MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

INFORMATION GUIDE FOR PROPOSED LARGE QUANTITY WATER WITHDRAWALS

INDEX

INTRODUCTION

The goal of this document is to provide basic information for property owners and other interested parties on the types of large quantity withdrawal (LQW) registrations, when they occur, and responsibilities of the property owner. In addition, this document identifies the most common types of additional data that can be submitted in support of a request for a site-specific review (SSR) by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) or in support of a permit application for a proposed LQW. The uses, pros, and cons of various data collection methods are summarized to guide the property owner's discussions with EGLE, consultants, licensed well drillers, and other interested parties. This document includes a discussion of which additional data collection methods require permits and when. A glossary is included to define common, statutory, and technical terms used in this document. Finally, the Water Use Program staffs' contact information is provided for any questions concerning this document or other aspects of the Water Use Program.

Part 327, Great Lakes Preservation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), requires all new or increased LQWs to be registered through one of the following processes: the online Water Withdrawal Assessment Tool (WWAT), an SSR, or a permit.

PART 1 – LQW REGISTRATIONS

Water Withdrawal Assessment Tool (WWAT) Registrations

The WWAT is an online screening tool found at https://www.egle.state.mi.us/wwat. Click "Start" on the "Welcome" page. Then, select the button labeled "Assess A New Withdrawal" and follow the prompts. Proposed LQWs that pass the WWAT can be registered without requiring a formal approval by EGLE. Regardless of whether your proposed LQW is authorized by the WWAT or by an SSR, you need to provide the following information:

1. The rated pump capacity for the withdrawal.

2. The location of the withdrawal.

3. The withdrawal source, whether surface water or groundwater.

4. For groundwater withdrawals, whether the source of the withdrawal is a glacial or bedrock aquifer.

5. The depth of the withdrawal if from groundwater.

6. The amount and rate of water to be withdrawn.

7. Whether the withdrawal will be intermittent.

8. The intended maximum monthly and annual volumes and rates of the proposed withdrawal, if different from what was submitted through the online request or the rated capacity of the equipment used for making the proposed withdrawal.

9. The pumping schedule (months per year, days per week, hours per day) needs to be submitted for intermittent withdrawals. If the amount and rate of the proposed

withdrawal will have seasonal fluctuations (i.e., limited number of months), the relevant information related to the seasonal use of the proposed withdrawal (the months proposed for withdrawal).

10. A description of how the water will be used and the location, amount, and rate of any return flow.

The WWAT will prompt you to provide the above information. You will also be prompted to provide the same information, plus any other information that the property owner would like EGLE to consider in making its determination, if you request an SSR through the link on the WWAT. You have the ability to request an SSR even if you are able to register your LQW using the WWAT. In this case, you will need to submit the above information, along with any additional information that you would like EGLE to consider, with your SSR request.

Proposed LQWs that pass the online WWAT will result in an automatic registration and you will be able to print your registration receipt and proceed with the well installation and water withdrawal immediately.

Your well driller has the responsibility to submit copies of your well log to your local health department within 60 days of the well's completion. Your local health department has 30 days to forward a copy to EGLE's Drinking Water and Environmental Health Division (DWEHD). ***Property owners who choose to install the pump in horizontal or vertical wells at a later date have the same responsibility to submit two copies of the pump log to their local health department (one of which they will forward to the DWEHD).***

If you develop your LQW differently than what was authorized by the WWAT (e.g., location, bottom of well casing depth, pump capacity, or pumping schedule), then ***it is your responsibility, as the property owner, to rerun the assessment tool and reenter the corrected data information into the assessment tool to determine if the registration will remain valid. The property owner needs to also notify EGLE of the corrected data and the corrected results from the assessment tool rerun*** (Subsection 32706b(5) of Part 327)***.*** If the corrected data do not change the determination of the assessment tool, the property owner should print a copy of the revised registration receipt and may proceed with the withdrawal. If you have any questions on how you should proceed, please contact the Water Use Program staff.

If the corrected data does not pass the assessment tool, then the property owner needs to contact EGLE to request an SSR. EGLE strongly recommends that you contact the department before incurring the expense of proceeding with the well installation, in case modifications need to be made to obtain a valid registration.

While notification of changes is your responsibility as the property owner, you may request that your driller make these changes on your behalf. However, in these cases, good communication and documentation between you, your driller, and EGLE is extremely important.

Site-Specific Review (SSR) Registrations

If the proposed LQW cannot be authorized by the WWAT, the WWAT will inform the property owner that a request for an SSR must be submitted. The LQW must be authorized through the SSR process before putting the LQW into operation. To apply for an SSR using the WWAT, click the "submit SSR" button and fill out the personal information for the request. The WWAT will submit the personal registrant information and the information for the LQW you were trying to register as an SSR request to EGLE that will include the information required under Subsection 32706a(3) of Part 327.

As in the case of the automatic registration, ***if you receive a registration through the SSR process, you must contact EGLE immediately if any of the parameters (for example, location, bottom of well casing depth, pump capacity, or schedule) used to obtain the LQW registration change so that EGLE can evaluate the impact of the changes and determine if the registration will remain valid*** (Subsection 32706c(7) of Part 327)**.** Again, EGLE recommends that you contact EGLE before incurring the expense of the well installation in case the LQW needs to be modified to avoid an Adverse Resource Impact (ARI).

PART 2 – REPLACEMENT OF AN EXISTING LQW

In some cases, a property owner may want to use their established "baseline capacity" for a well replacement. Stream flow depletions from LQWs that were installed and in-use on or before October 1, 2008, are considered to be accounted for in the stream index flow determinations that Part 327 required by that date (Subsection 32701(1)(x)). This point becomes the baseline of the WWAT. If an LQW pump capacity was reported to the Michigan Department of Agriculture and Rural Development (MDARD) or EGLE by April 1, 2009, in an annual water use report, then the reporting of the LQW pump capacity established a baseline capacity for the withdrawal. If a property owner did not report a pump capacity to the MDARD or EGLE to establish their "baseline capacity," then the highest amount of water use as reported in an annual water use report submitted by April 1, 2009, is considered the baseline capacity for the withdrawal. Water Use Program staff will work with the property owner and MDARD to verify if a property owner has an established baseline capacity for an LQW.

In the case of a quarry or mine, if water use was not reported by April 1, 2009, then the baseline capacity for a quarry or mine that holds a Part 31, Water Resources Protection, of the NREPA, discharge permit is the discharge volume stated in that authorization as of February 28, 2006 (Subsection 32701(1)(d)).

If a property owner did not report the pump capacity or report the annual water use by April 1, 2009, then baseline capacity was not established.

A property owner can use his/her baseline capacity to replace a baseline capacity surface or groundwater withdrawal with another LQW of the same or lesser pump capacity in the ***same*** watershed management area (WMA) as the original LQW. This may be helpful as watersheds reach a Zone D classification, which means that no additional depletions can be withdrawn based on current watershed information. Because any stream flow depletions from the baseline capacity were already accounted by the WWAT's original estimate of the stream index flows, no additional stream flow depletions will be calculated for the LQWs replacing baseline capacity LQWs (provided that the replacement's pump capacity does not exceed the baseline capacity).

The amount of the baseline capacity that is requested for the replacement well is documented in the determination letter and registration receipt that is sent to the property owner. This determination letter and registration receipt will also document any remaining baseline capacity that may not have been used. Any remaining baseline capacity may be used for another subsequent well that the property owner may want to install within that same watershed.

In some cases, existing LQWs may need to be replaced. Replacement is often related to maintenance for wells that cease to function as intended, or to switch from using an existing surface water pump to using a groundwater well withdrawal. The date the withdrawal to be replaced was installed, the nature of the replacement, and whether the water use has been reported to the MDARD or EGLE determines how the replacement needs to be handled to remain in compliance with Part 327. The following summarizes the basic types of replacements:

Surface Water Pump Replacement – If you want to replace a surface water pump for which you have established a baseline capacity (or reported the use to EGLE or the MDARD by April 1, 2009) with a groundwater well, it is best to contact the Water Use Program staff to discuss the details of the request to facilitate the processing. However, you can also request the withdrawal through the online WWAT (https://www.egle.state.mi.us/wwat) by selecting the button labeled "Replace an Existing Withdrawal" and following the prompts. Make sure that you add the information on the pump you want to replace in the comment section of the registration (such as pump name, capacity, pump ID, years reported, maximum use, latitude and longitude in decimal degrees, etc.). This will assist Water Use Program staff in verifying the established replacement capacity, as necessary.

Keep in mind that your replacement well's capacity (the pump capacity in gallons per minute [gpm]) must be the same as or less than the established baseline capacity of the surface water pump and the surface water pump and the replacement well must be in the same WMA. If you do not need a replacement well that uses all of your established baseline capacity for a particular pump within a WWAT watershed, then the remaining baseline surface water pump capacity will be documented in your determination letter provided under the Water Use Program registration process. The Water Use Program staff track both the cumulative stream flow depletions (which are used by the WWAT) and the remaining base flow capacities that are available to authorize future replacements.

If you want to replace a surface water withdrawal that has an LQW registration number (i.e., installed on or after July 9, 2009) with a groundwater well in the same WWAT WMA, the replacement well cannot have a greater potential impact to the resource than the registered surface water withdrawal. If you received a registration for the surface water withdrawal immediately from the WWAT (i.e., an SSR was not required) for the surface water registration you want to replace, you can enter the modifications through the WWAT (https://www.egle.state.mi.us/wwat) by selecting the "Modify or Cancel a Registration" and following the prompts. If the replacement well has a greater potential impact than the existing surface water LQW, the WWAT will indicate the need to submit the request as an SSR. If the surface water pump received a registration number through the SSR process, you will need to contact the Water Use Program staff to discuss available options.

Groundwater Well Replacement (Maintenance) – If you want to replace an LQW well with a new well due to failure of the existing well or poor performance that cannot be corrected by repair or reconditioning the well, then it is best to contact the Water Use Program staff to discuss the details of the request to facilitate the processing. However, you can also request the withdrawal through the online WWAT (https://www.egle.state.mi.us/wwat) by selecting the button labeled "Replace an Existing Withdrawal" and following the prompts. The replacement well must be in the vicinity of the original well and within the same WMA. If needed, contact one of the Water Use Program staff with the coordinates of the proposed replacement well to verify it will be within the same WMA.

If the well being replaced was installed and in-use prior to July 9, 2009, make sure that you provide information that the new well requested is a replacement as prompted in the WWAT and add that information in the comment section. Include any information that can be used to verify the baseline or replacement capacity of the well; this will facilitate processing of your request. If you have not previously reported the water use for this well to establish the baseline capacity or highest water use, contact one of the Water Use Program staff to proceed.

If the well being replaced was installed and in use after July 9, 2009, and has an authorized LQW registration number, go to the online WWAT and select the button labeled "Modify or Cancel a Registration" and follow the online prompts to modify your registration or contact Water Use Program staff to identify the well and registration that you want to replace (especially if the original registration was authorized under the SSR process).

Groundwater Well Replacement (Other) – There may be situations where you want to replace an existing groundwater well with a new withdrawal in a different location in the same WMA or use the established baseline or replacement capacity for a withdrawal to address issues (e.g., discrepancies between how the well was authorized versus how it was constructed and operated) with one of your other wells in the same WMA. The new location for such a well cannot increase the impact that the withdrawal has on the WMA. Please contact Water Use Program staff to discuss potential options.

If the registration for a replacement well automatically passes the WWAT and you are provided with a registration receipt immediately, please contact Water Use Program staff to identify the registration as a replacement so the WMA status can be manually corrected. If the registration for the replacement well indicates that an SSR is required, submit the registration request through the WWAT, making sure that the replacement is noted and your current pump information is identified in the comment section.

To properly register any replacement well, you will also need to provide Water Use Program staff with a copy of form EQP 2044 Abandoned Well and Plugging Record (this form can be obtained from your local health department) for any groundwater well that is being replaced. The replaced well must be plugged and properly abandoned by a Michigan registered water well driller who will submit the forms to your health department and EGLE within 60 days of the well being abandoned. Information on properly abandoning wells can be found at https://www.michigan.gov/egle/about/Organization/Drinking-Water-and-Environmental-Health/water-well-construction/abandoned-water-wells or by contacting the DWEHD at 517-284-6542. If a surface water pump is being replaced, then the property owner should submit a short self-certification letter that is signed and dated stating that the subject surface water pump has been removed and is, therefore, no longer in use. If the property is being leased, then the self-certification letter should include the signatures of the property owner and property lessee.

PART 3 – SUBMITTAL OF ADDITIONAL SITE INFORMATION

Additional Information to Support an SSR Determination

The property owner can submit additional information for EGLE to consider in making its determination under an SSR. This information can be submitted in support of the initial SSR request or in response to an SSR denial. Submittal of additional site-specific information can also be done as part of a permit application.

Table 1 on the following page is a summary of the types of additional site-specific information that can be useful in supporting an SSR determination or a permit application. The table lists the various methods that can be used to produce the site-specific information. Comments are provided that list some of the pros and cons for the various data collection methods. The table also provides a rough estimate of the time frames (hours, days, weeks, and months) required for the various data collection methods.

Generally, additional data is submitted to EGLE to either document that the withdrawal aquifer is isolated from the surface water or to identify aquifer or stream/creek/river properties that are representative of site-specific conditions. For example, if site data submitted indicates that there is a continuous low permeability layer (e.g., clay or silt) separating deeper aquifers from surface water in the area affected by the pumping well, then an LQW request for the well proposed in the deeper aquifer can receive a "Geology Pass" authorization based on the deeper aquifer being isolated from surface water. Water level monitoring, aquifer pumping test data, water well logs, monitor well logs, soil boring logs, gamma ray logging, and stream bed characteristics are some of the data used to determine the degree of hydraulic connection between shallow and deeper aquifers and surface water.

Aquifer properties representative of site conditions may also be submitted to support an LQW/ SSR request. The WWAT's groundwater model assumes leaky confined conditions but the aquifer may actually be unconfined or confined. Aquifer pumping tests can provide site- or regional-specific transmissivity and aquifer storage values to determine local aquifer conditions. Slug tests and grain size analyses are other methods that can be used to estimate aquifer properties, but this data is inferior to that acquired during an aquifer pumping test since slug tests and grain size analyses only provide a limited amount of information about the sediments in the immediate vicinity of the tested well. Slug testing also does not provide any site-specific information regarding aquifer storage values. These new site-specific aquifer parameters can be used in the WWAT's analytical groundwater model or in site-specific analytical or numerical groundwater models to better predict whether a proposed LQW is likely to cause an ARI.

Consultation with a professional hydrogeologist or similarly trained environmental consultant is recommended to advise you on feasibility, options, and costs for selected site-specific testing. ***You or your consultant should also contact EGLE to discuss a work plan that details how each test will be completed. While hiring a consultant and discussing work plans with EGLE staff are not requirements, you are strongly recommended to do so to avoid wasting time and money collecting data that will not support the SSR request and be useful in EGLE's review.***

Permit Requirements

Some of the additional data collection methods in Table 1 require permits. Data collection methods that may require permits are footnoted in Table 1. Part 301, Inland Lakes and Streams, of the NREPA requires a permit to install monitor wells and other structures in the bottomlands of inland lakes and streams. If you are not the riparian owner of the bottomlands where the structure(s) is(are) located, then you will need written authorization(s) from the affected riparian(s) to act as their agent in applying for the permit. EGLE created a General Permit (GP) category for scientific measuring devices. The permit application fee for GP categories is $50 and applications for GP categories are not subject to Part 301's public notice requirements. The joint permit application and additional information is available at https://www.michigan.gov/jointpermit.

A permit is required from EGLE if there is the potential to discharge pollutants into the groundwater or surface water. You should contact the Groundwater Discharge Program, Water Resources Division (WRD), at 517-290-2570, if groundwater in the vicinity of the test well is potentially contaminated.

Table 1. Information Provided by the Selected Data Collection Method

Table 1	INFORMATION PROVIDED BY THE SELECTED DATA COLLECTION METHOD													
Data Collection Method	Aquifer Transmissivity	Aquifer Storage	Aquifer Hydraulic Connection to Surface Water	Identify Aquifer Boundary Conditions	Thickness & Lateral Extent of Confining Units	Streambed Conductance	Vertical Direction of Groundwater Flow	Deeper Aquifer Confined?	Hydraulic Conductivity	Site Geology	Stream Index Flow	Stream Temperature Classification	Comments	Estimated Time Required
Aquifer Pumping Test[1]	X	X	X	X[3]				X	X	X[3]			Site wide average aquifer parameter estimates, discharge of large water volumes may require permit	1-3 Days
Slug Test[2]	X								X				Data limited to area around well, done when pumping test not feasible	1 Day
Water Levels from Nested Wells During Aquifer Pumping			X[3]				X	X					Screened intervals must be isolated from the rest of the well	Days
Water Levels from Nested Wells without Aquifer Pumping							X						Screened intervals must be isolated from the rest of the well	Varies[4]
Water Levels from Wells in or Adjacent to Streams[2]			X			X[3]				X[3]			A permit is required if the well is installed in the stream bed	Varies[4]
Geologic Core Sampling[2]					X	X[3]			X[3]	X			Use of Geoprobe, hollow stem auger, Rotosonic rig or similar equipment to collect intact sediment sample	Days
Geophysical Logging					X			X		X			Pump typically needs to be removed from well before downhole geophysical logging	Hours
Laboratory Permeability Tests[2]	X	X[3]							X	X			Only estimates hydraulic conductivity in area/depth interval sampled	Weeks
Stream Flow/Discharge Measurements[2]											X		Typically collected July-September; should be collected at least 3-5 days after rainfall events	Months
Streambed Measurements[2]			X[3]			X			X	X			Requires seepage meter and/or nested wells; permit required	Days
Grain Size Testing[2]	X[3]								X	X			Intact core sample best but grab (disturbed) sample can be used	Weeks
Stream Temperature Probes and Data Loggers[2]			X									X	Can provide info on groundwater/surface water interaction	Months

Notes:
1 = A surface water or groundwater discharge permit may be required to dispose of the pumped water.
2 = Installing wells or other structures or collecting sediment samples in inland lakes or streams requires a permit.
3 = May provide this information depending on site conditions and specific methods.
4 = It may be necessary to collect quarterly or seasonal samples to assess site conditions, but typically requires 1-3 days.

Examples of additional data that can be submitted in support of a withdrawal request and the tests that can be conducted to obtain the data are listed below:

A. Site-Specific Aquifer Pumping Test - A site-specific aquifer test should be considered if you want to:

- Obtain data providing information on site-specific aquifer transmissivity and storage coefficient to be used to modify depletion calculations estimated in the WWAT (the WWAT uses a "leaky-confined" storage value of 0.01) to values more representative of site conditions. This would be most helpful if the transmissivity and/or aquifer storage values are thought to be higher or more favorable than those used by the WWAT. For example, a higher storage value than is usually associated with an unconfined aquifer (for example, storage values from 0.1 to 0.3 for sands and gravels) may result in a lower depletion estimate for the LQW request; the lower depletion may allow the LQW request to be authorized.

- Determine whether the aquifer is hydraulically connected to surface water bodies and identify any boundary conditions (e.g., impermeable buried valley walls, inducing recharge from surface water bodies, etc.). Pumping from a confined aquifer is considered to be isolated from the surface waters and, therefore, not likely to cause an ARI. In this case, the withdrawal would receive a "Geology Pass" and the LQW request could be authorized. While differences in static water levels collected in shallow and deep wells may indicate the potential that a deeper aquifer is confined or isolated from the shallow aquifer, the actual aquifer connection cannot be determined without applying a stress to the aquifer system by conducting an aquifer pumping test.

An aquifer pumping test involves applying a stress to an aquifer by extracting groundwater from a pumping well and measuring the aquifer's response to that stress by continuously monitoring the response of water level drawdown with time in multiple observation wells using pressure transducers and dataloggers. These results are incorporated into flow equations and graphs to calculate the site-specific aquifer transmissivity and storage coefficient.

A pumping test needs to be run long enough to reach a near steady-state condition and identify potential boundary conditions. The aquifer pumping test should be run for a minimum of 24 hours for a suspected confined aquifer and 72 hours for an unconfined aquifer. If your consultant doesn't know whether the aquifer is confined or unconfined, then he/she should plan on running the aquifer pumping test for 72 hours but analyze the field data after 24 hours to determine whether the pumping test can be terminated early because the aquifer is confined. In some cases, it may require additional time to provide adequate data. Late time aquifer pumping test data can provide information about the response of shallow aquifers and streams to pumping from deeper aquifers as it is more likely that the groundwater cone of depression may expand beyond discontinuous low permeability lenses.

The following table illustrates the recommended data collection schedule during the aquifer testing:

ELAPSED TIME	MEASUREMENT FREQUENCY
0 – 5 minutes	Every 0.5 minutes
5 – 10 minutes	Every 1 minute
10 – 20 minutes	Every 2 minutes
20 – 60 minutes	Every 5 minutes
60 – 180 minutes	Every 15 minutes
180 – 360 minutes	Every 30 minutes
360 – to completion	Every 60 minutes

The aquifer test data should be monitored during collection to be able to determine if additional time is required. A professional hydrogeologist or similarly trained environmental consultant should conduct the testing.

If you do not have the preferential flow direction and boundary conditions to the potentially affected stream determined for the aquifer, a minimum of two monitor wells should be installed in the same aquifer interval as the proposed pumping well. The monitor wells should be screened over the same interval as the pumping well and ideally be placed at right angles to each other unless specific aquifer boundary conditions are known (e.g., glacial deposits in a bedrock valley). Monitor wells should be located at a distance appropriate for the aquifer depth and thickness. Monitoring wells are generally located at distances from the pumping well one to five times the thickness of the aquifer. For an unconfined aquifer, one monitor well should be located approximately 30 feet from the pumping well, and a second no more than 300 feet from the pumping well. For sites with suspected complex geology or boundary conditions, additional monitor wells may be needed to obtain useable results. Due to the nature of the complex geometries involved in glacial geology and unknown boundaries (such as impermeable valley walls, sand pinch-outs, changes in aquifer thickness, etc.), the interpretation of the test results can be complex. If the monitor wells are not located correctly to be able to evaluate these boundaries, then the results of the aquifer test alone may not be enough for a determination. A professional hydrogeologist or similarly trained geologist/environmental consultant should be contacted to advise you on expected site conditions and test design requirements that may be needed to obtain the best results.

In addition to the deep monitor wells, a well installed in any shallower aquifer zones should also be monitored during the test, especially if a water table aquifer is present that could be in contact with the watershed’s stream/creek/river (for example, a shallow well would be installed near the pumping well and another well closer to the stream/creek/river if the well would be expected to exhibit drawdown based on distance from the pumping well and estimated site aquifer parameters). A shallow monitor well should be installed and monitored adjacent to the stream/creek/river as site access permits.

The water level measurements are best collected using pressure transducers connected to a datalogger. When working with transducers and dataloggers, it is a good practice to also obtain periodic manual measurements at each observation well to: (1) confirm transducer readings, and (2) provide backup readings in the event of accidental data loss. At a minimum, manual water level readings should be taken before and after an aquifer pumping test.

EGLE uses AquiferWin32 Modeling Version 5.02 and Aqtesolv Professional Version 4.5 to analyze step-drawdown pumping test and constant-rate aquifer pumping test data.

Disadvantages of aquifer pumping tests include the expense and time involved. In addition, the aquifer pumping test generates a large volume of water that must be disposed of in a manner that will not interfere with the aquifer pumping test. To obtain the best results, EGLE recommends that your consultant submit a work plan for the aquifer pumping test to EGLE for review.

B. Slug Testing - Slug testing involves causing a sudden change in the water level (rise or fall) in a monitor well or piezometer, and measuring the changes in the water level over time. Analysis of the water level measurements can provide information on the hydraulic parameters of the zone intercepted by the well screen. However, slug tests only provide information about a limited area surrounding the well and can be influenced by the well construction (e.g., gravel pack, poor well development, etc.).

Slug testing can be done:

- To obtain an estimate of aquifer properties where an aquifer test cannot be completed due to access limitations or when aquifer pumping tests are cost prohibitive. However, each test only provides information about the sediments in the immediate area of the test well. Multiple locations and tests will need to be completed on a property to assess the aquifer's hydraulic conductivity and calculate transmissivity estimates over the entire property. Additional site data will likely be needed (e.g., geology, permeability, grain size analysis, etc.) to make a determination regarding potential to cause an ARI.

- To obtain an estimate of hydraulic properties in materials that have lower hydraulic conductivity (e.g., silts and clays) and where pump testing would, therefore, not be suitable.

- To provide additional hydraulic information for use in 3D groundwater model development.

- To provide an estimate of the hydraulic conductivity of streambed sediments when the test is conducted in the streambed. The hydraulic conductivity value affects the stream conductance term that is used in the WWAT.

The water level measurements are best collected using pressure transducers connected to a datalogger. When working with transducers and dataloggers, it is a good practice to also obtain periodic manual measurements at each observation well to: (1) confirm transducer readings, and (2) provide backup readings in the event of accidental data loss. At a minimum, manual water level readings should be taken before and after a slug test.

Slugs of inert solid material or changes in air pressure are typically used to displace the static water level. Slugs of water can also be used, but this method can often add noise to the data. Several slug tests should be conducted across a property or area with several tests completed at each location and depth of interest to obtain site location averages and to be able to identify any variances in site conditions. Slug testing can be conducted in unconfined or confined aquifers but the well must be constructed appropriately for each case. Slug tests are often less accurate in highly conductive sediments, such as very coarse sands and gravels, because the water level returns to its normal level so quickly.

Slug tests do have the advantage over aquifer pumping tests of not requiring the temporary storage and disposal of large volumes of water from the pumping well. They are much less expensive and take less time than aquifer pumping tests. One disadvantage of the slug test is that it does not provide a direct estimate of the aquifer's storage.

EGLE uses AquiferWin32 Modeling Version 5.02 and Aqtesolv Professional Version 4.5 to analyze slug test data.

C. **Information Regarding the Vertical Component of Groundwater Flow –** Nested monitoring wells or piezometers can provide information on the vertical direction and gradient of groundwater flow. Monitoring wells or piezometers are installed close together above and below clay layers separating shallow and deeper aquifers to determine the degree of hydraulic connection between the aquifers and the direction of the vertical component of groundwater flow.

Monitoring data collected from nested wells may be useful if:

- Supplemental information is needed to interpret the results of an aquifer pumping test to provide additional evidence that an aquifer may be confined.

- Obtain data supporting the interpretation that a potential recharge boundary observed on aquifer pumping test data is actually from leakage through a clay layer.

- Provide information on whether the confining layers are "leaky" or not.

- Provide information needed to design a site-specific groundwater model.

Piezometers or monitor wells can also be installed in a streambed to assess the direction of vertical flow between groundwater and the stream through the streambed. These are usually best used in conjunction with seepage meter data, temperature, and/or stream flow measurements and restricted to use in shallower streams/creeks rather than fast flowing and deep rivers.

When drilling deep monitor wells through confining layers, use precautions to prevent cross-communication between the shallow and deep aquifer via the borehole. One way to do this is to set a protective outer casing into the confining layer, grouting the borehole back to the ground surface, and then drilling a smaller diameter well inside the outer casing into the deeper aquifer. The annular space between the inner and outer casings above the filter pack material placed around the well screen is filled with grout back to the ground surface. Double-cased monitor wells are more expensive and require more time to complete, but they avoid the potential liability for cross-contaminating aquifers.

D. Site-Specific Detailed Geologic Data – Drill cuttings data from water well data can be variable in their accuracy of the types of sediments being described; however, drill-cutting descriptions produced during water well installations (the data source for Wellogic records) provide some indication of the sediments encountered in a well; however, the texture, structure, or layering and the thickness of the sediments is lost. Intact soil and/or sediment cores need to be recovered to provide this information. This sedimentary layering/structure is important since it can affect the flow of water. For example, groundwater flow in, and the hydraulic properties of, a clayey sand are different than in interbedded sand and clay layers. In addition, site-specific geological data can identify the presence, thickness, and lateral extent of clay layers that might separate deeper aquifers from surface water that could be impacted by the withdrawal.

Intact soil and sediment cores can be retrieved using multiple methods, depending on the quality of the data required. These include but are not limited to split-spoon samplers or core barrel samplers with a hollow-stem auger drilling rig, or a Geoprobe core or a Rotosonic drilling rig in the proposed well area and between the proposed well and nearby surface water bodies. Selection of sample collection methods should be suggested by the qualified hydrogeologist or environmental consultant and discussed with EGLE in an effort to provide defensible data at a reasonable cost. Geological information should be collected over the area potentially impacted by the pumping well's cone of depression.

On-site geological data can be useful if:

- Additional data is needed to support the interpretation that an aquifer is confined or isolated from the surface water. In this case, refined collection of drill cuttings, hollow stem auger split spoon, or Geoprobe samples would be collected across a site with a focus on the areas between the withdrawal wells and surface water.

- Using downhole gamma logging of multiple holes may provide additional information to better correlate confining zones, if possible

- Information on aquifer properties and site-specific sediments and geology for use in creating a conceptual model of the site to be used in 3D groundwater modeling of the area to support a withdrawal request is obtained.

- The presence of a large lake may alter the depletion estimates in the home or neighboring water management areas, particularly where stream linework representing the lake is not included in the WWAT. Providing information regarding the lakebed's depth profile (used in determining area for seepage estimates), the sediments and glacial deposits underlying inland lakes may be useful in determining the lakes impact on depletion estimates.

The advantage of collecting site-specific detailed geologic data is that it allows a more accurate, site-specific assessment of the potential impacts of groundwater LQWs on nearby surface water bodies than is available using only available water well logs and other published information sources. The disadvantages include the expense and time required to collect the geologic data.

E. Geophysical Logging - Downhole geophysical logging is an additional data acquisition method that can be used to provide more specific stratigraphic data from older cased wells, as well as stratigraphic confirmation in new well installations, in complicated LQW requests. Geophysical logging (such as natural gamma ray, spontaneous potential, resistivity, neutron density, etc.) will provide relative information that needs to be coupled with actual physical geologic site-specific data to provide more accurate interpretations of the data. This geophysical data, interpreted in conjunction with detailed geologic data of the proposed well and existing wells in the site area, provides information on sand and clay continuity and thickness. Downhole geophysical logging can be done in existing water supply and irrigation wells if the pumps aren't in the wells (otherwise the logger could get tangled with the pump cables) to supplement the geological information in the water well log and cores. When downhole geophysical logging is selected for any new water supply or irrigation wells, it is recommended that the logging be conducted before the pumps are installed. Geophysical logging requires a properly trained, qualified operator to conduct the logging to ensure valid data collection in appropriate wells (cased or noncased).

Geophysical logging should be considered to:

- Obtain additional supporting information on the location of a confining clay/clay rich layer that may be inferred to be present and better define site continuity of such layers when historical well data is not available to determine if a withdrawal interval is confined and therefore isolated from surface water. Existing or new wells need to be accessible for logging across the aquifer interval potentially within the drawdown cone of influence for the withdrawal well.

- Obtain additional site-specific data to be used in the conceptual model development and subsequent 3D groundwater model design in support of an LQW request, particularly in complex areas.

An advantage of using downhole geophysical logging is that it can provide more detailed or specific geological information than is available from water well logs (or even from geological descriptions of intact soil and sediment cores). Detailed geological descriptions from intact soil cores are useful to correlate and substantiate the presence of specific material types with the downhole geophysical logs. Disadvantages of downhole geophysical logging include: finding a consultant that has access to and is experienced with the logging equipment, the expense, time requirements, and that they cannot be used in wells that have pumps in the cased hole.

F. Laboratory Permeability Tests - Samples from aquifer material or a potential clay confining layer may be collected via core/Shelby Tube (pushed ahead of a drill bit to collect sample in an unconsolidated aquifer) or equivalent method and submitted to a qualified laboratory for determination of sediment permeability estimates using approved American Society for Testing and Materials standard permeameter methods. A permeameter is typically a laboratory device (although there are field versions of this instrument that can do in-situ measurements) that measures the rate at which a sample of geologic material will transmit water. A constant head permeameter is used to measure the permeability of porous materials like sands and gravels. A falling head permeameter measures the permeability of cohesive sediments such as clay and silt. Field collected samples can provide a range of values to be used in preparing for the aquifer test.

Care should be taken not to open a pathway for groundwater flow through a prospective confining layer between the aquifer and shallow groundwater (see the discussion of double-cased wells in Section C, Information Regarding the Vertical Component of Groundwater Flow, above). An environmental consultant should evaluate the potential site impact of obtaining the samples. The consultant and/or qualified laboratory should be contacted to advise on specific collection methods, applicability, and costs.

Laboratory permeability testing should be considered to:

- Obtain additional site-specific hydraulic conductivity values to support an interpretation that a clay layer or other impermeable zone known to exist in a site area has a permeability that would be consistent with a true confining layer.

- Obtain hydraulic conductivity estimates for aquifer sediments if an aquifer pumping test or slug test cannot be conducted. However, the results will not be as accurate as an aquifer pumping test or a slug test since the sample may be disturbed. These samples only provide information about the immediate area where the sample was collected and can provide a range of values to be validated during the aquifer tests and do not account for changes in the aquifer material laterally or vertically across a site. Therefore, the collection of multiple samples from different locations and/or the evaluation of additional data may be required.

- Obtain additional site-specific data about aquifer parameters for use in designing a 3D groundwater model in support of an LQW request, particularly in complicated areas.

G. Stream Flow/Discharge Measurements – This document will be updated when guidance on stream flow measurements and stream index flow calculations are completed. In the interim, please contact Leah Clark, Great Lakes Shorelands Unit, Surface Water Assessment Section, WRD (contact information is located on the last page of this document), for assistance with collecting stream flow and stream discharge measurements.

H. Streambed Measurements – The conductance of the streambed (creek or river) is another parameter used in the WWAT to determine the potential depletion for a proposed LQW. Streambed conductance is a measure of the permeability of the sediment layer separating the stream/creek/river from the underlying groundwater. The streambed conductance term used in the WWAT can be revised based on site-specific data from various types of seepage meters, grain size analyses, in-situ hydraulic permeameters, and piezometers.

Seepage meters installed in the base of streams, creeks, or rivers of concern can be used to measure the flow of water between the surface water and shallow groundwater. The direction of flow provides information on whether the stream is gaining (groundwater flows into the stream) or losing (surface water flows into the groundwater). Measurements conducted before, during, and after a pumping test can be used to evaluate changes and assess the connection between the surface water and groundwater in the streambed.

Seepage meters are best used in smaller and shallower streams or creeks and in streambeds comprised of sands, silts, or soft clay with no gravel. Monitor wells or piezometers can also be driven into the streambed with the screened interval set below the surface of the streambed so that the difference between the water level in the well/piezometer and stream can be measured/monitored.

The streambed conductance flow measurements combined with the width of the stream/ creek/river and grain size analyses of the bottom sediments provide additional information to be used to revise the streambed conductance term in the WWAT. The information can also be used when additional numerical groundwater models may be needed.

I. Grain Size Testing – Grain size testing can be done to:

- Obtain information on aquifer properties to supplement aquifer pumping test data or provide estimates of conductivity if an aquifer pumping test cannot be conducted. This test can give an estimate of the hydraulic properties of a core sample collected from the proposed aquifer sediment or confining layer sediment at a particular depth. The information would normally be used in conjunction with other additional site data such as geology data and slug testing.

- Obtain an estimate of the grain size of the coarse fraction of sediment in the aquifer zone using water well drill cuttings. Only the coarse fraction of sediment is available since the drilling mud and any fine sediment may have been washed from the grab sample collected. This method would tend to overestimate the hydraulic conductivity of the sample and should be submitted with additional site data. The transmissivity estimated using this data would be applied conservatively to adjust or modify the transmissivity value used in the WWAT.

- Obtain information on the hydraulic properties of the streambed/creek/river to support a revised streambed conductance value for depletion calculations.

Grain size or mechanical analysis of sediment samples uses a series of sieves with decreasing mesh size for each succeeding sieve that are then bolted together and placed on a mechanical “shaker.” A premeasured sample of sediment from a specific cored depth is set in the first sieve before the “shaker” is started. The sediment then falls through the sieves until the sediment falls on the sieve that corresponds to its size. Information on the weight percent of sediment retained on each sieve is collected and used in appropriate equations to provide information on the estimated hydraulic properties expected for a particular grain size distribution.

It is preferable to collect the aquifer or confining layer samples for sieve analysis from intact core samples rather than disturbed well drill cuttings. Finer sediments (e.g., clay or silt) are more likely to be lost than coarser sized sediments (e.g., sand or gravel) when drill cuttings are collected. The sieve analysis of the well drill cuttings are typically what drillers use to determine the correct slot size for a well screen and only provide information on the coarser fraction of the sediment. Estimates of aquifer properties using grain size distribution are more accurate for coarser sediments.

J. Site Photographs - Site photographs can be submitted to:

- Document the conditions observed in nearby streams, creeks, or rivers such as "water depth," presence of flowing water, lack of water flow, or totally dry streambed or creek. Photographs of the locations closest to the proposed well should be included, as well as photographs of locations upstream and downstream of the proposed LQW, as warranted. This information can be used to help determine whether a given stream reach is perennial or nonperennial. See EGLE's SSR Process Steps guidance document for further information about how perennial versus nonperennial stream determinations are used in the SSR decision-making process. Additional information about perennial versus nonperennial stream determinations is found in WRD Policy and Procedure Number WRD-SWAS-026, "Perennial Stream Identification."

- Document the location of monitor wells or stream sampling locations and devices used.

- Document nearby conditions (nearby LQWs, surface water withdrawals, etc.) that may impact the proposed LQW.

- Document site conditions. Each photograph should be dated and include the location with reference to local map features (e.g., road crossings, culverts, or bridges) or GPS coordinates with explanation of the direction of view (including upstream and downstream views at road crossings) and reason for the photograph. Site photographs can be submitted as jpg, png, or pdf file formats.

K. Stream Temperature Data – Temperature data collected from streams/creeks/rivers can be used to:

- Assess the nature of the connection between the surface water and underlying groundwater. This would best be used in conjunction with other data related to the vertical flux of water that is collected using seepage meters, piezometers installed in the streambed, and area stream flow information.

- Provide data for input in an analytical model to determine flow rates, direction of flow, and streambed hydraulic conductivity.

Stream temperature data can be collected using temperature meters and temperature dataloggers to provide information on stream/creek/river temperature and temperature changes. Examples of stream temperature probes and dataloggers used by EGLE and the Michigan Department of Natural Resources' Fisheries Division include:

- Onset Hobo Water Temperature Pro V2 data logger.
- YSI 600 XLM Continuous Sondes (collect temperature and dissolved oxygen).
- YSI 600 XL Sondes (collect stream and lake temperature) to collect stream water temperature data.

The temperature probes and dataloggers should be deployed so they are not subject to direct sunlight as it may affect the daytime temperature readings. The temperature loggers are typically secured inside a 3- to 4-inch diameter pipe casing that is cabled to a tree or post in a shaded area.

Temperature loggers can be used to monitor both the surface water (above the sediment-water interface) and water at various depths within the streambed. Temperature gradients measured from two or more depths within the saturated streambed can provide information on the flow direction between the stream and the groundwater (gain of groundwater or loss of surface water). Naranjo and Turcotte, 2015, showed that comparison between the stability of groundwater temperature and daily variability of stream water temperature can provide an indication of groundwater flow direction relative to a stream/creek/river. In a strongly gaining stream (inflow of groundwater), the temperature of water in the streambed would be controlled largely by the groundwater and would be expected to be more constant over time. In a strongly losing stream (outflow of the stream to the groundwater), the temperature of water in the streambed will mimic the stream water temperature, and the average temperature would be expected to be closer to the average stream water temperature. If there is no flow between the stream and groundwater, the temperature of the water in the streambed would tend to vary during the day like the stream water, but the average temperature would be between the stream water temperature and the temperature expected based on the measurement of the streambed thermal gradient.

Temperature and pressure data can also be input into numerical models such as the USGS Variably Saturated 2-Dimensional Heat (VS2DH) and a graphical interface (VS2DI) to model the responses and provide streambed hydraulic and thermal conductivity through inverse modeling.

L. Return Flow Credit – Portions of water applied to irrigate crops are lost to evaporation, flow overland to surface water, transpiration, crop use, and absorption by soil particles in the vadose zone. The remainder infiltrates down to the water table. The return flow credit is the portion that infiltrates down to the water table. The return flow credit is affected by factors such as the irrigation method, crop type, and soil type. The generalized published water use coefficient for agricultural irrigation in Michigan is 90 percent. That means that 10 percent of the water applied will not be used by the crops, runoff, or evaporation. If the near surface consists of sediments that will allow infiltration back into the groundwater, a generalized return flow credit of 10 percent can be applied to the depletion estimates for an LQW request.

Site-specific information can be submitted to support a different return flow credit value or that your water use process is not related to irrigation (e.g., public water supply or industrial water use) and a different use coefficient would apply. Information that may be used includes grain size analysis of surface sediments, sediment description, rates of water infiltration from surface depressions, crop water use coefficients (evapotranspiration can be measured directly using a lysimeter), soil moisture measurements, etc. Mass balance calculations (e.g., volume of water entering the water supply intake minus consumptive use equals the volume of treated water discharged) can also be used to determine an appropriate return flow credit.

The local MDARD, Michigan State University Agricultural Extension Agent, or the Natural Resources Conservation Service may be of assistance in assessing soil types, crop coefficients, and site-specific infiltration rates to justify an alternative return flow credit. Environmental consultants can help with mass balance calculations.

M. Documentation for a Bedrock Well - If a bedrock LQW request triggers an SSR, the driller should submit a field log before the proposed well is installed showing the geology for the proposed withdrawal well to facilitate the SSR determination. The field log will be used to document that the well withdrawal will indeed be from bedrock at the proposed location and depth. The log will also provide information regarding the glacial sediments immediately overlying the bedrock at the location. This can provide information that indicates whether the bedrock interval is expected to be isolated from the glacial sediments and surface water or if a recalculation of the estimated water management area depletion based on the bedrock aquifer characteristics is required.

N. Seasonal Monitoring While Irrigating - Seasonal monitoring may be proposed if:

- All possible data (summarized herein) submitted to EGLE with the intention of proving that the withdrawal interval is isolated from surface water or that the withdrawal is not expected to cause an ARI, has not been conclusive.

- The property owner wants to propose monitoring as a preventative measure in a permit application submitted under Part 327.

Continuous monitoring before, during, and after the next irrigation season may be proposed as a preventative measure as part of a permit application under Part 327. Preventative measures could include permit conditions that require shutting down or reducing the pumping rate and/or schedule if the monitoring suggests that an ARI may occur. Subsection 32723(8) of Part 327 requires EGLE to enter into a legally enforceable implementation schedule for completion of the preventative measure(s). Typically, continuous monitoring of the deep aquifer, shallow groundwater, and stream/creek potentially impacted will require water level data collection using pressure transducers and a datalogger at 10- to 15-minute intervals before irrigation (to establish background conditions), during irrigation, and following the end of the irrigation season (to monitor the groundwater recharge). Discharge or stream flow data may also be required. After the end of the growing season monitoring, the data will be analyzed and a determination made regarding the potential for the withdrawal to cause an ARI. If no ARI is expected, the LQW request would be authorized. However, if an ARI remains likely, the proposed LQW will not be authorized unless modifications can be found to mitigate the potential ARI.

O. Groundwater Models - A groundwater model can be helpful if some of the additional data described above is not feasible or did not conclusively indicate that the withdrawal interval is isolated from surface water. It should be noted that some level of site-specific data collection is necessary to calibrate the model. A 3D groundwater model can be used to predict stream water loss based on more realistic parameters within a defensible conceptual model. The conceptual model would ideally incorporate the layering and geological complexities of the area. This information would be used to revise a determination if less stream depletion or aquifer isolation is predicted by the model using actual site-specific data compared to the results of the WWAT's screening models.

Analytical or numerical groundwater models for the proposed LQW can be provided by the property owner or the owner's consultant. Groundwater models should use one or more of the following analytical and numerical groundwater modeling and ancillary software that EGLE uses:

- Groundwater Vistas Professional Version 6 - used for 3D MODFLOW/MODPATH/MT3D modeling
- Aquifer Win32 Modeling Version 5.02 - used for analytical element 2D modeling and analyses of aquifer pumping, step, and slug test data
- GW3D Version 3.0 - used for 3D model visualization of groundwater model domain, model results, and aquifer properties for Groundwater Vistas models
- Surfer Version 11.6 - used for elevation layer and aquifer property contouring, analyses, and groundwater model parameter inputs
- Global Mapper Version 14.2 - used for geographic information system (GIS) data processing and groundwater model inputs
- ArcGIS Version 10.1

Groundwater models need to be designed using an appropriate conceptual model, site aquifer, and geological parameters, and be calibrated using site-specific data (e.g., groundwater elevations). Available data in a WMA can be used but additional data will likely be needed. The water user is advised to contact a professionally trained hydrogeologist or environmental consultant experienced in creating groundwater models.

PART 4 – PERMIT APPLICATION

An Application for a Permit can be Submitted

Under Section 32723 of Part 327, a person proposing an LQW can apply for a permit if an SSR request has been denied or if a permit is required by law.

A permit is required for:

- A new withdrawal capacity or an increase over their baseline capacity of more than 2 million gallons of water per day.
- A new or increased capacity over their baseline capacity of more than 1 million gallons of water per day in a watershed that has been determined to be in a Zone C.
- A new or increased capacity over their baseline capacity that will result in an intrabasin transfer of more than 100,000 gallons per day averaged over any 90-day period.

A permit is not required for an LQW for a community supply that holds a permit under the Safe Drinking Water Act, 1976 PA 399, MCL 325.1001 to 325.1023; a seasonal withdrawal for not more than 2 million gallons per day average in any consecutive 90-day period; or for the production of bottled drinking water approved by EGLE under a source water review. A water withdrawal permit application must include all of the information required for an SSR request (see Part 3, above), an evaluation of the existing hydrological and hydrogeological site conditions, and a $2,000 permit application fee. The applicant may propose to undertake a preventative measure along with the withdrawal. If so, the property owner must include a detailed description of the preventative measure(s) and relevant information on how the preventative measure(s) will be implemented.

A permit application is considered to be administratively complete 30 days after the permit application is received unless EGLE notifies the applicant in writing of any missing information and/or fees. Once EGLE has an administratively complete permit application, it is placed on public notice for 45 days. EGLE has 120 days from receipt of an administratively complete application to make its decision whether to grant or deny a permit.

The permit decision criteria are outlined in Section 32723 of Part 327. An applicant for a permit may wish to review these criteria when deciding what information to submit with an application under Subsection 32706c(1)(e) of Part 327.

GLOSSARY:

Adverse Resource Impact (ARI): Defined in Subsection 32701(1)(a) of Part 327, Great Lakes Preservation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. An ARI in rivers and streams is defined in terms of reductions of the characteristic or thriving fish populations and/or reductions in the river's or stream's index flow.

Aquifer: A water-bearing layer of sediment or rock that is capable of transmitting significant or useful quantities of water to wells or springs. Glacial sand and gravel deposits are examples.

Aquifer – Confined: A confined aquifer has upper and lower boundaries that are defined by a confining unit that impedes the flow of water through its boundaries.

Aquifer – Leaky-Confined: Leaky-confined aquifers are overlain and/or underlain by semipermeable layers (aquitards) that can transmit varying quantities of water through the boundaries of the aquifer.

Aquifer Storage: Aquifer storage for unconfined aquifers is referred to as specific yield and represents the volume of water drained from the aquifer by gravity drainage (values typically range from 0.1 to 0.3 but can be lower based on silt and clay content). For confined aquifers, the storage term represents the volume of water released due to a reduction in pressure (typical values are 0.001 or less). The WWAT uses a storage value of 0.01, which is appropriate for a leaky-confined aquifer.

Aquifer – Unconfined (or Water Table): An unconfined aquifer does not have an impermeable upper boundary; the aquifer's upper boundary is the water table.

Aquiclude (Confining Layer): A water-bearing layer of sediment or rock that is relatively impermeable to the flow of water; clay or unfractured shale is an example.

Aquitard (Leaky-Confining Layer): A water-bearing layer of sediment or rock that impedes the movement of groundwater but which may transmit small quantities of water between sediment or rock layers; silt or sandy clay are examples.

Cone of Depression: The depression (or drawdown) in the aquifer's water level (e.g., the water table) or an area of reduced pressure in a confined aquifer caused by pumping a well.

Datalogger: An electronic device that records data over time in relation to a location either with a built-in instrument or sensor or via external instruments and sensors such as pressure transducers. Dataloggers with pressure transducers installed in monitoring wells are used to collect water level data during aquifer pumping tests, for example.

Hydraulic Conductivity: A property that describes fluid flow through a porous medium (such as sediment or rock) under a hydraulic gradient. Hydraulic conductivity is a function of the permeability of the sediment or rock and the properties of the fluid.

Index Flow: The 50 percent exceedance flow (the flow is greater than this 50 percent of the time) for the lowest summer flow month of the flow regime for the applicable stream reach, as determined over the period of record or extrapolated from analyses of the USGS flow gages in Michigan. In the Lower Peninsula of Michigan this usually occurs in August or September. The flow of the river/creek/stream is determined from long-term (ten years or more) stream gage data and stream flow measurements.

Intrabasin Transfer: A diversion of water from the source watershed of a Great Lake prior to its use to the watershed of another Great Lake.

Large Quantity Withdrawal (LQW): One or more cumulative total withdrawals of over 100,000 gallons of water per day average in any consecutive 30-day period that supplies a common distribution system. From a practical perspective, this equates to a withdrawal with a rated pump capacity of 70 gpm or greater.

Leaky-Confined Aquifer: A water-bearing layer of sediment or rock that receives a significant inflow of water from adjacent sediment or rock layers. Groundwater flow through this type of aquifer is accelerated during well pumping.

Monitoring Well: A monitoring well is usually a small diameter well (five inches in diameter or less) that is used to measure water levels and collect groundwater samples or other data.

Nested Monitoring Wells: Monitor wells installed in close proximity that are screened across different depth intervals (e.g., shallow and deeper aquifers). Water level data from nested monitoring wells can give information on the direction of vertical flow of groundwater in an area.

Perennial: A perennial stream is a stream (channel) that has continuous flow in parts of its stream bed year-round during years of normal rainfall as a result of groundwater discharge or surface runoff. During unusually dry years, a normally perennial stream may cease flowing for days, weeks, or months depending on severity of drought.

Permeability: The capacity of a porous rock, sediment, or soil for transmitting a fluid. Permeability is a measure of the degree that the pore spaces in the rock or sediment are connected, allowing fluid flow. Sand has high permeability while clay has low permeability.

Piezometer: A special type of monitoring well that is a tightly sealed well (usually small diameter) that is constructed to measure the water level in a specific zone.

Porosity: The percentage of pore spaces in the rock or sediment. Clay has a high porosity but a low permeability.

Site-Specific Review (SSR): EGLE's independent review under Section 32706c of Part 327, Great Lakes Preservation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, to determine whether a proposed LQW can be authorized or if the withdrawal is likely to cause an ARI.

Specific Storage: The amount of water per unit volume of saturated formation that is stored or expelled from storage due to the compressibility of the aquifer material and the pore water per unit change in head.

Specific Yield: The absorption of water into or release of water from storage when the water level changes.

Step-Drawdown Pumping Test: An aquifer pumping test where the pumping rate is increased in steps at regular intervals (as opposed to a constant rate aquifer pumping test).

Storage Coefficient (or Storativity): The volume of water that a permeable unit will either absorb or expel from storage per unit area per unit change in head. The storage coefficient for a confined aquifer is the product of the specific storage and the aquifer thickness. In an unconfined aquifer, the storage coefficient is the sum of the specific yield and the product of the thickness of the saturated zone and the specific storage.

Transmissivity: The rate of water flow through an aquifer, equal to the product of the hydraulic conductivity and the aquifer thickness.

Vadose Zone: The soils above the water table where water in the soil pores is at less than atmospheric pressure (also known as the zone of aeration or the unsaturated zone).

Water Table: The upper surface of the zone of water saturation that is under the influence of gravity and it is at atmospheric pressure.

Water Withdrawal Assessment Tool (WWAT): Online registration process for new or increased LQWs provided for in Section 32706a of Part 327. The online tool can be found at https://www.egle.state.mi.us/wwat.

Watershed Management Area (WMA): The surface drainage area that supports a unique ecological character of a river or stream segment. The minimum area of a WMA varies depending upon the stream temperature classification. The stream network geographic information system data layer used by the WWAT divides Michigan into approximately 5,400 WMAs.

References Cited:

Naranjo, Ramon C., and Robert Turcotte, "A new temperature profiling probe for investigating groundwater-surface water interaction." ***Water Resources Research***, 2015, 51(9): 7790-7797.

Water Use Program Staff Contact Information:

Jill Van Dyke, 517-881-1607, vandykej1@michigan.gov (SSRs and additional data collection)
Nathaniel Shuff, 517-599-6259, shuffn@michigan.gov (SSRs and stream flow measurements)
Andy LeBaron, 517-599-3792, lebarona@michigan.gov (WWAT, permits, water use reporting)
Clay Joupperi, 517-881-7807, joupperic1@michigan.gov (SSRs, stream flow measurements)
Hannah Arnett, 517-599-9767, arnetth2@michigan.gov (Part 327 compliance)
Christopher Gothberg, 517-881-7604, gothbergc@michigan.gov (Part 327 compliance)
Jim Milne, 517-284-5559, milnej@michigan.gov

For information or assistance on this publication, please contact the WRD's Water Use Program, through EGLE Environmental Assistance Center at 800-662-9278. This publication is available in alternative formats upon request.