Guidesheet I
Hydrogeologic Study Requirements
PART 22 Groundwater Discharge Permits

Table of Contents

EGLE Environmental Assistance Center
800-662-9278
Michigan.gov/EGLE
09/2021

1.0 INTRODUCTION

Groundwater discharge permits authorize the discharge of wastewater to the groundwater in compliance with the provisions of Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended (NREPA). The information provided in a hydrogeologic study allows the Department of Environment, Great Lakes, and Energy (Department) to evaluate the fate and transport of groundwater impacted by a discharge and to ensure that all affected groundwater is not, or is not likely to, cause an adverse impact on drinking water supplies or surface water bodies. In addition, R 323.2204 of Part 22, Groundwater Quality (Part 22 Rules), promulgated pursuant to Part 31, Water Resources Protection, of the NREPA, does not allow discharges to be, or to become, injurious or to create a facility as defined in Part 201, Environmental Remediation, of the NREPA.

The information required in a hydrogeologic study is complex and can be extremely technical. It is strongly recommended that the applicant consider the following:

Hiring professionals with a background in the field of hydrogeology, preferably those that have some familiarity with the groundwater discharge permit program.

Request that their consultant provide a hydrogeologic study Work Plan, in accordance with R 323.2221(3), for review and approval to the Water Resources Division (WRD) Groundwater Permits Unit (GPU) prior to commencing any fieldwork. Approval of a Work Plan does not mean an applicant will be guaranteed approval of their authorization application. It does ensure that the location and scope of work will meet the expectations of the Rules and reduce or eliminate the need for multiple iterations of the same hydrogeologic study.

1.1 Hydrogeologic Study Requirements for Reissuance under R 323.2218

R 323.2221 of the Part 22 Rules of Part 31 of the NREPA requires that before obtaining a discharge permit authorized under R 323.2218, an applicant shall provide a hydrogeologic report that meets the requirements of this rule. R 323.2221(2) requires the hydrogeologic study to describe the regional hydrogeologic conditions; identify whether the discharge will occur in a wellhead protection area (WHPA); determine whether the discharge is to a usable aquifer, an unusable aquifer, or groundwater not in an aquifer; define the areal and vertical extent and physical properties of the geologic materials that assimilate and transmit the discharge; and provide sufficient information to propose a groundwater monitoring program to measure compliance with the Part 22 Rules.

1.2 Supplemental Hydrogeologic Investigations

Under certain conditions, the GPU may also require the completion of supplemental hydrogeologic studies for applicants permitted under R 323.2218 or require a hydrogeologic study for applicants authorized to discharge under a permit category other than R 323.2218. These conditions include, but are not limited to:

The applicant has applied for a modification to the discharge quantity, effluent characterization, or treatment process from that previously permitted.

The data collected and/or information provided in previously submitted hydrogeologic reports does not meet the requirements under R 323.2221 and/or are not able to demonstrate compliance with R 323.2222 or R 323.2204. Under R 323.2204(2)(a), the discharge shall not be, or not likely to become, injurious; (e) the discharge shall be consistent with the requirements of Rules 1041 to 1117 (Part 4, Water Quality Standards, promulgated pursuant to Part 31, Water Resources Protection, of the NREPA); (f) the discharge shall not create a facility as defined in Part 201.

Under R 323.2227(2), if the Department determines that a limit on the concentration of a substance in the effluent or groundwater has been exceeded, the Department may require the discharger to (b) develop and implement a groundwater monitoring program if one is not in place; (c) if the discharge is in a WHPA, assess the effects of the discharge on the public water supply system; (e) define the extent to which groundwater quality exceeds the applicable criteria established by the Department under Section 20120a(1)(a), or Section 21304(a) of the act, if applicable.

If an existing treatment system includes wastewater treatment or storage lagoons, R 2237(4)(b) allows the Department to approve an existing or proposed system if it provides equal or greater environmental protection to the protection provided by a liner constructed according to 2237(1). For an existing system, a demonstration can be made through monitoring of the groundwater and a hydrogeologic demonstration approved by the Department that the lagoon has not impacted, and is not likely to impact, groundwater above the standards of R 323.2222.

2.0 HYDROGEOLOGIC REPORT REQUIREMENTS (R 323.2221)

2.1 Elements of a Hydrogeologic Report

A Hydrogeologic Report shall contain the following elements to meet the requirements of R 323.2221 of the Part 22 Rules.

2.1.1 Narrative

The narrative portion of the hydrogeologic report must contain a discussion of the following items:

- ☐ Historical land use of the site.
- ☐ Land use in the vicinity of the site.
- ☐ Regional geology.
- ☐ Surface waters and drainage patterns in the area.
- ☐ If the discharge is located within a designated WHPA.
- ☐ Purpose of the hydrogeologic study.
- ☐ Discussion of field activities.
- ☐ Conclusions relative to the hydrogeologic conditions of the site and acceptability of the discharge.

Recommendations as to the following:
- ☐ Additional hydrogeologic investigation.
- ☐ Upgrade of wastewater treatment system.
- ☐ Modifications to disposal method.

2.1.2 Characterization of Site Geology

The site geology must be characterized by the following field activities:

- ☐ A minimum of five soil borings for a five-acre site and three soil borings for each additional five acres.
- ☐ Soil borings must be of sufficient depth to characterize the site geology where the discharge will be received.
- ☐ Soil samples shall be collected by standard soil sampling techniques.
- ☐ The particle size distribution, by both sieve and hydrometer.
- ☐ The classification under the Standard Classification of Soils for Engineering Purposes, Unified Soil Classification System (ASTM D2487).
- ☐ Vertical permeability.
- ☐ Phosphorus adsorption capacity (PAC).

2.1.3 Groundwater Characterization

Groundwater conditions beneath the site must be characterized by determining the following:

- ☐ Depth to groundwater.
- ☐ Thickness of saturated formation.
- ☐ Direction of groundwater flow, both vertical and horizontal.
- ☐ Velocity of groundwater flow.
- ☐ Interconnection of groundwater formations.
- ☐ Locations where groundwater is anticipated to vent to surface water.
- ☐ Background groundwater quality.
- ☐ Existing groundwater quality.
- ☐ Groundwater mounding calculations.

2.1.4 Groundwater Monitoring

The following should be included to address groundwater monitoring:

- ☐ Proposal for a groundwater monitoring program to be incorporated into the groundwater discharge permit.
- ☐ A sampling and analysis plan.

2.1.5 Tables

Soil boring and well information:

- ☐ Top of casing.
- ☐ Ground elevation.
- ☐ Depth to groundwater.
- ☐ Static water elevation.
- ☐ Depth and elevation of screened interval.
- ☐ Elevations should be referenced to the United States Geological Survey (USGS) datum.
- ☐ Groundwater and effluent quality data.
- ☐ Hydraulic conductivity test results.
- ☐ PAC test results.
- ☐ Vertical permeability test results.

2.1.6 Maps

☐ Regional topography map with property boundaries of site location.
☐ Residential well log map. The map must include the locations of residential wells within a half mile of the discharge location. The residential well locations should be cross-referenced to well logs submitted as part of the hydrogeologic report.
☐ Site map. The site map must include the following:
  ☐ Property boundaries.
  ☐ Soil boring and well locations.
  ☐ Wastewater treatment facility and discharge location.
  ☐ Surface waters, including wetlands.
  ☐ Groundwater contours with the maximum contour interval being 1.0 foot.
  ☐ Geologic cross-sections generated from soil borings and wells at the site.

2.1.7 Calculations

Appendices should be included which contain calculations for each of the following:
☐ Groundwater flow direction.
☐ Horizontal and vertical hydraulic gradient of the underlying aquifer.
☐ Vertical and horizontal hydraulic conductivity data.
☐ Groundwater flow velocity.
☐ Groundwater mounding.
☐ PAC of soils.
☐ Nutrient uptake of cover crop.

2.1.8 Raw Data

The following raw data should be included in each hydrogeologic report:
☐ Soil boring logs.
☐ Monitor well construction logs.
☐ Domestic well logs within ½ mile of the discharge.
☐ Laboratory data sheets for groundwater and effluent quality sampling.
☐ Soil size gradation data.
☐ Hydraulic conductivity data.

3.0 CHARACTERIZATION OF SITE GEOLOGY

3.1 Drilling Method

The drilling method used should be capable of clearly identifying the horizon from which samples are collected and allow collection of undisturbed samples. Examples of acceptable drilling methods include Hollow Stem Augers (HSA), Rotosonic, and the use of Direct Push technology (Geoprobe). Mud rotary and solid core augers are <u>not</u> acceptable drilling methods. Hand augering and manually driven monitoring wells are also not acceptable without prior Department approval.

3.2 Soil Borings

To accurately characterize the subsurface, the collection of continuous soil samples will be required at each soil boring to a minimum of 30 feet below ground surface (bgs). The GPU may require the collection of continuous soil samples beyond 30 feet bgs depending on the anticipated geologic conditions. The collection of discontinuous samples or other alternatives may be approved on a site-specific basis once an extensive study has already been completed and the hydrogeology is thoroughly understood.

For most discharges, a minimum of five soil borings will be required for the first five acres of discharge area and a minimum of three soil borings will be required for each additional five acres or portion thereof. The total number of required soil borings may be adjusted up or down based on the complexity of the site geology or on the total size of a discharge area.

Acceptable soil sampling techniques for soil identification and logging include Split-Barrel/Split-Spoon sampling (ASTM D1586), Continuous Coring using HSA (D6151), Direct-Push sampling (ASTM D6282), or Sonic drills (ASTM D6914). Shelby Tube samplers (ASTM D1587) are acceptable for the collection of undisturbed soil samples for laboratory testing of in-situ physical and hydraulic properties, i.e., vertical permeability. Shelby Tube samplers are not recommended for coarse-grained, cemented, or very hard soils. Alternative soil samplers may be used including soil coring devices (see ASTM D6169 for guidance).

3.2.1 Boring Logs

R 323.2221(4)(a) requires a log to be generated for each soil boring. Each log must include (i) soil and rock descriptions; (ii) the method of soil sample collection; (iii) the depth of each soil sample; (iv) the date of boring advancement; (v) water level measurements, i.e., depth to groundwater; (vi) the USGS ground surface elevation; (vii) soil test data; and (viii) standard penetration number calculated in accordance with the method specified in the standard penetration test, ASTM D1586. All soil and rock descriptions should be in accordance with the ASTM D2487, or the "Standard Practice for Description and Identification of Soils, Visual Manual Procedure" (ASTM D2488). All elevation data collected (ground surface, water level, and total depth of boring) should be corrected to the USGS datum.

3.2.2 Abandonment

R 323.2221(5) requires all test wells (soil borings) not converted to observation wells to be backfilled, plugged, and recorded according to approved procedures provided in Part 127, Water Supply and Sewer Systems, of the Public Health Code, 1978 P.A. 368, as amended.

3.3 Soil Testing

Soils testing should be performed on samples collected from each soil layer or change in lithology. These tests include, but are not limited to, particle size distribution by sieve and/or hydrometer (ASTM D2487), and the Standard Penetration Test (ASTM D1586).

In addition, testing of the unsaturated zone sufficient to determine the ability of the geologic materials to percolate and transmit the volume of liquids resulting from the discharge, and the vertical and horizontal extent of mounding resulting from the discharge will need to be provided. Allowable test methods to make these determinations are provided in *Guidesheet II: Guidance for the Development of a Discharge Management Plan, Appendix B*. The Department will not accept permeability determinations of soils based upon particle size distribution or upon disturbed samples.

4.0 GROUNDWATER CHARACTERIZATION

To comply with all the items listed under R 323.2221(4)(c)(i), the installation of a minimum of three monitoring wells is required. Additional monitoring wells may be required on a site-specific basis depending on the complexity of the site hydrogeology.

4.1 Monitoring Well Installation

4.1.1 Casing Materials

The selection of appropriate materials for monitoring well casing must take into account several site-specific factors including: (1) geologic environment; (2) natural geochemical environment; (3) anticipated well depth; (4) types and concentrations of discharge parameters; and (5) design life of the monitoring well. Materials that are commonly used for monitoring wells in this program are polyvinyl chloride (PVC), galvanized, and stainless steel. PVC is recommended to be used at sites where metals are a constituent of concern.

4.1.2 Well Diameter

The diameter of the casing for a monitoring well is generally selected to accommodate downhole equipment. Additional casing diameter selection criteria include: (1) drilling or well installation method used; (2) anticipated depth of the well and associated strength requirements; (3) ease of well development; (4) volume of water required to be purged prior to sampling; and (5) rate of recovery of the well after purging. Generally, a two-inch inside diameter well casing is acceptable.

4.1.3 Screen Size, Length, and Placement

The screen design must accommodate varying physical and chemical characteristics. Screens with the following characteristics provide the best service in most geological conditions: (1) slot openings should be continuous around the circumference of the screen, permitting maximum accessibility to the aquifer so that efficient development is possible; (2) slot openings should be spaced to provide maximum open area consistent with strength requirements to take advantage of the aquifer hydraulic conductivity; (3) screens must be sufficiently strong to withstand stresses normally encountered during and after installation. In addition, the slot size of the well screen should be determined relative to the grain size analysis of the stratum interval to be monitored and the gradation of the filter pack material. This is most commonly done with a sieve analysis. In most circumstances, the use of a 10-slot well screen is acceptable.

Screen length should be adequate to supply enough water to obtain a representative sample. However, it should not be of such length that a diluted sample is collected. It should be noted that screening over much of the aquifer thickness could contribute to vertical movement of the parameters of concern. A screen length of three to five feet is appropriate in most cases.

Shallow monitoring wells are typically screened with the top of screen located between 5 and 15 feet below the first encountered saturated zone or water table. A well screen that straddles the water table is not acceptable for monitoring the saturated zone. A monitoring well cluster or clusters may be required depending on the site-specific hydrogeologic conditions. Well clusters can be used to determine vertical gradients, may be used to monitor discrete zones, and/or may be used to evaluate chemical stratification within a thick zone of saturation. R 323.2223(4)(b) requires at least one hydraulically downgradient monitoring well cluster if the aquifer receiving the discharge is more than 20 feet in thickness. If monitoring wells are required to be set beneath a low-permeability formation, R 323.2223(4)(e) requires a discharger to install double-cased wells when drilling through confining layers to prevent the hydraulic connection of fluids between formations above and below a confining layer.

4.1.4 Well Screen Packing

Once the well is in place, the screen should be surrounded by materials that are coarser, have a uniform grain size, and have a higher permeability than natural formation material. This allows groundwater to flow freely into the well from the adjacent formation material while minimizing or eliminating the entrance of fine-grained materials.

This can be accomplished by designing the well in such a way that either the natural coarse-grained formation materials or artificially introduced coarse-grained materials, in conjunction with appropriately sized well screen openings, retain the fine materials outside the well while permitting water to enter. Thus, there are two types of wells and well intake designs; naturally developed wells and wells with an artificially introduced filter pack.

In natural collapse or development, a highly permeable zone is created around the screen from materials existing in the formation. This method of well screen packing is typically not acceptable. In filter packing, a specially graded sand or gravel having high porosity and permeability is placed in the annulus between the screen and the natural formation. Filter packing is the preferred method.

4.1.5 Annular Seals

Any annular space that is produced as the result of the installation of well casing in a borehole provides a channel for vertical movement of water and/or contaminants unless the space is sealed. The seal serves several purposes: (1) to provide protection against infiltration of surface water and potential contaminants; (2) to seal off discrete sampling zones; and (3) to prohibit vertical migration of water.

The annular seal in a monitoring well is placed above the filter pack in the annulus between the borehole and the well casing. R 323.2223(4)(e) requires the annular space to be grouted from the ground surface to two feet above the well screen to prevent vertical leakage of fluids between the casing and the drill hole.

4.1.6 Surface Completion and Protective Measures

Two types of surface completions are common for groundwater monitoring wells: (1) aboveground completion; and (2) flush-to-ground surface completion. An aboveground completion is preferred whenever practical. The primary purposes of either type of completion are to prevent surface runoff from entering and infiltrating down the annulus of the well, and to protect the well from accidental damage or vandalism.

Whichever type of completion is selected for a well, there should always be a surface seal of neat cement or concrete surrounding the well casing and filling the annular space between the casing and the borehole at the surface.

A protective casing is generally installed around the well casing by placing the protective casing into the cement surface seal while it is still wet and uncured. The protective casing discourages unauthorized entry into the well and prevents damage by contact with vehicles. This outer casing should be kept locked between sampling events. Like the inner well casing, the outer protective casing should be vented near the top to prevent the accumulation and entrapment of potentially explosive gases and to allow water levels in the well to respond naturally to barometric pressure changes.

4.1.7 Well Development

Well development has two broad objectives: (1) repair damage done to the formation by the drilling operation so that the natural hydraulic properties are restored, and (2) alter the basic physical characteristics of the aquifer near the borehole so that water will flow more freely to the well. All new wells should be developed before being put into use. In addition, older wells often require periodic redevelopment.

Effective development procedures should cause reversals of flow through the screen openings that will agitate the sediment, remove the finer fraction, and then rearrange the remaining formation particles. Examples of methods that apply this principal are backwashing and mechanical surging. Using a bailer or one directional pumping to develop a well is not acceptable.

4.1.8 Well Construction Information and Survey Data

If a monitoring well is installed at a boring location, all well construction information should be submitted including the well casing and well screen construction material and size, the total depth of the well in feet bgs, the surveyed ground surface elevation, the surveyed top of casing elevation, and the screened interval recorded in feet bgs and feet above mean sea level (amsl). This information can be submitted as a diagram or in a tabular format. R 323.222(4)(g)(iv) requires all top of well casings be surveyed and referenced to USGS data accurate to 0.01-foot by a land surveyor licensed under the Occupational Code, 1980 P.A. 299, as amended. All elevation data collected (ground surface, water level, and total depth of boring) should be corrected to the USGS datum

4.1.9 Monitoring Well Abandonment

R 323.2223(4)(j) requires a monitoring well to be permanently abandoned according to the plugging procedures in Part 127, Water Supply and Sewer Systems, of the Public Health Code, 1978 P.A. 368, as amended.

4.2 Aquifer Testing

4.2.1 Water Level Measurement and Groundwater Flow Direction

The basic water level measuring device is an electronic water level indicator. When the sensor encounters conductive fluid, the circuit is completed, and an audible or visual signal is displayed at the surface. All measurements should be related to a known USGS datum, which should be measured from a clearly identified location on each casing. Water levels must be recorded to an interval of 0.01-foot.

A minimum of three monitoring wells must be installed to obtain a groundwater flow direction. The water level measurements recorded from the monitoring wells in feet amsl can be used to draw a water table contour map that represents the surface of an unconfined aquifer as represented by elevation contours.

A contour map uses a minimum of three groundwater level measurements from wells, according to the United States Environmental Protection Agency (USEPA). Measured water levels converted to elevations become the basis for contours of equal elevation. A resulting water table map shows the plane of the unconfined water below ground within the triangle of space defined by the three measurement points.

4.2.2 Horizontal Hydraulic Conductivity

To determine the horizontal hydraulic conductivity of the aquifer, either a pump test or a slug injection or recovery test will need to be performed. Pumping tests are typically performed in wells with high transmissivity and in wells with a diameter large enough to accommodate the pumping equipment. Nearby observation wells are generally required to measure aquifer response. Conversely, slug injection or recovery tests, that add or remove smaller amounts of water, are typically performed in formations with low transmissivity and in a single, smaller diameter well.

4.2.3 Groundwater Sampling

4.2.3.1 Collection Methods

A wide variety of groundwater sampling devices are available to meet the requirements of a groundwater-monitoring program. The collection method used should be tailored to fit the chemicals being monitored, the hydrogeologic situation, and the design of the monitoring wells. The methodology used in the sampling procedure is critically important if the true chemical nature of the groundwater at the site is to be determined. The most common groundwater sample collection methods include the Multiple-Volume Purge method and the Low-Flow/Minimal Drawdown method. If another method is chosen to collect groundwater samples, you will need to demonstrate how you will collect representative samples from the monitoring wells.

The Multiple-Volume Purge method involves removing a minimum of three well volumes of water from the top of the water column with a bailer or pump and then sampling when the well has achieved stability of water quality parameters and adequately low turbidity. This is a traditional method and consistent results are generally obtained with samplers of varying skill. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The Low-Flow method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multiple-Volume Purge and generates less purge water. The method requires more skill and judgment on the part of the samplers.

Before a monitoring well is sampled, stagnant water in the well casing must be removed or purged to obtain a representative groundwater sample. Common instruments used for purging include bailers, submersible pumps, and peristaltic pumps.

Prior to purging, the water level in the well and the total depth of the well should be measured to determine the volume of water in the well. When using a bailer, a minimum of three well volumes should be purged, unless the well runs dry. When using low-flow methods, purging should continue until the selected indicator parameters have stabilized.

Once purging is completed or the groundwater in the well recovers, the groundwater pH, temperature, specific conductance, and turbidity should be measured. After the correct sample containers have been prepared, sampling may proceed.

Purging and sampling should occur in a progression from the least contaminated well to the most contaminated well, if this information is known; disposable equipment should be used for each well or equipment must be decontaminated prior to use and between each well.

4.2.3.2 Calculations

If it is necessary to calculate the volume of water in the well, use the following equation:

Well volume (gallons) = $\pi r^2 h$ (cf)
Where:

r = radius of monitoring well (feet)
h = height of the water column (feet
(This may be determined by subtracting the depth to the water from the total depth of the well as measured from the same reference point.)
cf = conversion factor (gallons/linear foot) = 7.48 gal/ft^3

If the diameter of the monitoring well is known, standard conversion factors can be applied to simplify the equation above. Monitoring well diameters are typically two, three, four, or six inches.

4.2.3.3 Representative Sample Collection

The primary goal in performing groundwater sampling is to obtain a representative sample of the aquifer or water-bearing zone. Prior to sample collection, monitoring wells are purged to remove the stagnant water within the well casing. An undisturbed monitoring well will have little or no vertical mixing of the water within the casing, and stratification will occur over time. The well water in the screened interval will mix with incoming groundwater due to normal flow patterns, but the well water above the screened interval will remain isolated, become stagnant, and may no longer be representative of the groundwater quality. Also, stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in a non-representative sample.

Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls. As many contaminants (metals and many organics) will sorb to the formation particles, a sample including these particles will not represent the concentrations of constituents in the aquifer. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

To safeguard against collecting non-representative stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. As a general rule, all monitoring wells should be purged prior to sampling. To obtain a representative sample using the Multiple-Volume Purge method, a minimum of three volumes of water in the well casing should be removed. To determine when a well has been adequately purged, field investigators should also monitor, at a minimum, the pH, specific conductance, and turbidity of the groundwater removed, and the volume of water removed during purging. When using Low-Flow methods, purging should continue until the selected indicator parameters have stabilized. Indicator parameters typically used in low-flow purging include pH, specific conductivity, turbidity, temperature, dissolved oxygen, and oxidation-reduction potential. In general, an adequate purge is achieved when the pH and specific conductance of the groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Alternatively, for low-yielding groundwater formations, the well can be pumped dry and sampled upon recovery. In a high-yielding groundwater formation where there is no stagnant water in the well casing, purging is not as critical.

2. When purging with a pump, the pump should be set within the screened interval. When sampling a screened well, the sample should also be collected from the same depth within the screened interval at which the pump was set.

3. The well should be sampled as soon as possible after purging.

4. For wells that are pumped or bailed to dryness prior to the purging procedure being completed, the well should be allowed to recover (for up to, but no longer than, 24 hours) prior to sample collection.

5. A non-representative sample can also result from excessive purging of the well. Stratification of the constituent concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to lower portions of the aquifer. Excessive pumping can dilute or increase the constituent concentrations relative to those at the sampling point of interest.

6. A sampling methodology must be used that accounts for the effects of aquifer heterogeneities, while minimizing alterations in water chemistry that could result from sampling disturbances. The GPU will accept properly conducted purging methods designed to minimize drawdown, by controlling the flow from the well while monitoring stabilization indicator parameters, commonly referred to as low-flow methods. Available low-flow procedures include:

   USEPA, Office of Research and Development, Office of Solid Waste and Emergency Responses, EPA/540/S-95/504, April 1996, USEPA Ground Water Issue, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, Robert Puls and Michael Barcelona.

   USEPA, Region 1, July 30, 1996, Revision 3, *Low Stress (Low-Flow) Purging and Sampling Procedure for the Collection of Ground Water Sampled from Monitoring Wells*

The Low-Flow/Minimal drawdown method is strongly recommended for the collection and analysis of metals samples to ensure the data are representative for compliance purposes.

Samples may not be representative of groundwater conditions for the following reasons:

1. The sample was taken from stagnant water in the well, which is usually chemically different from the water in the ground near the well bore.
2. The water sample was contaminated by entrained sediment because the well was not developed properly.
3. The sample was taken so long after pumping began that it represents water far enough from the well site that the groundwater chemistry is not representative.
4. Release of carbon dioxide during pumping caused an increase in pH, which in turn caused may metallic ions to come out of solution.
5. Numerous chemical changes took place because the sample was oxidized during recovery.
6. Chemical residues in the pump or sampling equipment contaminated the water sample.
7. The sample was not preserved correctly, so chemical changes occurred in the sample during storage.

It is recommended that groundwater sampling be conducted by experienced field personnel, from the testing laboratory, or by other groundwater professionals.

4.2.3.4 Filtration and Preservation

The GPU will not accept filtered groundwater sampling results for inorganics unless the applicant has demonstrated that filtered samples are necessary based on site-specific conditions. If the collection of filtered samples has been approved by the GPU, a 0.45-micron filter pore size is typically used. Flush or rinse filter membranes and sample containers with laboratory grade water before use unless the equipment is already pre-washed and rinsed. In addition, discard the first 150 milliliters of sample that passes through the filter before filling sample containers. Use positive pressure filtration rather than vacuum filtration, which causes excessive aeration and agitation of the samples.

Preserving samples retards biodegradation reactions, hydrolysis reaction, precipitation and coprecipitation reactions, and sorption reactions. Sample preservation usually involves reducing or increasing pH by adding an acid or base preservative. Samples are also preserved by cooling them to 4°C. Add preservative to the container before or immediately after collecting the sample. If a sample requires filtration, add preservative after filtration, not before.

4.3 Venting Demonstration

R 323.2222(7)(b)(i) allows the Department to approve a standard different from the standards established in subrules (2) through (6) of this rule when a demonstration is made that the groundwater affected by the discharge vents to surface water, uses of the surface water are protected in accordance with R 323.1041 to R 323.1117, and the distance between the point of discharge and the point of venting to surface water is less than 1,000 feet. The applicant may be required to demonstrate that 100 percent of groundwater impacted by the discharge vents to surface water for the Department to approve standards other than those established in subrules (2) through (6). In situations where there is potential for groundwater to impact both drinking water and surface water, both sets of limits may be applicable in the same permit. This demonstration will need to be included within the hydrogeologic investigation report and can be accomplished using one or a combination of the following methods:

1. Cluster Wells and Vertical Gradients: Cluster wells may be placed at the groundwater surface water interface for the collection of static groundwater elevation data to determine the vertical gradient of the aquifer. Well locations must be along the entire length of the proposed venting location at approved spacing. This method is not acceptable in situations where contaminants of concern have the potential to migrate vertically within the aquifer and travel horizontally below the surface water body potentially impacting downgradient receptors.

2. Groundwater Flow Direction: A minimum of three monitoring wells may be placed on each side of the surface water body where venting is expected to occur for the collection of static groundwater elevation data. In addition, a staff gauge must be installed in the surface water body. Groundwater flow maps can then be generated to show that groundwater on each side is flowing toward the surface water body. This method is not acceptable in situations where contaminants of concern have the potential to migrate vertically within the aquifer and travel horizontally below the surface water body potentially impacting downgradient receptors.

3. Totally Discharging System (100 percent of groundwater impacted by the discharge vents to surface water): Soil borings and cross-sectional data may be used to demonstrate that the aquifer is of limited vertical extent and that the bottom of the surface water body is at or near the top of regional aquitard. The data must also demonstrate the following:

   a) The aquitard is a minimum of 20 feet in thickness and free of sand and gravel lenses;

   b) The aquitard material must have a saturated vertical hydraulic conductivity of not more than $1x10^{-7}$ centimeters per second (cm/s); and

   c) The aquitard is regionally continuous.

The applicant will also need to demonstrate that venting occurs throughout the year and is not just seasonal phenomena.

4.4 Groundwater Not in an Aquifer or in an Unusable Aquifer Demonstration

1. A demonstration may be made that the discharge in question is not in hydraulic communication with groundwater in a usable aquifer. This criterion can be met through any one or a combination of the following:

   a) A demonstration is made that shows the receiving aquifer is unable to be utilized for any economic or potable use. The applicant must provide information concerning the regional geology supplemented with adequate site-specific information (boring/monitoring well logs, geophysical information, analytical results, etc.) sufficient for the GPU to make a determination on the validity of the demonstration.

Such a demonstration must be approved by the GPU. Given the geology of Michigan, such a demonstration is likely to be approved only in extremely rare circumstances.

b) A demonstration that the groundwater is venting 100 percent to a surface water body (that is not locally recharging an aquifer) can be used to show that a saturated hydrogeologic unit does not impact a usable aquifer. This demonstration must also show that all applicable groundwater surface water interface (GSI) criteria are/will be met at the venting location. (The applicant may request site-specific GSI criteria be developed by applying for a mixing zone evaluation by the Department's WRD, Permits Section). The venting demonstration would eliminate the concern regarding a connection to the underlying aquifer. A demonstration would also need to be made that the receiving surface water body in question does not in turn discharge to another aquifer at a different location.

4.5 Establishing Background Groundwater Quality

R 323.2222 (5)(a) and R 323.2222 (7)(c)(I), limits inorganic substances not described in subrule (2)(a) or (b) or (c) of this rule by the following criteria:

> The concentration of the inorganic substance in groundwater shall not exceed a concentration halfway between the background groundwater quality and the concentration at which the site would be a facility as defined by Part 201.

The inorganic substance limit established in a permit shall be determined by one of the following methods:

1. The concentration that is halfway between background groundwater quality and the concentration at which the site would be a facility as defined by Part 201.
2. The applicant may choose a default background groundwater quality value, which is the limit of detection as established by the State Environmental Laboratory, and have a permit limit halfway between the limit of detection and the concentration at which the site would be a facility as defined by Part 201.

If the applicant chooses to establish a site-specific background groundwater quality value, background shall be determined by the following method:

> A minimum of three wells approved by the WRD as being representative of unimpacted background groundwater shall be sampled for the parameters of concern at least every other month for one year. Two replicate samples shall be obtained for each sampling event. The arithmetic mean concentrations shall be calculated from each well and the geometric mean shall be calculated between wells. Anomalous results (results affected by high turbidity or otherwise inconsistent with either temporal results from the same well or spatial results from nearby wells)

shall not be used in the calculation. Anomalous results will be determined by the WRD. The background groundwater quality shall be calculated as the geometric mean of the spatial variability between individual wells plus one standard deviation.

5.0 HYDROGEOLOGIC STUDY WORK PLANS

R 323.2221(3) allows an applicant applying for a groundwater permit under R.323.2218 to submit a work plan for the development of a hydrogeologic report for Department approval. The Department may also request the submittal of a work plan under other permitted categories under certain conditions as described in Section 1.2. The submittal of a hydrogeological work plan is optional. However, the submittal of a work plan and subsequent approval by the Department is strongly recommended given the complexities of hydrogeologic investigations. A work plan should contain the following information:

2221(3(b)(i): A map indicating the surface geology of the area with the discharge location identified.

2221(3)(b)(ii): A map indicating the topography of the area with the discharge location identified.

2221(3)(b)(iii): Logs of domestic wells adequate to characterize each water supply formation within a half mile in all directions from the discharge. A map must be provided that correlates each well log to a specific map location.

2221(3)(b)(iv): A map delineating an established or proposed designated wellhead protection area that may be affected by the discharge.

2221(3)(b)(v): For all proposed observation wells to be drilled, all of the following information:
(A) Number of wells.
(B) Location of wells.
(C) Depth of wells.
(D) Drilling method.
(E) Well construction materials.
(F) Well development method.

2221(3)(b)(vi): For all proposed soil borings, all of the following information:
(A) Number of soil borings.
(B) Location of borings.
(C) Depth of borings.
(D) Drilling and plugging method.

2221(3)(b)(vii): A description of all physical testing to be done to identify soil properties and aquifer characteristics and locations where testing is to occur.

2221(3)(b)(viii): A groundwater sampling and analysis plan meeting the requirements of R 323.2221(3)(a), (d), (e), (f), (g), and (h). If a map is required, it must be drawn to scale and have a north orientation arrow.

6.0 SAMPLING AND ANALYSIS PLANS

R 323.2223(3) requires all 2218 applicants propose a groundwater sampling and analysis plan (SAP). A SAP may also be required to be submitted under other permitted categories if groundwater sampling and/or effluent monitoring are required. The purpose of the SAP is to establish the criteria for the collection of representative groundwater and/or effluent samples. The SAP should serve as an "instruction manual" and provide the operator or any other party responsible for sample collection with a reference document that encompasses all the sampling methods, sampling requirements, sample collection locations, and analytical parameters in a groundwater discharge permit. The submittal of a SAP also allows the Department to verify that the sample collection methods and laboratory analytical methods are appropriate to demonstrate compliance with the permit.

A SAP for effluent monitoring only should include the number and description of the location of all effluent monitoring points, a description of the sample collection method, sampling frequency, a list of the substances to be analyzed, sample handling and preservation methods, laboratory analytical methods, and the laboratory method detection levels.

A SAP that includes groundwater sampling must contain all of the following items:

- 2223(3)(a): the number and location of wells to be included in the groundwater monitoring system. A site map showing all of the monitoring well locations is acceptable.
- 2223(3)(b): the depth and screened interval for each monitoring well. The screened interval must be referenced to USGS data. This information is typically summarized in a table.
- 2223(3)(c): requires the well construction materials and installation techniques be included in the SAP. This information is typically included in the well construction logs.
- 2223(3)(d): requires the sampling frequency be included in the SAP.
- 2223(3)(e): requires a list of the substances to be sampled.
- 2223(3)(f): requires a description of sampling procedures including: (i) the method and volume of water removed from each well during sampling; (ii) steps taken to prevent cross-contamination between wells; (iii) sample handling and preservation methods; (iv) laboratory analysis method; (v) laboratory method detection level; and (vi) quality assurance and quality control program.
- 2223(3)(g): requires a description of the techniques used to present and evaluate groundwater quality monitoring data.
- 2223(3)(h): requires a description of the method used to collect static water levels and present groundwater flow data.

7.0 HYDROGEOLOGIC STUDY REQUIREMENTS FOR GROUNDWATER PERMIT REISSUANCE

The hydrogeologic information required for reapplication of a groundwater discharge permit under R 323.2218 is listed under R 323.2218(b)(iii). This information includes a narrative discussion, maps, and raw data.

7.1 Narrative

The narrative portion of the hydrogeologic study for a reissuance application must include a discussion of the groundwater and effluent compliance history of the facility. The applicant should summarize the effluent and groundwater quality results during the previous permitted time interval and indicate whether compliance was achieved during that time. If there were exceedances of permit limits, steps taken to bring the facility into compliance should be described.

This portion should also include a discussion of the groundwater monitoring system. Groundwater contour maps generated during the timeframe of the permit should be reviewed, and a determination made whether the groundwater monitoring system is appropriate. If there are indications that, as a result of mounding or other factors, the groundwater flow direction has changed, a proposal and workplan for an updated groundwater monitoring system should be included.

The narrative should also discuss whether changes from the original permit application and issuance have occurred. This should include the volume of treated wastewater discharged, the treatment system used to meet permit limits, addition of waste streams or changes in wastewater influent quality, and methods and areas of disposal.

7.2 Maps

R 323.2218(b)(iii)(D) requires the submittal of an updated site map. This map should be drawn to scale and indicate the location of the treatment/storage facilities, discharge location(s), observation and monitor wells, property boundaries and surface waters within the area of the map.

R 323.2218(b)(iii)(E) requires the submittal of a current groundwater contour map. This map should indicate the location of all wells used to establish groundwater flow direction and should be generated using the most recent static water levels measured in all wells at the facility. Static water levels measured in each well must be collected on the same date.

7.3 Raw Data

All of the required raw data listed below should be submitted via MiWaters as part of the compliance monitoring requirements in the “in effect” permit.

- R 323.2218(3)(b)(iii)(F) requires the submittal of the most recent groundwater monitoring results from all monitoring wells.

- R 323.2218(3)(b)(iii)(G) requires the submittal of the most recent effluent quality results.
- R 323.2218(3)(b)(iii)(H) requires the submittal of the most recent static water levels and groundwater elevations for all on-site monitoring wells.