

APPENDIX A - PROTOCOL FOR DETERMINING GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER

SUMMARY OF GUDI ASSESSMENT PROCESS

GUDI is an acronym for Groundwater Under the Direct Influence of surface water. It refers to situations where microbial pathogens can travel from surface water through an aquifer to a water well. The purpose of this document is to provide a process for determining whether a water well is GUDI or non-GUDI. The Nova Scotia GUDI assessment process consists of three steps. The steps are shown on the flow chart in Figure A.1 and are summarized below. For wells that complete all three steps, the process can take up to two years because of the sampling and monitoring requirements under Steps 2 and 3.

Step 1 is a screening step used to rapidly identify obvious non-GUDI wells based on available information. Step 1 considers four evaluation criteria: 1) the sensitivity of the well and aquifer setting; 2) the distance from the well to the nearest surface water body; 3) the well construction; and 4) the raw well water quality. A well can be classified as non-GUDI if it satisfies all of these four criteria (details on criteria evaluation are provided in Section A.2 of this appendix). If the well does not meet these criteria, it fails Step 1 and proceeds to Step 2.

Step 2 is used to determine if there is a hydraulic connection through the aquifer that could allow rapid recharge of the well by surface water. Rapid recharge is defined as recharge that occurs between the well and surface water with a travel time of 90 days or less. Step 2 includes a review of available hydrogeologic information and one year of water quality monitoring at the wellhead and a nearby surface water body. At a minimum, the monitoring shall include weekly temperature and electrical conductivity measurements. If no hydraulic connection is identified between the well and surface water that could allow recharge within 90 days, the well can be classified as non-GUDI. If a hydraulic connection is identified that could allow recharge from surface water within 90 days, the well fails Step 2 and proceeds to Step 3.

Step 3 is used to determine if there are surface water particulates (e.g., insects, organic debris, etc.) present in the well that indicate it has been influenced by surface water. This is done using a laboratory test called the Microscopic Particulate Analysis (MPA). The results from Step 2 are needed to determine when the MPA samples should be collected. A minimum of two MPA samples are required. The MPA test results are used to determine if the well has a low, medium or high risk of being influenced by surface water. Wells that have low risk MPA results can be classified as non-GUDI. Wells that have medium or high risk MPA results are classified as GUDI.

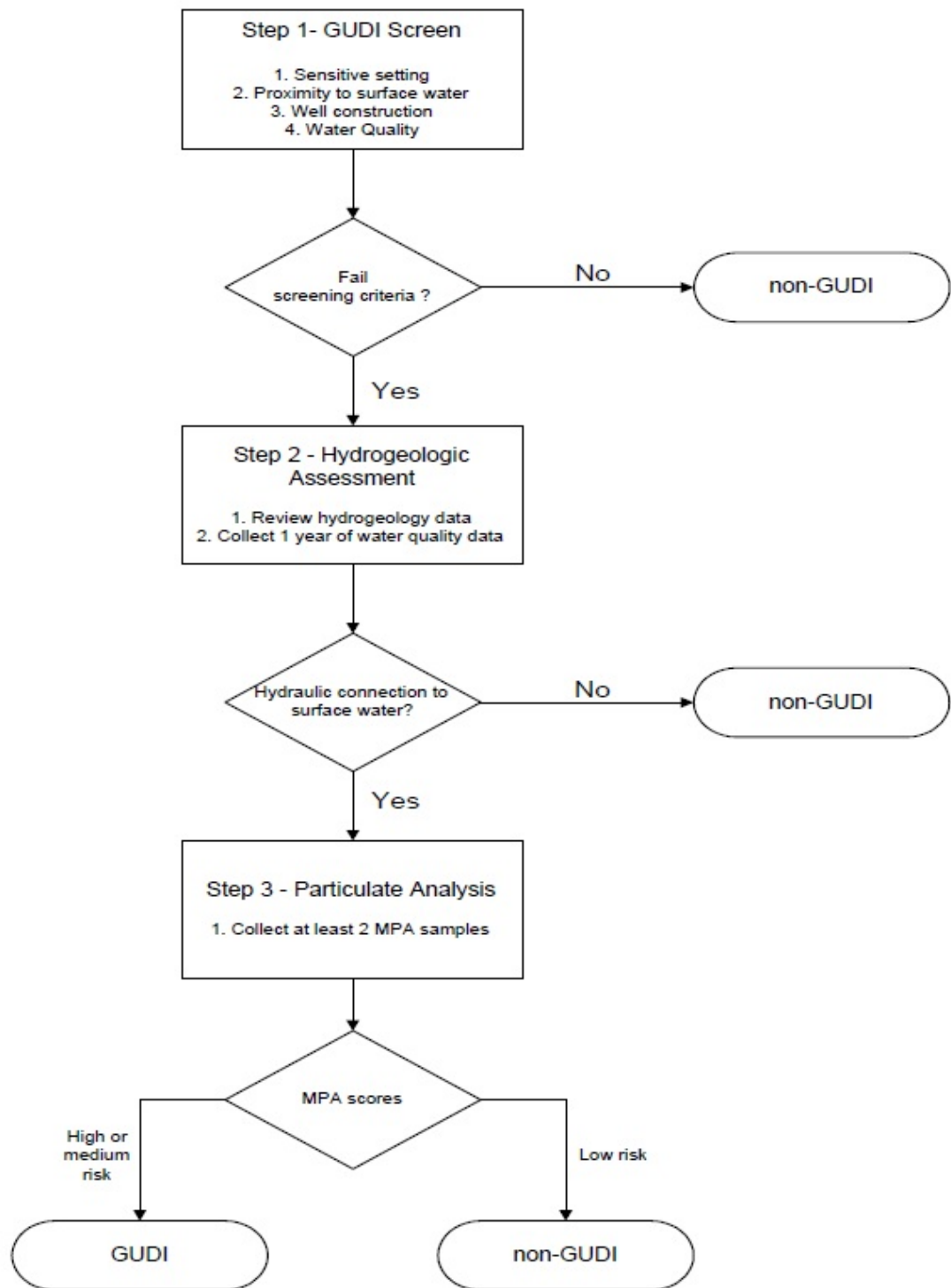


Figure A.1: GUDI Assessment Flow Chart

A.1 INTRODUCTION

GUDI is an acronym for Groundwater Under the Direct Influence of surface water. It refers to groundwater sources (e.g., wells, springs, infiltration galleries, etc.) where microbial pathogens are able to travel from surface water to the groundwater source. The purpose of this document is to provide a process for determining whether or not a groundwater source is GUDI, where GUDI is defined as (U.S.EPA, 1991): “any water beneath the surface of the ground with:

- i) significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as *Giardia lamblia* or *Cryptosporidium*; or
- ii) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions.”

Part (i) of the definition is aimed at determining if there are particulates present in the well that are indicative of surface water. This may be determined using Microscopic Particulate Analysis (MPA) which analyzes for significant numbers of large macro-organisms, algae and surrogate indicators of surface water. Part (ii) of the definition is aimed at establishing whether there is a hydraulic connection between the groundwater source and surface water. This implies that if groundwater is rapidly recharged by surface water, then microbial pathogens can enter the groundwater source.

The GUDI assessment process described in this document is based on guidance provided by U.S.EPA (1991), AWWA (1996), AWWA (2001) and the Ontario MOE (2001). The process consists of three steps, beginning with a screening step that provides a method to rapidly identify obvious, non-GUDI sources (i.e., true groundwater) that do not require a detailed investigation. Sources that fail Step 1 shall proceed to Step 2 to determine if there is a hydraulic connection which allows rapid recharge between the groundwater source and surface water. If there is no hydraulic connection identified in Step 2, the source can be classified as non-GUDI. If a hydraulic connection exists, Step 3 shall be completed to determine if there are particulates present in the groundwater source that are indicative of surface water. A flow chart showing the GUDI assessment process is presented in Figure 1 and explanation of each step is provided in Section A.2 of this appendix.

GUDI assessments shall be carried out by, or under the supervision of, a qualified hydrogeologist which is defined here as a person with hydrogeology training and experience, and licenced to practice in Nova Scotia by APGNS or APENS.

A GUDI assessment shall be completed for each well in a wellfield and each well shall be classified as either GUDI or non-GUDI. This also means that when water quality data is collected under Step 2 and Step 3 of the GUDI assessment (e.g., temperature, conductivity, MPA tests, etc.), the samples shall be collected from each individual well, not from a point in the distribution system where water has already been mixed with water from other sources.

A.2 GUDI ASSESSMENT PROCESS

A.2.1 Step 1

The objective of this step is to identify obvious non-GUDI sources that do not need further investigation. The screening step will normally involve a file search, review of well construction details and a site visit. If the well passes Step 1 it can be classified as non-GUDI; if it fails Step 1 it shall proceed to Step 2.

For a groundwater source to be considered non-GUDI it shall satisfy all of the four criteria listed below. If it does not meet these criteria, it fails Step 1 and proceeds to Step 2.

- 1. Sensitive settings** - the well shall not fall into any of the following categories: spring, infiltration gallery, horizontal collection well, wells in karst aquifers, unconfined aquifers and wells that are part of an enhanced recharge/infiltration project.
- 2. Proximity to surface water** - the well shall be greater than 60 metres from the nearest intermittent or permanent surface water body (i.e., a surface water body is defined as water open to the atmosphere and subject to surface runoff, such as ponds, lakes, wetlands, lagoons, reservoirs, estuaries, rivers, streams, brooks, ditches).
- 3. Well construction** - the well shall meet the current Well Construction Regulations; the casing shall extend at least 12 metres below ground surface; and the well shall have a drive shoe, wellhead and annular seal that will prevent surface water from entering the well and prevent water from migrating within the annular space.
- 4. Water quality** - there shall be no confirmed record of total coliforms or *E. coli* bacteria in untreated samples collected over three years. Confirmed means the result was verified by re-sampling.

If a well fails Step 1 due to well construction issues, modifications can be made to the well so it meets the screening criteria. If after the modifications are made the well still fails the screening criteria, then Step 2 shall be completed. Note that if well construction improvements are planned, they shall be completed prior to proceeding to Step 2 because changes to the well may affect the results of Step 2.

If the well will fail Step 1 because bacteria was detected in a single sample, additional sampling shall be carried out to confirm whether or not bacteria is regularly present. A minimum of four additional bacteria samples shall be collected, one per month. If any of these additional samples contain bacteria the well shall fail Step 1, unless subsequent corrective action and sampling demonstrate the well does not regularly contain bacteria.

A.2.2 Step 2

The objective of Step 2 is to determine if there is a hydraulic connection that could allow rapid recharge of the well by precipitation or surface water. Rapid recharge is defined as recharge that occurs between the well and surface water with a travel time of 90 days or less. Step 2 shall include the collection of one year of water quality data (temperature, electrical conductivity) and a review of available hydrogeologic information. Additional hydrogeologic data may also be collected if the review of available data indicates there is insufficient information to determine if a hydraulic connection is present.

Raw water quality data shall be collected at the well and a nearby surface water body for a period of one year to determine if there is a close relationship between changes in the surface water quality and the well water quality. Patterns are best recognized from one-year hydrographs; however, a shorter time may be sufficient if a hydraulic connection is recognized early in the monitoring program.

Water quality parameters shall include, but not necessarily be limited to, temperature and electrical conductivity. Temperature and conductivity measurements shall be measured on a weekly basis at a minimum, however, hourly or daily measurements collected with a datalogger are recommended.

The water quality data shall be plotted and the graphs inspected for rapid changes and obvious similarities between surface water and groundwater. The time lag between peaks or inflection points of the surface water and groundwater temperature and conductivity graphs shall be used to estimate the time-of-travel. The well is considered rapidly recharged if the time-of-travel is less than 90 days.

If there is no surface water body located within 500 metres of the wellhead, precipitation data shall be used for comparison to the groundwater temperature and conductivity data. A rainfall gauge shall be used at the well site to measure precipitation. The precipitation records from an Environment Canada climate station can be used in lieu of an on-site rainfall gauge if the climate station is located within 20 km of the wellhead.

The hydrogeologic information review shall be used to assess whether there is potential for a hydraulic connection and to estimate the time-of-travel between the well and surface water. The review shall include, but not be limited to, an evaluation of the following:

- well characteristics (well depth, casing depth, annular seal, etc.);
- aquifer characteristics (aquifer type, confining layers, unsaturated zone thickness, hydraulic conductivity, effective porosity, depth to water bearing zones, the degree of connection between the surface water and aquifer - does the surface water body penetrate the aquifer?);
- hydraulic gradient (vertical gradient under pumping conditions, horizontal gradient between the well and the surface water body under pumping conditions, variation of static water level and surface water level with time, variation of static water level with precipitation);
- surface water features; and
- groundwater quality and flow (time-of-travel between the surface water and well).

At the end of Step 2 it shall be determined if there is a hydraulic connection that could allow rapid recharge of the well by surface water within 90 days. If there is no such hydraulic connection, the well passes Step 2 and can be classified as non-GUDI. If there is a hydraulic connection that could allow recharge within 90 days, then the well fails Step 2 and shall proceed to Step 3.

A.2.3 Step 3

The objective of Step 3 is to determine if there are significant particulates present in the well that are indicative of surface water. This is determined using Microscopic Particulate Analysis (MPA) in accordance with the method described in U.S. EPA, 1992, or an alternative method approved in writing by NSE.

A minimum of two MPA samples shall be collected. The samples are to be collected during periods when there is the greatest probability that surface water is impacting groundwater. The results from Step 2 shall be used to help select the most appropriate MPA sampling times (e.g., if there is a 15 day time-of-travel, then the well shall be sampled 15 days after a surface water event). It is recommended that one sample be collected in the spring after a heavy rainfall (25-50 mm) or snow melt and one be collected in the fall after a prolonged dry period.

The MPA scores shall be evaluated based on the risk factors specified by the U.S. EPA (1992) as follows:

- low risk = MPA score < 10
- medium risk = MPA score 10 to 19
- high risk = MPA score >20

Wells that have low risk MPA scores for both samples can be classified as non-GUDI. If any of the MPA samples fall into the medium or high risk categories the well shall be classified as GUDI unless remedial action and/or further sampling demonstrates otherwise.

If remedial action is completed, the well may be reclassified if Step 3 is repeated and the results show the well is low risk. However, prior to proceeding with remedial action the utility shall obtain written approval of their approach from the NSE regional hydrogeologist. In evaluating this request, the NSE regional hydrogeologist will consider the likelihood that remedial action will be effective, as per the guidance on the modification of sources in US EPA (1991).

MPA results shall be submitted to NSE complete with a qualified hydrogeologist's report that documents the timing of the MPA sample collection relative to weather events and confirms that it corresponds to a period in which there is the greatest probability that surface water is impacting groundwater in the sampled well as described above.

A.3 GUDI CLASSIFICATION

The final determination of whether a well is GUDI or non-GUDI shall be based on all the evidence collected. Wells that have no evidence of existing or potential hydraulic connection with surface water shall be classified as non-GUDI, and wells that have a hydraulic connection with a medium or high risk MPA score shall be classified as GUDI. If a water well is declared GUDI at any point in the process, the additional investigation steps are not required.

A.4 REFERENCES

American Water Works Association (AWWA). 1996. Determining Groundwater Under the Direct Influence of Surface Water.

American Water Works Association (AWWA). 2001. Investigation of Criteria for GWUDI Determination.

Ontario Ministry of the Environment (MOE). 2001. Terms of Reference, Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water. October 2001.

U.S. Environmental Protection Agency (U.S.EPA). 1991. Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Waters. U.S. Environmental Protection Agency, Office of Drinking Water. March 1991.

U.S. Environmental Protection Agency (U.S.EPA). 1992. Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA). U.S. Environmental Protection Agency. EPA 910/9-92-029. October 1992.