Protocol for Determining Groundwater Under the Direct Influence of Surface Water

INTRODUCTION

GUDI is an acronym for Groundwater Under the Direct Influence of surface water. This term refers to groundwater sources (e.g., wells, springs, infiltration galleries, etc.) where microbial pathogens are able to travel from nearby surface water to the groundwater source. The Nova Scotia Treatment Standard for Municipal Surface Source Water Treatment Facilities requires all municipal Public Water Systems using surface water or GUDI sources to meet the requirements of the standard.

The purpose of this document is to present a protocol for determining whether or not a groundwater source is GUDI, where GUDI is defined as: "any water beneath the surface of the ground with:

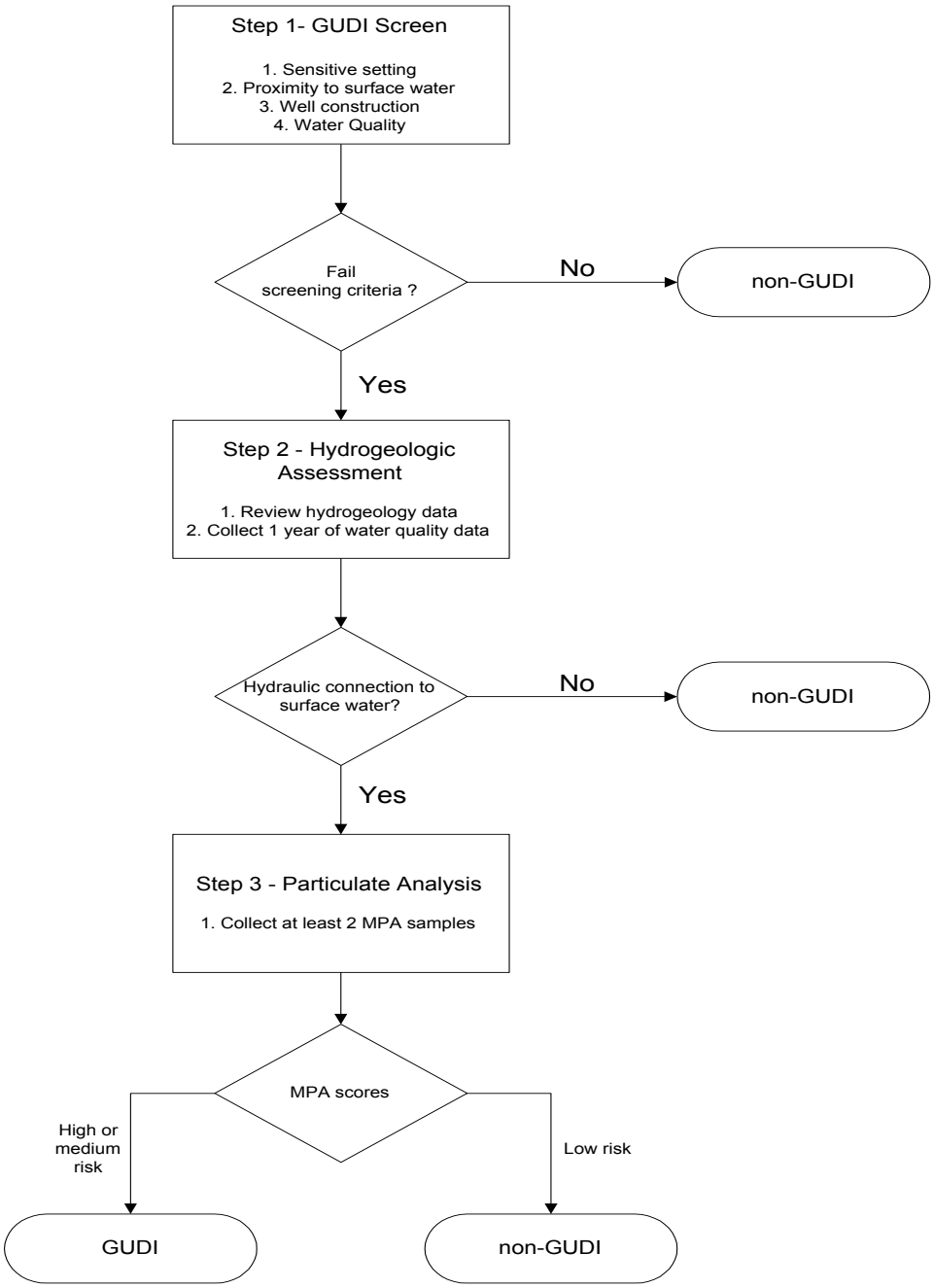
> i) significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as *Giardia lamblia* or *Crytosporidium*; or
>
> ii) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely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

Part (i) of the definition is aimed at determining if there are particulates present 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 protocol presented here is based on guidance provided in USEPA (1991), AWWA (1986), AWWA (2001) and MOE (2001). The protocol should be carried out by, or under the supervision of, a qualified hydrogeologist. The protocol 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 the screening step are considered potentially GUDI and proceed to Step 2 to determine whether there is a hydraulic connection which allows rapid recharge

between the groundwater source and surface water. If there is no hydraulic connection the source is non-GUDI. If a hydraulic connection exists, Step 3 is completed to determine if there are particulates present in the groundwater source that are indicative of surface water. A flow chart for the protocol is presented in Figure 1 and explanation of each step is provided below. If a well is declared GUDI at any point in the protocol, the additional investigation steps are not required.

Figure 1: Flow Chart for Making GUDI Determinations



STEP 1 - GUDI SCREENING

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. At the end of Step 1 the well should be classified as either non-GUDI or potentially GUDI. The screening step may also identify remedial measures, such as well construction improvements, to reduce the potential to be influenced by surface water. If remedial measures are recommended, they should be completed before proceeding to Step 2 and 3.

For a groundwater source to be considered non-GUDI it must satisfy all of the criteria below. If it does not meet these criteria it is considered potentially GUDI.

1. **Sensitive settings** - the source must not fall into any of the following categories: spring, infiltration gallery, horizontal collection well, wells in karst aquifers, wells in unconfined aquifers and wells that are part of an enhanced recharge/infiltration project.
2. **Proximity to surface water** - the well must be greater than 60 m from the nearest surface water body (i.e., 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 must meet the current Well Construction Regulations; the casing must extend at least 12.2 m below ground surface; and the well must 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** - available data must show the raw well water does not regularly contain total coliforms or exceed turbidity guidelines.

STEP 2 - HYDROGEOLOGICAL ASSESSMENT

The objective of this step is to determine if there is either an existing or potential hydraulic connection that could allow rapid recharge of the well by surface water or precipitation. Step 2 will normally involve a review of available hydrogeologic information and collection of one year of water quality data (such as temperature, conductivity, turbidity, pH). Additional hydrogeologic data may also be collected if

the review of available data indicates there is insufficient information. At the end of this step the well can be classified as either:

- non-GUDI (i.e., no hydraulic connection with surface water/precipitation);
- in hydraulic connection with surface water/precipitation; or
- potentially in hydraulic connection, if there is significant uncertainty.

The hydrogeologic information review should 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 should 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 (eg., time-of-travel between the surface water and the well).

Raw water quality data should be collected at the well and a nearby surface water body for a one year period to determine if there is a close relationship between changes in the surface water quality and the well. Patterns are best recognized from one-year hydrographs; however, a shorter duration may be sufficient if a hydraulic connection is recognized early on in the monitoring program. Water quality parameters should include, but not necessarily be limited to, temperature and conductivity and should be measured on a weekly basis at a minimum. A rainfall gauge can be used to measure cumulative rainfall each week.

The water quality data should 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 can be used to estimate the time-of travel. The well is considered to be rapidly recharged if the time-of travel is less than 90 days.

STEP 3 - PARTICULATE ANALYSIS

The results of the Hydrogeological Assessment in Step 2 may determine that there is a hydraulic connection between the well and surface water. However, if the aquifer provides sufficient natural filtration to remove surface water organisms and debris, the well is not under the direct influence of surface water. 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). The MPA test involves filtering approximately 4,500 L of water to concentrate organisms and debris which are then identified and quantified using a microscope. At the end of this step the MPA score is used to classify the well as either a low, medium or high risk.

A minimum of two MPA samples should 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 should 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 should 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 should be evaluated based on the risk factors specified by the USEPA (1992) as follows:

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

If any of the MPA samples fall into the medium or high risk categories the well should be considered GUDI unless remedial action and/or further sampling demonstrates otherwise.

GUDI DETERMINATION

The final determination of whether a well is GUDI or non-GUDI will be a matter of professional judgement based on all of the evidence collected. In general, wells that have no evidence of existing or potential hydraulic connection with surface water will be considered non-GUDI, and wells that have a hydraulic connection and a medium or high risk MPA score will be considered GUDI. Evidence that a well is GUDI is usually more conclusive than evidence that a well is non-GUDI. If there is significant uncertainty, it is appropriate to err on the side of public health and safety and consider the well to be GUDI.

REFERENCES

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

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USEPA. 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.

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

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