration, there is a lack of evidence of connection between the Middleton Street wells and the Grand River and, therefore, no WHPA-E zone has been delineated for the Middleton Street wells.~~

~~Trichloroethylene (TCE), sodium and chloride have been identified as Issues for the Middleton Street wells. The corresponding Issue Contributing Area has been delineated as the 25-year capture zone for the Middleton Street wellfield.~~

~~The water quality threats assessment shows that 955 activities on 681 properties, and 9 conditions, may be significant threats within WHPA-A, B, and ICA.~~

~~Shades Mill Well Field~~

~~The water supply for the Shades Mill well field is obtained from production wells G7, G8, G38 and G39. The production wells are completed within the Grand River Outwash Sediments Aquifer (AFA2) and screened from 14 m BGS to 43 m BGS.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8 and 6, WHPA-D, 6, 4 and 2. Several clusters of wells, septic systems and underground services were identified in the Shades Mills Wellhead Protection area within the WHPA-B through WHPA-D of the production wells, which warranted an increased ISI.~~

~~Wells G38 and G39 are classified as GUDI wells with effective filtration due to their proximity to the Shades Mill Reservoir. As such, a WHPA-E zone has been delineated in addition to the WHPA-A to D. The vulnerability score of the WHPA-E is 6.3.~~

~~The water quality threats assessment shows that 152 activities on 63 properties, and 3 conditions, may be significant threats within WHPA-A and B. No water quality Issues or Issue-based threats have been identified.~~

~~Fountain Street Well Field~~

~~The water supply for the Fountain Street well field is obtained from production well P16. A Class Environmental Assessment was completed in 2014 for the addition of a new well on Maple Grove Rd. (P18) to the Fountain Street Wellfield (MTE, 2014). Production well P16 is screened from approximately 33 m BGS to 38 m BGS, while P18 is screened from approximately 43 to 53 m BGS. Both wells are screened within the Pre-Catfish Creek Aquifer (AFD1).~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 6 and 4, WHPA-D 4 and 2. Vulnerability scores have been increased in parts of WHPA-B through D to account for transport pathways (several clusters of wells, septic systems underground services).~~

~~The water quality threats assessment shows that 19 activities on 6 properties may be a significant threat within WHPA-A. No water quality Issues or Issue-based threats have been identified.~~

~~Willard Well Field~~

~~The water supply for the Willard well field is obtained from production well G15 with a screen depth of approximately 28 to 58 m below ground surface in the bedrock aquifer. A thin layer of gravel deposits is found overlying the bedrock in this area.~~

~~The Willard Wellfield has been classified as GUDI with effective filtration, and thus a WHPA-E protection zone has been delineated with a score of 8.1.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 6, 4 and 2, WHPA-D, 4 and 2. Analysis of the attributes of each potential transport pathway in the Willard WHPA identified well and septic system clusters within the WHPA-A through D zones that warranted increases to the ISI. Similarly, analysis of the attributes of each potential transport pathway in the Willard WHPA-E resulted in the identification of numerous storm sewers which were incorporated into the final WHPA-E delineation.~~

~~The water quality threats assessment shows that 54 activities on 42 properties may be significant threats within the WHPA-A, B and E. No Issues or Issues-based threats have been identified.~~

~~26.4.18 Ayr – Region of Waterloo~~

~~The water supply for the Ayr well field is obtained from production wells A1, A2 and A3. All of the production wells are screened from approximately 43 to 51 m below ground surface within the Pre-Catfish Creek Aquifer (AFD1), which is overlain by an aquitard and aquifer sequence including the Middle Maryhill Till (ATB2) and Waterloo Moraine Sands (AFB1/AFB2). The Ayr water supply system supplies water to approximately 4,337 people.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 6 and 4, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Ayr WHPA resulted in the identification of well clusters within the WHPA-B through WHPA-D and two adjacent areas defined as aggregate resources in the WHPA-D which warranted an increase to the ISI.~~

The water quality threats assessment shows that 14 activities on 9 properties may be a significant threat within WHPA-A and B. No Issues or Issue-based threats were identified within the municipal groundwater system.

26.4.19 Branchton Meadows – Region of Waterloo

The water supply for the Branchton Meadows well field is obtained from production wells BM1, BM2 and BM3. BM1 and BM2 wells are open hole within a dense sand and gravel conglomerate unit approximately 29 m to 34 m BGS. BM3 was completed slightly deeper as open hole from 39 to 47 m BGS in the Guelph Formation bedrock aquifer. Near the wells, a vertically extensive surficial aquitard overlies the dense sand and gravel conglomerate. The Branchton Meadows system supplies water to approximately 121 people.

Final vulnerability scores include; WHPA-A, 10, WHPA-B, 6, WHPA-C, 4, WHPA-D, 4 and 2. Several septic systems are located adjacent to the wells within WHPA-A and WHPA-D zones that warranted an increase to the ISI at this wellfield.

Chloride has been identified as Issue for the Branchton Meadows well. The corresponding Issue Contributing Area has been delineated as the 25-year capture zone for the Branchton Meadows wellfield.

The water quality threats assessment shows that 10 activities on 7 properties may be significant threats within WHPA-A and the Issue Contributing Area.

26.4.20 Conestogo – Region of Waterloo

The water supply for the Conestogo wellfield is obtained from production wells C3, C4, C5 and C6, which provide water to approximately 864 people. Production wells C5 and C6 are referred to as the Conestogo Golf wellfield, while wells C3 and C4 are collectively referred to as the Conestogo Plains wellfield. These two wellfields are found on opposite sides of the river from each other. All of the production wells are screened at depths ranging from 15 m BGS to 33 m BGS within the Pre-Catfish Creek Aquifer (AFD1), which is a confined aquifer system separated from surface and the overlying Middle Waterloo Moraine Sands (AFB2) by an extensive aquitard unit corresponding to the Maryhill and Catfish Creek Tills.

The intrinsic vulnerability of the Conestogo Golf wellfield (Wells C3 and C4) is low. Final vulnerability scores are 10 in WHPA-A, 6 in WHPA-B and 4 and 2 in WHPA-C and D, respectively. There were no increases in the vulnerability scoring to account for transport pathways.

The intrinsic vulnerability of the Conestogo Plains wellfield (Wells C5 and C6) ranges from low to moderate, with minimal high intrinsic vulnerability. Final vulnerability scores are 10 in WHPA-A, 8 and 10 in WHPA-B, 4 to 8 in WHPA-C and 2 and 4 in WHPA-D. Vulnerability scores have been increased in WHPA – B, C and D to account for transport pathways (clusters of wells and underground service).

The water quality threats assessment shows that 43 activities on 34 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.

26.4.21 Elmira – Region of Waterloo

~~The water supply for the Elmira well field is obtained from production well E10. The production well is completed with a screened interval of approximately 45 to 53 m below ground surface within the Pre-Catfish Creek Aquifer (AFD1), which overlies bedrock~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 8, 6 and 4, WHPA-D, 6, 4 and 2. Analysis of the attributes of each potential transport pathway in the Elmira WHPA resulted in the identification of well and septic system clusters situated in the WHPA-A through WHPA-D that warranted increases to the ISI.~~

~~The water quality threats assessment shows that 34 activities on 7 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.22 Foxboro Green – Region of Waterloo~~

~~The water supply for the Foxboro Green wellfield is obtained from production wells FG1, FG2A, and FG4. All of the production wells are open hole at depths ranging from 47 m BGS to 67 m BGS within the Salina bedrock aquifer. The bedrock is overlain by units consistent with the Pre-Catfish Creek Aquifer (AFD1), Catfish Creek (ATC1), the Maryhill Tills (ATB1 & ATB2) and the Waterloo Moraine Sands present near ground surface The Foxboro water supply system serves a population of approximately 410.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 6, WHPA-C, 4, WHPA-D, 2. There were no increases in the vulnerability scoring to account for transport pathways~~

~~The water quality threats assessment shows that 1 activities on 1 property may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.23 Heildelberg – Region of Waterloo~~

~~The water supply for the Heidelberg well field is obtained from production wells HD1 and HD2. All of the production wells are screened at depths ranging from approximately 54 m to 60 m below ground surface within the Pre-Catfish Creek Aquifer (AFD1), which is overlain by stratigraphic units consistent with the Catfish Creek (ATC1) and Maryhill Tills (ATB2) and the Waterloo Moraine Sands (AFB1/AFB2) near ground surface. The Heidelberg water supply system serves a population of approximately 1,013.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 4, WHPA-D, 2. Analysis of the potential transport pathways in the Heidelberg WHPAs identified several clusters of septic systems and wells in WHPA-A and WHPA-B that warranted increases to the ISI.~~

~~The water quality threats assessment shows that 25 activities on 14 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.24 Linwood – Region of Waterloo~~

~~The water supply for the Linwood well field is obtained from production wells L1A and L2. These production wells are open hole within bedrock of the Bois Blanc/Salina formations at depths ranging from 64 m to 80 m below ground surface. It supplies water to approximately 781 people.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 4 and WHPA-D, 2. Analysis of the potential transport pathways in the Linwood WHPA noted several clusters of septic systems and wells within the WHPA-A through WHPA-C zones that warranted increases to the ISI.~~

~~The water quality threats assessment shows that 27 activities on 15 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.25 Maryhill – Region of Waterloo~~

~~The water supply for the Maryhill well field is obtained from production wells MH1, MH2, MH3 and MH4A. There are two separate distribution systems that cover only a portion of the settlement area. MH1 and MH2 (Maryhill) distribute water to approximately 141 people, while MH4A and MH5 (Maryhill Heights) distribute to approximately 143 people. All of the production wells are screened within sand and gravel in the Pre-Catfish Creek Aquifer (AFD1) at depths ranging from 18 m to 33 m below ground surface.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10, 8 and 6, WHPA-C, 6 and 4, WHPA-D, 4 and 2. Analysis of the potential transport pathways in the WHPAs for the Maryhill wells located several clusters of septic systems and wells in WHPA-A through WHPA-D that warranted increases to the ISI.~~

~~The water quality threats assessment shows that 42 activities on 25 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.26 New Dundee – Region of Waterloo~~

~~The water supply for the New Dundee well field is obtained from Production Wells ND4 and ND5. The production wells are screened at depths ranging from 14 m BGS to 16 m BGS within the Middle Waterloo Moraine Sands (AFB2). AFB2 is between the Maryhill Till (ATB2) aquitard and the overlying Upper Waterloo Moraine Sands (AFB1Since the Upper Maryhill Till (ATB1) is not present in this area, AFB2 and AFB1 act as a single aquifer in the area resulting in the use of AFB1 for the vulnerability scoring at this Wellfield. The New Dundee water supply system serves a population of approximately 1,049.~~

~~Final vulnerability scores include; WHPA-A, 10, WHPA-B, 10 and 8, WHPA-C, 8 and 6, WHPA-D, 6 and 4. Since the Upper Maryhill Till (ATB1) is not present in this area, AFB2 and AFB1 act as a single aquifer in the area resulting in the use of AFB1 for the vulnerability scoring at this Wellfield.~~

~~The water quality threats assessment shows that 43 activities on 26 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

26.4.27 New Hamburg – Region of Waterloo

The water supply for the New Hamburg well field is obtained from Production Well NH3, with NH4 installed for operational redundancy. This production wells are open hole from approximately 57 to 76 m BGS within the bedrock of Salina Formation. Overlying material corresponds to Catfish Creek Till (ATC1) and pre-Catfish Creek (AFD1) aquifer deposits. A portion of WHPA-B through WHPA-D extends into the Township of Perth East.

Final vulnerability scores include: WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 4, WHPA-D, 2. Analysis of the potential transport pathways within the WHPA areas noted several clusters of septic systems and wells within the WHPA-B zone that warranted increases to the ISI

The water quality threats assessment shows that 16 activities on 7 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.

26.4.28 Roseville – Region of Waterloo

The water supply for the Roseville well field is obtained from production wells R5 and R6. The production wells have screen depths ranging from 48 to 52 m below ground surface within Lower Waterloo Moraine or Catfish Creek Till Outwash Aquifer (AFB3), and are overlain by the Catfish Creek (ATC1) and Maryhill Till (ATB2) units, with the Waterloo Moraine Sands (AFB1/AFB2) identified near ground surface. The Roseville system supplies water to approximately 290 people.

Final vulnerability scores include; WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 6 and 4, WHPA-D, 4 and 2.Analysis of the potential transport pathways within the WHPA areas noted several clusters of septic systems and wells within the WHPA-A through WHPA-D zones that warranted increases to the ISI.

The water quality threats assessment shows that 25 activities on 22 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.

26.4.29 St. Clements – Region of Waterloo

The water supply for the St. Clements well field is obtained from production wells SC2, SC3 and SC4. SC2 and SC3 are screened over depths ranging from 15 m to 20 m below ground surface within the Upper Waterloo Moraine Sands (AFB1) and resulted in the application of AFB1 for vulnerability scoring. SC4 is screened deeper in the Middle Waterloo Moraine Sands (AFB2) from approximately 30 to 37 m BGS but is hydraulically connected to the AFB1 unit due to the absence of the ATB1 till unit. The St. Clements water supply system serves a population of approximately 1,267.

Final vulnerability scores include: WHPA-A, 10, WHPA-B, 10, WHPA-C, 8 and 6, WHPA-D, 6, 4, and 2. Vulnerability scores have been increased in WHPA-A through D to account for transport pathways (clusters of wells and septic systems).

The water quality threats assessment shows that 73 activities on 62 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a

~~review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.30 Wellesley – Region of Waterloo~~

~~The water supply for the Wellesley well field is obtained from Production Wells WY1 and WY5. WY1 is screened within a sand and gravel unit corresponding to the Pre-Catfish Creek Aquifer (AFD1) from 45 m BGS to 54 m BGS, while WY5 is screened across both aquifer AFD1 and approximately 3 m of dolostone bedrock from 45 to 54 m BGS The Wellesley water supply system serves a population of approximately 3,472.~~

~~Final vulnerability scores include: WHPA-A, 10, WHPA-B, 8 and 6, WHPA-C, 4, WHPA-D, 6 and 2. Analysis of the attributes of each potential transport pathway in the Wellesley WHPA resulted in the identification of two aggregate properties within WHPA-D, and several well clusters within the WHPA-A and WHPA-B zones that warrant increased ISI.~~

~~The water quality threats assessment shows that 20 activities on 6 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.31 Hidden Valley~~

~~The Hidden Valley intake is located on the Grand River, supplies the Mannheim Water Treatment Plant and is part of the Integrated Urban System (IUS) that serves approximately 488,342 (2009) people.~~

~~The source vulnerability factor of 0.9 has been assigned to this Type C intake. The overall vulnerability scores are 9 for IPZ-1 and 7.2 for IPZ-2. The IPZ-3 for the Hidden Valley intake extends up the Grand and Conestogo Rivers. Vulnerability scores for the IPZ-3 range from 7.2 in close proximity with urban runoff potential to 0.9 for far proximity undeveloped lands such as wetlands and forests.~~

~~The water quality threats assessment shows that no significant threats were identified for the Hidden Valley intake. An issues-based threats analysis was also completed through a review of water quality data collected from the intake. No issue-based threats were identified for this municipal surface water system.~~

~~26.4.32 Acton – Town of Halton Hills~~

~~The Community of Acton has six wells which serve a population of approximately 9,500, all located in the Credit Valley Source Protection Area. Portions of WHPA-B, C, D for these wells cross into the Grand River Source Protection Area, with vulnerability scores of 2 - 8. Nitrate has been identified as an issue for one of these wells (Davidson Well 1), and the Issue Contributing Area delineated for it partly overlaps into the Grand River Source Protection Area as well.~~

~~The water quality threats assessment shows 21 activities on 3 properties may be significant drinking water threats, within the Grand River Source Protection Area. Both threats-based and issue-based threats have been enumerated and are located within the WHPA-B, WHPA-C, and Issue Contributing Area.~~

~~26.4.33 Milverton – Township of Perth East~~

~~The Milverton municipal well, located in the Village of Milverton in the Township of Perth East, serves a population of approximately 1,750 people. The drinking water system consists of two bedrock wells: Well 4 and Well 6. Both wells are completed in the Amherstburg Formation. The bedrock is reached at a depth of approximately 40 m.~~

~~Final vulnerability scores include 10 in WHPA-A, 6 in WHPA-B, and 2 in WHPA-C and D. There were no increases to the vulnerability to account for transport pathways.~~

~~The water quality threats assessment shows that 4 activities on 3 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.34 Bright – County of Oxford~~

~~The Bright water system in the County of Oxford includes two wells, referred to as Well 4A and Well 5, located at a site in the west part of the village. Well 5 is completed to a depth of 25.9 m below ground surface (bgs) in the Waterloo Moraine sand and gravel aquifer. Well 4A is completed to a depth of 26.7 m bgs and is screened across the Waterloo Moraine sand and gravel aquifer. Final vulnerability scores include 10 in WHPA-A, 10 and 8 in WHPA-B, 8, 6 and 2 in WHPA-C and 4 and 2 in WHPA-D. There were no increases to the vulnerability to account for transport pathways.~~

~~The water quality threats assessment shows that 32 activities on 31 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.35 Drumbo-Princeton – County of Oxford~~

~~The community of Drumbo and Princeton are supplied by groundwater from three wells: Well 1, Well 2A and Well 3Well 1 is screened over a depth interval of 33 to 37 m bgs. Water well records indicate that the approximate screen depth intervals are 40 to 44 m bgs at Well 2A and 26 to 32 m bgs at Well 3. The well completion zones were considered to be part of the deep overburden sand silty aquifer Final vulnerability scores include 10 in WHPA-As, 6 in WHPA-Bs, 4 in WHPA-Cs and 2 in WHPA-Ds. There were no increases to the vulnerability to account for transport pathways.~~

~~The water quality threats assessment shows that 16 activities on 8 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.36 Plattsville – County of Oxford~~

~~The Plattsville water system is supplied by two overburden wells located on the western edge of the community. Both wells, completed at depths ranging from 12 to 15 m below ground surface, tap an unconfined, shallow overburden aquifer. Final vulnerability scores include 10 in WHPA-A, and B, 8 in WHPA-C and 6 and 4 in WHPA-D. There were no increases to the vulnerability to account for transport pathways.~~

~~The water quality threats assessment shows that 13 activities on 6 properties may be significant threats within WHPA-A and B. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~Village of Lynden – City of Hamilton~~

~~The City of Hamilton operates a groundwater source water supply system in the hamlet of Lynden that serves 380 people. The water supply system is comprised of two wells which draw water from a confined gravel aquifer that is situated directly on the bedrock surface. Vulnerability, assessed using the SAAT method, is low. Vulnerability scores in most of the wellhead protection are moderate to low with an area of high vulnerability within the 100-metre area around the wells.~~

~~The water quality threats assessment shows that 26 activities on 7 properties may be significant threats within WHPA-A. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.37 Airport – County of Brant~~

~~The Airport groundwater supply provides water to 764 users. The water supply source at the Airport site consists of one operational pumping well that is completed in an unconfined sand and gravel aquifer. A second pumping well was constructed in 2014 to meet projected future demands in addition to providing redundancy during maintenance and fire flow conditions; this well is in the process of being connected to the existing water distribution system. Intrinsic vulnerability, assessed using the surface to aquifer advection time (SAAT) method, is high. Vulnerability scores are high in the WHPA-A, B and C and medium in WHPA-D. There were no increases to the vulnerability to account for transport pathways.~~

~~The water quality threats assessment shows that 79 activities on 21 properties may be significant threats within WHPA-A, B and C. An Issues-based threats analysis was also completed through a review of water quality data collected from the municipal wells. No Issue-based threats were identified within the municipal groundwater system.~~

~~26.4.38 Mount Pleasant – County of Brant~~

~~The Mount Pleasant groundwater supply provides water to 801 users. The Mount Pleasant well field consists of two wells completed in a sand and gravel aquifer that exists under unconfined conditions in the vicinity of the well site. The aquifer is overlain by a glacial till aquitard with a thickness up to 65 metres in the vicinity of the wells. Intrinsic vulnerability, assessed using the SAAT method, is medium to high. In general, vulnerability scores are high in the WHPA-A, B and C and medium in WHPA-D. Vulnerability scores were adjusted within the aggregate operation limits (primarily within WHPA-D) to reflect the increased risks posed by the potential reduced surface to well travel times.~~

~~An Issues evaluation was also completed through a review of water quality data collected from the municipal wells. Chloride concentrations have declined since 2008 and is no longer identified as an Issue for the Mount Pleasant well supply system.~~

~~The water quality threats assessment shows that 38 activities on 9 properties may be significant threats within WHPA-A, B and C.~~

~~26.4.39 St. George – County of Brant~~

~~The St. George well field provides water to 572 users in the former village of St. George. The water supply system consists of the three wells located in one pumping station. The St. George wells, which flow under non-pumping conditions, are completed in a confined to semi-confined sand and gravel aquifer. Intrinsic vulnerability, assessed using the SAAT method, is primarily medium to high. Vulnerability scores are high in the WHPA-A, B and C and generally medium in WHPA-D. There were no increases to the vulnerability to account for transport pathways.~~

~~An Issues evaluation was also completed through a review of water quality data collected from the municipal wells. Nitrate is identified as an Issue for the St. George wells. The 25-year capture zone has been delineated as the Issue Contributing Area for the wells.~~

~~The water quality threats assessment shows that 218 activities and on 93 properties, and 2 conditions, may be significant threats within WHPA-A, B, and the Issue Contributing Area in the overburden well supply; 10 activities on 3 properties may be significant threats within WHPA-A and Bin the bedrock well supply.~~

~~26.4.40 Town of Paris – County of Brant~~

~~The community of Paris is supplied by three well fields; Bethel, Gilbert and Telfer that provide water to 12,651 users. Within the north Paris area, there are three general hydrogeologic units: an upper, unconfined aquifer, an intermediate unit that has been characterized as an aquitard (primarily glacial till consisting of Catfish Creek and Port Stanley Till units) with some aquifer units within it, and a lower bedrock aquifer. These two aquifer units form the two groundwater supply sources for the north Paris wellfields.~~

~~The Gilbert well field consists of 8 wells; 6 wells are completed in the upper overburden aquifer, and 2 wells are completed in the upper bedrock (Salina Formation).~~

~~Three wells comprise the Telfer well field, P31, P32 and P36. Wells P31 and P32 are bedrock wells, while P36 is an overburden well that is currently inactive.~~

~~The thickness of the overburden varies up to approximately 60 m and locally along parts of the Grand River the overburden is absent. The surficial overburden deposits are mostly sand and gravel.~~

~~Vulnerability for the overburden wells was assessed using the SAAT method. The overburden Gilbert wells are in an area of high intrinsic vulnerability. Vulnerability scores are high in the WHPA-A and WHPA-B, and high to medium in the WHPA-C. Vulnerability for the bedrock wells was assessed using the intrinsic susceptibility index (ISI) method. The vulnerability of the bedrock wells is generally low. Vulnerability scores are high in the WHPA-A but drop to medium in the WHPA-B and low in the WHPA-C and D except where the wellhead protection areas are overlain by the wellhead protection areas for other north Paris overburden wells. Vulnerability scores in the WHPA-D for the bedrock aquifer have been adjusted to account for transport pathways (aggregate pits), although there is no change to the final mapping as the overburden aquifer was already a high vulnerability.~~

~~Four wells at the Bethel Road site are completed in the intermediate to deep overburden sediments and are considered to be groundwater under the direct influence of surface water (GUDI) with effective filtration due to the unconfined nature of the aquifer that would allow for relatively rapid infiltration of surface water. In general, vulnerability for the Bethel Road wellfield~~

~~is high. Vulnerability scores are high in the WHPA and B, high to medium in WHPA-C and medium in WHPA-D.~~

~~An Issues evaluation was also completed through a review of water quality data collected from the municipal wells. Nitrate is identified as an Issue for the Gilbert overburden wells and the Telfer wells. For the Gilbert overburden wells and Telfer wells, the 25-year capture zone, based on average current pumping rates, has been delineated as the Issue Contributing Area for the wells.~~

~~The water quality threats assessment shows that 257 activities on 74 properties may be significant threats within the WHPA-A, B, C, and the Issue Contributing Areas for the north Paris wellfields (Gilbert and Telfer). 46 activities on 7 properties may be significant threats within the WHPA-A, and B for the Bethel Road wells.~~

~~26.4.41 Brantford - Water Treatment Plant~~

~~The Brantford Water Treatment Plant is owned and operated by the City of Brantford and treats water from the Grand River via the Holmedale Canal. The Brantford Water Treatment Plant is a class IV facility servicing the City of Brantford and the town of Cainsville, County of Brant, with a population of approximately 99,000. This plant has a rated capacity of 100,000 m3/day. The raw water access to the Holmedale Canal is located approximately 1.5 km upstream of the water treatment plant.~~

~~The source vulnerability factor of 1.0 was assigned to this Type C intake. The overall vulnerability scores are 10 for IPZ-1 and 9 for IPZ-2. The IPZ-3 for the Holmedale Water Treatment Plant extends up the Grand, Nith, Speed and Conestogo Rivers. Vulnerability scores for the IPZ-3 range from 8 for close proximity with an urban runoff potential to 1 for far proximity with a low runoff potential.~~

~~An issues evaluation was also completed through a review of water quality data collected from the drinking water intake. Organic nitrogen and E. coli were identified as parameters of concern for the Brantford Water Treatment Plant water supply that require further, more detailed spatial and temporal monitoring before a determination can be made whether these parameters are Issues under Technical Rule 114.~~

~~The water quality threats assessment shows that 273 activities on 195 properties may be significant threats within IPZ-1, 2 and 3.~~

~~26.4.42 Six Nations (Ohsweken)~~

~~Six Nations uses the Grand River as a source of water for a communal water system at Ohsweken. This water system is a First Nations system, but under a resolution from Six Nations requesting the Minister of the Environment to request the Lieutenant Governor in Council to make a regulation the Six Nations' Grand River intake at Ohsweken was brought into the Grand River Assessment Report. The water treatment plant has a design capacity of 1,040 m3/day and serves a population of approximately 2,000.~~

~~The source vulnerability factor of 1.0 was assigned to this Type C intake. The overall vulnerability scores are 10 for IPZ-1 and 8 for IPZ-2. The IPZ-3 for Ohsweken extends up the Grand, Nith, Speed and Conestogo Rivers, Fairchild Creek, and well as other smaller tributaries. Vulnerability scores for the IPZ-3 range from 8 for close proximity with an urban runoff potential to 1 for far proximity with a low runoff potential.~~

~~An Issues-based threat analysis was also completed using water quality from upstream locations as very little data exists for the raw water quality at the Ohsweken Water Treatment Plant. No Issue-based threats were identified, but there is a high uncertainty associated with this assessment. It is recommended that further, more intensive sampling of the raw water at the Ohsweken WTP be completed.~~

~~The water quality threats assessment shows that 52 activities on 25 properties may be significant threats within the IPZ-2 (off-reserve) and IPZ-3.~~

~~26.4.43 Dunnville – County of Haldimand~~

~~Lake Erie Intake~~

~~The Dunnville Water System, operated by the Corporation of Haldimand County, is situated on the shore of Lake Erie at the mouth of the Grand River. Raw water is collected from a pumping station 10km away in Port Maitland through an intake pipe located in Lake Erie approximately 460m offshore. The pumping station has a design capacity of 26,400 m3/day and supplies both the Dunnville Water Treatment Plant and the Port Maitland industrial area. The Dunnville plant has a design capacity of 14,500 m3/day and serves a population of approximately 11,300.~~

~~The source vulnerability factor of 0.7 was assigned to this Type A intake. The overall vulnerability scores are 7 for IPZ-1 and 4.9 for IPZ-2.~~

~~There are no significant drinking water threats for the Dunnville Water System.~~

~~Grand River Emergency Intake~~

~~In addition to the Lake Erie Intake and emergency drinking water intake is located in the Grand River. This intake is only operated under extreme circumstances. The source vulnerability factor of 1.0 was assigned to the Type D intake. The overall vulnerability scores is 10 for IPZ-1 and 8 for IPZ-2.~~

~~The water quality threats assessment shows that there are 12 activities on 6 properties that may be significant drinking water threats. All activities are located in IPZ-1. There were no significant drinking water threats enumerated in IPZ-2.~~

~~27.0 TABLE : SUMMARY ENUMERATION OF SIGNIFICANT WATER QUALITY THREATS FOR THE GRAND RIVER SOURCE PROTECTION AREA~~

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Southgate - Dundalk	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Melancthon - Shelburne	0	0	2	0	2	0	2	0	1	0	0	0	0	1	0	0	0	0	8
Grand Valley - Grand Valley	0	1	1	0	1	0	0	0	1	0	0	0	0	23	6	0	0	0	33
Amaranth - Waldemar	1	35	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	39

~~Threat Activity2 / Municipality - Well System~~	~~Waste Disposal Sites~~	~~Sewage Systems or Sewage Works~~	~~Application of ASM to Land~~	~~Handling and Storage of ASM~~	~~Application of NASM to Land~~	~~Handling and Storage of NASM~~	~~Application of Commercial Fertilizer to Land~~	~~Handling and Storage of Commercial Fertilizer~~	~~Application of Pesticide to Land~~	~~Handling and Storage of Pesticide~~	~~Application of Road Salt~~	~~Handling and Storage of Road Salt~~	~~Storage of Snow~~	~~Handling and Storage of Fuel~~	~~Handling and Storage of DNAPLs~~	~~Handling and Storage of Organic Solvents~~	~~Livestock Grazing / Pasturing, Outdoor Confinement Areas~~	~~The establishment and operation of a liquid hydrocarbon pipeline~~	~~Total~~
~~East Garafraxa - Marsville~~	~~0~~	~~7~~	~~1~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~10~~
~~Orangeville - Orangeville~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~11~~	~~7~~	~~5~~	~~0~~	~~9~~	~~0~~	~~0~~	~~0~~	~~32~~
~~Wellington North - Arthur~~	~~1~~	~~2~~	~~3~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0~~	~~3~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~1~~	~~0~~	~~0~~	~~14~~
~~Mapleton - Drayton~~	~~4~~	~~2~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~7~~	~~4~~	~~0~~	~~0~~	~~18~~
~~Mapleton - Moorefield~~	~~1~~	~~1~~	~~2~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~2~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0~~	~~9~~

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Centre Wellington - Fergus/Elora	32	209	5	6	5	5	0	0	2	1	416	416	416	69	141	32	5	0	1761
Guelph/ Eramosa - Rockwood	6	40	30	30	29	29	0	9	19	9	0	0	0	41	7	6	37	0	292
Guelph Eramosa - Hamilton Drive	1	24	7	7	7	7	2	5	1	0	0	0	0	3	9	1	7	0	82
Guelph - Guelph	60	471	68	19	0	4	2	27	67	38	0	0	2	284	608	160	20	0	1830
Halton -	0	3	2	2	0	0	3	3	2	1	0	0	0	1	0	1	3	0	21

~~Threat Activity2 / Municipality - Well System~~	~~Waste Disposal Sites~~	~~Sewage Systems or Sewage Works~~	~~Application of ASM to Land~~	~~Handling and Storage of ASM~~	~~Application of NASM to Land~~	~~Handling and Storage of NASM~~	~~Application of Commercial Fertilizer to Land~~	~~Handling and Storage of Commercial Fertilizer~~	~~Application of Pesticide to Land~~	~~Handling and Storage of Pesticide~~	~~Application of Road Salt~~	~~Handling and Storage of Road Salt~~	~~Storage of Snow~~	~~Handling and Storage of Fuel~~	~~Handling and Storage of DNAPLs~~	~~Handling and Storage of Organic Solvents~~	~~Livestock Grazing / Pasturing, Outdoor Confinement Areas~~	~~The establishment and operation of a liquid hydrocarbon pipeline~~	~~Total~~
~~Region of Waterloo - Waterloo~~	~~1~~	~~44~~	~~2~~	~~1~~	~~0~~	~~0~~	~~3~~	~~1~~	~~5~~	~~1~~	~~529~~	~~72~~	~~1~~	~~3~~	~~2~~	~~1~~	~~0~~	~~0~~	~~666~~
~~Region of Waterloo - Kitchener~~	~~11~~	~~603~~	~~56~~	~~43~~	~~4~~	~~5~~	~~87~~	~~46~~	~~22~~	~~10~~	~~1226~~	~~170~~	~~17~~	~~9~~	~~16~~	~~4~~	~~41~~	~~0~~	~~2370~~
~~Region of Waterloo - Cambridge~~	~~34~~	~~261~~	~~19~~	~~21~~	~~1~~	~~3~~	~~5~~	~~12~~	~~20~~	~~25~~	~~1229~~	~~215~~	~~21~~	~~32~~	~~18~~	~~14~~	~~5~~	~~0~~	~~1935~~
~~Region of Waterloo - Ayr~~	~~0~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~8~~	~~0~~	~~0~~	~~3~~	~~0~~	~~0~~	~~0~~	~~0~~	~~14~~

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Region of Waterloo - Branchton Meadows	0	8	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	10
Region of Waterloo - Conestogo	0	31	0	0	0	0	2	2	0	2	1	0	0	0	1	0	0	0	39
Region of Waterloo - Elmira	0	2	5	2	0	0	5	3	5	2	3	0	0	2	0	0	5	0	34
Region of Waterloo - Foxboro Green	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2

~~Threat Activity2 / Municipality - Well System~~	~~Waste Disposal Sites~~	~~Sewage Systems or Sewage Works~~	~~Application of ASM to Land~~	~~Handling and Storage of ASM~~	~~Application of NASM to Land~~	~~Handling and Storage of NASM~~	~~Application of Commercial Fertilizer to Land~~	~~Handling and Storage of Commercial Fertilizer~~	~~Application of Pesticide to Land~~	~~Handling and Storage of Pesticide~~	~~Application of Road Salt~~	~~Handling and Storage of Road Salt~~	~~Storage of Snow~~	~~Handling and Storage of Fuel~~	~~Handling and Storage of DNAPLs~~	~~Handling and Storage of Organic Solvents~~	~~Livestock Grazing / Pasturing, Outdoor Confinement Areas~~	~~The establishment and operation of a liquid hydrocarbon pipeline~~	~~Total~~
~~Region of Waterloo - Heidelberg~~	~~0~~	~~14~~	~~1~~	~~1~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0~~	~~3~~	~~0~~	~~0~~	~~2~~	~~0~~	~~25~~
~~Region of Waterloo - Linwood~~	~~0~~	~~14~~	~~0~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~	~~0~~	~~1~~	~~4~~	~~0~~	~~0~~	~~2~~	~~1~~	~~0~~	~~4~~	~~0~~	~~27~~
~~Region of Waterloo - Maryhill~~	~~0~~	~~25~~	~~3~~	~~0~~	~~0~~	~~0~~	~~3~~	~~0~~	~~2~~	~~3~~	~~4~~	~~0~~	~~0~~	~~2~~	~~0~~	~~1~~	~~2~~	~~0~~	~~45~~
~~Region of Waterloo - New Dundee~~	~~0~~	~~28~~	~~2~~	~~2~~	~~0~~	~~0~~	~~1~~	~~1~~	~~1~~	~~1~~	~~0~~	~~0~~	~~0~~	~~4~~	~~0~~	~~0~~	~~3~~	~~0~~	~~43~~

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Region of Waterloo - New Hamburg	0	6	1	1	0	0	2	1	1	1	1	0	0	2	0	0	0	0	16
Region of Waterloo - Roseville	0	23	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	25
Region of Waterloo - St. Clements	0	67	0	0	0	0	0	0	0	0	1	0	0	4	0	1	0	0	73
Region of Waterloo - Wellesley	0	1	1	1	0	0	1	2	1	2	6	0	0	3	0	0	2	0	20

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Region of Waterloo - Hidden Valley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perth East - Milverton	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	4
Oxford - Bright	0	29	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	32
Oxford - Drumbo-Princeton	0	7	4	0	0	0	4	0	0	0	0	0	0	0	0	0	1	0	16
Oxford - Plattsville	1	1	2	0	0	0	0	0	1	0	0	0	0	3	3	2	0	0	13

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Hamilton - Lynden	0	5	6	0	0	0	0	2	6	0	0	0	0	6	0	0	1	0	26
Brant - Airport	9	21	3	3	0	0	0	0	3	1	0	0	0	16	18	5	0	0	79
Brant - Mount Pleasant	0	10	7	4	0	0	1	0	3	0	3	3	0	5	1	1	0	0	38
Brant - St. George	4	77	31	21	0	0	39	17	6	4	0	0	0	12	3	3	12	1	230
Brant - Paris	12	45	42	37	0	0	37	13	31	11	0	0	0	26	20	6	17	2	299

Threat Activity2 / Municipality - Well System	Waste Disposal Sites	Sewage Systems or Sewage Works	Application of ASM to Land	Handling and Storage of ASM	Application of NASM to Land	Handling and Storage of NASM	Application of Commercial Fertilizer to Land	Handling and Storage of Commercial Fertilizer	Application of Pesticide to Land	Handling and Storage of Pesticide	Application of Road Salt	Handling and Storage of Road Salt	Storage of Snow	Handling and Storage of Fuel	Handling and Storage of DNAPLs	Handling and Storage of Organic Solvents	Livestock Grazing / Pasturing, Outdoor Confinement Areas	The establishment and operation of a liquid hydrocarbon pipeline	Total
Brantford - Homedale	0	11	29	34	0	0	0	0	192	0	0	0	1	0	0	2	4	0	273
Six Nations - Ohsweken	0	2	10	8	10	0	0	0	0	0	0	0	0	0	0	0	22	0	52
Haldimand - Dunnville L. Erie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haldimand - Dunnville Grand R.	0	4	0	0	0	0	0	1	0	1	2	0	1	0	2	1	0	0	12
Total	179	2137	347	243	60	53	203	147	402	116	3446	883	464	565	879	247	193	3	10,567

1. Values above were determined by adding the subcategory values together for each Prescribed Drinking Water Threat category, as shown in the Significant Drinking Water Quality Threats tables for each drinking water system.

~~2. There are no existing occurrences of Prescribed Drinking Water Threats numbers 5 or 18 within the Grand River Source Protection Area.~~
~~3. Conditions and local threats are not included~~

~~Table : Summary Enumeration of Significant Water Quantity Threats for the Grand River Source Protection Area~~

~~Threat Activity / Water Quantity Vulnerable Area~~	~~An activity that takes water from an aquifer or a surface water body without returning the~~	~~An activity that reduces the recharge of an aquifer (Km2):~~
~~Bethel WHPA-Q~~	~~19~~	~~2.43~~
~~Halton Hills~~	~~9~~	~~-~~
~~Orangeville~~	~~44~~	~~-~~
~~Centre Wellington~~	~~2,715~~	~~4.3~~
~~Total~~	~~2,787~~	~~-~~

~~28.0~~

~~29.0~~

~~30.0~~

~~31.0~~

~~32.0~~

~~33.0~~

~~34.0~~

~~35.0~~

~~36.0~~

~~37.0~~

~~38.0~~

~~39.0~~

~~40.0~~27.0 REFERENCES

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~~41.0~~28.0 MAP REFERENCES

These maps are for information purposes only and the Grand River Conservation Authority takes no responsibility for, nor guarantees, the accuracy of all the information contained within these maps.

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Additional references for specific maps are given in the table below:

Map #	Description	Reference
Map 2-5:	Population and Population Density in Watershed by Municipality and Reserve	Grand River Conservation Authority, August 2018. Summary of Population Statistics for Grand River Watershed.
Map 2-7:	Physiography of Grand River Watershed Area	Physiography of Southern Ontario Geological Survey dataset MRD228, Chapman, L.J. and Putnam, D.F. 2007. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.

Map #	Description	Reference
Map 2-8:	Hummocky Topography	Various Authors, 1967-1993, Quaternary and Pleistocene Geology, Southern Ontario, Ontario Geological Survey. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2003.
Map 2-10:	Bedrock Topography	Gao, C., Shirota, J., Kelly, R.I., Brunton, F.R. and van Haaften, S. 2006. Bedrock topography and overburden thickness mapping, southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 207.

Map #	Description	Reference
Map 2-11:	Bedrock Geology	Paleozoic Geology of Southern Ontario, Ontario Geological Survey dataset MRD219, Armstrong, D.K., Dodge, J.E.P., 2007. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.
Map 2-12:	Quaternary (Surficial) Geology	Various Authors, 1967-1993, Quaternary and Pleistocene Geology, Southern Ontario, Ontario Geological Survey. Ministry of Northern Development and Mines, Copyright © Queen's Printer, 2010.
Map 2-13:	Overburden Thickness	Holysh, S., Pitcher, J., and Boyd, D. 2001. *Grand River Regional Groundwater Study.* Grand River Conservation Authority, Cambridge, ON.
Map 2-14:	Water Table Surface of the Grand River Watershed	AquaResource Inc. 2009a. Integrated Water Budget Report, Grand River Watershed: Final Report, June 2009.
Map 2-15:	Potentiometric Surface of the Grand River Watershed	AquaResource Inc. 2009a. Integrated Water Budget Report, Grand River Watershed: Final Report, June 2009.

Map #	Description	Reference
Map 2-17:	Groundwater Discharge Map	Groundwater Discharge derived from Figure 70 (page 169) of: AquaResource Inc., June 2009. Final GRCA Integrated Water Budget Report.
Map 2-18:	Average Annual Temperature	Based on Environment and Climate Change Canada data. Produced using information under License with the Grand River Conservation Authority © Grand River Conservation Authority, 2019.
Map 2-19:	Average Annual Precipitation	Based on Environment and Climate Change Canada data. Produced using information under License with the Grand River Conservation Authority © Grand River Conservation Authority, 2019.
Map 18-2:	Groundwater Discharge Map in the Grand River Watershed	Groundwater Discharge derived from Figure 70 (page 169) of: AquaResource Inc., June 2009. Final GRCA Integrated Water Budget Report.
Map 18-4:	Water Quantity Stress Levels by Groundwater Assessment Area within the Grand River Watershed	Adapted from AquaResource Inc. 2009. Tier 2 Water Quantity Stress Assessment Report: Grand River Watershed, Final Report December 2009. AquaResource Inc., Breslau, ON.
Maps 19-1 to 19-12:	Region of Waterloo Tier 3 Water Budget and Risk Assessment	Matrix Solutions Inc. 2014. Region of Waterloo Tier Three Water Budget and Local Area Risk Assessment. Matrix Solutions Inc., Waterloo, ON.
Maps 20-1 to 20-12:	Whitemans Creek Tier 3 Water Budget and Risk Assessment	Earthfx Inc., 2018. Whitemans Creek Tier Three Local Area Water Budget and Risk Assessment: Risk Assessment Report.
Maps 22-1 to 22-8:	Centre Wellington Tier 3 Water Budget and Risk Assessment	Matrix Solutions Inc. 2020. Centre Wellington Tier Three Water Budget Final Risk Assessment Report. Matrix Solutions Inc., Guelph, ON.

~~41.1 APPENDIX A~~
~~Public Consultation Comments~~

~~**Draft Updated Grand River Source Protection Plan**~~

~~**Summary of Public Comments and How Comments were Addressed**~~

~~The public consultation period was scheduled from January 25 to February 28, 2023. Public consultation comments and how they are addressed can be found in Table 1.~~

~~Detailed public consultation comments and how they were addressed for previous iterations of the Grand River Assessment Report are available upon request.~~

~~**Table 1: Public consultation comments that address the amendments proposed in this update**~~

~~Number~~	~~AR Section~~	~~Comment~~	~~How Comment is Addressed~~
~~1~~	~~S5, Dufferin County~~	~~Source: Ministry of the Environment, Conservation and Parks~~ ~~The version of the Technical Rules should have been mentioned in **5.3.3. Drinking Water Threats Assessment**: "…as set out in the Director's Technical Rules, Clean Water Act, 2006." Please update to refer to the 2021 Technical Rules (Page 5.70).~~	~~Sentence amended to read, "…as set out in the 2021 Director's Technical Rules, Clean Water Act, 2006."~~
~~2~~	~~S5, Dufferin County~~	~~Source: member of the public~~ ~~RE: Source Water Protection Report dated December 20, 2022~~ ~~My comments set out below relate to the Melancthon portion of the report, more specifically to the area surrounding wells 7 and 8 of the Shelburne water supply system.~~ ~~I consider it mandatory that the report state clearly that tile draining is an acceptable farming practice in the WHPA in the western portion of the Township.~~ ~~An inescapable characteristic of the western portion of the Township is that a high percentage of the agricultural land is plagued by having a high water level and poor natural drainage. In order to participate in the modern agricultural industry the poor drainage if eliminated by tile drainage – it's essential.~~ ~~I recognize that tile draining is not identified on the list of "Transport Pathways" that could represent a significant drinking water threat. However the list is usually qualified by the words "may include, but are not limited to the following". So where does that leave tile draining – maybe yes, maybe no, we would have to look at it. With a WHPA of over 1000 acres it is long past the time to have had a look at it.~~	~~Tile draining is not a prescribed drinking water threat activity under the *Clean Water Act, 2006*, and as such, cannot be managed or restricted through policies in source protection plans. If, for example, tile draining on a particular property was determined to be a transport pathway, the vulnerability scores of the WHPAs overlapping the area of the transport pathway, could potentially be increased because of the presence of the transport pathway. This may result in the identification of significant drinking water threat(s). These threats are currently restricted to 20 prescribed drinking water quality threat activities.~~ ~~Further, and specific to PW7 and PW8, groundwater for these wells is drawn from a deep bedrock aquifer. The bedrock aquifer which supplies these wells is protected by an~~

Number	AR Section	Comment	How Comment is Addressed
		Any restriction on tile draining would have an unacceptable negative impact on agricultural and, undoubtedly even worse, would be potential hit on property values. Restricting tile draining on a clean 100 acre farm inhibiting the usual poor drainage could easily result in a hit of $500,000. If this ends up to be the case we have to seriously question why the source wells were located here, especially when there exists a clear alternative with less risk and little or no impact on active agriculture. I refer specifically to the rough lands east / northeast of town. In conclusion, I restate my main issue. The report must clearly state that tile draining is an acceptable farming practice in the WHPA.	aquitard overburden unit (Tavistock Till) and bedrock (Eramosa Formation) which also behaves as an aquitard, which both slow the downward movement of water. Tile drains are typically shallow installations, which means they would be located in the upper overburden unit. It is very unlikely that there is a connection between water conveyed through the tile drains and the aquifer which supplies the municipal wells.

APPENDIX B
Written Notice from Director Classifying Intakes per Technical Rule 55.1
Requests for Approval of Alternative Approach

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APPENDIX C
Correspondence Regarding Excavation that Breaches the Aquitard

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