Technical Report on the Transport Pathway Assessment

for the Halton-Hamilton Source Protection Region

August 30, 2021

Table of Contents

1.0 Introduction

1.1 BACKGROUND

Conservation Halton and the Hamilton Conservation Authority partner together as Source Protection Authorities (SPAs) to form the Halton-Hamilton Source Protection Region (HHSPR) in Ontario, under the *Clean Water Act, 2006*. They support the protection of municipal drinking water sources through a multi-stakeholder approach.

A transport pathway is a human-made feature below ground surface that increases the vulnerability of the sources of our drinking water supplies. Transport pathways bypass the natural protection provided by soil and rock layers and natural processes, resulting in a greater risk of contamination of our water sources.

Under the Clean Water Act O. Reg. 287/07, municipalities must notify the source protection authority and source protection committee (SPC) about proposals that may result in new or modified transport pathways, as they may affect the vulnerability of the drinking water source to contamination. The source protection authority and SPC may also become aware of potential transport pathways through other means. The source protection authority and SPC must assess whether the vulnerability score for the wellhead protection area (WHPA) should be increased or an intake protection zone (IPZ) expanded. These changes may result in the identification of additional threat activities that require management through source protection plan policies.

Per technical rules 39 through 41, the area vulnerability around groundwater supplies can be increased because of a presence of an anthropogenic transport pathway upon consideration of:

- Hydrogeological conditions
- The type and design of transport pathways
- The cumulative impact of any transport pathways, and
- The extent of any assumptions used in the assessment of the vulnerability of groundwater.

1.2 SCOPE OF WORK

This technical study provides updates to vulnerabilities based on transport pathway assessment for the wellhead protection areas (WHPA) within the HHSPR. The work was conducted by Conservation Halton staff in 2020-2021 per Section 36 of the *Clean Water Act, 2006*. It follows the 2017 Technical Rules of the *Clean Water Act*. This report provides a list of the transport pathways, criteria used to complete the assessment and the results in terms of vulnerability adjustments.

2.0 Transport Pathway Assessment

2.1 METHODOLOGY

2.1.1 Overview

In the HHSPR, a surface to well advection time (SWAT) method was used to assess the intrinsic vulnerability within WHPAs. The SWAT analysis assesses a time of travel through the unsaturated portion of subsurface (Unsaturated Zone Advection Time – UZAT) plus a time of travel from a water table, through the aquifer to a municipal well (Water Table to Well Advection Time – WWAT). The SWAT analysis is thought to be the most comprehensive of the four vulnerability assessment methods as proposed in the 2017 technical rules under the Clean Water Act. However, the method does not account for anthropogenic (human-made) changes to the subsurface.

The aquifers that supply municipal drinking water systems in the HHSPR are protected at the surface by low permeability deposits of various thicknesses overlying either sand and gravel or fractured bedrock aquifers. Anthropogenic transport pathways remove, decrease the thickness or reduce the protective capability of that protective blanket. These pathways can potentially include poorly constructed wells, pits and quarries that breech the confining layer, underground infrastructure such as storm sewers and sanitary sewers, pipelines, road ditches, etc.

The following potential transport pathways within WHPAs were reviewed:

- Wells constructed prior to Ontario Regulation 903
- Municipal linear infrastructure
- Septic systems
- Geothermal systems
- Communications infrastructure
- Gas mains
- Any other excavations
- Pits and quarries
- Oil and gas wells
- Pipelines.

2.1.2 Well Transport Pathways

HHSPR staff analysed and identified well transport pathways in the WHPAs around municipal drinking water system wells.

The Ministry of Environment, Conservation and Parks (MECP) Water Well Record Information System (WWIS) database was used for the analysis. The WWIS houses water well record information submitted by drillers when a new well is constructed or abandoned. Some of the information included on the water well record is well location, drilling date, name of the owner, stratigraphy encountered during drilling including depths and soil/ rock description, groundwater level depth and pumping test data, well

construction details including total depth, well screen size and location, casing diameter, basic water quality data, well contractor name and license, etc.

The following criteria were used by staff to identify potential transport pathways in WHPAs A-D:

1. Wells constructed prior to the Ontario Regulation 903 (Wells);
2. Clusters of six or more wells within 100m radius; and
3. Reported margin of error of a well's location to be 30m or less.

The criteria are explained in detail below, and are similar to analyses conducted by neighboring source protection areas (SPAs) and SPRs including the Niagara Peninsula SPA and the Credit Valley, Toronto and Region and Central Lake Ontario (CTC) SPR. Note that municipal drinking water system wells are excluded from the analysis.

Wells constructed prior to the Ontario Regulation 903 (Wells)

In 1990, under the Ontario Water Resources Act, the Ontario Regulation 903 (Wells) was enacted, which increased minimum requirements for well construction and decommissioning of all well types. Some of the main changes introduced in this regulation were requirements for a new well to have at least 0.4 metres length be above ground surface; a proper drainage away from a well; an installation of a proper seal around a well near the surface; and not allowing for private water supplies to be installed in pits.

All these changes increase the safety of a water supply and lowered the possibility of a well to be subject to surface water entering (potentially carrying chemical and/or pathogenic contaminants), circumventing the protective layer, and contaminating the underlying aquifer. Therefore to identify wells with potential issues due to age and construction, the year 1990 was used to screen the WWIS database.

Wells constructed after 1990 are likely constructed to a higher standard and are less likely to become a transport pathway. Older wells i.e. those constructed in or prior to 1990 are considered potential transport pathways.

Clusters of six or more wells within 100 m radius of each other

Considering that not all old wells are poorly constructed, clusters of older wells were identified instead of individual wells. Specifically, clusters of six wells or more within a 100m radius of each other were examined. To identify a cluster of wells adjacent to the WHPA, staff applied a 100m buffer or "area of influence" to the outermost WHPA, with the criteria that at least one well of the cluster is located within any of the WHPA - A, B, C or D zones.

Reported margin of error of a well's location to be 30m or less

Some of the well locations in the WWIS database, especially for older wells, may not be as accurate as for newer wells. The WWIS database includes location confidence indices which are helpful and provide estimated margins of error for each well location. If the reported margin of error for wells identified within clusters is more than 30 metres, they are not identified as potential transport pathways.

2.1.3 Linear Infrastructure and Other Transport Pathways

In early 2021, staff contacted other source protection regions and areas to obtain methodologies to assess various types of transport pathways. Only one report is available with detailed information: Matrix Solutions Inc. completed a technical study including transport pathway assessment in 2018. Their work is summarised in "Township of Centre Wellington Wellhead Protection Area Delineation, Issue Contributing Area Delineation, And Vulnerability Scoring Report - Lake Erie Source Protection Region" (version 1) report for the Grand River Conservation Authority and County of Wellington.

According to the Matrix Inc. 2018 study, a linear infrastructure, deep excavation, and septic system becomes a transport pathway if it is located either within 2 metres of the water table or below the top of aquifer. Similarly, HHSPR used the depth to the top of aquifer and the depth to water table to assess if any anthropogenic features would become transport pathways. In HHSPR, features that intersected water table or were within 2 metres of the top of aquifer were adjudged to have higher risk and were confirmed as transport pathways. An area of influence of 15m was delineated as a "buffer" around the identified transport pathway (excluding septic systems), and within this area the vulnerability was reviewed.

The depth to water table and the top of aquifer surfaces were obtained from groundwater models that were used to delineate each specific WHPA. These were exported into GIS software for a desktop analysis.

The data to complete the assessment was obtained from several sources as described below:

- Storm sewer mapping obtained from local municipalities
- Roadside ditch mapping developed based on LiDAR and Orthophotos analysis by Conservation Halton engineering staff
- Watermain mapping obtained from Halton Region and the City of Hamilton
- Sanitary sewer mapping obtained from Halton Region and the City of Hamilton
- Detailed septic system locations were not available; an aerial photo analysis was conducted in areas of shallow water table or the top of aquifer to identify areas where potentially septic systems exist. Due to a large number of properties with septic systems within Freelton WHPA, a GIS screening of parcel fabric and land use map was completed to identify locations with potential septic systems instead.
- Oil and gas well and pit and quarry mapping obtained from Land Information Ontario (LIO) open data resources
- Pipeline mapping obtained from pipeline owners
- Geothermal system data were obtained from local municipalities and MECP.

Linear infrastructure and septic systems

A GIS-based assessment was completed to compare the actual depth (if available) or assumed depth of the potential transport pathways as listed in **Table 1**, with the depth to water table or depth to the top of aquifer.

Table 1: Assumptions of Depths of Transport Pathways

Transport Pathway Type	Assumptions	Wellhead Protection Areas (WHPAs) with presence of potential transport pathway
Stormwater (storm sewers)	Assumed to be 2 meters below ground surface. Note that Lake Erie SPR also assumed 5 m (Matrix Solutions Inc., 2018).	Campbellville Carlisle Greensville Freelton
Stormwater (roadside ditches)	Assumed to be 1 metre below ground surface	Kelso Campbellville Walkers Line Carlisle Greensville Freelton
Water main	Assumed to be 2 meters below ground surface. There are local water mains existing within HH SPR WHPAs to distribute water to local water users. Our understanding is that these are shallow installations just below a frost line. Note that Lake Erie SPR assumed 5 m depth (Matrix Solutions Inc., 2018).	Kelso Campbellville Walkers Line Carlisle Greensville Freelton
Septic systems	Assumed to be 2 meters below ground surface. Private septic systems are usually very shallow due to financial reasons and to properly function to avoid interactions with shallow groundwater. Note that Lake Erie SPR assumed 5 m depth for septic systems (Matrix Solutions Inc., 2018).	Kelso Campbellville Walkers Line Carlisle Greensville Freelton
Wastewater	For possible (but unlikely) future scenarios, assessments may assume the infrastructure to be 5 meters below ground surface. This is consistent with Lake Erie transport pathway assessment by Matrix Solutions Inc., 2018.	There are no sanitary sewers within HHSPR WHPAs.
Communication infrastructure and gas mains	Assumed to be 1 metre below ground surface	Potentially present in HHSPR WHPAs however no information was available at the time of this report
Geothermal systems	Assumed 5 metres depth for the shallow systems and 20 metres for the deep vertical systems or actual depth if data available.	There are no geothermal systems in Kelso, Campbellville or Walkers Line WHPAs

Potential transport pathways identified below the water table or within 2 metres of the top of aquifer were confirmed as transport pathways. To avoid identifying features as transport pathways in areas where there are upward gradients (artesian conditions) and upward water movement, an assessment of artesian conditions was completed. In areas where potentiometric surface obtained from a steady state groundwater model is within average annual groundwater level fluctuation of 2.1 m (based on local PGMN wells) a potential transport pathway would be confirmed as a transport pathway. Where potentiometric surface is more than 2.1 m above ground surface a potential transport pathway would not be confirmed as a transport pathway as there is less chance for vertical gradient reversal.

Pits and Quarries

Pits and quarries within WHPA are assessed on a site-specific basis. The methodology to complete the transport pathways assessment is as follows:

1. If a specific pit or quarry was inactive and represented in the numerical model (which was used to estimate the time of travel from the water table to a municipal well intake and subsequent unsaturated zone time of travel estimate to assess intrinsic vulnerability), such quarry would not be a transport pathway. If there is a proposal for more extraction within the area which intersects with WHPA, methodology in point 2 below is used.
2. If a specific pit or quarry was not represented in the model or is still active, and there is enough information available about the depth of licensed extraction, subsurface conditions, and state of rehabilitation, the same criteria for linear infrastructure would be used; otherwise the entire aggregate operation would be identified as a transport pathway.

2.2 ASSESSMENT AND RESULTS

2.2.1 Well Transport Pathways

The **Table 2** below summarizes the analysis and identification of non-municipal wells as transport pathways for the municipal well supply system WHPAs within HHSPR. Note that in order to increase vulnerability due to the transport pathways, a 30-metre area of influence was delineated around the identified transport pathway well within WHPAs. This area of influence receives a vulnerability increase by one category: low to medium or medium to high. This in turn results in an increase in vulnerability score. Where the vulnerability is already high, no change is made.

Table 2: Wells as Transport Pathways in Halton-Hamilton Wellhead Protection Areas

No.	Summary of the Analysis and Identification
1	**Kelso drinking water system** One cluster of eight wells were identified within a 100m radius, located south-east of the reservoir. Another cluster of six wells were identified within a 100m radius, located west of the reservoir. However, based on information from the WWIS database, the margin of error of the location of each of these wells was greater than 30m. Therefore, these were **not** considered as transport pathways.
2	**Campbellville drinking water system** A cluster of six wells were found in and around the WHPA-B and C (of which one well is within the WHPA-C). Based on information from the WWIS database, the margin of error of the location of the well within the WHPA-C was 30m or less. **Therefore, this well is considered to be a transport pathway.** As a result, the vulnerability within a 30 m area of influence around that well was increased by one level. This applies to the portions of WHPA-B (vulnerability score of 6 increased to 8) and WHPA-C (vulnerability score of 2 increased to 4) that fall within the 30 m area of influence. The attached **Figure 1** shows the results of applying the screening criteria to the Campbellville WHPAs and updated vulnerability scores including an increase in vulnerability scores in the WHPA-B and WHPA-C due to the presence of the transport pathways.
3	**Walkers Line drinking water system** There were **no** clusters of potential wells transport pathways located in the WHPA that met all of the criteria.
4	**Greensville drinking water system** A cluster of nine wells were found in and around the WHPA-A, and also close to the WHPA-B. However, based on information from the WWIS database, the margin of error of the location of each of these wells was greater than 30m. Therefore, these were **not** considered as transport pathways.
5	**Carlisle drinking water system** There were **no** clusters of potential well transport pathways located in the WHPA that met all of the criteria.
6	**Freelton drinking water system** There were **no** clusters of potential well transport pathways located in the WHPA that met all of the criteria.

Considering the uncertainty of the water well record database in terms of well location and the criteria used to identify well transport pathways may miss wells which are transport pathways, it is recommended that a house to house well survey be completed within WHPA-A and if practical WHPA-B (up to 2-year time of travel) to identify any unused wells and/or wells which do not comply with current well construction requirements. Unused wells should be properly abandoned and wells with construction issues should be upgraded to meet the current requirements.

2.2.2 Linear Infrastructure and Other Transport Pathways

This section summarizes the results of linear infrastructure and other transport pathway analysis and presents the final results in terms of vulnerability updates. Note that in order to increase vulnerability level due to the transport pathways, a 15-metre area of influence was delineated around and/or along the identified transport pathways within WHPAs except septic systems and pits and quarries. The transport pathway and the area of influence area receives a vulnerability increase by either one category: low to medium or medium to high, or by two categories low to high taking into account technical rule 41 factors:

- Hydrogeological conditions
- The type and design of transport pathways
- The cumulative impact of any transport pathways, and
- The extent of any assumptions used in the assessment of the vulnerability of groundwater.

This in turn results in an increase in vulnerability score following technical rule 83 Table 2(b) (below). Where the vulnerability is already high, no change is made.

Table 2(b): Wellhead Protection Vulnerability Scores - SAAT or SWAT

Groundwater Vulnerability Category for the Area	Location Within a WHPA: WHPA-A	Location Within a WHPA: WHPA-B	Location Within a WHPA: WHPA-C	Location Within a WHPA: WHPA-C1	Location Within a WHPA: WHPA-D
High	10	10	8	8	6
Medium	10	8	6	6	4
Low	10	6	2	2	2

Figure a: Wellhead Protection Area Vulnerability Scores, from the Clean Water Act Director's Technical Rules 83, Table 2(b)

The **Table 3** below summarizes the identification and analysis of linear infrastructure and septic system transport pathways for the municipal well supply system WHPAs within HHSPR.

It is **important to note** that septic systems although mentioned in the table below, are **not** confirmed as transport pathways, but remain as research only at this time. This is due to a detailed discussion and with municipalities at a meeting hosted by HHSPR in May 2021. The exact locations of septic systems are unknown and more importantly, there is consensus amongst the municipal staff that septic systems should not be considered as potential transport pathways at all; and rather continue to be considered as prescribed threat activities within the Clean Water Act technical framework. This approach finds consistency with the neighbouring CTC SPR (while being inconsistent with the Lake Erie SPR); however HHSPR staff concur with the municipalities that there is inadequate scientific rationale at this time to include septic systems as potential transport pathways.

Table 3: Linear Infrastructure and Septic System Transport Pathways

No.	Technical Analysis and Identification of Transport Pathways
1	**Campbellville drinking water system** There are **no** areas within the Campbellville WHPA where groundwater table or depth of the top of aquifer is shallow enough for linear infrastructure to become a transport pathway. The final results of transport pathway assessment and vulnerability scores are presented on **Figure 1**.
2	**Kelso drinking water system** There two areas within Kelso WHPA where transport pathways were identified. A roadside ditch located along Sixth Line north of Campbellville Road intersects the water table within WHPA-B. A 15-metre area of influence was delineated around the section of the road side ditch and vulnerability was increased from low to medium which resulted in a vulnerability score increase from 6 to 8. Septic systems are present west of the Kelso Reservoir within WHPA-B; however are not considered as transport pathways as described above this table. The identified transport pathways with appropriate areas of influence and resulting updates to vulnerability scores are presented on **Figure 2**.
3	**Walkers Line drinking water system** There are a few areas within the Walkers Line WHPA where linear infrastructure met the criteria to become a transport pathway. There is a section of roadside ditch along Walkers Line within WHPA-B which intersects water table and therefore is a transport pathway. A 15 metre buffer was delineated around this section of the ditch and vulnerability was increased from medium to high which resulted in a vulnerability score increase from 8 to 10. A watermain located in WHPA-A and C in an area of shallow water table is a transport pathway. 15 metre buffer was delineated around this section of the ditch. The area of identified section of watermain within WHPA-A has already maximum vulnerability score of 10, and therefore no changes are made. For the section of watermain and buffer within WHPA-B and C vulnerability level was increased by one level which resulted in an increase in vulnerability score from 6 to 8 in WHPA-B and from 6 to 8 in WHPA-C. The results are presented on **Figure 3**.
4	**Greensville drinking water system** There is one area within the Greensville WHPA where a local storm sewer intersects groundwater table and therefore is a transport pathway. This section of storm sewer is located in WHPA-A and therefore no changes to vulnerability score is possible. The results are shown on **Figure 4**.
5	**Carlisle drinking water system** There are five areas within the Carlisle WHPA where linear infrastructure meet the criteria to be transport pathways. Two areas are sections of roadside ditch within WHPA-B, at the north-west end, along 10 Concession Road East, which intersect the water table and therefore are transport pathways. Septic systems are in the same general area in WHPA-D and WHPA-B; however are not considered as transport pathways as described above this table. A 15 metre area of influence was delineated around the sections of roadside ditch and vulnerability was increased by one level which resulted in a vulnerability score increase from 6 to 8 in WHPA-B and a small portion of a ditch area of influence located in WHPA-C resulted in vulnerability increase from 2 to 6. The results are presented on **Figure 5**.

No.	Technical Analysis and Identification of Transport Pathways
6	**Freelton drinking water system** There are multiple areas within the Freelton WHPAs where linear infrastructure including watermains and roadside ditches meet the criteria to become transport pathways. Septic systems are present; however are not considered as transport pathways as described above this table. Municipal well FDF01: A number of transport pathways were identified in well FDF01 WHPA-A and WHPA-B; however, most of the area has a high vulnerability and already received a maximum vulnerability score of 10 and therefore no vulnerability score changes were made. Vulnerability in a few small areas with medium vulnerability was increased to high and vulnerability score changed accordingly. Municipal well FDF03: Similarly, roadside ditches and watermains were identified as transport pathways within WHPA-A through WHPA-D of well FDF03. Vulnerability was increase from low to medium or from medium to high and vulnerability scores adjusted. The results of the assessment are presented on **Figure 6**.

Geothermal System Transport Pathways

An assessment of geothermal systems as transport pathways follows same criteria as for linear infrastructure. There are mainly two types of geothermal systems: deep vertical and shallow either vertical or horizontal. The deep vertical systems require an Environmental Compliance Approval (ECA) from MECP while the shallow systems require a building permit from local municipalities. There were no ECA for geothermal systems identified in any of HHSPR WHPAs. 14 shallow geothermal systems were identified in the Town of Milton; however, all of the systems are located outside of HHSPR WHPAs, and therefore are not assessed as transport pathways. Staff is waiting for the City of Hamilton to report if there are any shallow geothermal systems within Hamilton WHPAs to complete the assessment.

Pits and Quarries Transport Pathways

Pits and Quarries as transport pathways within WHPA were completed on a site-specific basis. There are two (2) inactive pit and quarry operations identified in the Kelso WHPA and
two active pits intersecting the Walkers Line WHPA.

The two aggregate operations intersecting Kelso WHPA are former Campbellville Sand and Gravel pit and former Halton Crushed Stone quarry. Both operations were represented in the numerical model used to delineate WHPAs and the assessment of vulnerabilities, and therefore are not transport pathways.

Aggregate operations within the Walkers Line WHPA-A, B, C and D are sand and gravel pits owned by Springbank Sand & Gravel Ltd. They are:

- Leaver Pit ARA License No 5619, and
- Hayward Pit ARA License No 5507.

Both pits are Category 3 - Class A above water type. Both pits were partially rehabilitated when vulnerability assessment was completed in the previous round. However, considering there is insufficient information about which areas were rehabilitated, the state of present extraction and

the subsurface conditions at pit locations, there is the potential for removal of the aquifer material. Therefore, following the proposed methodology, the licence pit area which intersects with the Walkers Line WHPA is a transport pathway. As a result, vulnerability categories were increased by one step. The results are presented on **Figure 3**.

Communication infrastructure and gas mains

Data for communication infrastructure and gas mains were not available during preparation of this report. The depth of these types of infrastructure is usually very shallow and was assumed at 1 metre. The locations are usually along roadways where either roadside ditches or watermains exist; therefore it is highly likely that the roadside ditches or watermains transport pathways areas of influence already identified in this report would capture the communications infrastructure and gas mains.

Oil and Gas Well Transport Pathways

There are no oil and gas wells identified within HHSPR WHPAs.

Pipelines Transport Pathways

There are no pipelines that cross the HHSPR WHPAs.

3.0 Authors and Acknowledgements

This technical study was undertaken by Conservation Halton staff Jacek Strakowski (Hydrogeologist), Brad Rennick (GIS Team Lead), Florentina Perju (GIS/Data Specialist) and Chitra Gowda (Senior Manager, Watershed Planning and Source Protection).

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APPENDIX A

FIGURES OF TRANSPORT PATHWAYS IN WELLHEAD PROTECTION AREAS

No.	Title
1	Campbellville WHPA Transport Pathway Vulnerability Assessment
2	Kelso WHPA Transport Pathway Vulnerability Assessment
3	Walkers Line WHPA Transport Pathway Vulnerability Assessment
4	Greensville WHPA Transport Pathway Vulnerability Assessment
5	Carlisle WHPA Transport Pathway Vulnerability Assessment
6	Freelton WHPA Transport Pathway Vulnerability Assessment