Well Water Research Project

TO:	Chair and members of the Board of Health
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Recommendations

It is recommended that the Board of Health:

1. **Receive this report for information.**

Key Points

- The Well Water Research Project identifies opportunities to reduce the burden of enteric illness related to drinking water in Wellington, Dufferin and Guelph (WDG). It's objectives are:
  - To understand WDG well water sampling frequency trends and adverse results.
  - To increase the number of private domestic wells that are regularly tested for bacteriological contamination.
  - To identify and raise awareness of environmental risk factors that may increase the potential for contamination of wells.
- Private well owners are responsible for the safety of their drinking water.
  - Only 44.2% of wells in WDG were tested at least once between 2011 and 2015
  - Annual sampling rates were lower, with an average of 14.7% of wells in WDG sampled each year.
- Bacterial contamination was detected in 19% of samples submitted in WDG. Nearly 3% contained evidence of *E.coli* bacteria.
- Descriptive spatial analyses detected 13 geographic areas that had an increased risk of bacterial contamination. Four of these clusters are detailed in the report.
- Next steps will investigate barriers to well water sampling and explore potential environmental causes for the high risk clusters.

Discussion

Background

In WDG, 100% of drinking water comes from groundwater sources. Many residents in cities and towns get their drinking water from municipal supply systems. These municipalities are responsible for making sure that the water delivered to people's homes is safe to drink. On the other hand, residents who get their water from a private domestic well are responsible for the quality of their own drinking water. Private well owners can have the bacteriological quality of their well water tested for free through public health. Unfortunately, data suggests that well water sampling for bacterial contamination is quite low in other Ontario communities.[1, 2] A recent Canadian study found that individuals who receive their water from private wells have a 5.2 times higher risk of enteric disease than those who get their water from municipal groundwater systems.[3]

Wellington-Dufferin-Guelph Public Health (WDGPH) is mandated by the Safe Water standard of the Ontario Public Health Standards to prevent or reduce the burden of waterborne illnesses related to drinking water. Specifically, WDGPH is to conduct surveillance of drinking water sources and systems, carry out epidemiological analysis of surveillance data and use the information obtained to inform safe water programs. The Well Water Research Project described in this report examined sample submission rates to identify where there is a need for interventions to increase well water sampling. Geographic patterns in bacterial contamination of samples were also examined in order identify areas where well water may be at increased risk for contamination.

More information on the project background and the well water sampling process can be found in an earlier Board of Health report BH.01.APR0517.R09.[4]

Goals and Objectives

Project Goal: To reduce the burden of enteric illness related to drinking water in WDG.

Objectives:

1. To understand trends in well water sampling frequency and adverse results in WDG.
2. To increase the number of private domestic wells that are regularly tested for bacteriological contamination.
3. To identify and raise awareness of environmental risk factors that may increase the potential for contamination of wells.

Data Used in Analyses

Samples Submitted

Between 2011 and 2015, a total of 36,485 well water samples were submitted within the WDG jurisdiction. Of these samples, 3,167 were rejected by the Public Health Ontario (PHO) laboratory due to improper collection. The remaining 33,318 samples were tested for bacterial contamination and their results were sent to WDGPH. Of these records, 1,725 had incomplete address information and were excluded from analyses, resulting in a final data set of 31,593 sample records.

Number of Private Domestic Wells in WDG

Sample submissions with matching addresses were assumed to have been collected from the same well. Between 2011 and 2015, private well owners submitted samples for 9,487 unique wells. According to the best available information, there are 21,481 private domestic wells in WDG as provided by the Well Water Information System (WWIS) maintained the Ministry of the Environment and Climate Change (MOECC). Throughout the report, the term "sampled wells" refers to the 9,487 wells for which samples were submitted between 2011 and 2015. The term "existing wells" refers to the 21,481 private domestic wells included in the WWIS database.

Private Well Sampling in WDG

Most well owners sampled their wells infrequently. Nearly two of every five wells (38.1%) that were sampled between 2011 and 2015 were only sampled once. Only 3.4% of all sampled wells were sampled at least once every year between 2011 and 2015. As can be seen in **Table 1**, the total number of wells that were sampled each year remained relatively stable over time.

Compliance with Former Sampling Guidelines for Sampled Wells

The PHO recommendation that owners of private domestic wells test their well at least three times a year (spring, summer and fall) changed approximately three years ago. PHO now recommends that wells be tested "often".[5] Without a clear guideline, many health units still recommend that well owners test at least three times a year and more frequently if there has been heavy rain or flooding or if owners notice a change in the smell, taste or colour of their water. For the analyses detailed in this report, well owners that submitted at least three water samples with no evidence of bacterial contamination in a given year, were considered to have "met the former guidelines" for that year.

As can be seen in **Table 1** relatively few locations met the former guidelines. The percentage of wells sampled in a given year that met the former guidelines remained fairly stable throughout the 5 year period, ranging from 15.8% to 18.6%.

Table 1. All wells that were sampled at least once and met sampling guidelines by year.

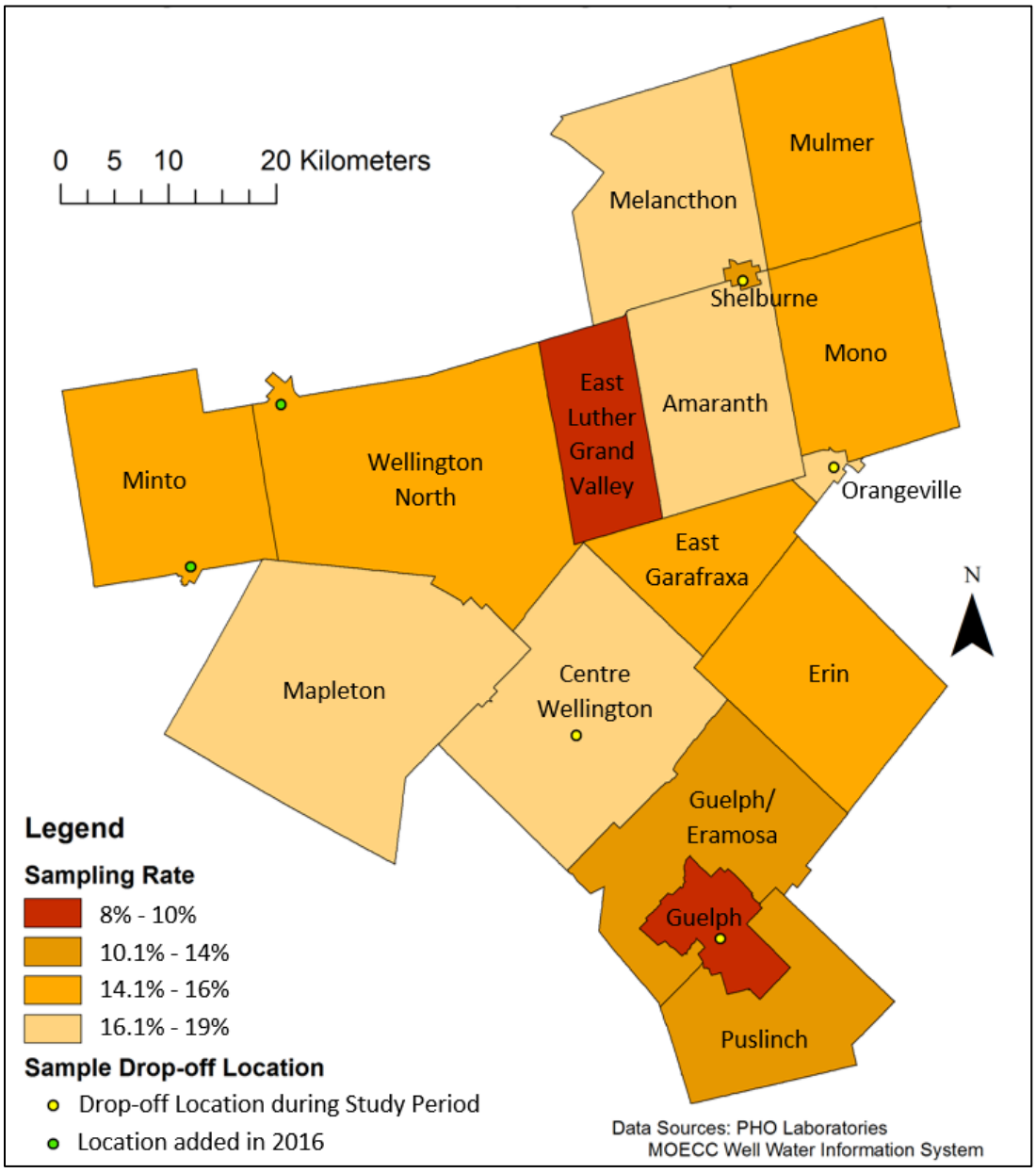
Year	No. of Wells Sampled (at least once)	% of Sampled Wells that met Former Sampling Guidelines
2011	3285	16.9%
2012	3170	18.6%
2013	3054	16.3%
2015	3096	16.1%
2015	3187	15.8%

The majority of sampled wells did not meet the former guidelines during any of the years in the study (78.1%). In fact, less than 4% met the former guidelines during two or more years. Only 0.32% of all sampled wells met the former guidelines every year between 2011 and 2015.

Sampling Rates of Existing Wells

Only 44.2% of all existing wells were sampled at least once between 2011 and 2015. However, annual sampling rates were much lower, with an average of 14.7% of existing wells in WDG sampling in a given year. This was considerably lower than the 25% sampling rate reported by a neighbouring health unit in 2005.[2] **Figure 1** shows the average annual sampling rate for each municipality. Lighter shading indicates a higher average sampling rate.

Figure 1. Average rate of existing wells sampled annually for each municipality.



Average sampling rates were lowest in Guelph and East Luther Grand Valley. Mapleton had the highest average annual sampling rate, with nearly one of every five (18.8%) existing wells sampled. Annual sampling rates by municipality and year are included in Appendix “A”.

Sampling rates did not appear to be higher in municipalities that contained sample drop-off locations.

The purpose of determining municipal sampling rates was to identify areas that might benefit from targeted interventions to improve sampling rates. However, it is evident that annual sampling rates are quite low across WDG, suggesting that the entire area may benefit from an intervention. Next steps include further data collection to identify barriers to well water sampling in areas with particularly low sampling rates. The information collected will then be used to develop an intervention which will be implemented across WDG.

Bacterial Contamination in WDG Wells

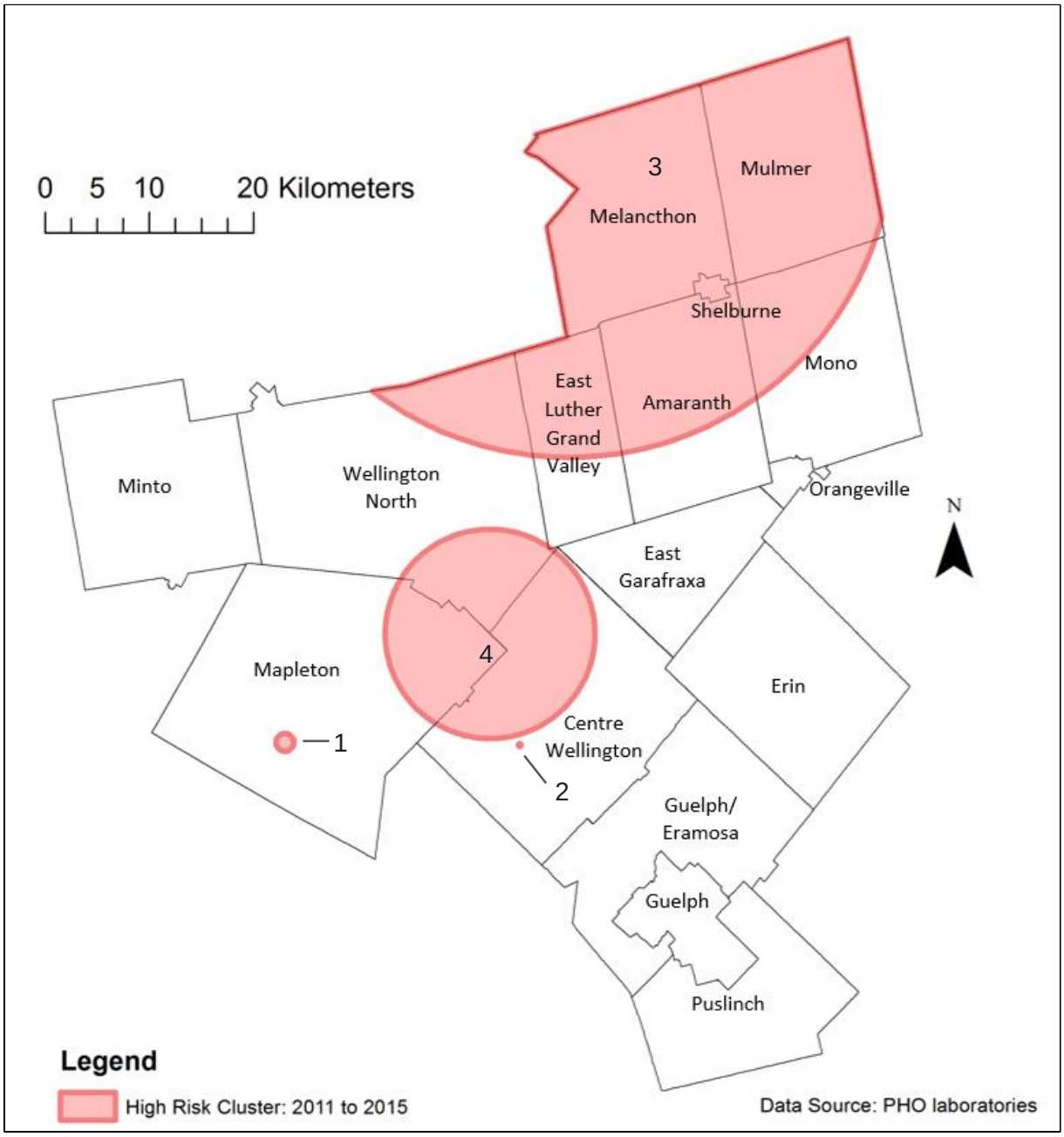
Once submitted, well water samples are tested for the two indicators of bacterial contamination: coliform bacteria and *Escherichia coli* (*E.coli*). Coliform bacteria are often found in sewage, animal waste, soil and vegetation. The presence of coliform bacteria is an indication of potential surface water contamination and that the well water *may* be unsafe to drink. *E.coli* is normally found in the digestive systems of humans and animals. The presence of these bacteria in water is an indicator of faecal contamination. Well water that contains *E.coli* bacteria *is* unsafe to drink. If significant evidence of either indicator is detected in a well water sample, owners are notified and instructed to call WDGPH for further information.

Between 2011 and 2015, 19% of samples submitted for the WDG jurisdiction contained evidence of bacterial contamination. *E.coli* was found in 2.9% of all samples submitted. Nearly one third (29.5%) of all locations that sampled between 2011 and 2015 submitted at least one sample with evidence of bacterial contamination.

High Risk Clusters

When well owners submit their well water samples for testing, they are asked to include the address of the source well. These addresses were geocoded, to find the geographic coordinates of each well that sampled between 2011 and 2015. Spatial analyses were performed to detect areas where the proportion of contaminated samples was significantly higher than in the rest of WDG. These areas are called high risk clusters. Between 2011 and 2015, thirteen statistically significant high risk clusters were detected. However, nine of the clusters are not reported here for privacy reasons, as they contained fewer than six unique well locations. **Figure 2** displays the four remaining high risk clusters. Clusters varied considerably in size and relative risk. Descriptive details for each cluster can be found in Appendix “B”.

Figure 2. High risk clusters for bacterial contamination between 2011 and 2015.



Note: Numbers beside or within clusters are used for identification purposes.

Spatial analyses were based on all samples submitted for testing between 2011 and 2015, meaning that these clusters are based upon all sampled wells rather than all existing wells. As the majority of well owners in WDG do not sample regularly, the data used for this analysis represents only a subset of the larger population. It is possible that, if more complete data were available, some additional clusters would be detected and some clusters in Figure 2 would become statistically insignificant. Spatial cluster detection relies on individual sample results and

does not recognize that samples from the same geographic location are likely from the same well. Therefore, it is prone to interpreting multiple tests from the same contaminated well as a very small cluster of independent samples.

WDGPH will continue to investigate high risk clusters in order to identify environmental risk factors that may increase the potential for contamination of well water. Risk factors that will be investigated include: well characteristics (such as well type, age and state of repair), farming and land use practices, hydrogeology, precipitation and extreme weather events. Upon identifying potential environmental conditions linked to increased bacterial contamination WDGPH will use this information to inform programming, which may include educating affected private well owners on how to mitigate risks to their drinking water.

Conclusion

Analysis was conducted using a data set containing 31,593 samples from 9,487 wells tested between 2011 and 2015. Although approximately 44.2% of existing wells were sampled at least once during this period, annual sampling rates were much lower. This suggests that all of WDG will likely benefit from interventions designed to increase awareness of and reduce barriers to well water sampling. Further data collection will be done in areas with particularly low sampling, but interventions informed by this data will be implemented across WDG.

Spatial analyses were performed to identify areas at increased risk of bacteriological contamination. These analyses detected statistically significant clusters where well samples contained evidence of bacterial contamination at a significantly higher rate than the rest of WDG. WDGPH will continue to explore environmental factors that could be responsible for increased bacterial contamination of drinking water in these areas.

Ontario Public Health Standard

Safe Water program standard.

WDGPH Strategic Direction(s)

☒ **Health Equity:** We will provide programs and services that integrate health equity principles to reduce or eliminate health differences between population groups.

☒ **Organizational Capacity:** We will improve our capacity to effectively deliver public health programs and services.

☐ **Service Centred Approach:** We are committed to providing excellent service to anyone interacting with WDG Public Health.

☒ **Building Healthy Communities:** We will work with communities to support the health and well-being of everyone.

Health Equity

WDGPH will use the results of this research to inform interventions that reduce disparities in well water testing and promote safe drinking water for all residents. Identifying barriers to sampling in areas with low sampling rates will allow WDGPH to implement evidence informed interventions across WDG. Although some studies have identified well water testing barriers, such as inconvenience or lack of time, very little research has explored how social and economic factors can compound these barriers.[3] A social determinants of health perspective will be used when collecting data regarding barriers to well water sampling. Health equity considerations will also be included in every step of intervention planning and implementation.

References

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2. Hexemer AM, Pintar K, Bird TM, Zentner SE, Garcia HP, Pallari F. An investigation of bacteriological and chemical water quality and the barriers to private well water sampling in a southwestern Ontario community. J Water Health. 2008;6(4):521-25.
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4. Wellington-Dufferin-Guelph Public Health. HBOH report - BH.01.APR0517.R09 Well Water Health Analytics [Internet]. 2017 April 5. [cited 2017 Sept 8] Available from: https://www.wdgpublichealth.ca/sites/default/files/bh.01.apr0517.r09_-_well_water_health_analytics_access.pdf
5. Public Health Ontario. Well testing: submit a water sample [Internet].[cited 2017 Aug 30]. Available from: https://www.publichealthontario.ca/en/ServicesAndTools/LaboratoryServices/Pages/Water-Testing-SubmitASample.aspx

Appendices

Appendix "A" – Yearly Well Water Sampling Rates by Municipality; and
Appendix "B" – High Risk Clusters for Bacterial Contamination.

Appendix "A"

Yearly Well Water Sampling Rates by Municipality

Area	% of existing wells that sampled at least once in…					Average Annual Sampling Rate	Sampled at all between 2011- 2015
	2011	2012	2013	2014	2015		
Dufferin County	**15.5%**	**15.0%**	**14.6%**	**14.4%**	**15.6%**	**15.0%**	**46.4%**
Amaranth	18.4%	15.5%	15.5%	15.0%	16.0%	16.1%	50.8%
East Garafraxa	16.5%	15.6%	12.9%	12.9%	14.5%	14.5%	46.5%
East Luther Grand Valley	6.4%	8.2%	10.7%	9.7%	10.7%	9.1%	31.6%
Melancthon	15.5%	17.3%	14.6%	17.9%	16.2%	16.3%	52.6%
Mono	15.7%	15.6%	14.7%	13.0%	16.0%	15.0%	45.0%
Mulmer	16.2%	14.5%	16.2%	16.2%	16.8%	16.0%	45.4%
Orangeville	15.8%	15.8%	15.8%	17.5%	17.5%	16.5%	70.2%
Shelburne	3.8%	7.7%	15.4%	19.2%	15.4%	12.3%	53.8%
Wellington County	**15.5%**	**14.9%**	**14.4%**	**14.7%**	**14.8%**	**14.9%**	**44.0%**
Erin	14.2%	14.5%	13.8%	14.3%	14.6%	14.3%	44.5%
Guelph/Eramosa	12.9%	11.2%	11.7%	12.6%	12.7%	12.2%	36.7%
Centre Wellington	17.1%	17.2%	16.5%	15.4%	16.4%	16.5%	47.4%
Mapleton	20.7%	18.0%	17.5%	20.0%	17.8%	18.8%	51.3%
Minto	17.4%	14.4%	15.0%	16.1%	16.4%	15.9%	49.2%
Puslinch	13.3%	13.4%	12.5%	12.1%	11.7%	12.6%	38.9%
Wellington North	14.9%	16.0%	14.1%	14.6%	16.4%	15.2%	44.9%
Guelph	**8.9%**	**9.8%**	**7.5%**	**7.8%**	**7.8%**	**8.4%**	**27.8%**
Total	***15.3%***	***14.8%***	***14.2%***	***14.4%***	***14.8%***	***14.7%***	***44.2%***

Appendix “B”

High Risk Clusters for Bacterial Contamination

Cluster Number	Radius (km)	P-value	Observed Samples with Bacterial Contamination	Expected Samples with Bacterial Contamination	Relative Risk in Cluster
1	0.85	<0.001	30	10.5	2.88
2	0.12	0.039	43	20.6	2.10
3	31.02	<0.001	1431	1104.8	1.39
4	10.05	<0.001	609	475.7	1.31