

Major Aquifers and Ground Water Quality in Ohio

Ohio has abundant ground water resources, but the amount available at a given location depends on local geology and well construction. Water quality also varies from place to place and over time, depending on the local geology, sensitivity and land use.

This fact sheet identifies the types of geologic materials that provide water to wells, discusses factors that influence water quality, and provides typical water quality test results.

Where does my well water come from?

Ground water is replenished by rain and melted snow infiltrating through the soil column. Average precipitation in Ohio ranges between 30 to 44 inches a year. Much of the water entering the soil is used by plants. A small amount is held in the soil, and the rest (3 to 16 inches per year) moves downward (called recharge). Any zone of saturated earth materials that is capable of providing useable quantities of water to a well is called an aquifer. The surface of the first or shallowest saturated zone or aquifer is called the water table. The amount of ground water that can flow through soils or rock depends on the size of the spaces in the earth material and how well they are connected. In most aquifers, ground water moves slowly (typically 10 to 1,000 feet per year).

Are all aquifers the same?

No. Ohio has three major aquifer types, as illustrated in Figure 1, including:

- sand and gravel deposits (blue);
- sandstone bedrock (beige); and
- carbonate bedrock, (light green).

The sand and gravel aquifers consist of loose (unconsolidated) sand and gravel units with fine grained interbedded material like silts and clay or till. Most of these aquifers occur in old river valleys that have been filled with unconsolidated material and are frequently referred to as buried valley aquifers. In northwest Ohio, the unconsolidated aquifers (patches of blue) are sheets of sand and gravel deposited in glacial lake environments. Water production (yield) from the coarse-grained and thick sand and gravel aquifers range up to 500 to 1,000 gallons per minute (gpm), but are generally much lower.

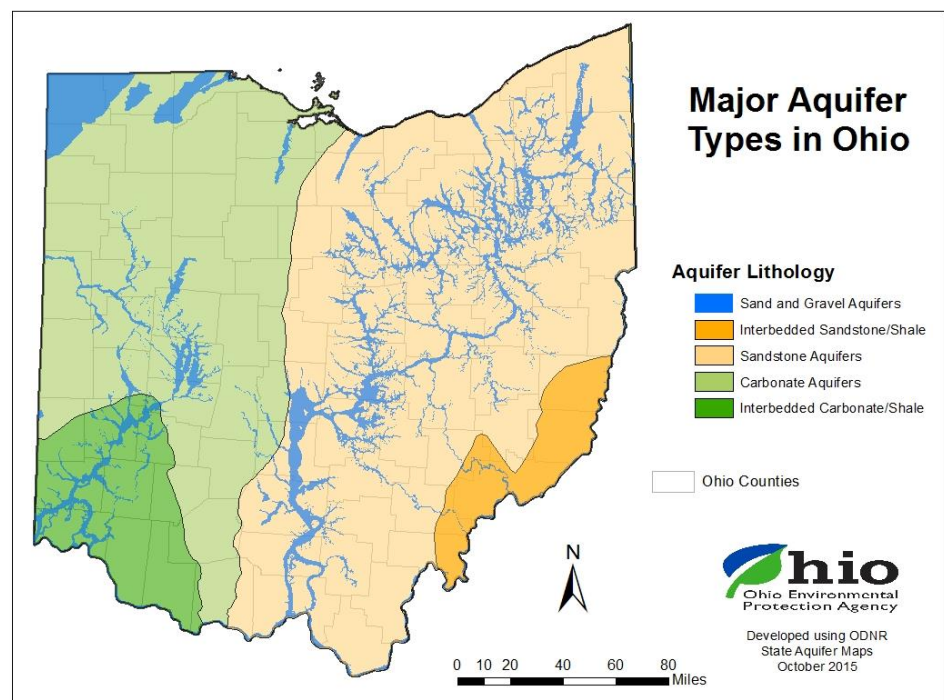


Figure 1 — Major Aquifer Types in Ohio

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The sandstone bedrock aquifers are consolidated (cemented) rock layers, interbedded (like a layer cake) with siltstones and shales. A well may receive water from multiple sandstone layers. Thicker sandstones can yield 25—100 gpm, but 25 gpm is good. Many wells in the southeast portion of Ohio produce 5 gpm and less. Where shale dominates, like the sediments (brown) in southeast Ohio, yields are low.

The carbonate aquifers in western Ohio consist mainly of limestone and dolomite and may reach a thickness of 300 to 600 feet. These aquifers are capable of yielding more than 100 gpm. Most of the ground water flow in carbonate aquifers is along fractures or bedding planes. An increase in the percentage of shale within the carbonate bedrock in southwest Ohio results in lower yields. If shale dominates, as in the shale-rich carbonates in southwest Ohio (darker green color), yields are generally less than 5 gpm. Typical well yields for Ohio aquifers are available on the ODNR website at:

<http://soilandwater.ohiodnr.gov/maps/statewide-aquifer-maps>

How do I know which aquifer my water comes from?

You may be able to tell from Figure 1, but the best way to identify your aquifer is to locate the log for your well. Drillers must file a Well Log and Drilling Report with the Ohio Department of Natural Resources (ODNR) for wells they drill. Well logs provide information, including the aquifer or geologic material providing water, the well depth, and well construction details. Your well log (or logs for adjacent wells if you cannot locate yours) can be found at: <http://soilandwater.ohiodnr.gov/search-file-well-logs>



Should I be concerned about the water quality in my well?

Generally, the water quality in Ohio is good, but contaminants (naturally occurring, as well as associated with local land use) may affect your water quality. Contaminated drinking water causes problems that range from harmless (such as an unpleasant taste) to adverse health concerns. Individual well owners have primary responsibility for the safety of the water drawn from their wells. Routine testing of your well water may identify potential water quality issues, and helps you decide if treatment is necessary.

What can I expect to find in my well water?

There is significant variability in local water quality depending on the composition of the aquifer, the sensitivity of the aquifer to contamination, and local land use. Water is called the universal solvent, and as it passes through soil and rocks to recharge the local aquifer, it dissolves materials and picks up mineral constituents. The composition of ground water is determined mainly by the character of the soil and rock materials it contacts and the length of time it takes to move to and through the aquifer. Local water quality can also be affected by surface land use that releases contamination, which can be transported to the aquifer by recharge. Table 1 provides typical ranges of some constituents in Ohio aquifers.

How can I interpret my water quality results? How will I know if there is a problem?

Testing your well water and analyzing the sample for constituents representative of natural sources and potential contamination around your well (such as analyzing for chloride to check for the impact of road salts) helps to answer these questions. If you want to evaluate the potential impact to your well from a new activity or land use, it is best to collect samples prior to the initiation of the activity. These early samples will provide background information on water quality before potential impact. Successive samples that show an increasing trend of a constituent, whether starting from background values or not, can document water quality impacts. Determining what caused the impact, however, is not always easy.



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Table 1 below provides typical water quality ranges for each of Ohio's major aquifer types. The ranges in the table are 10th and 90th percentiles of well averages for Ohio EPA's Ambient Ground Water Quality Monitoring Program. If your test results are within the ranges listed for your aquifer type, your water quality is considered typical. Some of the constituents listed have primary and secondary maximum contaminant levels (MCL and SMCL, respectively). MCLs are regulatory health-based standards for water served to the public. SMCLs are advisory levels of selected constituents for aesthetic water quality issues such as taste and odor. The MCLs and SMCLs provide useful benchmarks for evaluating sample results, but owners of private water wells that exceed the MCLs are not required to install treatment. Individual private well owners need to decide if treatment will be installed.

Table 1. Typical Water Quality Ranges for Ohio Ground Waters by Aquifer Type

Constituent	Symbol/Description	MCL [#] /SMCL ^{s#}	Sand and Gravel Range	Sandstone Range	Carbonate Range	Units *
Alkalinity	Total as CaCO ₃		185-325	130-315	175-360	ppm
Ammonia	NH ₄		0.05-0.5	0.05-0.8	0.07-0.8	ppm
Arsenic (total)	As	10	2-12	2-2.8	2- 7.3	ppb
Barium	Dissolved Ba	2000	55-275	20-515	15-160	ppb
Bromide	Br		30-135	30-270	35-250	ppb
Calcium	Total Ca		65-120	15-90	85-175	ppm
Chloride	Cl	250 ^s	10-70	7-150	6-50	ppm
Conductivity	At 25 °C		500-900	400-1,025	650-1,275	µmohs/cm
Fluoride	F	4.0 / 2.0 ^s	0.2-1.0	0.2-0.6	0.65-2.1	ppm
Iron	Dissolved Fe	300 ^s	60-2,900	50-1,900	135-2,125	ppb
Magnesium	Total Mg		15-40	5-25	35-80	ppm
Manganese	Dissolved Mn	50	15-450	10-550	10-60	ppb
Nitrite	as nitrogen	10	0.1-2.1	0.1-0.65	0.1-0.25	ppm
Phosphorus	Total P		0.01-0.7	0.01-0.12	0.01-0.7	ppm
Potassium	Total K		2.0-3.2	2.0-3.2	2.0-4.3	ppm
pH	[H ⁺]	7-10.5 ^s	7.1-7.5	6.8-7.85	7.0-7.4	SU
Sodium	Total Na		11-43	11-170	9.5-75	ppm
Strontium	Sr		160-6,300	105-850	5750-30,650	ppb
Sulfate	SO ₄	250 ^s	40-130	5-90	70-585	ppm
Total Dissolved Solids (TDS)	TDS	500 ^s	340-600	245-620	500-1100	ppm

^s Indicates secondary MCL

[#] if blank, no MCL or SMCL determined

* Units: ppm = parts per million (equivalent to mg/L)

ppb = parts per billion (equivalent to µg/L)

SU = Standard Units

µmohs/cm = micromhos per centimeter

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Individual Parameters

A short description of the constituents listed in Table 1 is provided below. Additional information on these constituents and others is available in the Know Your Well Water web page, which can be accessed from the Know Your Well Water Tab on the Ohio Watershed Network website at: <http://ohiowatersheds.osu.edu/well-educated-ohio>

- **Alkalinity** measures the ability of water to neutralize acid or combine negative ions with positive hydrogen ions. Waters with high bicarbonate or carbonate ions have high alkalinity.
- **Ammonia (NH₄)** is found distributed through fertile soil at low concentrations and is a component of human and animal waste and fertilizers. It may be present in reduced settings (dissolved oxygen is absent).
- **Arsenic (As)** is a toxic metal that may be present when dissolved oxygen is low, typically occurring in deeper wells where ground water is isolated from the atmosphere.
- **Barium (Ba)** may be elevated in brines, and barite (BaSO₄) is a common component of heavy drilling mud. High barium may indicate well construction breaches.
- **Bromide (Br)** is a salt and behaves like chloride. The chloride: bromide ratio can be used to help identify the source of salt contamination (e.g. road salt, natural brines).
- **Calcium (Ca)** concentrations are highest in aquifers dominated by carbonate. Carbonate is composed of calcite (CaCO₃) and dolomite (CaMg(CO₃)₂), which are relatively soluble minerals.
- **Chloride (Cl)** is a salt and is highly concentrated in brines. The application of road salt (NaCl) to melt snow and ice or disposal of water softener backwash can contribute to elevated chloride concentrations. Chloride is a useful tracer.
- **Conductivity** is generally measured in the field and has a strong correlation to total dissolved solids. Dissolved inorganic parameters or brines exhibit elevated conductivity and rainfall has low conductivity.
- **Fluoride (F)** is the naturally occurring form of gaseous fluorine and is commonly present in ground water. The carbonate aquifers exhibit the highest levels in Ohio's ground water due to dissolution of fluorite.
- **Iron (Fe)** is elevated when iron oxides or other iron-rich minerals dissolve. This occurs when dissolved oxygen is low, typically occurring in deeper wells where ground water is isolated from the atmosphere.
- **Magnesium (Mg)** is generally associated with dissolution of dolomite (CaMg(CO₃)₂) aquifers (a common carbonate aquifer), but elevated magnesium is also present in brines.
- **Manganese (Mn)**, like iron, is generally present when ground water is low in dissolved oxygen (reduced).
- **Nitrate (NO₃)** naturally-occurs at low concentrations in Ohio. If nitrate is greater than 2 ppm it suggest surface contamination from chemical fertilizers, manure, or sewage waste is reaching the ground water. Nitrate is not present in deep wells that are isolated form the atmosphere (reduced conditions).
- **Phosphorus (P)** is generally present at low concentrations, but elevated values may indicate the influence of manure, chemical fertilizers, or septic waste.
- **Potassium (K)** is generally low in potable water aquifers but is elevated in brines.
- **pH** is a measure of the concentration of hydrogen ions. It is measured in the field and indicates the acidity of the water (pH =7 is neutral). Brines have pH that is less than that of most drinking water.
- **Sodium (Na)** is generally low in ground water but elevated concentrations may result from contamination from road salt application, salt storage, softener backwash disposal, or septic waste. Sodium can be a useful tracer.
- **Strontium (Sr)** is elevated in portions of Ohio's carbonate aquifers due to the presence Celestine (SrSO₄) in fractures.
- **Sulfate (SO₄)** is common at low concentration. In Ohio, carbonate aquifers can exhibit elevated sulfate concentrations due to the presence of gypsum (CaSO₄ 2H₂O). Gypsum is common is some of Ohio's carbonate sequences.
- **Total dissolved solids (TDS)** is a measure of the total dissolved load in water. Drinking water has low TDS, generally less than 800 ppm. Brines exhibit very high TDS (> 100,000 ppm).

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Is ground water quality variable?

Ground water quality is generally stable because flow is slow. However, in areas of sensitive aquifers where rapid recharge can transport surface contaminants to aquifers quickly, water quality can vary over time. Figure 2 illustrates water quality that varies annually, a case in which the elevated nitrate occurs in the spring and lower concentrations occur in the fall. This well is located close to a stream in an agricultural area. When pumping, this well draws in surface water from the stream, resulting in the annual cycle. This example exhibits more variation than most wells, but it illustrates the potential for systemic water quality variation.

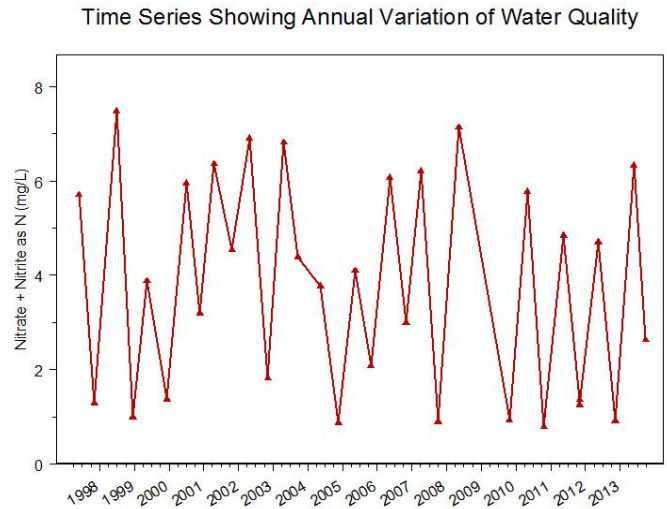


Figure 2 — Example of annual water quality variation.

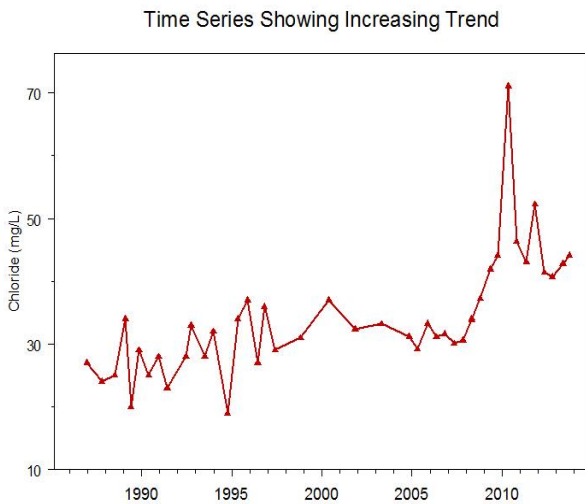


Figure 3 — Example of increasing trend.

Do you see trends in your data?

Ground water quality in a single well may vary over time naturally or the variation may reflect impacts associated with local land use. If multiple samples are collected at different times (2-6 months apart), you may be able to document trends in the data. To identify trends, plot the data on a graph with parameter concentration on the vertical axis against time on the horizontal axis. Increasing concentrations with time document potential water quality impacts as illustrated in Figure 3. If the increase is significant, based on the concentrations given in Table 1, call ODH or Ohio EPA for more information. Figures 2 and 3 provide examples of significant variability in ground water data, and they indicate that the more data collected, the better you will understand your well.

Where can I get more information?

Ohio Department of Health (ODH)

Phone: (614) 644-7558

Email: BEH@odh.ohio.gov

<http://www.odh.ohio.gov/odhprograms/eh/water/PrivateWaterSystems/main.aspx>

(private water system link)

Ohio EPA, Division of Drinking and Ground Waters

Phone: (614) 644-2752

Email: gwq@epa.ohio.gov

<http://epa.ohio.gov/ddagw/gwqcp.aspx>

Your Local Health Department

www.odh.ohio.gov/localhealthdistricts/lhdmain.aspx

Know Your Well Water: Test, Understand and Protect

Accessed through the Ohio Watershed Network at

<http://ohiowatersheds.osu.edu>

This fact sheet is part of a series discussing the water quality of Ohio's aquifers. A companion report, available online at http://epa.ohio.gov/Portals/28/documents/gwqcp/Aquifer&Geochem_ts.pdf, describes the distribution of major aquifers in Ohio and the associated water quality in Ohio's major aquifers in more detail.