

**GROUND WATER POLLUTION POTENTIAL
ASHTABULA COUNTY, OHIO**

GROUND WATER POLLUTION POTENTIAL NO. 10

BY

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ABSTRACT

A ground water pollution potential mapping program for Ohio has been developed under the direction of the Division of Water, Ohio Department of Natural Resources, using the DRASTIC mapping process. The DRASTIC system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system for pollution potential.

Hydrogeologic settings form the basis of the system and incorporate the major hydrogeologic factors that affect and control ground water movement and occurrence including depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media and hydraulic conductivity of the aquifer. These factors, which form the acronym DRASTIC, are incorporated into a relative ranking scheme that uses a combination of weights and ratings to produce a numerical value called the ground water pollution potential index. Hydrogeologic settings are combined with the pollution potential indexes to create units that can be graphically displayed on a map.

Ashtabula County lies within the Glaciated Central Region. The county is covered by variable thicknesses of glacial lake deposits, tills and outwash. In the northern portion of the county, areas of glacial lake deposits have a moderate vulnerability to contamination. In areas of glacial till over bedrock, pollution potential indexes range from low to moderate. Buried valleys containing sand and gravel deposits, and areas of outwash have moderately high to high vulnerability to contamination. Beach ridges, swamps and areas of alluvium adjacent to rivers throughout the county exhibit a moderate to high pollution potential. Nine hydrogeologic settings were identified in Ashtabula County with computed ground water pollution potential indexes ranging from 90 to 207.

The ground water pollution potential mapping program optimizes the use of existing data to rank areas with respect to relative vulnerability to contamination. The ground water pollution potential map of Ashtabula County has been prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring and clean-up efforts

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 per cent of Ohio citizens rely on ground water for their drinking and household uses from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 700,000 rural households depend on private wells; approximately 5,700 of these wells exist in Ashtabula County.

The characteristics of the many aquifer systems in the state make ground water highly vulnerable to contamination. Measures to protect ground water from contamination usually cost less and create less impact on ground water users than clean up of a polluted aquifer. Based on these concerns for protection of the resource, staff of the Division of Water conducted a review of various mapping strategies useful for identifying vulnerable aquifer areas. They placed particular emphasis on reviewing mapping systems that would assist in state and local protection and management programs. Based on these factors and the quantity and quality of available data on ground water resources, the DRASTIC mapping process (Aller et al., 1987) was selected for application in the program.

Considerable interest in the mapping program followed successful production of a demonstration county map and led to the inclusion of the program as a recommended initiative in the Ohio Ground Water Protection and Management Strategy (Ohio EPA, 1986). Based on this recommendation, the Ohio General Assembly funded the mapping program. A dedicated mapping unit has been established in the Division of Water, Ground Water Resources Section to implement the ground water pollution potential mapping program on a county-wide basis in Ohio.

The purpose of this report and map is to aid in the protection of our ground water resources. This protection can be enhanced partly by understanding and implementing the results of this study which utilizes the DRASTIC system of evaluating an area's potential for ground-water pollution. The mapping program identifies areas that are more or less vulnerable to contamination and displays this information graphically on maps. The system was not designed or intended to replace site-specific investigations, but rather to be used as a planning and management tool. The results of the map and report can be combined with other information to assist in prioritizing local resources and in making land use decisions.

APPLICATIONS OF POLLUTION POTENTIAL MAPS

The pollution potential mapping program offers a wide variety of applications in many counties. The ground water pollution potential map of Ashtabula County was prepared to assist planners, managers, and state and local officials in evaluating the relative vulnerability of areas to ground-water contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring and clean-up efforts.

An important application of the pollution potential maps for many areas will be to assist in county land use planning and resource expenditures related to solid waste disposal. A county may use the map to help identify areas that are more or less suitable for land disposal activities. Once these areas are identified, a county can collect more site-specific information and combine this with other local factors to determine site suitability.

A pollution potential map can also assist in developing ground-water protection strategies. By identifying areas more vulnerable to contamination, officials can direct resources to areas where special attention or protection efforts might be warranted. This information can be utilized effectively at the local level for integration into land use decisions and as an educational tool to promote public awareness of ground water resources. Pollution potential maps may also be used to prioritize ground water monitoring and/or contamination clean-up efforts. Areas that are identified as being vulnerable to contamination may benefit from increased ground water monitoring for pollutants or from additional efforts to clean up an aquifer.

Pollution potential maps may also be applied successfully where non-point source contamination is a concern. Non-point source contamination occurs where land use activities over large areas impact water quality. Maps providing information on relative vulnerability can be used to guide the selection and implementation of appropriate best management practices in different areas. Best management practices should be chosen based upon consideration of the chemical and physical processes that occur from the practice, and the effect these processes may have in areas of moderate to high vulnerability to contamination. For example, the use of agricultural best management practices that limit the infiltration of nitrates, or promote denitrification above the water table, would be beneficial to implement in areas of relatively high vulnerability to contamination.

Other beneficial uses of the pollution potential maps will be recognized by individuals in the county who are familiar with specific land use and management problems. Planning commissions and zoning boards can use these maps to help make informed decisions about the development of areas within their jurisdiction. Developments proposed to occur within ground-water sensitive areas may be required to show how ground water will be protected.

Regardless of the application, emphasis must be placed on the fact that the system is not designed to replace a site-specific investigation. The strength of the system lies in its ability to make a "first-cut approximation" by identifying areas that are vulnerable to contamination. Any potential applications of the system should also recognize the assumptions inherent in the system.

SUMMARY OF THE DRASTIC MAPPING PROCESS

The system chosen for implementation of a ground water pollution potential mapping program in Ohio, DRASTIC, was developed by the National Water Well Association for the United States Environmental Protection Agency. A detailed discussion of this system can be found in Aller et al. (1987).

The DRASTIC mapping system allows the pollution potential of any area to be evaluated systematically using existing information. The vulnerability of an area to contamination is a combination of hydrogeologic factors, anthropogenic influences and sources of contamination in any given area. The DRASTIC system focuses only on those hydrogeologic factors which influence ground water pollution potential. The system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system to determine pollution potential.

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area assuming a contaminant with the mobility of water, introduced at the surface, and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than one-hundred acres in size, and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

To facilitate the designation of mappable units, the DRASTIC system used the framework of an existing classification system developed by Heath (1984), which divides the United States into fifteen ground water regions based on the factors in a ground water system that affect occurrence and availability.

Within each major hydrogeologic region, smaller units representing specific hydrogeologic settings are identified. Hydrogeologic settings form the basis of the system and represent a composite description of the major geologic and hydrogeologic factors that control ground water movement into, through and out of an area. A hydrogeologic setting represents a mappable unit with common hydrogeologic characteristics, and, as a consequence, common vulnerability to contamination (Aller et al., 1987).

Figure 1 illustrates the format and description of a typical hydrogeologic setting found within Ashtabula County. Inherent within each hydrogeologic setting are the physical characteristics which affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

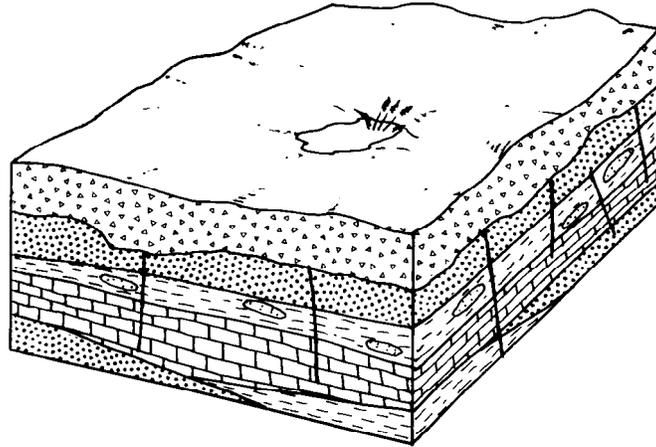
- D - Depth to Water
- R - Net Recharge
- A - Aquifer Media
- S - Soil Media
- T - Topography
- I - Impact of the Vadose Zone Media
- C - Conductivity (Hydraulic) of the Aquifer

These factors incorporate concepts and mechanisms such as attenuation, retardation and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms coupled with existing conditions in a setting provide a basis for determination of the area's relative vulnerability to contamination.

Depth to water is considered to be the depth from the ground surface to the water table in unconfined aquifer conditions or the depth to the top of the aquifer under confined aquifer conditions. The depth to water determines the distance a contaminant would have to travel before reaching the aquifer. The greater the distance the contaminant has to travel the greater the opportunity for attenuation to occur or restriction of movement by relatively impermeable layers.

Net recharge is the total amount of water reaching the land surface that infiltrates into the aquifer measured in inches per year. Recharge water is available to transport a contaminant from the surface into the aquifer and also affects the quantity of water available for dilution and dispersion of a contaminant. Factors to be included in the determination of net recharge include contributions due to infiltration of precipitation, in addition to infiltration from rivers, streams and lakes, irrigation and artificial recharge.

Aquifer media represents consolidated or unconsolidated rock material capable of yielding sufficient quantities of water for use. Aquifer media accounts for the various physical characteristics of the rock that provide mechanisms of attenuation, retardation and flow pathways that affect a contaminant reaching and moving through an aquifer.



7Aa Glacial Till Over Bedded Sedimentary Rocks

This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sedimentary rocks consisting of sandstone, shale and limestone which are covered by varying thicknesses of glacial till. The till is principally unsorted deposits which may be interbedded with loess or localized deposits of sand and gravel. Although ground water occurs in both the glacial deposits and in the intersecting bedrock fractures, the bedrock is typically the principal aquifer. The glacial till serves as a source of recharge to the underlying bedrock. Although precipitation is abundant in most of the region, recharge is moderate because of the glacial till and soils which are typically clay loams. Depth to water is extremely variable depending in part on the thickness of the glacial till, but averages around 30 feet.

Figure 1. Format and description of the hydrogeologic setting - 7Aa Glacial Till Over Bedded Sedimentary Rocks.

Soil media refers to the upper six feet of the unsaturated zone that is characterized by significant biological activity. The type of soil media can influence the amount of recharge that can move through the soil column due to variations in soil permeability. Various soil types also have the ability to attenuate or retard a contaminant as it moves throughout the soil profile. Soil media is based on textural classifications of soils and considers relative thicknesses and attenuation characteristics of each profile within the soil.

Topography refers to the slope of the land expressed as percent slope. The amount of slope in an area affects the likelihood that a contaminant will run off from an area or be ponded and ultimately infiltrate into the subsurface. Topography also affects soil development and often can be used to help determine the direction and gradient of ground water flow under water table conditions.

Impact of the vadose zone media refers to the attenuation and retardation processes that can occur as a contaminant moves through the unsaturated zone above the aquifer. The vadose zone represents that area below the soil horizon and above the aquifer that is unsaturated or discontinuously saturated. Various attenuation, travel time and distance mechanisms related to the types of geologic materials present can affect the movement of contaminants in the vadose zone. Where an aquifer is unconfined, the vadose zone media represents the materials below the soil horizon and above the water table. Under confined aquifer conditions, the vadose zone is simply referred to as a confining layer. The presence of the confining layer in the unsaturated zone significantly impacts the pollution potential of the ground water in an area.

Hydraulic conductivity of an aquifer is a measure of the ability of the aquifer to transmit water, and is also related to ground water velocity and gradient. Hydraulic conductivity is dependent upon the amount and interconnectivity of void spaces and fractures within a consolidated or unconsolidated rock unit. Higher hydraulic conductivity typically corresponds to higher vulnerability to contamination. Hydraulic conductivity considers the capability for a contaminant that reaches an aquifer to be transported throughout that aquifer over time.

Weighting and Rating System

DRASTIC uses a numerical weighting and rating system that is combined with the DRASTIC factors to calculate a ground water pollution potential index or relative measure of vulnerability to contamination. The DRASTIC factors are weighted from 1 to 5 according to their relative importance to each other with regard to contamination potential (Table 1). Each factor is then divided into ranges or media types and assigned a rating from 1 to 10 based on their significance to pollution potential (Tables 2-8). The rating for each factor is selected based on available information and professional judgement. The selected rating for each factor is multiplied by the assigned weight for each factor. These numbers are summed to calculate the DRASTIC or pollution potential index.

Once a DRASTIC index has been calculated, it is possible to identify areas that are more likely to be susceptible to ground water contamination relative to other areas. The higher the DRASTIC index, the greater the vulnerability to contamination. The index generated provides only a relative evaluation tool and is not designed to produce absolute answers or to represent units of vulnerability. Pollution potential indexes of various settings should be compared to each other only with consideration of the factors that were evaluated in determining the vulnerability of the area.

Pesticide DRASTIC

A special version of DRASTIC was developed to be used where the application of pesticides is a concern. The weights assigned to the DRASTIC factors were changed to reflect the processes that affect pesticide movement into the subsurface with particular emphasis on soils. Where other agricultural practices, such as the application of fertilizers are a concern, general DRASTIC should be used to evaluate relative vulnerability to contamination. The process for calculating the Pesticide DRASTIC index is identical to the process used for calculating the general DRASTIC index. However, general DRASTIC and Pesticide DRASTIC numbers should not be compared because the conceptual basis in factor weighting and evaluation significantly differs. Table 1 lists the weights used for general and pesticide DRASTIC.

TABLE 1. ASSIGNED WEIGHTS FOR DRASTIC FEATURES

Feature	General DRASTIC Weight	Pesticide DRASTIC Weight
Depth to Water	5	5
Net Recharge	4	4
Aquifer Media	3	3
Soil Media	2	5
Topography	1	3
Impact of the Vadose Zone Media	5	4
Hydraulic Conductivity of the Aquifer	3	2

TABLE 2. RANGES AND RATINGS FOR DEPTH TO WATER

DEPTH TO WATER (FEET)	
Range	Rating
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	Pesticide Weight: 5

TABLE 3. RANGES AND RATINGS FOR NET RECHARGE

NET RECHARGE (INCHES)	
Range	Rating
0-2	1
2-4	3
4-7	6
7-10	8
10+	9
Weight: 4	Pesticide Weight: 4

TABLE 4. RANGES AND RATINGS FOR AQUIFER MEDIA

AQUIFER MEDIA		
Range	Rating	Typical Rating
Massive Shale	1-3	2
Metamorphic/Igneous	2-5	3
Weathered Metamorphic / Igneous	3-5	4
Glacial Till	4-6	5
Bedded Sandstone, Limestone and Shale Sequences	5-9	6
Massive Sandstone	4-9	6
Massive Limestone	4-9	6
Sand and Gravel	4-9	8
Basalt	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

TABLE 5. RANGES AND RATINGS FOR SOIL MEDIA

SOIL MEDIA	
Range	Rating
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrinking and / or Aggregated Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Nonshrinking and Nonaggregated Clay	1
Weight: 2	Pesticide Weight: 5

TABLE 6. RANGES AND RATINGS FOR TOPOGRAPHY

TOPOGRAPHY (PERCENT SLOPE)	
Range	Rating
0-2	10
2-6	9
6-12	5
12-18	3
18+	1
Weight: 1	Pesticide Weight: 3

TABLE 7. RANGES AND RATINGS FOR IMPACT OF THE VADOSE ZONE MEDIA

IMPACT OF THE VADOSE ZONE MEDIA		
Range	Rating	Typical Rating
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
Limestone	2-7	6
Sandstone	4-8	6
Bedded Limestone, Sandstone, Shale	4-8	6
Sand and Gravel with significant Silt and Clay	4-8	6
Metamorphic/Igneous	2-8	4
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

HYDRAULIC CONDUCTIVITY (GPD/FT ²)	
Range	Rating
1-100	1
100-300	2
300-700	4
700-1000	6
1000-2000	8
2000+	10
Weight: 3	Pesticide Weight: 2

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7Aa1 Glacial Till Over Bedded Sedimentary Rock, identified in mapping Ashtabula County, and the pollution potential index calculated for the setting. Based on selected ratings for this setting, the pollution potential index is calculated to be 131. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 65 to 223. The diversity of hydrogeologic conditions in Ashtabula County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the nine settings identified in the county range from 90 to 207.

Hydrogeologic settings identified in an area are combined with the pollution potential indexes to create units that can be graphically displayed on maps. Pollution potential mapping in Ashtabula County resulted in a map with symbols and colors that illustrate areas of varying ground water vulnerability. The map describing the ground water pollution potential of Ashtabula County is included with this report.

INTERPRETATION AND USE OF A GROUND WATER POLLUTION POTENTIAL MAP

The application of the DRASTIC system to evaluate an area's vulnerability to contamination produces hydrogeologic settings with corresponding pollution potential indexes. The higher the pollution potential index, the greater the susceptibility to contamination. This numeric value determined for one area can be compared to the pollution potential index calculated for another area.

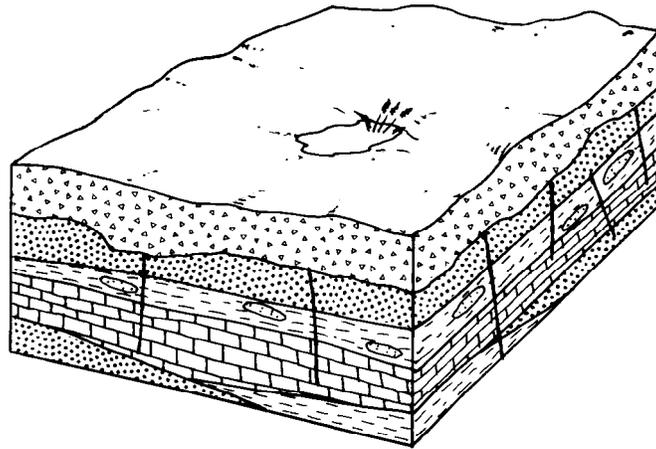
The map accompanying this report displays both the hydrogeologic settings identified in the county and the associated pollution potential indexes calculated in those hydrogeologic settings. The symbols on the map represent the following information:

- 7D1 - defines the hydrogeologic region and setting
- 154 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper case letter (D) refer to a specific hydrogeologic setting. The following number (1) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (154) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived in an area.

The maps are color coded using ranges depicted on the map legend. The color codes used are part of a national color coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow), representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet), representing areas of lower vulnerability to contamination.

The map also includes information on the locations of selected observation wells. Available information on these observation wells is referenced in Appendix A, Description of the Logic in Factor Selection. Large man-made features such as landfills, quarries or strip mines have also been marked on the map for reference.



SETTING 7Aa1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	5 - 15	5	9	45
Net Recharge	4 - 7	4	6	24
Aquifer Media	Bedded Ss, Ls, Sh Seq.	3	6	18
Soil Media	Silty Loam	2	4	8
Topography	0 - 2%	1	10	10
Impact Vadose Zone	Silt/Clay	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		DRASTIC	INDEX	131

Figure 2. Description of the hydrogeologic setting 7Aa1 Glacial Till Over Bedded Sedimentary Rocks.

GENERAL INFORMATION ABOUT ASHTABULA COUNTY

Demography

Ashtabula County occupies an area of approximately 705 square miles in the extreme northeast corner of Ohio (Figure 3). It is bounded on the north by Lake Erie, on the east by Pennsylvania, on the south by Trumbull County, and on the west by Lake and Geauga Counties.

The Ashtabula County seat is Jefferson, located near the center of the county, about 55 miles northeast of Cleveland. The 1986 Census Bureau estimate of the population of Ashtabula County was 101,200 (U.S. Department of Commerce, 1987).

Physiography

Ashtabula County lies within two physiographic provinces: the Eastern Lakes Section of the Central Lowland Province, and the Southern New York Section of the Appalachian Plateau Province (Fenneman, 1938) (Figure 4). The Central Lowland Province occupies a belt 3 to 5.5 miles wide roughly paralleling the lake shore (White and Totten, 1979). This physiographic region typically shows low topography with a gentle slope towards the lake. Ancient beach ridges, left behind by ancient lakes that stood at higher levels than present day Lake Erie, provide the most pronounced surface relief within this province.

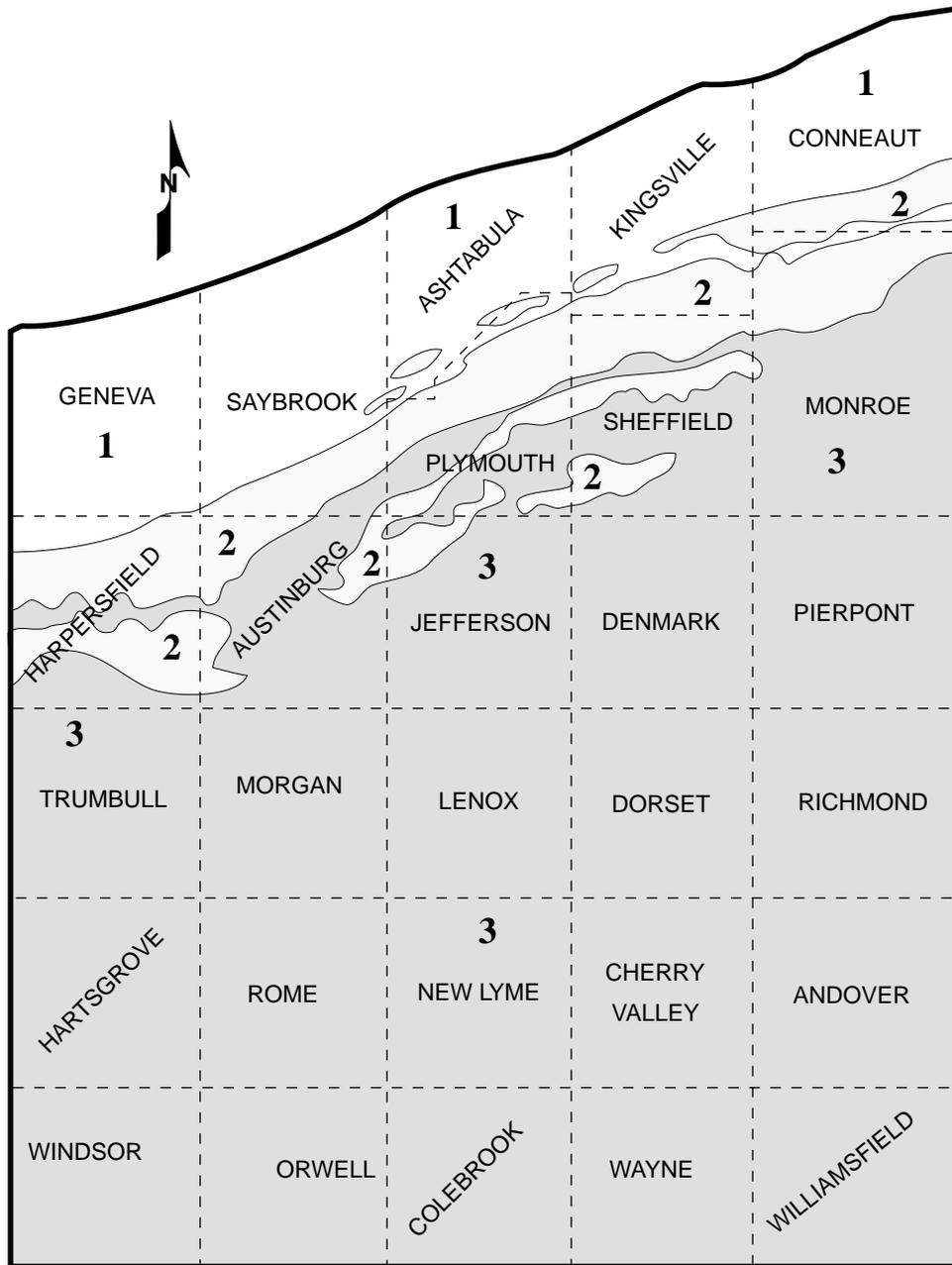
The Portage Escarpment that parallels the lake shore separates the Central Lowland Province from the Appalachian Plateau Province. In Ashtabula County, the Escarpment consists of a belt of bedrock cliffs and glacial end moraines that average 1.5 miles in width and are as wide as 3 miles (White and Totten, 1979).

South of the crest of the Escarpment belt, the topography drops off slightly, then rises gently to a final elevation near 1200 feet (M.S.L.) at the southeastern edge of the county. Relief south of the Escarpment is more pronounced than in the Central Lowland Province. This is particularly true where the major streams flow through steep-walled valleys that are cut deep into the bedrock (White and Totten, 1979).



ASHTABULA COUNTY

Figure 3. Location of Ashtabula County in Ohio.



1.  Lake Plain (Central Lowland Province)
2.  Escarpment Belt
3.  Appalachian Plateau Province

Figure 4. Physiographic Divisions of Ashtabula County, Ohio (after White and Totten, 1979).

The Northeast Region of Ohio, which includes all of Ashtabula County, has a fifty year (1931-1980) average annual precipitation of 36.97 inches. The average annual temperature for the same period was 49.7 degrees Fahrenheit (U.S. Department of Commerce, 1981). For the thirty-year period from 1951 through 1980, the U.S. Weather Bureau Station at Ashtabula recorded an average annual precipitation of 38.31 inches. The 30-year (1951-1980) average annual temperature was 49.2 degrees Fahrenheit (U.S. Department of Commerce, 1982).

Ashtabula County lies entirely within the Lake Erie drainage basin. The principal streams flowing through the county include Conneaut Creek, the Ashtabula River and the Grand River. In addition, Pymatuning Creek, Rock Creek, and Mill Creek provide a significant portion of the drainage in the county.

Glacial Geology

Throughout most of Ashtabula County, material of glacial origin overlies bedrock. These glacial deposits accumulated during the Pleistocene Epoch which began 2 million years ago, and ended approximately 10,000 years ago. During this time period, at least four separate episodes of glaciation occurred in North America. These glacial advances were separated by interglacial periods that were warm in climate, similar to present climatic conditions. In Ohio, evidence exists for three of these periods: the Wisconsinan, which occurred between 70,000 and 10,000 years ago; the Illinoian, which occurred at least 120,000 years ago, and the pre-Illinoian (Kansan). Approximately two-thirds of the state is covered by a mantle of glacial material deposited during these periods.

The majority of the glacial materials presently observed on the surface in Ohio were deposited by the Wisconsinan glaciers. Less extensive Illinoian-age deposits are found in the northwestern counties of the state and along most of the glacial boundary. Pre-Illinoian (Kansan) deposits in Ohio average 35 to 40 feet in thickness. However, thicknesses range from less than a foot to more than 500 feet (Stout et al., 1943) (Figure 5).

Glacial till (Wisconsinan age) covers most of the Appalachian Plateau in Ashtabula County. Glacial till was deposited directly by glacial ice and is typically a poorly sorted mixture of clay, silt, sand, and gravel. In Ashtabula County the Wisconsinan tills range in texture from clay-rich deposits with very little sand and gravel, to sandy and gravelly deposits with a low clay content. Throughout most of this region the till is less than 10 feet thick. Erosional forces stripped away the till along some portions of the stream valleys leaving bedrock exposed at the land surface (White and Totten, 1979) (Table 9).

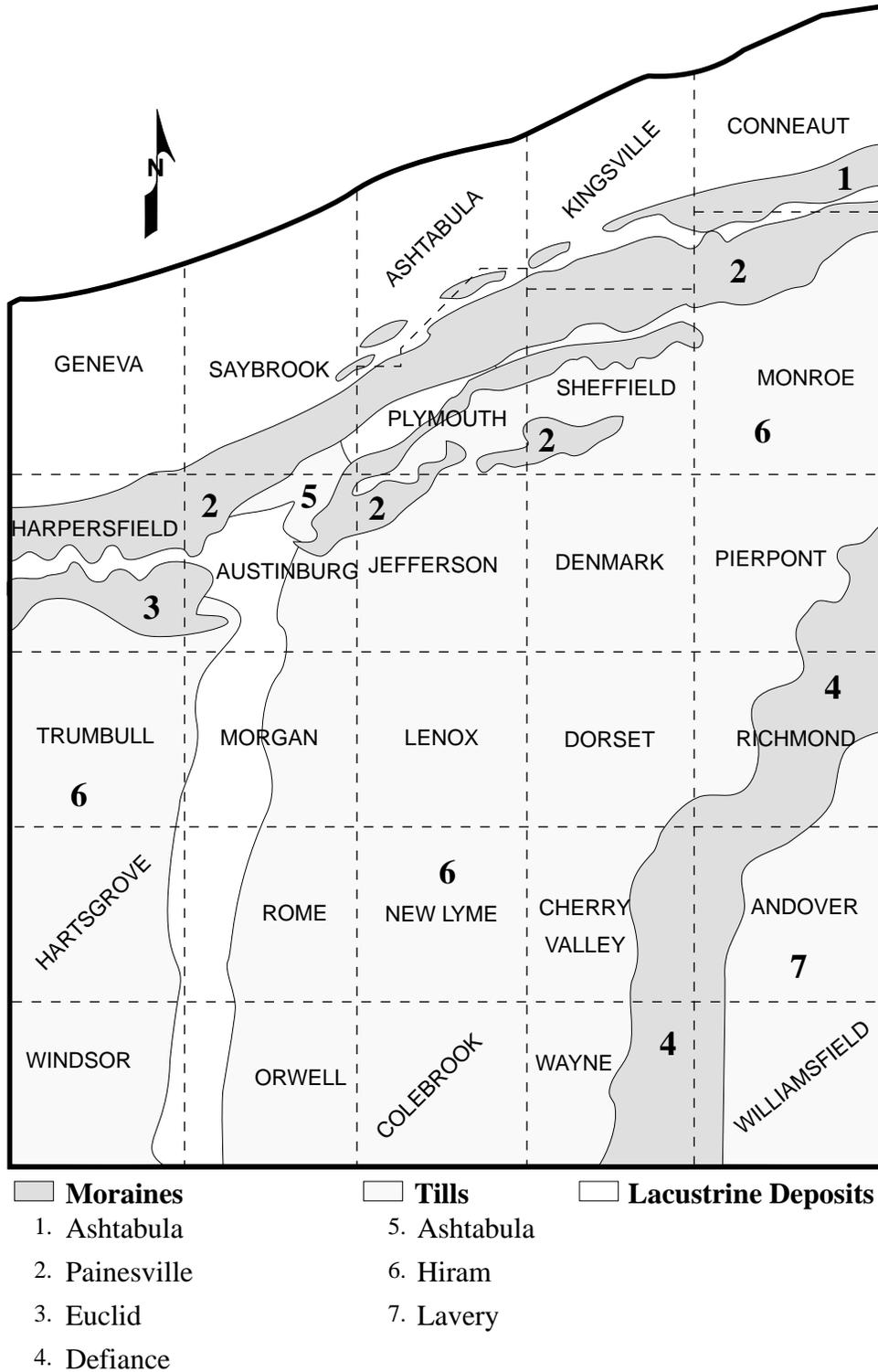


Figure 5. Generalized glacial map of Ashtabula County, Ohio.
(after White and Totten, 1979).

TABLE 9. GLACIAL DEPOSITS IN ASHTABULA COUNTY, OHIO
(after White and Totten, 1979).

Stage	Substage	Unit	Color (oxidized)	Color (unoxidized)	Texture
Wisconsinan Till	Woodfordian	Ashtabula Till	Brown	Gray	Silty, clayey
		Hiram Till Lavery Till	Dark brown Brown	Gray Gray	Clayey, few pebbles Silty, clayey, moderate number of pebbles
		Kent Till	Yellow brown	Gray	Sandy, coarse
		Paleosol			
	Altonian	Titusville Till	Olive brown	Gray	Sandy, stony, very hard
?	Early Altonian or Illinoian	Keefus Till	Red to red brown	Red to Brownish red	Silty, very hard
Pre-Wisconsinan Till		Unnamed Till(s)	?	Gray	In deep subsurface in Austinburg, rare elsewhere

Three glacial end moraines (the Euclid Moraine, the Painesville Moraine, and the Ashtabula Moraine) exist within the Escarpment belt. Typically, in northeast Ohio, end moraines represent thick deposits of glacial till that form hummocky ridges or hills. Some outwash or kame deposits may also be associated with the end moraines. The end moraines in Ashtabula County have been interpreted as indicating the farthest extent of the advance of a glacier.

The Euclid Moraine is the southernmost end moraine within the Escarpment belt. This moraine is a strip of land 1 to 2 miles wide beginning south of the Grand River in eastern Ashtabula County, and extending to south of the Ashtabula River in the western portion of the county. Glacial drift within the moraine ranges from less than 20 to as much as 50 feet in thickness (White and Totten, 1979).

North of the Euclid Moraine lies the Painesville Moraine. This feature extends across the county in a northeasterly direction from northern Harpersfield Township to the Pennsylvania state line. The Painesville Moraine ranges from 1.5 to 2.5 miles wide and exhibits pronounced hummocky topography. Drift thickness within the moraine varies from 30 feet to more than 100 feet, except where it crosses a buried valley in Austinburg Township. At this location the drift is as much as 250 feet thick (White and Totten, 1979).

The Ashtabula Moraine occupies a belt of land, north of the Euclid Moraine, extending from the City of Ashtabula eastward into Pennsylvania. Between the Ashtabula and Conneaut corporation limits, the Moraine has been eroded into individual fragments ranging from 0.25 to 1 mile long. Gaps between the moraine fragments may be as wide as 1.75 miles. East of the Conneaut corporation limit and extending to the Pennsylvania line, the moraine varies from 1.25 to 1.5 miles in width. The surface of the Ashtabula Moraine is hummocky, with some knolls up to 30 feet high (White and Totten, 1979).

South of the Escarpment a fourth end moraine crosses part of Ashtabula County. The Defiance Moraine enters the county in Wayne and Williamsfield Townships and continues almost due north to northwestern Andover Township. At this point the moraine trends northeast to the Pennsylvania state line. The Defiance Moraine varies in width from 4 miles, where it enters the county, to 1.5 miles in parts of Andover and Richmond Townships (White and Totten, 1979).

Outwash deposits, kames and kame terraces are relatively common in the Appalachian Plateau Province of Ashtabula County. These deposits are especially prevalent within the valleys currently occupied by the larger streams that flow through the county (White and Totten, 1979).

As glacial ice melts, a tremendous volume of water is released. This meltwater carries with it sand, gravel, silt and clay previously trapped within the glacial ice. The moving water sorts these materials by size, weight, and shape, depositing the coarse sand and gravel near the source of the meltwater and carrying away the silt and clay downstream. Outwash deposits are formed when sand and gravel is

deposited directly on the land surface in front of glacial ice. A kame deposit forms when sand and gravel is deposited directly in holes or depressions on the ice, and subsequently accumulates on the land surface as the ice melts. In areas where ice remained in the valleys while the uplands were ice-free, meltwater deposited sand and gravel accumulated in bands along the margins between the ice and the uplands forming kame terraces.

North of the Escarpment, lacustrine (lake bottom) deposits cover most of the Central Lowland Province. Layers of silt and fine sand are the primary components of these deposits. Surface runoff washed these sediments into glacial lakes that covered parts of Ashtabula County prior to the existence of modern Lake Erie. Over a period time the silt and sand settled to the bottom of the lakes and accumulated. Lacustrine deposits in the Central Lowland Province of Ashtabula County are relatively thin and are underlain in most areas by a layer of glacial till (White and Totten, 1979).

Also occurring within the Central Lowland Province are linear ridges of sand and gravel overlying glacial till. These ridges are the remnants of beaches deposited along the shores of ancient glacial lakes. Typically ranging from 10 to 30 feet in height, these ridges form topographic highs in the otherwise flat terrain (White and Totten, 1979).

Lacustrine deposits are also present in the Appalachian Plateau Province of Ashtabula County. These deposits are found primarily within the Grand River Valley from Windsor Township through Austinburg Township. Unlike the lake bottom materials north of the escarpment, these deposits are primarily composed of silty clay and clay (White and Totten, 1979).

Wind-blown dunes are found adjacent to the beach ridges in some parts of the Central Lowland Province. These deposits are composed primarily of well-sorted sand (White and Totten, 1979).

Buried Valleys

Inter- and pre-glacial streams had a profound effect on the bedrock topography of Ashtabula County. During the time in which they flowed through the county, these streams cut deep valleys into the surface of the bedrock. The largest and deepest of these ancient bedrock valleys in Ashtabula County underlies much of the present day Grand River Valley in Windsor, Orwell, Rome, Hartsgrove, Morgan and Austinburg Townships. Although the modern Grand River turns sharply to the west in central Austinburg Township, the ancient river valley continues north under the Portage Escarpment and the Central Lowland Province (White and Totten, 1979).

As glacial ice advanced through the county, flow in the streams ceased and the bedrock valleys were partially, and in some areas totally, filled with glacial drift. This glacial drift is primarily till but does contain some significant layers of outwash

sand and gravel in many areas. The depth of glacial deposits in these buried valleys generally averages 100 feet, with thicknesses in the Grand River Valley exceeding 250 feet in some sections.

Bedrock Geology

Bedrock underlying Ashtabula County belong to the Devonian and Mississippian Systems, and were deposited 395 to 325 million years ago (Table 10). With the exception of the southeast and southwest corners of the county, the predominant bedrock formation is the Ohio Shale of the Devonian System. This formation is typically a hard, dark colored, impermeable shale containing a few thin layers of hard, impermeable sandstone (Szmuc, 1953). The Ohio Shale in Ashtabula County consists of two members, the Chagrin and Cleveland Shale. These shales are believed to have formed in large continental seas that covered much of Ohio during this time. Rivers and streams, flowing from the east and southeast, deposited fine silts and clays into these basins, subsequently forming a thick sequence of shales (Hoover, 1960). Joint and fracture patterns in the Ohio shales have been well documented and can be observed at nearly every exposure of the formation (Hoover, 1960). Most joints appear to extend a significant distance both vertically and laterally; however, the spacing between joints tends to vary by location.

In the southeast and southwest corners of the county, bedrock formations belong to the Mississippian System. The principal formations include, from youngest to oldest, the Orangeville Shale, the Berea Sandstone, the Bedford Shale and the Cussewago Sandstone. During the early part of the Mississippian period, the depositional environment in northeastern Ohio changed. A broad system of rivers flowing into the area formed fan-like deltas, depositing varying thicknesses of well-sorted sands (Szmuc, 1953). These sands formed the Cussewago Sandstone which range from 20 to 80 feet thick in Ashtabula County. The existence of the Bedford Shale indicates a return to a marine environment.

The Berea Sandstone was formed by a river system depositing sand and silt along a broad delta slowly building into a shallow sea. The sands were deposited in channels and deltas forming either stringers or thick masses of sandstone interbedded with shales. In Ashtabula County, the Berea is a fine-grained sandstone that becomes increasingly silty to the east (Rau, 1969). The return of marine conditions in Ohio marked the subsequent formation of the Orangeville Shale, the Sharpsville Sandstone, and the Meadville Shale. These formations represent typically thin-to-medium bedded shales and siltstones, with occasional interbeds of limestone (Szmuc, 1953). The Meadville Shale and the Sharpsville Sandstone, two minor formations within Ashtabula County, are found only in the southwest corner of Williamsfield Township (Szmuc, 1953).

Hydrogeology

Ashtabula County lies within the Glaciated Central hydrogeologic region (Heath, 1984). The entire county is covered by variable thicknesses of glacial till and sporadic deposits of outwash sand and gravel. The thickest glacial deposits are found in a buried valley that roughly parallels and underlies the present-day Grand River. The coarse-grained deposits constitute the major ground water resources; yields from the till are variable but generally low. Recharge through the till is enhanced by the low topography and alluvium that finely dissects the county. The glacial deposits also serve as the source of recharge to the underlying bedrock aquifers.

Aquifers within Ashtabula County are divided into two general categories: unconsolidated glacial deposits and consolidated sandstone and shale formations within the bedrock. North of the Portage Escarpment the most pervasive glacial aquifer occurs at the bedrock and till interface. The principal water-bearing unit within this formation is a layer of relatively coarse deposits near the bedrock surface. Wells are typically drilled through this zone and into the underlying shale to tap any additional ground water contained within the bedrock. This combination typically yields only meager ground water supplies, often barely adequate for domestic use. In areas where the glacial deposits are thin, the shale bedrock serves as the only available aquifer. Yields from this formation are typically less than three gallons per minute (Hartzell, 1978). Other, less widespread, aquifers north of the Escarpment include the beach ridge sand deposits, and alluvial sand and gravel deposits underlying portions of the flood plains of the larger streams.

South of and including the Portage Escarpment, water is obtained both from glacial deposits and from the underlying bedrock. In the buried valley underlying the Grand River the uppermost aquifer is outwash sand and gravel. Yields from these units may be as high as 10 gallons per minute (Hartzell, 1978). Outwash and kame terrace deposits are the principal aquifers along the course of Pymatuning and Mill Creeks in Wayne, Cherry Valley and Dorset Townships. Five to 10 gallons per minute are the typical yields from these formations.

TABLE 10 GENERALIZED BEDROCK STRATIGRAPHY OF ASHTABULA COUNTY, OHIO. (After Szmuc, 1935; and Rau, 1969)

SYSTEM	GROUP	FORMATION		ROCK TYPE
MISSISSIPPIAN	Cuyahoga	Meadville Shale		Blue, gray and blue-gray shale with siltstone and limestone interbeds
		Sharpsville Sandstone		Blue, brown, gray or buff-gray siltstones with shale and limestone interbeds
		Orangeville Shale		Blue-gray to olive-gray or gray-black shale
		Berea Sandstone		Buff-brown to dark-brown, medium grained sandstone. Sandstone grades into siltstone in the southwest corner of the county.
		Bedford Shale		Olive-gray to brownish gray silty shales with some siltstone and sandstone layers
		Cussewago Sandstone		Greenish- to buff-brown, medium- to coarse-grained sandstone; contains some siltstone beds
DEVONIAN		Ohio Shale	Cleveland Shale	Black shale
			Chagrin Shale	Gray to blue shales with siltstone and sandstone interbeds

The bedrock aquifer underlying most of the Appalachian Plateau region of Ashtabula County is the Ohio Shale. Ground water yields from this formation are meager, usually less than three gallons per minute. The upland areas in the southeast and southwest corner of the county are underlain by formations of the Mississippian System. The most significant aquifers in these areas are the Berea Sandstone and the Cussewago Sandstone. Yields from these formations range from 5 to 15 gallons per minute.

REFERENCES

- Aller, L., T. Bennett, J. H. Lehr, R. J. Petty and G. Hackett, 1987. DRASTIC: a standardized system for evaluating ground-water pollution potential using hydrogeologic settings. United States Environmental Protection Agency, Publication Number 600/2-87-035, 622 pp.
- Bownocker, J. A., 1965. Geologic map of Ohio. Ohio Department of Natural Resources, 1 map.
- Cummins, J. W., 1959. Buried river valleys in Ohio. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory Report No. 10, 3 pp., 2 plates.
- Fenneman, N.M., 1938. Physiography of the eastern United States. McGraw-Hill Book Co., Inc., New York, New York, 714 pp.
- Forsyth, J. L., 1959. Beach ridges of northern Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Information Circular 25, 10 pp.
- Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey, p. 29.
- Goldthwait, R. P., G. W. White and J. L. Forsyth, 1967. Glacial map of Ohio. Ohio Department of Natural Resources, Division of Geological Survey, I-316, 1 map.
- Hartzell, G. W., 1978. Ground water resources of Ashtabula County. Ohio Department of Natural Resources, Division of Water, 1 map.
- Heath, R. C., 1984. Ground-water regions of the United States. U.S. Geological Survey, Water Supply Paper 2242, U.S. Department of the Interior, 78 pp.
- Hoover, K.V., 1960. Devonian-mississippian shale sequence in Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Information Circular No. 27, 154 pp, 3 plates.
- Hutton, Charles W., 1940. Geology of the Conneaut and Ashtabula quadrangles, Ohio. Ohio State University M.S. thesis, unpublished, 66 pp.
- Moody and Associates, Inc., 1972. Ground-water development: Holiday Camplands, Andover, Ohio; Meadville Pennsylvania, unpublished, 16 pp. plus attachments.
- Moody and Associates, Inc., 1973. Addendum, Ground-Water Development: Holiday Camplands, Andover, Ohio. Meadville, Pennsylvania, unpublished, 9 pp. plus appendix.

- Ohio Department of Natural Resources, 1961. Water inventory of the Mahoning and Grand River Basins. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory No. 16, 90 pp., maps.
- Ohio Drilling Company, 1971. Ground-water potential of northeast Ohio. Massillon, Ohio, unpublished, 360 pp., 2 plates.
- Ohio Environmental Protection Agency, 1986. Ground water protection and management strategy. 67 pp.
- Rau, J. L., 1969. Hydrogeology of the Berea and Cussewago Sandstones in northeastern Ohio. U.S. Geological Survey Hydrologic Investigations Atlas HA-341, 2 maps with text.
- Reeder, N. E. and V. L. Riemenschneider, 1973. Soil survey of Ashtabula County. United States Department of Agriculture, Soil Conservation Service, 114 pp., 84 maps.
- Risser, M., 1985. Sand and gravel resources of Ashtabula County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, 1 map with text.
- Stout, W. K. Ver Steeg, and G.F. Lamb, 1943. Geology of water in Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 44, 69 pp., 8 maps.
- Szmuc, E. J., 1953. Stratigraphy of the post-Berea rocks in northeastern Trumbull and southeastern Ashtabula Counties, Ohio. Ohio State University Masters Thesis, Unpublished, 149 pp.
- U.S. Dept. of Commerce, 1981. Divisional normals of temperature and precipitation 1931-1980. National Oceanic and Atmospheric Administration, National Climatic Data Center, Climatography of the United States No. 85.
- U.S. Department of Commerce, 1982. Monthly normals of temperature, precipitation and heating and cooling degree days 1951-1980 Ohio. National Oceanic and Atmospheric Administration, National Climatic Data Center, Climatology of the United States, No. 81 (by state) 16 pp.
- U.S. Department of Commerce, 1987. Local population estimate. Bureau of Census, Current Population Reports, Series p-26.
- White, G. W., 1982. Glacial geology of Lake County, Ohio. Ohio Department of Natural Resources, Report of Investigations No. 117, 20 pp., 1 plate.
- White, G. W. and S. M. Totten, 1979. Glacial geology of Ashtabula County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 112, 48 pp., 1 plate.

APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Water-level information was obtained by using located water well completion reports available at the Ohio Department of Natural Resources, Division of Water. All located wells were plotted and data was interpreted with respect to geology and topography.

In general, water levels average 5 to 15 feet or 15 to 30 feet throughout the county except along the Escarpment where water levels average 30 to 50 feet west of the Ashtabula River and 50 to 75 feet east of the Ashtabula River. Water levels along the rivers in the River Alluvium hydrogeologic setting, the marshy areas along Rock and Pymatuning Creeks, and the beach ridges of the Escarpment, that roughly parallel the existing Lake Erie shoreline average 5 to 15 (9) feet. Shallow water levels averaging 5 to 15 feet (9) are also present in the glacial lake deposits in the northern one-fifth of the county. Where glacial lake deposits occur in the county south of the Escarpment, water levels are shallower again averaging 5 to 15 feet (9) except for one isolated area along the Grand River where water levels are 15 to 30 feet (7). Water levels in the glacial lake deposits and beach ridges deepen to 30 to 50 feet (5) in a thin band along the Escarpment in the western part of the county. Water levels in the outwash deposits are typically shallow with depths of 5 to 15 feet (9) except for deposits along the southern portion of Pymatuning Creek where water levels average 15 to 30 feet (7). Where outwash overlies sedimentary rock, water levels are more variable ranging from 5 to 15 feet (9), 15 to 30 feet (7) and 30 to 50 feet (5). Water levels in the buried valleys and in areas where glacial till overlies shale and/or interbedded sandstone and shale bedrock typically average 5 to 15 feet (9) and 15 to 30 feet (7) except along the Escarpment where water levels are deeper, 30 to 50 feet (5) and 50 to 75 feet (3). Water levels are also deeper in one other area on the east side of Pymatuning Creek where water levels average 30 to 50 feet (5).

Net Recharge

Published references for net recharge could not be located for this county. Net recharge rates were estimated based on precipitation and predicted infiltration due to geology, soils and topography. General statements about the relationship of cover materials were found in Ohio Department of Natural Resources (1961).

Values of 4 to 7 inches per year (6) were assigned to the majority of the county, recognizing that recharge is most likely in the lower portion of this range. Where sandy beach deposits and more permeable outwash deposits were delineated, values of 10+ inches per year (9) were chosen. One area of marsh along Pymatuning Creek was assigned a value of 10+ inches per year (9) based on the gravelly surficial deposits. River alluvium and the other marsh area with more clayey surficial deposits were assigned values of 7 to 10 ten inches per year (8). Values of 4 to 7 inches per year (6), 7 to 10 inches per year (8) and 10+ inches per year (9) were chosen in the buried valley based on the character of the overlying surficial deposits.

Aquifer Media

Information on aquifer media was primarily derived from: White and Totten (1979), Hartzell (1978), Risser (1985), Rau (1969) and well completion reports from the Ohio Department of Natural Resources, Division of Water. Additional information was gleaned from the Ohio Drilling Company (1971), Cummins (1959), Ohio Department of Natural Resources (1961), Szmuc (1953), Hutton (1940), Bownocker (1965), Goldthwait et al. (1967) and Forsyth (1959).

Till was chosen as the aquifer in the Glacial Lake Deposits hydrogeologic setting and assigned a typical value of (5) because ground water frequently occurs in the glacial till zone between the till/bedrock interface. Where the unconsolidated deposits were thinner than 25 feet (primarily in the western part of the county), the underlying shale was considered the aquifer and assigned a value of (2). In other parts of the county where glacial deposits overlie shale bedrock, the underlying shale was also assigned a value of (2). In the southern part of the county where the till overlies predominantly interbedded sandstone and shale bedrock, the underlying sandstone was chosen as the aquifer and assigned a value of (6). The aquifer in the beach ridges was identified as sand and gravel and assigned a value of (8). Although the beach ridges are of limited thickness, as described by White (1982) in Lake County, they serve as an important source of ground water. Sand and gravel was also chosen as the aquifer in the outwash areas. Where the deposits were noted as kames, a value of (9) was assigned because of the abundance of coarser-grained material; a value of (8) was assigned in the terrace deposit areas. In the marsh areas, the alluvium along the major rivers, and the alluvium in the northern one-fifth of the county north of the Escarpment areas, sand and gravel was chosen as the aquifer and assigned a typical value of (8). In areas south of the Escarpment where alluvium occurs along tributaries, the underlying bedrock was chosen as the aquifer. In these areas, bedded sandstone, limestone and shale sequences were assigned a value of (6) and shale a value of (2). Sand and gravel was chosen as the aquifer in the Buried Valley hydrogeologic setting. Values of (8) were assigned for the majority of these areas. Where kame deposits were indicated, a value of (9) was assigned because of the abundance of coarse-grained material. Similarly, a value of (7) was assigned in the deltaic deposits to represent the finer fraction.

Soil

Soils were mapped based on the soil survey of Ashtabula County (Reeder and Riemenschneider, 1973). The soil media was assigned using the general soil association map in approximately 80 percent of the county; the remainder was re-mapped using DRASTIC-based parameters.

Soils formed in the glacial till and glacial lake areas are predominantly silty loam (4). Silty loam is also present in parts of the outwash areas along the southern part of the Grand River and along Rock and Conneaut Creeks and in the tributaries to these and the other rivers and creeks in the county. Sand (9) or gravel (10) predominate in the beach ridges, the alluvium of the major rivers, the outwash areas and the marsh along Pymatuning Creek, but may also be found in other more isolated areas. Shrinking clay is present in a major portion of the Buried Valley hydrogeologic setting coincident with the Grand River northeastward along Coffee Creek and along the southern section of Rock Creek, but also occurs in all other areas of the county except in the areas where glacial deposits overlie bedded sedimentary rock.

Topography

Percent slope was estimated by using 7 1/2 minute USGS topographic quadrangle maps. Contour intervals on the topographic maps were 10 feet on all quadrangles. Topography averages 0 to 2 percent (10) in the majority of the county. Slopes of 2 to 6 percent (9) are encountered only along the Escarpment and adjacent to major rivers.

Impact of the Vadose Zone Media

Information on the vadose zone media was primarily obtained from White and Totten (1979), Risser (1985) and well completion reports from the Ohio Department of Natural Resources, Division of Water. Additional information was gleaned from Rau (1969), Hartzell (1978), Szmuc (1953), Bownocker (1965), Goldthwait et al. (1967) and Forsyth (1959).

Silt/clay was chosen as the vadose zone media in all of the Glacial Lake Deposits and Glacial Till Over Shale hydrogeologic settings (7F and 7Ae) and in the majority of the Glacial Till Over Bedded Sedimentary Rocks hydrogeologic setting (7Aa). The silt/clay designation was assigned a value of (5) in the northern one-third of the county where the surficial deposits are designated Ashtabula Till. Deposits designated as Lavery Till in the southeastern part of the county were also assigned a silt/clay value of (5). A value of (4) was assigned in the majority of the county where the less coarse Hiram Till is the surficial deposit. Where gravelly moraines were present in sufficiently large areas, a value of (6) was assigned. Silt/clay was also chosen as the vadose zone media in the Buried Valley hydrogeologic setting and assigned a value of (5) based on the presence of sandy clays. Where glacial till is

thin and/or water levels deeper in the Glacial Till Over Bedded Sedimentary Rocks setting, bedded limestone, sandstone and shale sequences were chosen as the vadose zone media and assigned a typical value of (6). Vadose zone media in the beach ridges was chosen as sand and gravel and assigned a typical value of (8). Sand and gravel was also chosen as the vadose zone media in the outwash areas. A value of (9) was assigned where kames are present and a value of (8) was assigned in the terrace areas. Similarly, the sand and gravel vadose zone in the Buried Valley hydrogeologic setting was assigned values of (9) in kame areas, (8) in terrace areas and (7) in deltaic deposits. Sand and gravel with significant silt and clay was chosen as the vadose zone media in the River Alluvium hydrogeologic setting and the portion of the Buried Valley hydrogeologic setting overlain by alluvial deposits. Values of (6) were assigned along the major rivers and creeks and values of (5) were assigned in the tributaries.

Hydraulic Conductivity of the Aquifer

Only limited published data on hydraulic conductivity of the sandstone bedrock were found for this county in Rau (1969). Values of hydraulic conductivity were primarily estimated by reading descriptions in Hartzell (1978), Ohio Department of Natural Resources (1961), Ohio Drilling Company (1971) and Moody and Associates (1972) and (1973), and referring to the appropriate values referenced by Freeze and Cherry (1979).

Values of 1 to 100 gallons per day per square foot (1) were assigned to the glacial till and the shale bedrock based on cited low yields from these areas. Values of 100 to 300 gallons per day per square foot (2) were chosen for the bedded sandstone/shale areas based on information on Rau (1969) and anticipated yields in Hartzell (1978). Values of 300 to 700 gallons per day per square foot (4) were assigned to the sand and gravel aquifer in the buried valley based on anticipated yields in Hartzell (1978). River alluvium, marsh areas and beach ridges were estimated to have values of 700 to 1000 gallons per day per square foot (6). Outwash areas were assigned values of 1000 to 2000 gallons per day per square foot (8). Other sand and gravel areas in the buried valley were assigned 700 to 1000 gallons per day per square foot (6) when the aquifer was in the alluvial deposits and 1000 to 2000 gallons per day per square foot (8) in outwash areas.

APPENDIX B

DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Ashtabula County resulted in the identification of nine hydrogeologic settings within the Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 11. Computed pollution potential indexes for Ashtabula County range from 90 to 207.

TABLE 11. HYDROGEOLOGIC SETTINGS MAPPED IN ASHTABULA COUNTY, OHIO

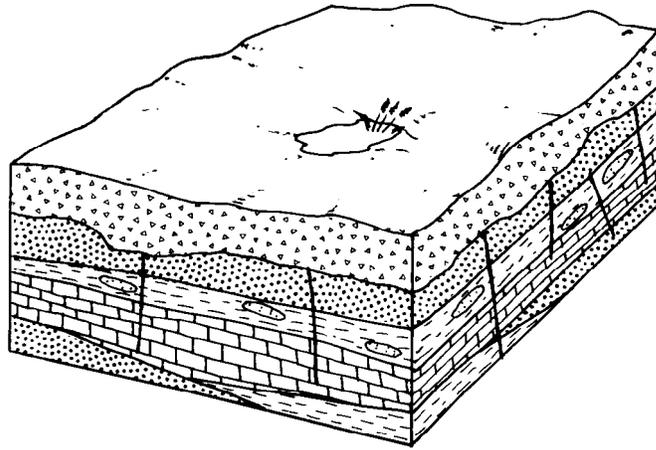
Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa Glacial Till Over Bedded Sedimentary Rocks	116-140	13
7Ae Glacial Till Over Shale	90-137	18
7Ba Outwash	184-207	7
7Bb Outwash Over Bedded Sedimentary Rocks	166-199	9
7D Buried Valley	127-195	17
7Eb River Alluvium Without Overbank Deposits	128-179	8
7F Glacial Lake Deposits	109-142	15
7H Beaches, Beach Ridges & Sand Dunes	161-193	6
7I Swamp/Marsh	178-188	2

In general, the location of the designated hydrogeologic settings within Ashtabula County can be described as follows:

1. Glacial Till Over Bedded Sedimentary Rocks (7Aa) occurs only in two northward protrusions into the southern part of the county and along the southern half of the western county line;
2. Glacial Till Over Shale (7Ae) predominates in the three-fourths of the county, south of the Escarpment;
3. Outwash (7Ba) occurs primarily in the southern half of the county, most notably along the Grand River, the East Branch of the Ashtabula River and Pymatuning Creek, and in small isolated areas along various tributaries. This setting is used to designate kame and delta areas. Along the Grand River, kame and delta areas are partly obscured by the Buried Valley setting.

4. Outwash Over Bedded Sedimentary Rocks (7Bb) occurs primarily along the Ashtabula and Grand River and Conneaut, Mill and Rock Creeks. This setting is also found along other streams in more isolated areas and at the northern end of the Shenango Valley (site of Puyamating Reservoir);
5. Buried Valley (7D) underlies and parallels the Grand River in the southern two-thirds of the county. The buried valley forms a "Y" just south of the Escarpment; one branch continues northward toward Lake Erie, culminating north of Saybrook, and the other branch continues eastward to the Ashtabula River north of Coffee Creek. Although other buried valleys have been indicated by other authors, only those prominent valleys that were substantiated by well logs were mapped using this setting.
6. River Alluvium Without Overbank Deposits (7Eb) occurs along the major river valleys and major tributaries of the Grand and Ashtabula Rivers and Conneaut, Ashtabula, Mill, and Rock Creeks. Alluvium overlying the Buried Valley along parts of the Grand River has been included as part of the Buried Valley setting;
7. The Glacial Lake Deposits (7F) primarily occur in the northern one fifth of the county, north of the ridge, known as the Escarpment, that parallels Lake Erie; smaller areas occur in the Grand River Basin and in the southern central section of the county;
8. The Beaches, Beach Ridges and Sand Dunes (7H) occur in the northern portion of the county as three prominent thin bands that parallel Lake Erie; several smaller broken ridges are scattered around these major ridges;
9. The Swamp/Marsh (7I) corresponds to lowland areas of Pymatuning and Rock Creeks.

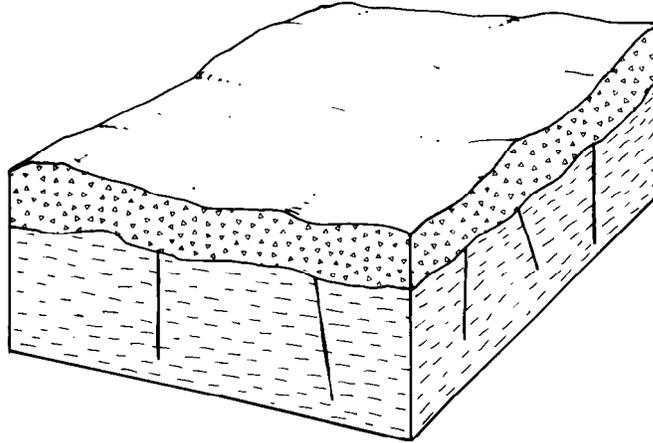
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide information on how the ground water pollution potential index was derived and are a quick and easy reference for the accompanying ground water pollution potential map. A complete discussion of the rating and evaluation of each factor in the hydrogeologic settings is provided in Appendix A, Description of the Logic in Factor Selection.



7Aa Glacial Till Over Bedded Sedimentary Rocks

This hydrogeologic setting is characterized by low topography and relatively flat-lying, fractured sedimentary rocks consisting of sandstone, shale, and limestone which are covered by varying thicknesses of glacial till. The till is principally unsorted deposits which may be interbedded with loess or localized deposits of sand and gravel. Although ground water occurs in both the glacial deposits and in the intersecting bedrock fractures, the bedrock is typically the principal aquifer. The glacial till serves as a source of recharge to the underlying bedrock. Although precipitation is abundant in most of the region, recharge is moderate because of the glacial till and soils which are typically clay loams. Depth to water is extremely variable depending in part on the thickness of the glacial till, but averages around 30 feet.

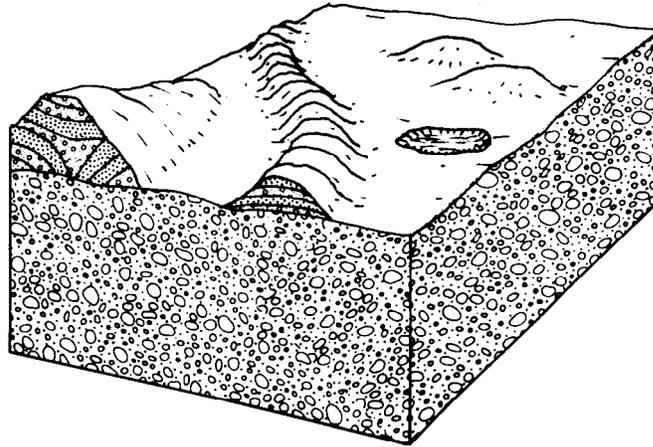
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7Aa1	5-15	4-7	Interbedded ss & sh	Silty Loam	0-2	Silt/Clay	100-300	131
7Aa2	5-15	4-7	Interbedded ss & sh	Silty Loam	2-6	Silt/Clay	100-300	140
7Aa3	5-15	4-7	Interbedded ss & sh	Silty Loam	0-2	Silt/Clay	100-300	136
7Aa4	15-30	4-7	Interbedded ss & sh	Silty Loam	2-6	Silt/Clay	100-300	130
7Aa5	15-30	4-7	Interbedded ss & sh	Silty Loam	0-2	Silt/Clay	100-300	126
7Aa6	15-30	4-7	Interbedded ss & sh	Silty Loam	2-6	Silt/Clay	100-300	120
7Aa7	30-50	4-7	Interbedded ss & sh	Silty Loam	2-6	Interbedded ss & sh	100-300	120
7Aa8	30-50	4-7	Interbedded ss & sh	Silty Loam	0-2	Silt/Clay	100-300	116
7Aa9	15-30	4-7	Interbedded ss & sh	Silty Loam	2-6	Silt/Clay	100-300	125
7Aa10	15-30	4-7	Interbedded ss & sh	Silty Loam	0-2	Interbedded ss & sh	100-300	131
7Aa11	5-15	4-7	Interbedded ss & sh	Silty Loam	2-6	Interbedded ss & sh	100-300	140



7Ae Glacial Till Over Shale

This hydrogeologic setting is characterized by varying thicknesses of glacial till overlying fractured, flat-lying shales. The till is principally unsorted deposits with interbedded lenses of loess and sand and gravel. Ground water is derived from either localized sources in the overlying till or from deeper, more permeable formations. The shale is relatively impermeable and does not serve as a source of ground water. Although precipitation is abundant, recharge is minimal from the till to deeper formations and occurs only by leakage of water through the fractures.

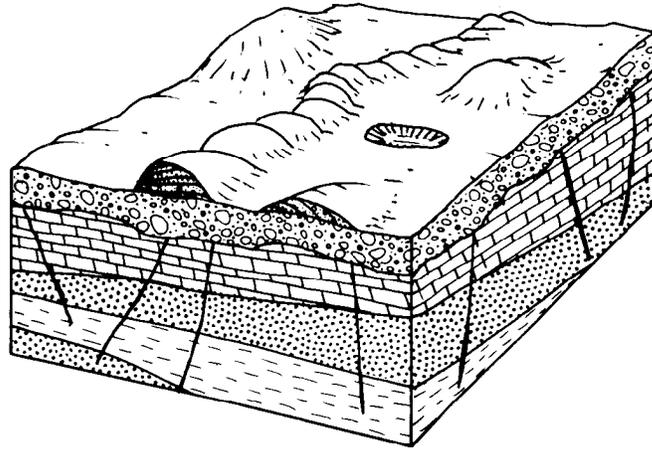
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7Ae1	30-50	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	100
7Ae2	30-50	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	101
7Ae3	5-15	4-7	Shale	Gravel	2-6	Silt/Clay	1-100	137
7Ae4	5-15	4-7	Shale	Gravel	2-6	Silt/Clay	1-100	132
7Ae5	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	116
7Ae6	5-15	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	115
7Ae7	15-30	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	115
7Ae8	15-30	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	111
7Ae9	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	121
7Ae10	5-15	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	120
7Ae11	15-30	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	110
7Ae12	15-30	4-7	Shale	Gravel	0-2	Silt/Clay	1-100	123
7Ae13	5-15	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	125
7Ae14	5-15	4-7	Shale	Shrinking Clay	0-2	Silt/Clay	1-100	122
7Ae15	50-75	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	90
7Ae16	15-30	4-7	Shale	Silty Loam	2-6	Silt/Clay	1-100	105
7Ae17	5-15	4-7	Shale	Shrinking Clay	2-6	Silt/Clay	1-100	121
7Ae18	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	126



7Ba Outwash

This hydrogeologic setting is characterized by moderate to low topography and varying thicknesses of outwash which overlie sequences of fractured sedimentary rocks. The outwash consists of water-washed deposits of sand and gravel which serve as the principal aquifer in the area. The outwash also serves as a source of recharge to the underlying bedrock. Precipitation is abundant throughout most of the area and recharge is moderate to high. Recharge is somewhat restricted by the sandy loam soil which typically develops in this setting. Water levels are extremely variable, but relatively shallow. Outwash generally refers to water-washed or ice-contact deposits, and can include a variety of morphogenic forms. Outwash plains are thick sequences of sands and gravels that are laid down in sheet-like deposits from sediment-laden waters draining off, and from within a glacier. These deposits are well-sorted and have relatively high permeabilities. Kames and eskers are ice-contact deposits. A kame is an isolated hill or mound of stratified sediments deposited in an opening within or between ice blocks, or between ice blocks and valley walls. An esker is a sinuous or meandering ridge of well-sorted sands and gravels that are remnants of streams that existed beneath and within the glaciers. These deposits may be in direct hydraulic connection with underlying fractured bedrock.

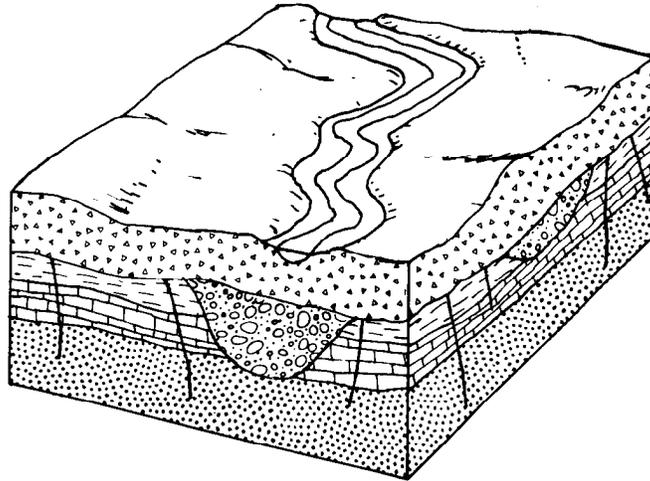
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7Ba1	5-15	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	1000-2000	207
7Ba2	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	1000-2000	195
7Ba3	5-15	10+	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel	1000-2000	201
7Ba4	5-15	10+	Sand & Gravel	Gravel	2-6	Sand & Gravel	1000-2000	206
7Ba5	15-30	10+	Sand & Gravel	Gravel	2-6	Sand & Gravel	1000-2000	196
7Ba6	15-30	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	184
7Ba7	5-15	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	194



7Bb Outwash Over Bedded Sedimentary Rocks

This hydrogeologic setting is characterized by moderately low topography and varying thicknesses of outwash which overlie sequences of fractured sedimentary rocks. The outwash consists of water-washed deposits of sand and gravel which serve as the principal aquifer in the area. The outwash also serves as a source of recharge to the underlying bedrock. Precipitation is abundant throughout most of the area and recharge is moderate to high. Recharge is somewhat restricted by the sandy loam soil which typically develops in this setting. Water levels are extremely variable, but relatively shallow. Outwash generally refers to water-washed or ice-contact deposits, and can include a variety of morphogenic forms. Outwash plains are thick sequences of sand and gravel that are laid down in sheet-like deposits from sediment-laden waters draining off, and from within a glacier. These deposits are well-sorted and have relatively high permeabilities. Kames and eskers are ice-contact deposits. A kame is an isolated hill or mound of stratified sediments deposited in an opening within or between ice blocks, or between ice blocks and valley walls. An esker is a sinuous or meandering ridge of well-sorted sands and gravels that are remnants of streams that existed beneath and within the glaciers. These deposits may be in direct hydraulic connection with underlying fractured bedrock.

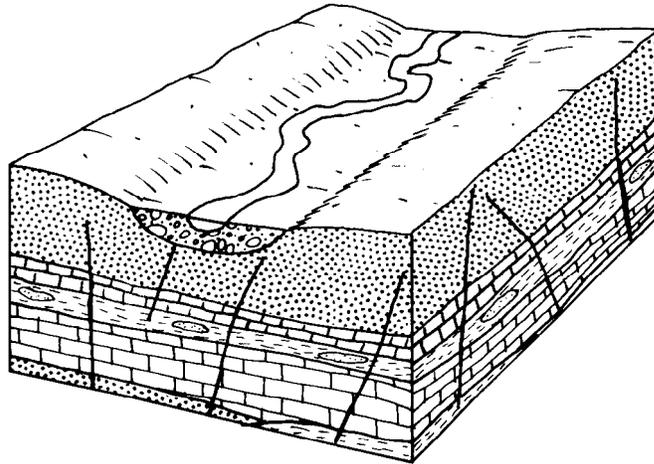
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7Bb1	5-15	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	186
7Bb2	15-30	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	176
7Bb3	15-30	10+	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel	1000-2000	183
7Bb4	5-15	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	1000-2000	199
7Bb5	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	1000-2000	187
7Bb6	15-30	10+	Sand & Gravel	Gravel	2-6	Sand & Gravel	1000-2000	188
7Bb7	30-50	10+	Sand & Gravel	Silty Loam	2-6	Sand & Gravel	1000-2000	166
7Bb8	5-15	10+	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel	1000-2000	193



7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a pre-glacial river valley) by glacial meltwaters. These deposits are capable of yielding large quantities of ground water. The deposits may or may not be in direct hydraulic connection with a stream. Glacial till or recent alluvium often overlies the buried valley. Usually the deposits are several times more permeable than the surrounding bedrock, with finer-grained alluvium covering the underlying sand and gravel. Soils are typically a sandy loam. Recharge to the sand and gravel is moderate and water levels are commonly relatively shallow, although they may be quite variable.

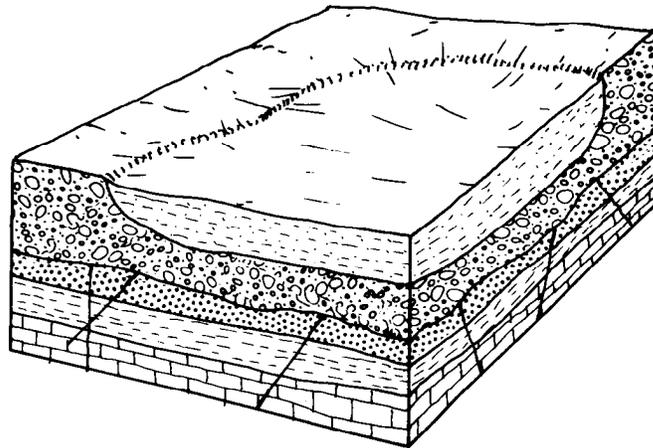
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7D1	5-15	4-7	Sand & Gravel	Shrinking Clay	0-2	Silt/Clay	300-700	154
7D10	5-15	4-7	Sand & Gravel	Silty Loam	0-2	Silt/Clay	300-700	148
7D11	5-15	10+	Sand & Gravel	Sand	0-2	Sand & Gravel	700-1000	191
7D12	15-30	10+	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel	1000-2000	183
7D13	5-15	4-7	Sand & Gravel	Sand	0-2	Silt/Clay	300-700	158
7D14	5-15	7-10	Sand & Gravel	Gravel	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	179
7D15	5-15	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	700-1000	193
7D2	5-15	7-10	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel	700-1000	175
7D3	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	1000-2000	195
7D4	5-15	7-10	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	173
7D5	5-15	4-7	Sand & Gravel	Silty Loam	2-6	Silt/Clay	300-700	147
7D6	30-50	4-7	Sand & Gravel	Silty Loam	0-2	Silt/Clay	300-700	128
7D7	30-50	4-7	Sand & Gravel	Silty Loam	2-6	Silt/Clay	300-700	127
7D8	15-30	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	1000-2000	189
7D9	15-30	4-7	Sand & Gravel	Shrinking Clay	0-2	Silt/Clay	300-700	144



7Eb River Alluvium Without Overbank Deposits

This setting is characterized by low topography and thin to moderately thick deposits of alluvium along portions of the river valley. No significant fine-grained floodplain deposits occupy the stream valley, resulting in significantly higher recharge where precipitation is adequate and sandy soils occur at the surface. The alluvium is underlain by fractured shales and/or sandstone bedrock. Water is obtained from the sand and gravel deposits within the river valley. Water levels are moderate to shallow in depth. Hydraulic contact with the surface stream is usually excellent, with alternating recharge/discharge relationship varying with stream stage. These deposits also serve as a good source of recharge to the underlying fractured bedrock.

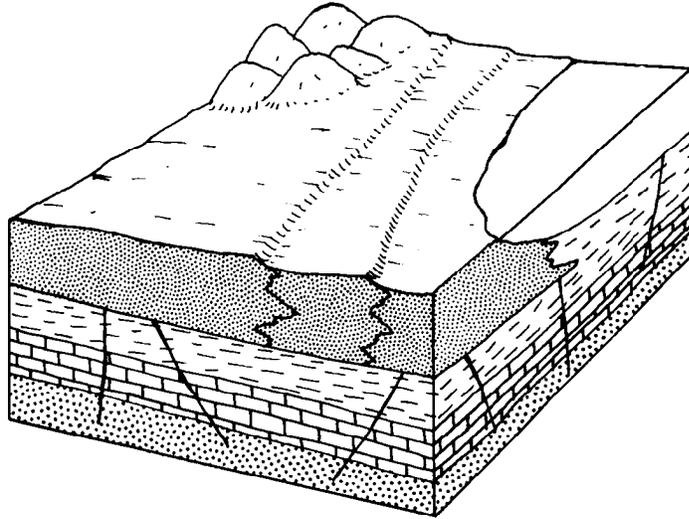
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7Eb1	5-15	7-10	Sand & Gravel	Silty Loam	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	167
7Eb2	5-15	7-10	Shale	Silty Loam	2-6	Sand & Gravel w/sig Silt/Clay	1-100	128
7Eb3	5-15	7-10	Sand & Gravel	Gravel	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	179
7Eb4	5-15	7-10	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	173
7Eb5	5-15	7-10	Shale	Silty Loam	0-2	Sand & Gravel w/sig Silt/Clay	1-100	129
7Eb6	5-15	7-10	Interbedded ss & sh	Silty Loam	0-2	Sand & Gravel w/sig Silt/Clay	100-300	144
7Eb7	5-15	7-10	Sand & Gravel	Sand	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	177
7Eb8	5-15	7-10	Interbedded ss & sh	Silty Loam	2-6	Sand & Gravel w/sig Silt/Clay	100-300	143
7Eb9	5-15	7-10	Shale	Shrinking Clay	0-2	Sand & Gravel w/sig Silt/Clay	1-100	135



7F Glacial Lake Deposits

This hydrogeologic setting is characterized by flat topography and varying thicknesses of fine-grained sediments that overlie sequences of fractured sedimentary rocks. The deposits are composed of fine-grained silts and clays interlayered with fine sand that settled out in glacial lakes and exhibit alternating layers relating to seasonal fluctuations. As a consequence of the thin, alternating layers there is a substantial difference between the vertical and horizontal permeability with the horizontal commonly two or more orders of magnitude greater than the vertical. Due to their fine-grained nature, these deposits typically weather to organic-rich sandy loams with a range in permeabilities reflecting variations in sand content. Underlying glacial deposits or bedrock serve as the major source of ground water in the region. Although precipitation is abundant, recharge is controlled by the permeability the surface clays; however, in all instances, recharge is moderately high because of the impact of the low topography. Water levels are variable, depending on the thickness of the lake sediments and the underlying materials.

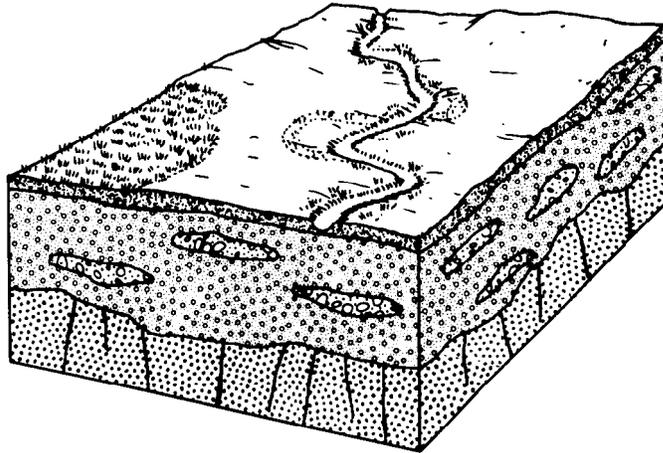
Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7F1	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	121
7F2	5-15	4-7	Shale	Sand	0-2	Silt/Clay	1-100	131
7F3	30-50	4-7	Glacial Till	Gravel	0-2	Silt/Clay	1-100	122
7F4	5-15	4-7	Shale	Gravel	0-2	Silt/Clay	1-100	133
7F5	30-50	4-7	Glacial Till	Silty Loam	2-6	Silt/Clay	1-100	109
7F6	5-15	4-7	Glacial Till	Sand	0-2	Silt/Clay	1-100	140
7F7	5-15	4-7	Glacial Till	Silty Loam	0-2	Silt/Clay	1-100	130
7F8	5-15	4-7	Glacial Till	Gravel	0-2	Silt/Clay	1-100	142
7F9	5-15	4-7	Glacial Till	Gravel	2-6	Silt/Clay	1-100	141
7F10	30-50	4-7	Glacial Till	Shrinking Clay	0-2	Silt/Clay	1-100	116
7F11	5-15	4-7	Glacial Till	Shrinking Clay	0-2	Silt/Clay	1-100	131
7F12	30-50	4-7	Glacial Till	Sand	0-2	Silt/Clay	1-100	120
7F13	15-30	4-7	Glacial Till	Shrinking Clay	0-2	Silt/Clay	1-100	126
7F14	5-15	4-7	Shale	Shrinking Clay	0-2	Silt/Clay	1-100	122
7F15	5-15	4-7	Shale	Silty Loam	0-2	Silt/Clay	1-100	116



7H Beaches, Beach Ridges and Sand Dunes

This hydrogeologic setting is characterized by low relief, sandy surface soil that is predominantly silica sand, extremely high infiltration rates, and low sorptive capacity in the thin vadose zone. The water table is very shallow beneath the beaches bordering the Great Lakes. These beaches are commonly ground water discharge areas. The water table is slightly deeper beneath the rolling dune topography and the vestigial inland beach ridges. All of these areas serve as recharge sources for the underlying sedimentary bedrock aquifers, and they often serve as local sources of water supply.

Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
7H1	5-15	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	700-1000	181
7H2	5-15	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	700-1000	193
7H3	5-15	10+	Sand & Gravel	Sand	0-2	Sand & Gravel	700-1000	191
7H4	30-50	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel	700-1000	173
7H5	30-50	10+	Sand & Gravel	Silty Loam	0-2	Sand & Gravel	700-1000	161
7H6	30-50	10+	Sand & Gravel	Sand	0-2	Sand & Gravel	700-1000	171



7I Swamp/Marsh

This hydrogeologic setting is characterized by low topographic relief, high water levels and high organic silt and clay deposits. These wetlands occur along the courses of floodplains and in upland areas as a result of vertically restricted drainage. Common features of upland wetlands include those characteristics attributable to glacial activity such as filled-in glacial lakes, potholes, and cranberry bogs. Recharge is moderate in most of the region due to restriction by clayey soils, and limited by precipitation. The swamp deposits vary rarely serve as significant aquifers but frequently recharge the underlying sand and gravel or bedrock aquifers.

Setting	Depth to Water	Recharge in./yr.	Aquifer Media	Soil Media	Topography % Slope	Vadose Zone Media	Hydro. Cond.	Rating
711	0-5	7-10	Sand & Gravel	Shrinking Clay	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	178
712	0-5	10+	Sand & Gravel	Gravel	0-2	Sand & Gravel w/sig Silt/Clay	700-1000	188

**ERRATA SHEET
ASHTABULA COUNTY
GROUND WATER POLLUTION POTENTIAL NO. 10**

The following errors occur on the printed map and accompanying report of the Ground Water Pollution Potential of Ashtabula County.

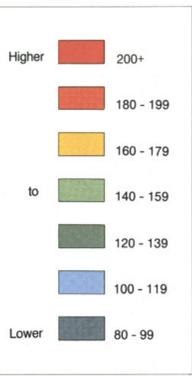
Setting 7Ae23 (map) These setting (southwestern Harpsfield Twp.) is listed in error. The setting 7Ae23 on the map should be replaced with 7Ae5. Please refer to the setting tables for 7Ae5.

Ground-Water Pollution Potential of ASHTABULA COUNTY

by
**Linda Aller and Karen L. Ballou
Geodyssey, Inc.**

Prepared in cooperation with
Ohio Department of Natural Resources, Division of Water

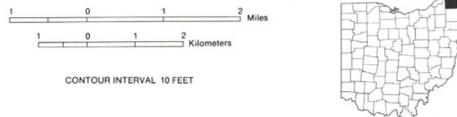
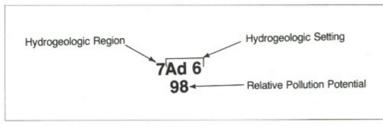
Pollution Potential Index Range



Hydrogeologic Settings

- 7Aa - Glacial Till Over Bedded Sedimentary Rock
 - 7Ae - Glacial Till Over Shale
 - 7Ba - Outwash
 - 7Bb - Outwash Over Bedded Sedimentary Rock
 - 7D - Buried Valley
 - 7Eb - River Alluvium Without Overbank Deposits
 - 7F - Glacial Lake Deposits
 - 7H - Beaches, Beach Ridges and Sand Dunes
 - 7I - Swamp/Marsh
- A more detailed description of the hydrogeologic settings and the evaluation of the pollution potential may be found in the publication "Ground-Water Pollution Potential of Ashtabula County", GWPP Report No. 10, Ohio Department of Natural Resources, Division of Water.

Description of Map Symbols



- County Line
- - - Township Line
- - - - - Incorporated City Limit

The ground-water pollution potential of this county has been mapped using the methodology described in U.S. EPA Publication EPA/600-2-87/035, "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings (Aller et al., 1987)".

