GROUND WATER POLLUTION POTENTIAL

OF STARK COUNTY, OHIO

BY

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GROUND WATER POLLUTION POTENTIAL REPORT NO. 6

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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.

Ground water pollution potential mapping in Stark County resulted in a map with symbols and colors which illustrate areas of varying ground water contamination vulnerability. Nine hydrogeologic settings were identified in Stark County with computed ground water pollution potential indexes ranging from 99 to 199.

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 Stark 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; 33,000 of these wells exist in Stark 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 Stark County has been 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 have been 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.

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 Stark 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

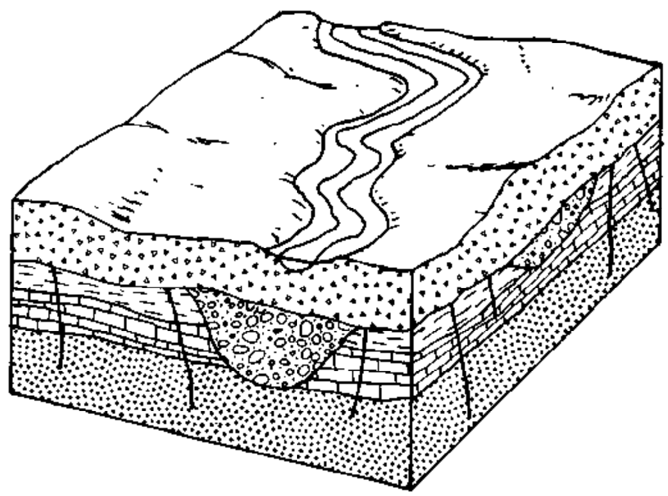
T - Topography

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.



7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that were laid down by glacial meltwater in a former topographic low, (i.e. a preglacial or interglacial river valley). These deposits are capable of yielding large quantities of water where they are sufficiently thick, permeable and receive adequate recharge. The deposits may or may not underlie or be in direct hydraulic connection with a present–day river. Glacial till, recent alluvium, kame, valley train or lacustrine deposits may overlie the buried valley. Soil texture is highly variable depending on the surface material. Recharge to the aquifer can be attributed to infiltration by precipitation or stream infiltration where the water table has been lowered due to pumping. The depth to water in this setting is extremely variable.

Figure 1. Format and description of the hydrogeologic setting - 7D Buried Valley.

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.

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 through 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.

The 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	

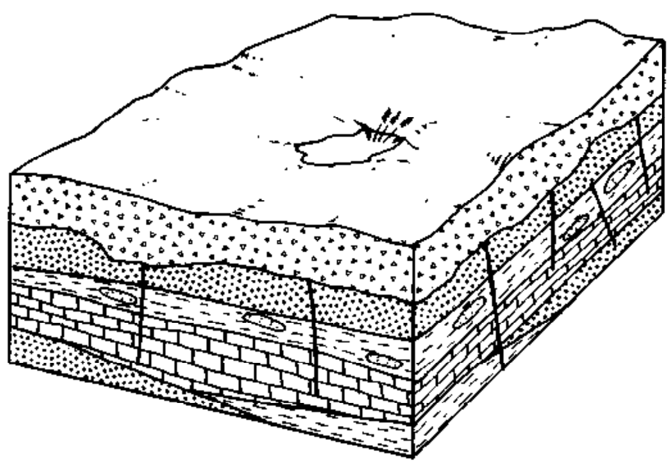
TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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 7Aa5 Glacial Till Over Bedded Sedimentary Rocks identified in mapping Stark 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 113. 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 Stark County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the seven settings identified in the County range from 90 to 199.

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 Stark County resulted in a map with symbols and colors that illustrate areas of ground water vulnerability. The map describing the ground water pollution potential of Stark County is included with this report.



SETTING 7Aa5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Bedded Ss,Ls,Sh & Coal	3	6	18
Soil Media	Clay loam	2	3	6
Topography	2-6	1	9	9
Impact Vadose Zone	s & g w/ sl & cl	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		DRASTIC	INDEX	113

Figure 2. Description of the hydrogeologic setting - 7Aa5
Glacial Till Over Bedded Sedimentary Rocks

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:

7Aa5 - defines the hydrogeologic region and setting

113 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (Aa5) refer to a specific hydrogeologic setting. The following number references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (113) 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.

GENERAL INFORMATION ABOUT STARK COUNTY

Stark County is located in northeastern Ohio, approximately 50 miles south of Cleveland (Figure 3). The County covers 579.4 square miles, ranking it 11th in area of all counties in Ohio (Delong and White, 1963). It is bounded on the north by Summit and Portage Counties, on the east by Mahoning and Columbiana Counties, on the south by Carroll and Tuscarawas Counties, and on the west by Holmes and Wayne Counties.

According to the Stark County Regional Planning Commission (SCRPC) (1986, 1989), approximately one-half (49.7%) of the land use in Stark County is agricultural, while 24.7 % is urban/suburban. Other major land uses in the County include: undeveloped land (23%), strip mined land (1.5%) and water (1.1%).

In 1986, Stark County had an estimated population of 373,500. Canton is the county seat and the largest city with a population of about 87,110 (U.S. Department of Commerce, 1988). The Canton and Massillon area is the center of industrial activity for the County; however, in recent years, growth of the industrial economy has declined.

Physiography

Stark County lies entirely within the Appalachian Plateaus physiographic province (Fenneman, 1938). The glacial boundary (see Figure 3) transects the southeast corner of the County subdividing the plateau into nonglaciated and glaciated regions.

The nonglaciated region of Stark County is characterized by narrow bedrock ridges and steeply sloped valleys. The relief in this area is about 500 to 1000 feet per mile. The floodplains and terraces along perennial streams, such as Sandy Creek and several of its tributaries, represent the only flat topography in the nonglaciated region of the County (Delong and White, 1963).

In contrast, the glaciated region of Stark County is generally characterized by flat to rolling topography with moderate relief and gentle slopes. The bedrock topography is mostly buried by glacial drift. The drift ranges in thickness from only a few feet on bedrock ridges to 250 feet in several of the buried valleys. Relief in this region usually does not exceed 100 feet per mile of distance (Delong and White, 1963). An exception to this characterization occurs along the "fringe" of the glacial boundary in southern Stark County. This area is marked by thin and discontinuous glacial till deposits that have only slightly modified the existing steep topography. Although glaciated, prominent bedrock hills are common in Sugar Creek, Bethlehem, Canton, Osnaburg and Paris Townships (Delong and White, 1963). This area shows physiographic characteristic more commonly found in the nonglaciated region.

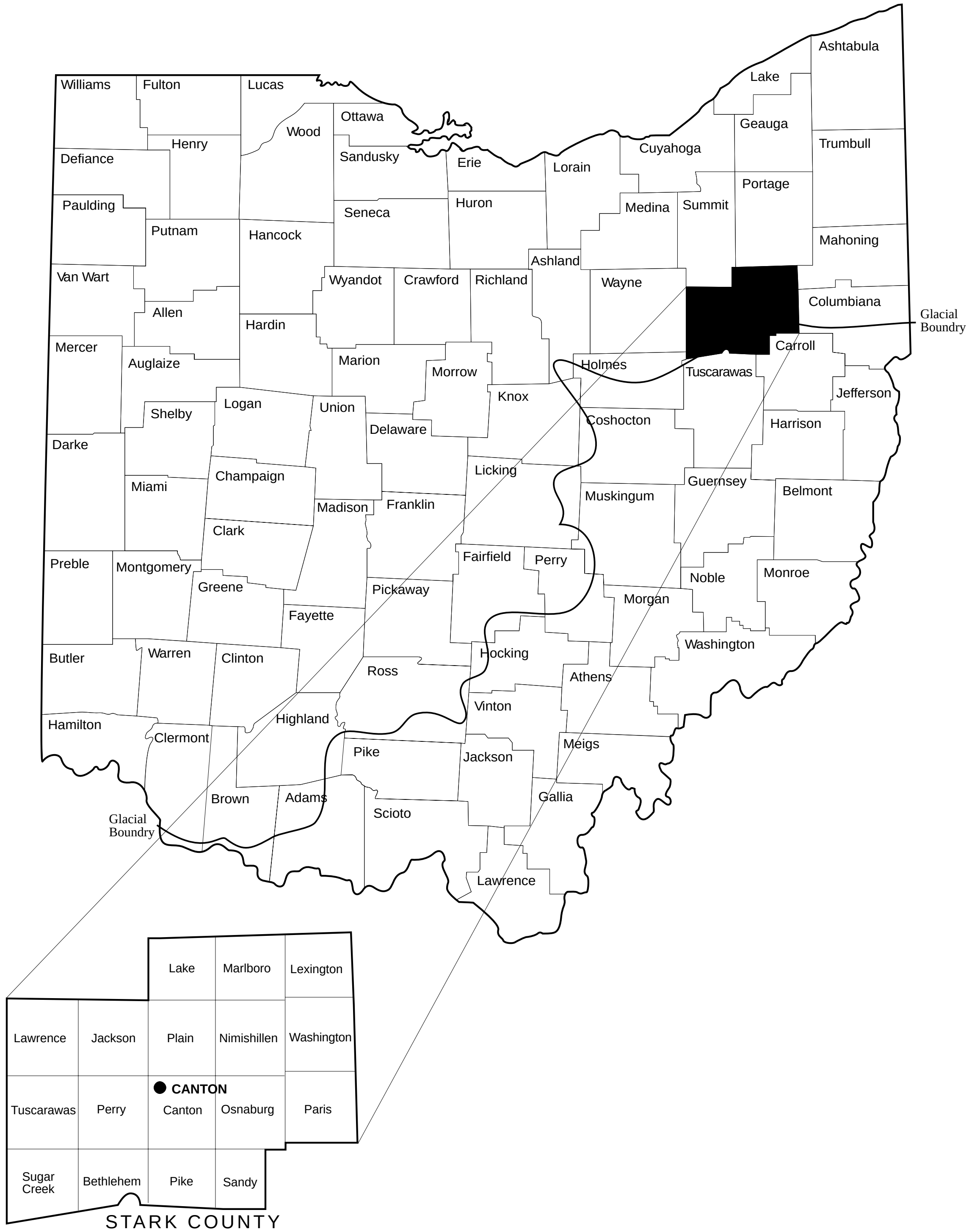


Figure 3. Location of Stark County, Ohio.

Drainage

Stark County lies within the boundaries of three major watersheds: the Tuscarawas River, the Mahoning River and the Cuyahoga River. The vast majority of surface water flows south via the Tuscarawas River to the Muskingum River of the Ohio River Basin. Tributaries of the Tuscarawas River which drain the County include Sugar Creek in southwestern Stark County and Sandy Creek in southeastern Stark County. The central portion of the County is drained by Nimishillen Creek which flows to Sandy Creek.

The Mahoning River, also part of the Ohio River Basin, drains Lexington, northern Washington and eastern Marlboro Townships in northeastern Stark County. The Cuyahoga River of the Lake Erie Basin drains only a small area of north-central Stark County via the Congress Lake Outlet.

Climate

Data from the U. S. Weather Bureau Station at the Akron-Canton Airport shows a 30–year (1951-1980) average annual precipitation of 35.90 inches and a mean annual temperature of 49.5 degrees Fahrenheit (U.S. Department of Commerce, 1982).

Preglacial Drainage

According to Stout et al., (1943), the preglacial Dover and Ravenna Rivers flowed northward and cut wide valleys through Stark County. The Dover River entered the County at Beach City, and continued on a course north to Brewster, Navarre, Massillon and Canal Fulton. The Tuscarawas River and Sugar Creek occupy portions of this valley today. Preglacial tributaries to the Dover River included Sandyville Creek, which was located in the southern part of the County, and an unnamed tributary located centrally in the vicinity of Canton (Delong and White, 1963) (Figure 4).

The Ravenna River drained a considerably smaller portion of Stark County than did the Dover River. The Ravenna River entered Stark County near Alliance and flowed northward and exited at the northeastern corner of the County. Both the Dover and Ravenna Rivers disappeared with the occurrence of Pleistocene glaciation (Delong and White, 1963).

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years ago) northern North America experienced at least four distinct periods of glaciation. These glacial stages are termed the Nebraskan (earliest), Kansan, Illinoian, and Wisconsinan (most recent).

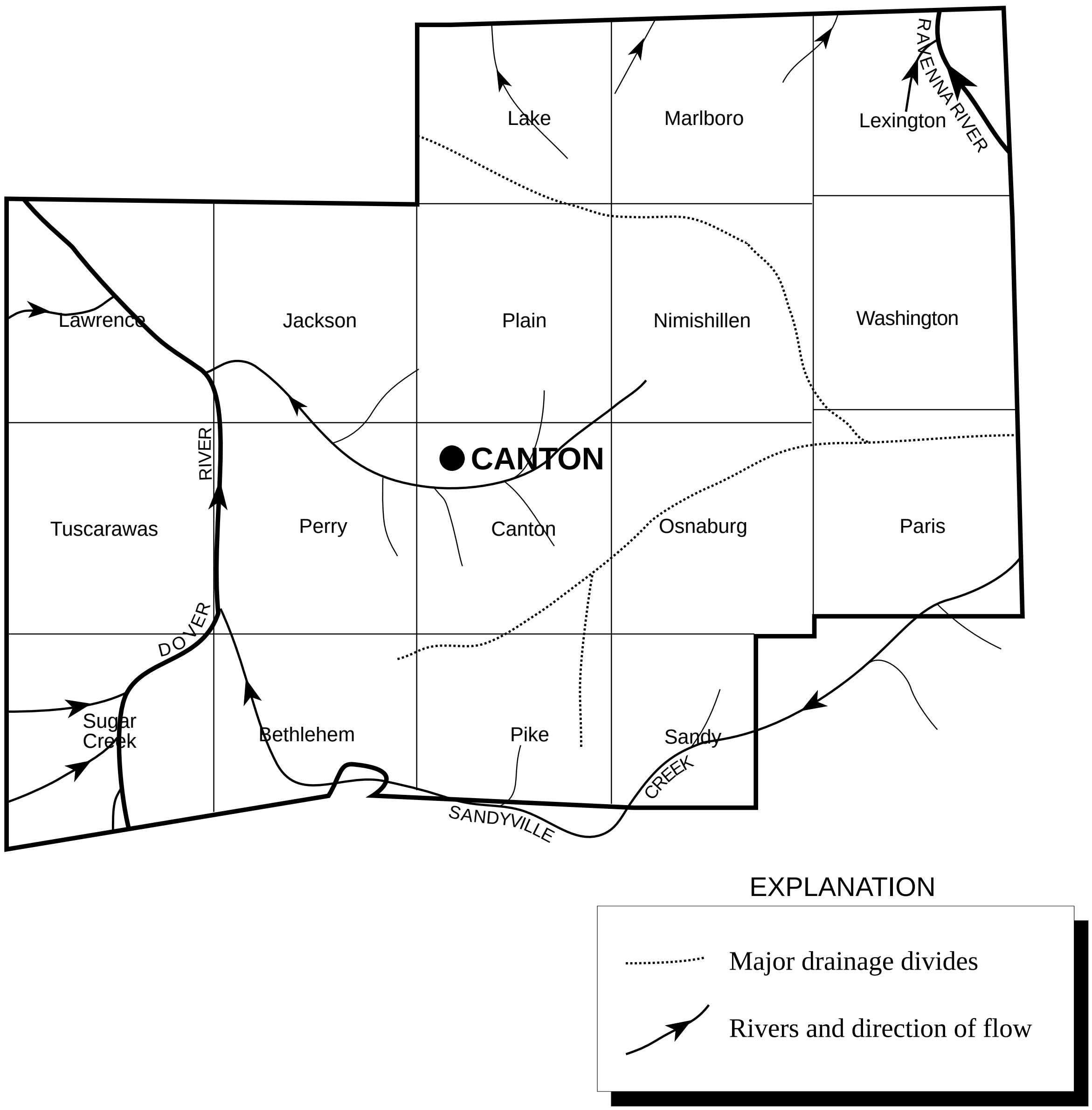


Figure 4. Preglacial drainage in Stark County

The Nebraskan and Kansan glacial periods are poorly defined and are commonly collectively referred to as the pre-Illinoian. Significant effects of all the glacial stages on Stark County are briefly discussed below, followed by a more detailed description of the glacial deposits observed in the County.

Pre-Illinoian

The most significant effect of pre-Illinoian glaciation on Stark County was the disruption of the preglacial drainage system. According to Delong and White, (1963), the northern outlet of the Dover River, and presumably the Ravenna River, was blocked by early Pleistocene glaciers. When the glaciers melted, floodwaters reversed the flow of the Dover River and established a new south-flowing stream, named the Newark River (Tight, 1903). The Newark River occupied the old Dover River valley throughout its course in Stark County. During a long interglacial stage between pre-Illinoian and Illinoian glaciation, the Newark River deeply entrenched this valley as much as 200 feet. The Deep Stage drainage system established during this period ended with the beginning of the Illinoian glaciation (Delong and White, 1963).

Illinoian and Wisconsinan

During the Illinoian and Wisconsinan stages, glacial ice advanced southward from the Erie basin in a series of lobes. Glacial ice of the Grand River lobe advanced over most of eastern Stark County, while ice of the Killbuck lobe glaciated the western portion of the County. These two lobes met north of Canton along the West Branch of Nimishillen Creek. This area is termed the interlobate zone (Delong and White, 1963). These glaciers covered most of Stark County, leaving only the southeastern corner of the County unglaciated.

Several important drainage changes occurred in Stark County as a result of Illinoian and Wisconsinan glaciation. In the southeastern part of the County, meltwaters from Illinoian or Wisconsinan ice cut several deep valleys that are evident today. These valleys are now occupied by Little Sandy Creek in Osnaburg Township and Hugle Run in Washington and Paris Townships. As a result of Wisconsinan glaciation, the south–flowing stream of the old Dover and Newark river valley was diverted at Navarre. The present course of the Tuscarawas River reflects this drainage change as it now occupies the former valley of Sandyville Creek to Bolivar. The abandoned valley from Navarre to Beach City is today mostly buried by glacial drift of Illinoian and Wisconsinan age (Delong and White, 1963).

Glacial Deposits

The glacial deposits found in Stark County are some of the more diverse of any county in Ohio. The variety of deposits can be classified primarily as Wisconsinan age ground moraine, end moraine, kames, and valley trains.

Ground moraine or till is deposited directly by the glacier and is composed of varying amounts of unsorted, unstratified clay, silt and sand with some gravel and cobbles. Figure 5 defines the extent of the major till sheets in Stark County. According to Delong and White

(1963), the individual till sheets vary in composition and thickness because each was deposited by a separate glacial advance. In general, the older tills are characteristically sandy and have numerous pebbles and cobbles. These would include the Millbrook and Titusville tills of the early Wisconsinan, and the overlying Navarre and Kent tills of mid-Wisconsinan. The younger Lavery, Hayesville and Hiram tills have few pebbles and cobbles and have considerably more silt and clay. The Hiram till in northeastern Stark County is particularly clay-rich, with an average composition of 13% sand, 42% silt and 46% clay (Delong and White, 1963). The thicknesses of glacial till sheets in Stark County are variable, ranging from thin and discontinuous to 15 feet thick (Delong and White, 1963). The topography of ground moraines is generally smooth to slightly undulating.

Two end moraines are evident in Stark County, the Buck Hill Moraine of the Killbuck lobe, and the Kent Moraine of the Grand River lobe. The Buck Hill Moraine begins 5 miles east of Beach City and extends northeast along the glacial boundary toward Canton. In this area the hummocky moraine is 1 to 2 miles wide and is composed mostly of till. At Canton, the till moraine gives way to numerous kames or knolls up to 100 feet high that are composed of sand and gravel with some interbedded till masses (White, 1982). The kames were formed when glacial ice of the Killbuck lobe stagnated and meltwaters poured through holes and crevices of the waning ice margin. The rugged kame and kettle topography extends northwest of Canton into Jackson and Lawrence Townships. The kame terraces in the valley of Sugar Creek are also associated with the Buck Hill Moraine (White, 1982).

The Kent Moraine roughly forms the outer margin of the Grand River lobe in Stark County. In the eastern part of the County, the moraine is composed of till masses in knolls, some up to 80 feet high. Near Canton, the Kent Moraine is composed of kames similar to the Buck Hill Moraine (White, 1982). The large kame and kettle complex of the Kent Moraine extends from Plain Township north to Lake and Marlboro Townships. Near Hartville, large kettle holes containing muck soils have been drained and are now used extensively for agriculture.

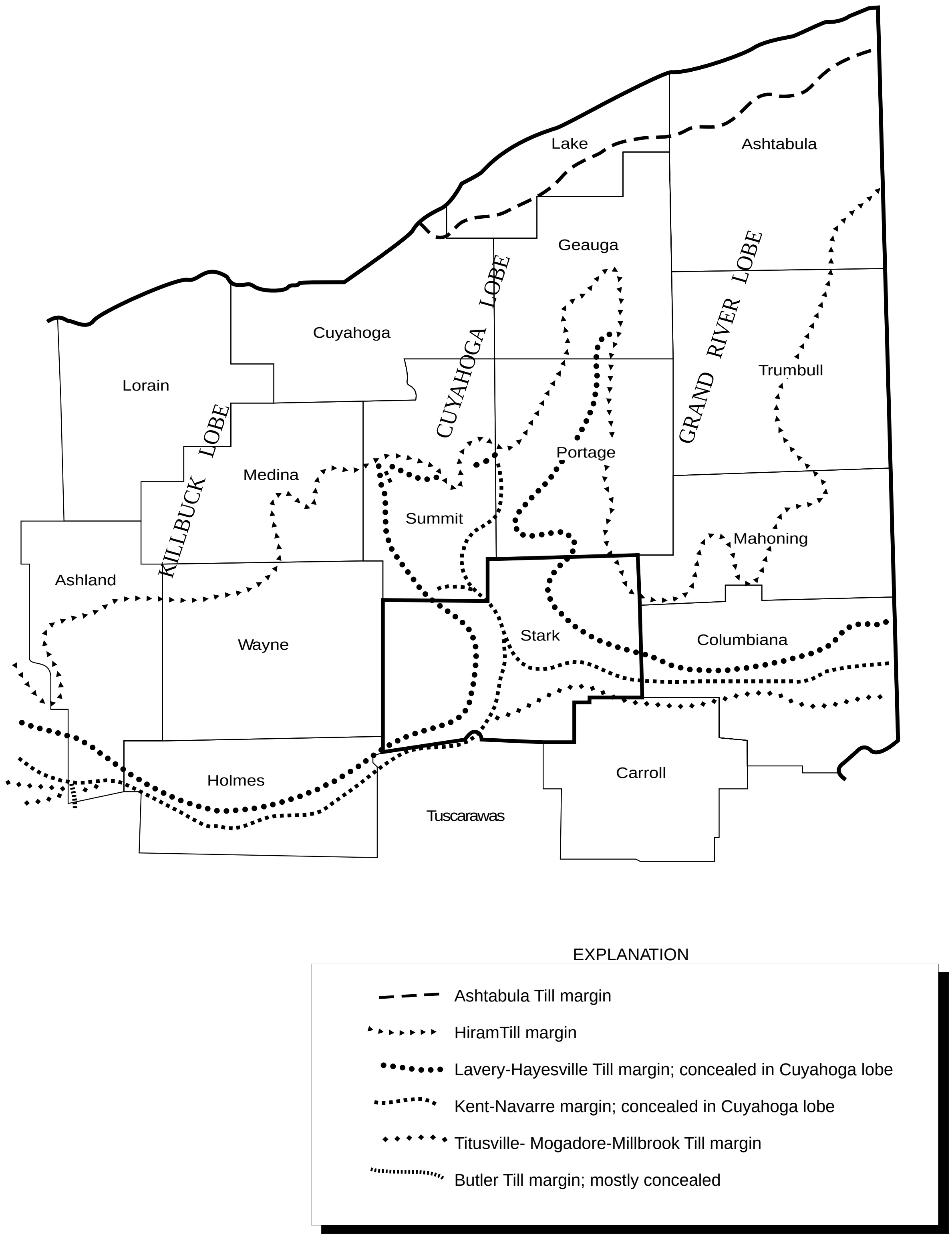


Figure 5. Ice-sheet margins in northeastern Ohio (after White, 1982).

Outwash valley fill deposits in Stark County contain stratified, well sorted and well washed sand and gravel that may be over 200 feet thick in some buried valleys. The sand and gravel was deposited by glacial meltwater flowing down valleys away from the dissipating ice margin. The valley fill deposits are located in the Tuscarawas River valley from Massillon to Bolivar, the Sugar Creek valley south of Beach City, and the Sandy Creek valley as well as several of its tributaries to include Nimishillen Creek, Little Sandy Creek and Hugle Run. The West, Middle and East Branches of Nimishillen Creek north of Canton also have extensive valley fill deposits. These valley deposits joined to form the extensive outwash plain upon which Canton is built (White, 1982).

Nonglacial Pleistocene Deposits

According to Delong and White, (1963), nonglacial lacustrine deposits of Pleistocene age are found in the valleys of Bear Run, Limestone Creek, Pleasant Valley and Indian Run in southeastern Stark County. The origin of these deposits is related to the deposition of outwash material across the outlet of each of these tributary streams. The lakes that were created received silt, sand, and fine gravel material from the surrounding unglaciated terrain. The lacustrine deposits were built to the level of the Sandy Creek valley train surface. Subsequent erosion has dissected these deposits leaving only terraced remnants along the valley walls.

Bedrock Geology

The bedrock exposed in Stark County, from oldest to youngest, includes the Pottsville and Allegheny Groups, and the lowest member of the Conemaugh Group of the Pennsylvanian System. These Groups are generally characterized by alternating layers of moderately fractured sandstone, limestone, shale, coal and clay. The sandstone and shale units have variable thicknesses and often grade laterally into shaley sandstones or sandy shales. The coal, clay and limestone units are relatively thin but are usually persistent across the county. Table 9 is a generalized stratigraphic column of the Pennsylvanian bedrock in Stark County.

According to Harker and Bernhagen (1943), the regional dip of strata in Stark County is approximately 14 feet per mile to the southeast. Thus, the Pottsville Group generally occurs at the bedrock surface in the western, central, and northern portion of the County, while the overlying Allegheny Group is exposed in the eastern and southern part of the county. The lowest member of the Conemaugh Group is found only on ridge tops in southeastern Stark County.

TABLE 9. GENERAL STRATIGRAPHIC COLUMN OF STARK COUNTY
(after Delong and White, 1963)

SYSTEM	GROUP	MEMBER	ROCK TYPE	THICKNESS Ft.	In.
PENNSYLVANIAN	Conemaugh	Lower Mahoning	Thin bedded shale and channel-fill sandstone	20-130	
	ALLEGHENY	Upper Freeport	Coal, variable	2	
			Clay	4	
			Limestone, discontinuous	3	
		Bolivar	Coal and Clay, discontinuous		3
		Shawnee	Limestone, discontinuous		4
		Upper Freeport	Shale and Sandstone	60	
		Door Run	Shale, local		6
		Lower Freeport	Coal		10
			Clay	3	6
			Limestone, discontinuous	1	7
		Lower Freeport	Shale and Sandstone	50	
		Upper Kittanning	Coal and Clay, very local		2
			Shale	23	
		Washingtonville	Shale, discontinuous		10
		Middle Kittanning	Coal	2	4
			Clay	6	
		Leetonia	Nodular Siderite, and Coal, local		7
		Middle Kittanning	Shale	17	
		Strasburg	Coal, local		9
		Oak Hill	Clay		6
		Strasburg	Shale	11	
		Columbiana	Shale	1	2
		Lower Kittanning	Coal	2	
			Clay	6	
		Lawrence	Coal and Clay, very local		2
			Shale	16	
		Vanport	Limestone discontinuous	8	
		Clarion	Shale	50	
		Putnam Hill	Limestome and Shale	10	
		Brookville	Coal	2	
	POTTSVILLE	Brookville	Clay	4	
		Homewood	Shale and channel-fill Sandstone	15-35	
		Tionesta	Coal, discontinuous		6
			Clay, local	8	
			Shale and Sandy Shale	10	
		Upper Mercer	Limestone	2	
		Bedford	Coal, persistent, irregular	1	6
			Clay	1	6
			Shale	23	
		Lower Mercer	Limestone	2	6
		Middle Mercer	Coal, irregular	1	6
			Clay	2	
			Shale and fine grained Sandstone	15	
		Flint Ridge	Coal	1	
			Clay	2	5
			Shale	15	
		Boggs	Limestone, irregular	2	
		Lower Mercer	Coal		6
			Clay	3	
			Silty Shale	18	
		Vandusen	Coal		6
			Clay		7
			Silty Shale and Siltstone	14	
		Bear Run	Coal		3
		Massillon	Massive Sandstone or Shale	30-100	
		Quakertown	Coal	1	
			Clay	?	
			Shale	34	
		Anthony	Coal		2
		Sciotoville	Clay	5	
			Shale	30	
		Sharon (No. 1)	Coal	0-5	
			Clay	?	
		Sharon	Conglomerate and Sandstone	?-200	

The Sharon Conglomerate is the lowermost member of the Pottsville Group and lies almost entirely below drainage in Stark County (Delong and White, 1963). The thickness of the Sharon varies considerably because it was deposited on the steeply eroded surface of Mississippian bedrock (Sedam, 1973). At one locality, the Sharon may be thin or non- existent and only several hundred yards away be over 200 feet thick (Harker and Bernhagen, 1943). The greater thicknesses of the Sharon were deposited in the deeper valleys of the Mississippian surface.

Overlying the Sharon are usually sequences of shale, coal and clay; however, in some localities, the Massillon Sandstone has coalesced with the Sharon Conglomerate. The Massillon Sandstone consists of a coarse–grained, channel-fill sandstone that varies in thickness from 30 to 100 feet. Characteristic of channel-fill sandstones, the Massillon changes rapidly laterally to a relatively thin, nonresistant shale. Above the Massillon, the rock units of the Pottsville Group consist mostly of thin shales and sandy shales interbedded with limestone, coal and clay. At the top of the Group, the Homewood Sandstone occurs locally as a medium to coarse grained channel-fill sandstone with a thickness of 15 to 35 feet (Delong and White, 1963).

The Allegheny Group in Stark County is characterized by shale and sandstone members interbedded with numerous clays and coals and several limestones. The sandstone members of the Allegheny Group are much less extensive than the sandstone members of the Pottsville Group. The thickest members of the Allegheny include the Clarion Shale and the Lower and Upper Freeport Shale and Sandstone. The Clarion is a slightly silty, nonresistant shale that contains vertical joints. The Lower Freeport typically grades upward from a fissile shale to a fine–grained sandstone, while the Upper Freeport is composed mostly of fine to medium–grained sandstone and grades vertically to silty shale (Delong and White, 1963). The numerous clay and coal beds of the Allegheny Group are a valuable resource; thus, they have been extensively strip mined in the County.

The Lower Mahoning Shale and Sandstone Member of the Conemaugh Group represents the youngest bedrock found in Stark County. In Paris Township, this member is composed of thinly–bedded shale, siltstone and sandstone approximately 20 feet thick. However, in Sandy, Pike, southern Canton and western Osnaburg Townships, the Lower Mahoning occurs as a channel-fill sandstone which may be 20 to 130 feet thick (Delong and White, 1963).

Hydrogeology

An aquifer is a body of consolidated or unconsolidated rock material capable of yielding sufficient quantities of water for use (Aller et al., 1987) The yield to a drilled well or spring is largely dependent on the number, shape and size of pore spaces within the rock material, and the degree of interconnection of pore spaces. As these factors change because of varied geologic conditions, so does the yield of an aquifer. In Stark County, aquifers may be divided into two broad categories: (1) consolidated sedimentary rocks of Pennsylvanian age and (2) unconsolidated glacial drift deposits of Pleistocene age.

Bedrock aquifers in Stark County are found primarily in the alternating strata of the Pottsville and Allegheny Groups of the Pennsylvanian System. The Conemaugh is generally not a water–bearing formation in Stark County due to its limited extent on bedrock ridge tops. Water wells drilled below the Pennsylvanian bedrock typically encounter salt water that can not be used as a water supply (Harker and Bernhagen, 1943).

In the Pottsville and Allegheny Groups, ground water typically occurs within the pore spaces between individual grains in sandstone and shale and also in fractures along bedding planes and vertical joints (Booth, 1988). Small amounts of ground water may occur along fractures in thin limestones and coal seams.

Bedrock water wells in Stark County are generally drilled to a sufficient depth to encounter sandstone or sandy shale aquifers, or less frequently, fractures within shale (Groenewold, 1974). Well logs indicate that occasionally water is available from limestone beds and coal seams. Although semi-confining conditions do occur, the aquifers are considered unconfined because of fracturing and downward leakage between units.

The two most productive bedrock aquifers in Stark County are the Sharon Conglomerate and the Massillon Sandstone of the lower Pottsville Group. These members are able to produce sustained yields of 50 gallons per minute (gpm) in some areas of the County (Walker, 1979).

Overlying the Massillon, the members of the Upper Pottsville and Allegheny Groups yield less than 25 gpm and typically only enough water for domestic supplies (Walker, 1979). Locally important aquifers within these Groups are the Homewood Sandstone, and the Lower and Upper Freeport Shale and Sandstone. Thin shale, coal and limestone members may contribute to the yield of a well, if the bedrock is sufficiently fractured.

The unconsolidated aquifers in Stark County are composed of clay, silt, sand and gravel deposited by glacial meltwater. The ability of the unconsolidated deposits to yield ground water depends largely on the percentage of fine material (clay and silt), the degree of sorting, and availability of recharge.

The glacial till deposits in Stark County are generally not a source of water. However, if localized sand and gravel lenses are encountered in thick glacial till, properly constructed drilled wells may yield 5 to 20 gpm (Walker, 1979). These conditions are found in portions of northeastern Stark County. Similarly, valley fill deposits primarily consisting of clay, but with sand and gravel lenses of limited thickness, can be expected to yield up to 30 gpm (Walker, 1979).

Unconsolidated deposits composed of mostly sand and gravel with some silt and clay provide good supplies of ground water. These deposits are often associated with kames and may yield 25 to 100 gpm (Walker, 1979).

The most permeable and highest yielding aquifers in the County are the buried valleys that contain thick valley fill deposits of well washed and sorted sand and gravel. The major buried valleys include: the old Dover and Newark River valley underlying portions of the Tuscarawas River and Sugar Creek; the network of buried valleys underlying Canton and the buried valley underlying Sandy Creek. These deposits of sand and gravel may yield several hundred or more gallons per minute and are suitable areas for industrial and municipal well fields (Walker, 1979).

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

This factor was primarily evaluated using information obtained from water well logs on file at the Ohio Department of Natural Resources, Division of Water. Water well logs provide important information such as depth to static water level and description of rock materials. The depth to water in an area was determined by the average static water level in the uppermost aquifer. In a multi-layer aquifer system, shallow wells more accurately reflect this condition. Other important sources of information include reports by Schaefer et al. (1946); Kazmann (1947); Kaser (1962); and Kaser and Harstine (1965). Observation well data was also obtained from the Ohio Department of Natural Resources, Division of Water. In areas of little or no depth to water data, interpretation of surface geology and topography were used to evaluate the depth to water rating. In bedrock aquifers overlain by glacial drift, depth to water averaged 30 to 50 feet below the surface. The corresponding DRASTIC rating for 30 - 50 feet is (5). In areas where glacial material is thin or absent, depth to water in bedrock aquifers was more variable, ranging from 30 to 50 feet (5), 50 to 75 feet (3) and 75 to 100 feet (2). In unconsolidated aquifers, depth to water was generally more shallow. The shallowest water levels are 5 to 15 (9) feet below the surface, occurring near ground water discharge areas (streams and wetlands). The deepest water levels in unconsolidated aquifers are 50 to 75 feet (3) found in some buried valleys covered by glacial till.

Net Recharge

Net recharge values are based primarily on information contained in Pettyjohn and Henning (1979). In this report, the "effective ground water recharge rate" is equated to ground water runoff and calculated from stream hydrographs and flow duration curves. The report gives the average effective recharge rate during a year of normal precipitation for different hydrogeologic regions in Ohio. To supplement this general information, two specific net recharge values were obtained for a buried valley aquifer setting in Stark County (Schaefer et al., 1946). These general and site specific values were used as guidance for estimating net recharge in Stark County. A net recharge of 2 to 4 (3) was chosen for unglaciated areas and where thin glacial till overlies bedrock. This is primarily due to the generally deep water table, the steep topography, and the shale and clay bedrock in the vadose zone. In strip mine areas, the net recharge was adjusted to 4 to 7 (6) because of the increased exposure of fractured bedrock and the ability of spoil material to retain and discharge precipitation. In areas were the surface material is glacial till or lacustrine sediments, a moderate net recharge of 4 to 7 (6) was chosen. For glacial outwash areas (kames and valley fill deposits), a net recharge of 7 to 10 (8) was generally selected to reflect the increased permeability of outwash material. The highest recharge rate, 10+ (9), was chosen for sand and gravel pits because of the lack of soil cover.

Aquifer Media

This factor was evaluated using information obtained from water well logs on file at the Ohio Department of Natural Resources, Division of Water and the following reports: Cummins (1947); Delong and White (1963); Delong (1965, 1967); Harker and Bernhagen (1943); Kazmann (1947, 1949); Schaefer et al. (1946); Sedam (1973); Walker (1979); and White (1982). In general, the uppermost bedrock aquifer in Stark County consists of alternating layers of sandstone, shale, limestone, and coal. Although semi-confining conditions do occur, these layers of rock are considered unconfined due to fracturing and downward leakage between units. A typical rating of (6) was applied to the bedrock aquifer, except in areas of particularly low yield as defined by Walker (1979) which were rated a (5). In areas where two unconsolidated aquifers are present, the uppermost aquifer was evaluated. These aquifers consist largely of sand and gravel with varying percentages of silt and clay. A typical rating of (5) was chosen for areas where glacial till containing some sand and gravel was considered the aquifer. In areas of discontinuous sand and gravel lenses in thick glacial till, sand and gravel is considered the aquifer media and a rating of (6) was chosen. Similarly, a rating of (6) was selected for buried valley aquifers where sand and gravel is of limited thickness and extent. A rating of (7) was chosen for buried valley aquifers and kame aquifers consisting mostly of sand and gravel but with interbedded silt and clay. In general, sand and gravel aquifers capable of yielding 100 to 500 gpm were rated an (8), while those capable of producing over 500 gpm were rated a (9). These deposits consist of well washed and sorted sand and gravel; thus, a higher pollution potential rating is appropriate.

Soil Media

This factor was evaluated using soil descriptions in the Soil Survey of Stark County (Christman et al., 1971; Bauder, 1987). Each soil was examined in terms of texture, organic composition, shrink/swell potential, permeability and average thickness. A soil media description and a DRASTIC rating were then assigned to each soil series based on these factors (Table 10). The Ohio Department of Natural Resources, Division of Soil and Water Conservation produced soil media maps at the scale of 1:24,000 on the Ohio Capability Analysis Program (OCAP). Soil media varied widely across the County because of the differing composition of the parent geologic materials. In areas of swamps or depressions, muck soils develop from decomposed organic matter. In these areas, a low pollution potential rating of (2) was assigned because of the high organic content. In glacial till areas, the soil media is often a silt loam (4) or a silt loam with fragipan (3).

TABLE 10. STARK COUNTY SOILS SERIES

SOIL SERIES	RANGE	DRASTIC RATING
Arkport: ArB, ArC, ArD	Sandy Loam	6
Bogart: BgA, BgB, BoA, BoB, BoC, Bu	Sandy Loam	6
Brooke: BwC2, BwE2	Clay Loam	3
Canadice: Ca	Clay Loam	3
Canfield: CdA, CdB, CdC, CdC2, CdD, CdD2, CeB, CeC,	Silty Loam*	3
Canfield: CfB, CfC	Clay Loam	3
Carlisle: Ch	Muck	2
Chagrin: Ck, Cm	Sand	9
Chili: CnA, CnB, CpA, CpB	Sand	9
Chili: CpC, CpC2, CuB, CuC, CuF	Sandy Loam	6
Chili: CoC, CoC2, CoD2, CoE2, CvF2	Gravel	10
Conotton: CwA, CyB, CyC, CyD2, CyE2	Gravel	10
Dekalb: DkB, DkC, DkE2, DkF2	Sandy Loam	6
Edwards: Ed :	Muck	2
Fitchville: FcA, FcB , FcC, Fu	Silty Loam	4
Geeburg: GbC2, GbE2	Shrink/Swell Clay	7
Gilpin: GdB, GdC, GdD	Silty Loam	4
Ginat: Ge	Sandy Loam	6
Glenford: GfA, GfB, GfC, GfC2, GfD2	Silty Loam	4
Keene: KeB, KeC, KeC2, KeD, KeD2, KeE	Clay Loam	3
Killbuck: Kk	Silty Loam	4
Latham: LaB, LaC, LaC2, LaD, LaD2, LaF	Clay Loam	3
Licking: LcA, LcB, LcC, LcC2, LcE2	Silty Loam	4
Linwood: Ld	Muck	2
Lobdell: Le	Silty Loam	4
Loudonville: LoB, LoC, LoC2, LoD, LoD2, LoE2, LoF2 , LuB, LuC	Silty Loam	4
Luray: Ly	Clay Loam	3
Luray: Lz	Sandy Loam	6
Mentor: MeA, MeB, MeC, MeD	Silty Loam	4
Montgomery: Mg	Shrink/Swell Clay	7
Muskingum: MsB,. MsC, MsD, MvE, MvE3, MvF, MvG, MwF	Slity Loam	4
Plainfield: PlB , PlC	Sand	9
Rainsboro: RaB. RaC	Silty Loam	4
Ramsey: RcC, RcD, RcE2, RcF2	Thin or Absent	10
Ravenna: ReA, ReB, Rn	Silty Loam*	3
Remsen: RoA, RoB, Ro	Shrink/Swell Clay	7
Rittman: RsB, RsC, RsC2, RsD2	Clay Loam	3
Sebring: Sb, Sg	Silty Loam	4
Sebring: Se	Clay Loam	3
Shoals: Sh	Loam	5
Sloan: Sl	Loam	5
Tilsit: TlC, TlD	Silty Loam	4
Trumbull: Tr	Shrink/Swell Clay	7
Wadsworth: WaA, WaB, WaC, WaC2, WbD	Clay Loam	3
Wallkill : Wa	Muck	2
Wayland: Wd	Silty Loam	4
Weikert: WeC, WeD, WeE2, WeF2	Thin or Absent	10
Weinbach: WhA, WhB, Wk	Sandy Loam	6
Wellston: WlB, WlC	Silty Loam	4
Wheeling: WmA, WmB, WmC2, WrA, WrB, WrC, WrC2, WsD2	Sandy Loam	6
Willette: Wt	Muck	2
Wooster: WuB, WuC, Wuc2, WuD2, WuE2, WuF2, WvD	Sandy Loam	6
Strip Mine Spoil, Gravel Pits: SoC, SoE, SoF, SsC, SsE, SsF, StC, StD, StF, Gp	Thin or Absent	10

Note: In the Glaciated Central Region, the soil medium, silt loam with an asterisk (*), indicates that a fragipan is present; thus, the rating has been reduced from a (4) to a (3).

The fragipan layer is composed of dense and cemented silt or fine sand that restricts infiltration; thus, a lower pollution potential rating is appropriate. In the upland areas, silt loam typically develops over bedrock. A rating of (4) was chosen for these areas. Soils that developed from slack water lacustrine deposits or river alluvium were described as silt loam (4) or loam (5). Soil associated with the Hiram Till in northeastern Stark County was rated a (7) because of its high shrink/swell potential. In kame and valley train areas, the soil media primarily were designated sandy loam (6), sand (9) or gravel (10). A soil media rating of thin or absent (10) was chosen for strip mines, gravel pits, and areas of soil less than 10 inches thick.

Topography

Percent slope maps were generated by the Ohio Department of Natural Resources, Division of Soil and Water Conservation on the OCAP mapping system. Information for the data base was obtained from the Soil Survey of Stark County (Christman et al., 1971). In general, percent slope is moderate in areas of glacial outwash and thick deposits of glacial till. In these areas, slope ranges from 0 to 2% (10), 2 to 6% (9), and 6 to 12% (5). An exception occurs in some areas of kames where slope averages 12 to 18% (3). In the unglaciated uplands and in areas of thin glacial till over bedrock, slope is generally steep, ranging from 6 to 12% (5), 12 to 18% (3) and greater than 18% (1).

Impact of the Vadose Zone Media

Determinations about this factor were made using information obtained from ODNR well log files; Christman et al. (1971); Delong and White (1963); Delong (1965, 1967); Groenewold (1974); Kazmann (1947, 1949); Schaefer et al. (1946); Walker (1979); and White (1982). Unconsolidated vadose zone media were rated largely on the proportion of fine material (silt and clay) to coarse material (sand and gravel). The Hiram Till in northeastern Stark County is mostly composed of silt/clay (4). Lucustrine deposits in several tributary valleys of Sandy Creek were rated as either silt/clay (4), or sand and gravel with significant silt and clay (5). Although these deposits are relatively thin, the silt and clay particles reduce infiltration and increase attenuation of potential contaminants. Besides the Hiram Till, most of the ground and end moraine glacial till is sandy and has numerous pebbles and cobbles. A vadose zone media of sand and gravel with significant silt and clay (5) or (6) was chosen to reflect the sandy nature of most of the glacial till deposits (i.e. Millbrook, Titusville, Navarre and Kent). Kames associated with the end moraines are composed of irregularly bedded, poorly washed and poorly sorted sand and gravel containing some till masses. For these deposits, a vadose zone media of sand and gravel with significant silt and clay (7) was chosen. The most permeable vadose media consist of well washed and sorted sand and gravel in valley fill deposits. Accordingly, these deposits were rated as sand and gravel (9). Vadose zone media of interbedded sandstone, limestone, shale, coal and clay occur in hydrogeologic settings 6Da, 6Db and 7G. Fracturing of the bedrock is considered moderate; thus, a typical rating of (6) was chosen for these settings.

Hydraulic Conductivity

Hydraulic conductivity values were based on published data from Sedam (1973); Schaefer et al. (1946) and general information from Walker (1979) and Freeze and Cherry (1979). Conservatively high estimates of hydraulic conductivity were chosen for bedrock aquifers to reflect a moderate degree of fracturing. A hydraulic conductivity value from 1 to 100 gpd/ft^2 (1) was chosen for low yield bedrock aquifers (3 to 10 gpm) and a value of 100 to 300 gpd/ft^2 (2) was chosen for higher yielding aquifers (10 to 25 gpm) (Walker, 1979).

The hydraulic conductivity of unconsolidated aquifers is partly dependent on the percentage of coarse-grained material and the degree of sorting. In setting 7Af - Sand and Gravel Interbedded in Glacial Till, the hydraulic conductivity of the glacial till aquifer is estimated to be 100 to 300 gpd/ft^2 (2) because of localized lenses of sand and gravel. In this same setting where sand and gravel lenses are more extensive, a hydraulic conductivity of 300 to 700 gpd/ft^2 (4) was chosen. In setting 7C - Moraine, hydraulic conductivity values ranged from 300 to 700 gpd/ft^2 (4) to 700 to 1000 gpd/ft^2 (6). In setting 7D - Buried Valley, the hydraulic conductivity of sand and gravel aquifers range from 300 to 700 gpd/ft^2 (4) to greater 2000 gpd/ft^2 (9).

APPENDIX B

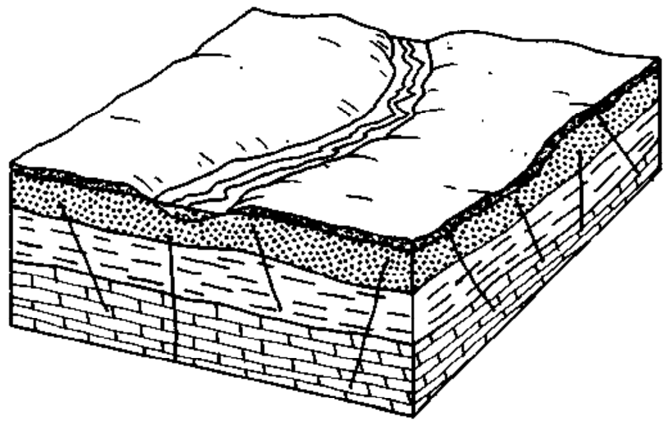
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

In mapping the pollution potential of Stark County, seven hydrogeologic settings were identified in the Glaciated Central Region and two were identified in the Nonglaciated Central Region. The list of these settings, the range of the pollution potential index calculations and the number of pollution potential index calculations for each setting are provided in Table 11. Computed pollution potential index values range from 90 to 199.

TABLE 11. HYDROGEOLOGIC SETTINGS MAPPED IN STARK COUNTY, OHIO

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da - Alternating Sandstone, Limestone, Shale, Coal and Clay - Thin Soil	102-116	4
6Db - Alternating Sandstone, Limestone, Shale, Coal and Clay - Deep Regolith	90-126	7
7Aa - Glacial Till Over Bedded Sedimentary Rock	99-125	20
7Af - Sand & Gravel Interbedded in Glacial Till	106-136	17
7Ba - Outwash	148-174	17
7Bb - Outwash Over Bedded Sedimentary Rock	123-164	14
7C - Moraine	129-140	6
7D - Buried Valley	111-199	101
7G - Thin Till Over Bedded Sedimentary Rock	90-132	23

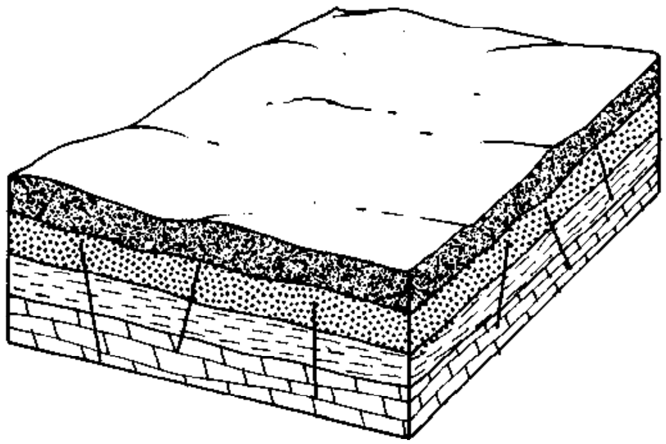
The following information provides a description of each hydrogeologic setting identified in Stark County, a block diagram illustrating the characteristics of each setting, and a listing of charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide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



6Da Alternating Sandstone, Limestone, Shale, Coal and Clay - Thin Soil

This hydrogeologic setting is characterized by moderate to steep topography, and absent or thin silty soils overlying slightly dipping alternating layers of fractured sedimentary rock. The sandstone and shale units are most prevalent and have variable thicknesses, while the interbedded limestones, coals and clays are relatively thin. Ground water is obtained primarily from sandstones and sandy shales, along the bedding planes, and in intersecting vertical fractures. Depth to water is usually greater than 50 feet. Strip mines in the nonglaciated region are included in this setting. The natural soils have been removed and strip mine spoil containing mostly weathered shale and sandstone may randomly occupy the surface. Bedrock is exposed where spoil material is absent. Recharge is moderate due to increased capacity of spoil material to retain and discharge precipitation.

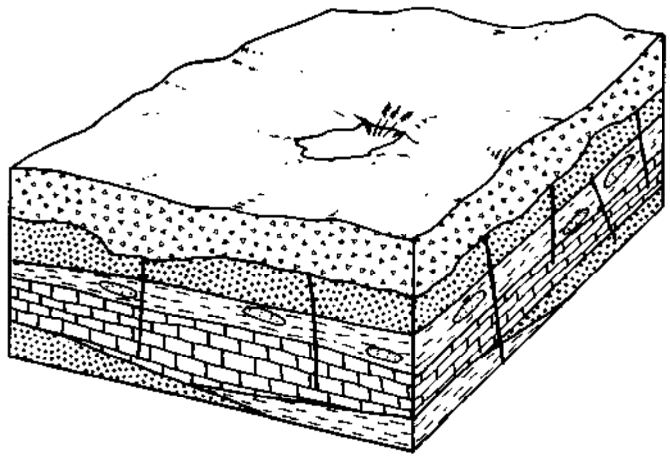
Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
6Da1	75-100	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	12-18	interbedded ss/sh/ls/cl/coal	100-300	111
6Da2	50-75	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	18+	interbedded ss/sh/ls/cl/coal	100-300	114
6Da3	50-75	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	12-18	interbedded ss/sh/ls/cl/coal	100-300	116
6Da4	50-75	2-4	interbedded ss/sh/ls/cl/coal	Thin or Absent	18+	interbedded ss/sh/ls/cl/coal	100-300	102



6Db Alternating Sandstone, Limestone, Shale, Coal and Clay - Deep Regolith

This hydrogeologic setting is similar to 6Da, except that deep soils are present over weathered bedrock or valley lacustrine deposits. The silt or clay loam soils in this setting help retard the movement of contaminants to the water table. Recharge in the uplands is low due to steep slopes and moderate on the gently sloped lacustrine deposits.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
6Db1	50-75	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	12-18	interbedded ss/sh/ls/cl/coal	100-300	92
6Db2	30-50	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	sd+gvl/silt+clay	100-300	115
6Db3	50-75	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	12-18	interbedded ss/sh/ls/cl/coal	100-300	90
6Db4	15-30	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	0-2	sd+gvl/silt+clay	100-300	126
6Db5	50-75	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	18+	interbedded ss/sh/ls/cl/coal	100-300	90
6Db6	15-30	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	silt/clay	100-300	120
6Db7	15-30	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	0-2	silt/clay	100-300	121

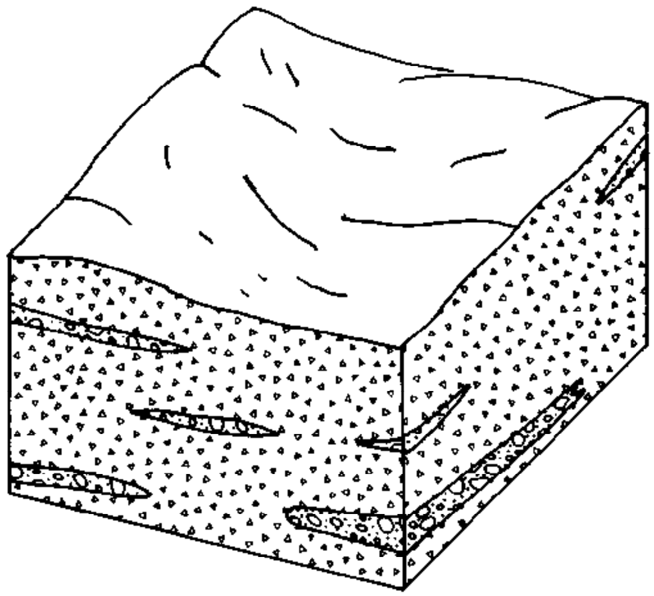


7Aa Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by low to moderate topography and varying thicknesses of glacial till covering alternating layers of fractured sedimentary rock. The glacial till occurs in layers or sheets each composed of varying amounts of unsorted clay, silt and sand with some pebbles and cobbles. Soil texture is variable depending largely on the composition of the uppermost till sheet. Although ground water may occur within the till and localized sand and gravel lenses, the bedrock is the principal aquifer. Ground water is obtained primarily from sandstones and sandy shales, along the bedding planes, and in intersecting vertical fractures. Precipitation infiltrating through the till serves as a source of recharge to the underlying bedrock. Depth to water is highly variable.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7Aa1	30-50	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	sd+gvl/silt +clay	100-300	115
7Aa2	50-75	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	6-12	sd+gvl/silt +clay	100-300	99
7Aa3	50-75	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	0-2	sd+gvl/silt +clay	100-300	106
7Aa4	50-75	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	sd+gvl/silt +clay	100-300	103
7Aa5	30-50	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	sd+gvl/silt +clay	100-300	113
7Aa6	30-50	4-7	interbedded ss/sh/ls/cl/coal	Sandy Loam	2-6	sd+gvl/silt +clay	100-300	119
7Aa7	30-50	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	0-2	sd+gvl/silt +clay	100-300	116
7Aa8	15-30	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	sd+gvl/silt +clay	100-300	125
7Aa9	50-75	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	sd+gvl/silt +clay	100-300	105
7Aa10	15-30	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	sd+gvl/silt +clay	100-300	123
7Aa11	30-50	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	6-12	sd+gvl/silt +clay	100-300	109
7Aa12	30-50	4-7	interbedded ss/sh/ls/cl/coal	Sandy Loam	6-12	sd+gvl/silt +clay	100-300	115

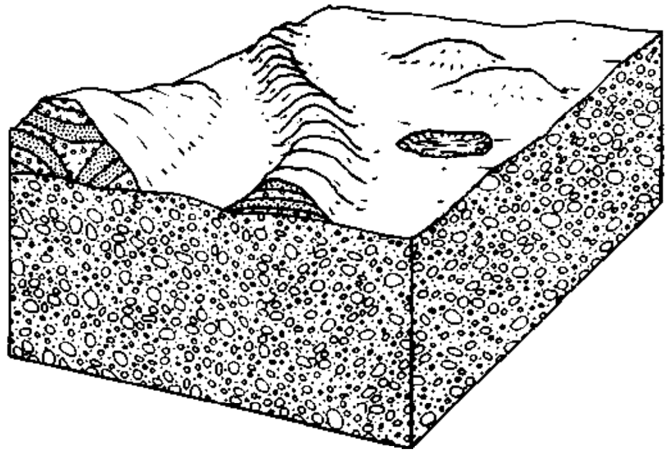
Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7Aa13	30-50	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	0-2	sd+gvl/silt +clay	100-300	114
7Aa14	30-50	4-7	interbedded ss/sh/ls/cl/coal	Sandy Loam	0-2	sd+gvl/silt +clay	1-100	114
7Aa15	30-50	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	6-12	sd+gvl/silt +clay	100-300	111
7Aa16	30-50	4-7	interbedded ss/sh/ls/cl/coal	Sandy Loam	0-2	sd+gvl/silt +clay	100-300	120
7Aa17	30-50	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	sd+gvl/silt +clay	1-100	107
7Aa18	30-50	4-7	interbedded ss/sh/ls/cl/coal	Clay Loam	0-2	sd+gvl/silt +clay	1-100	108
7Aa19	30-50	4-7	interbedded ss/sh/ls/cl/coal	Shrink-swell (Aggregated) Clay	0-2	silt/clay	1-100	111
7Aa20	30-50	4-7	interbedded ss/sh/ls/cl/coal	Shrink-swell (Aggregated) Clay	0-2	silt/clay	100-300	117



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is similar to 7Aa, except that the till is generally thick, and the sand and gravel lenses in the till serve as the principal aquifer. Recharge to the sand and gravel lenses occurs from precipitation infiltrating through the till. Depth to water is variable but averages around 30 feet.

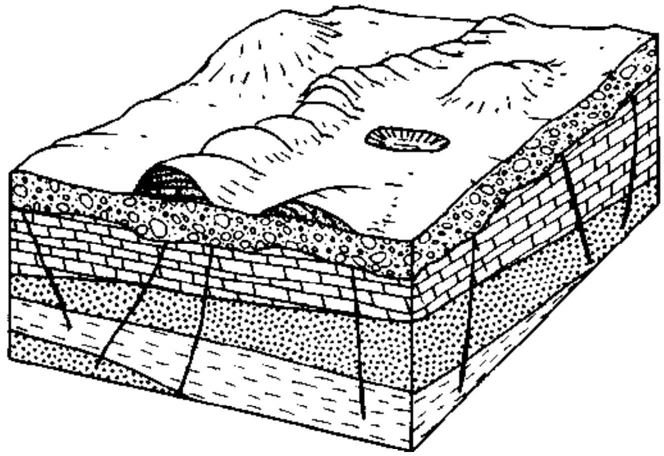
Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7Af1	30-50	4-7	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	100-300	106
7Af2	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	100-300	123
7Af3	15-30	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	100-300	120
7Af4	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	132
7Af5	15-30	4-7	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	300-700	136
7Af6	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	100-300	126
7Af7	15-30	4-7	sand/gravel	Clay Loam	0-2	sd+gvl/silt+clay	100-300	121
7Af8	15-30	4-7	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	100-300	126
7Af9	15-30	4-7	sand/gravel	Shrink-swell (Aggregated) Clay	0-2	silt/clay	300-700	133
7Af10	15-30	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	300-700	129
7Af11	15-30	4-7	sand/gravel	Loam	0-2	sd+gvl/silt+clay	300-700	134
7Af12	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	132
7Af13	15-30	4-7	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	100-300	116
7Af14	15-30	4-7	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	300-700	125
7Af15	15-30	4-7	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	100-300	122
7Af16	30-50	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	100-300	110
7Af17	15-30	4-7	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	300-700	131



7Ba Outwash

This hydrogeologic setting is characterized by moderate topography and varying thicknesses of outwash that overlie alternating layers of sedimentary rock. The outwash consists of glacial meltwater ice contact deposits of sand and gravel in the form of kames which serve as the principal aquifer. The kames contain irregularly bedded, poorly washed and sorted sand and gravel that may include till masses. Associated with kames are depressions called kettle holes that often contain muck soils or may form a swamp or lake if below the water table. The water table occurs at relatively shallow depths below the base of the kames. Recharge is high because of the typically sandy soils and permeable vadose zone media.

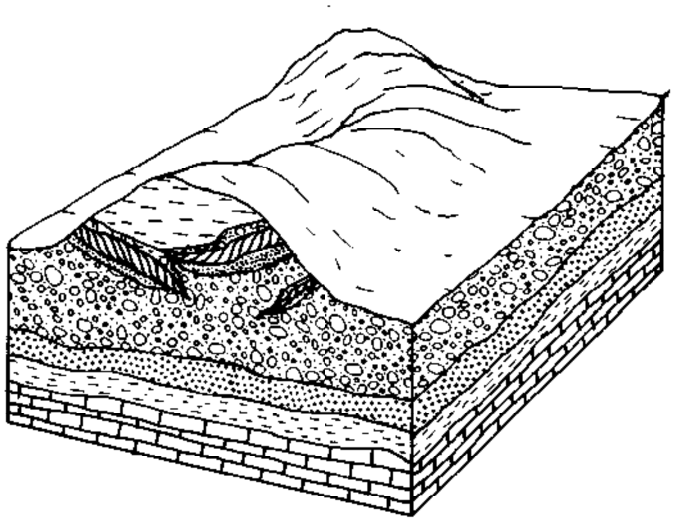
Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7Ba1	30-50	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	700-1000	148
7Ba2	30-50	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	700-1000	153
7Ba3	15-30	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	700-1000	163
7Ba4	15-30	7-10	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	700-1000	162
7Ba5	30-50	7-10	sand/gravel	Sand	6-12	sd+gvl/silt+clay	700-1000	154
7Ba6	15-30	7-10	sand/gravel	Gravel	6-12	sd+gvl/silt+clay	700-1000	166
7Ba7	15-30	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	700-1000	158
7Ba8	15-30	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	700-1000	155
7Ba9	15-30	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	1000-2000	167
7Ba10	15-30	7-10	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	1000-2000	171
7Ba11	15-30	7-10	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	1000-2000	165
7Ba12	15-30	7-10	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	1000-2000	161
7Ba13	15-30	7-10	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	700-1000	156
7Ba14	5-15	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	700-1000	173
7Ba15	5-15	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	700-1000	165
7Ba16	15-30	7-10	sand/gravel	Sand	2-6	sd+gvl/silt+clay	700-1000	168
7Ba17	5-15	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	1000-2000	174



7Bb Outwash Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by low to moderate topography and relatively thin outwash that overlies alternating layers of fractured sedimentary rock. The outwash consists of glacial meltwater deposits of sand and gravel in the form of kames and valley fill deposits. The kames contain irregularly bedded, poorly washed and sorted sand and gravel that may include till masses. The valley fill deposits contain stratified, well washed and well sorted sand and gravel with a small amount of clay and silt. Due to the relatively thin outwash, the underlying bedrock is the principal aquifer. Ground water is obtained primarily from sandstones and sandy shales, along the bedding planes, and in intersecting vertical fractures. Precipitation infiltrating through the outwash serves as the main source of recharge to the bedrock. Depth to water is variable, but averages 30 to 50 feet below the surface.

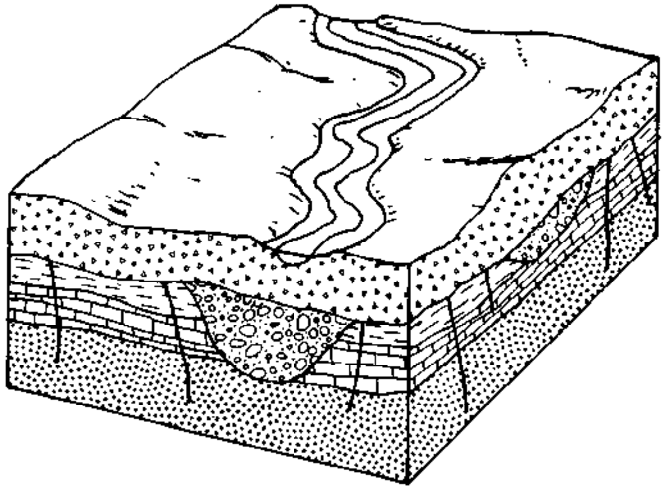
Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7Bb1	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sand	2-6	sd+gvl/silt+clay	100-300	143
7Bb2	30-50	4-7	interbedded ss/sh/ls/cl/coal	Silty Loam	0-2	sd+gvl/silt+clay	100-300	136
7Bb3	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sandy Loam	2-6	sd+gvl/silt+clay	100-300	137
7Bb4	50-75	7-10	interbedded ss/sh/ls/cl/coal	Sandy Loam	6-12	sd+gvl/silt+clay	100-300	123
7Bb5	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sandy Loam	6-12	sd+gvl/silt+clay	100-300	133
7Bb6	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sandy Loam	0-2	sd+gvl/silt+clay	100-300	138
7Bb7	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sand	6-12	sd+gvl/silt+clay	100-300	139
7Bb8	30-50	7-10	interbedded ss/sh/ls/cl/coal	Thin or Absent	12-18	sd+gvl/silt+clay	100-300	139
7Bb9	15-30	7-10	interbedded ss/sh/ls/cl/coal	Sandy Loam	0-2	sand + gravel	100-300	158
7Bb10	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sand	2-6	sand + gravel	100-300	153
7Bb11	30-50	7-10	interbedded ss/sh/ls/cl/coal	Clay Loam	6-12	sand + gravel	100-300	127
7Bb12	30-50	7-10	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	sd+gvl/silt+clay	100-300	131
7Bb13	30-50	7-10	interbedded ss/sh/ls/cl/coal	Sand	12-18	sd+gvl/silt+clay	100-300	137
7Bb14	15-30	7-10	interbedded ss/sh/ls/cl/coal	Sand	0-2	sand + gravel	100-300	164



7C Moraine

This hydrogeologic setting is characterized by hummocky topography and varying thicknesses of glacial till that includes sand and gravel. This setting is similar to 7Ba, in that the sand and gravel in the moraine deposit may be well sorted and serve as the principal aquifer. Moraines also contain sediments that are typically unsorted and unstratified; these deposits contain more fines than outwash deposits, are less permeable and are characteristic of glacial till. Soil texture is extremely variable depending on the composition of till sheets at the surface. Recharge by precipitation is moderate and depth to water is fairly shallow; averaging 15 to 30 feet below the surface.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
"7C1"	"15-30"	"4-7"	"sand/gravel"	"Clay Loam"	"2-6"	"sd+gvl/silt+clay"	"300-700"	129
"7C2"	"15-30"	"4-7"	"sand/gravel"	"Sand"	"6-12"	"sd+gvl/silt+clay"	"300-700"	137
"7C3"	"15-30"	"4-7"	"sand/gravel"	"Sandy Loam"	"2-6"	"sd+gvl/silt+clay"	"300-700"	135
"7C4"	"15-30"	"4-7"	"sand/gravel"	"Sandy Loam"	"6-12"	"sd+gvl/silt+clay"	"700-1000"	140
"7C5"	"15-30"	"4-7"	"sand/gravel"	"Clay Loam"	"6-12"	"sd+gvl/silt+clay"	"700-1000"	139
"7C6"	"15-30"	"4-7"	"sand/gravel"	"Clay Loam"	"2-6"	"sd+gvl/silt+clay"	"700-1000"	138



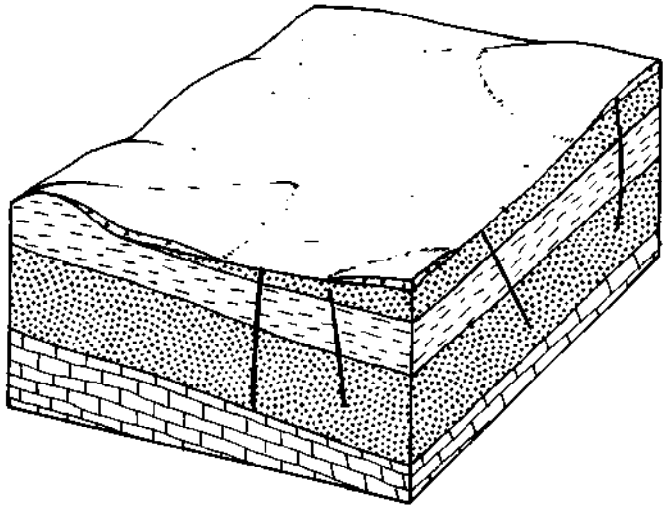
7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that were laid down by glacial meltwater in a former topographic low, (i.e. a preglacial or interglacial river valley). These deposits are capable of yielding large quantities of water where they are sufficiently thick, permeable and receive adequate recharge. The deposits may or may not underlie or be in direct hydraulic connection with a present–day river. Glacial till, recent alluvium, kame, valley train or lacustrine deposits may overlie the buried valley. Soil texture is highly variable depending on the surface material. Recharge to the aquifer can be attributed to infiltration by precipitation or stream infiltration where the water table has been lowered due to pumping. The depth to water in this setting is extremely variable.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7D1	30-50	7-10	sand/gravel	Sand	0-2	sd+gvl/silt+clay	700-1000	159
7D2	30-50	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	700-1000	141
7D3	30-50	7-10	sand/gravel	Sand	0-2	sd+gvl/silt+clay	1000-2000	168
7D4	30-50	4-7	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	700-1000	134
7D5	30-50	7-10	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	1000-2000	161
7D6	30-50	7-10	sand/gravel	Sand	2-6	sd+gvl/silt+clay	1000-2000	167
7D7	30-50	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	1000-2000	162
7D8	30-50	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	1000-2000	172
7D9	30-50	4-7	sand/gravel	Silty Loam	0-2	sand + gravel	1000-2000	160
7D10	5-15	4-7	sand/gravel	Silty Loam	0-2	silt/clay	300-700	137
7D11	30-50	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	300-700	154
7D12	30-50	7-10	sand/gravel	Sand	2-6	sand + gravel	300-700	159
7D13	30-50	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	122
7D14	30-50	7-10	sand/gravel	Sand	0-2	sand + gravel	2000+	187
7D15	50-75	7-10	sand/gravel	Gravel	6-12	sand + gravel	300-700	137
7D16	50-75	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	700-1000	118
7D17	50-75	4-7	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	700-1000	124
7D18	30-50	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	2000+	181

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7D19	30-50	10+	sand/gravel	Gravel	2-6	sd+gvl/silt+clay	300-700	155
7D20	30-50	7-10	sand/gravel	Sand	0-2	sand + gravel	300-700	160
7D21	50-75	4-7	sand/gravel	Sand	6-12	sd+gvl/silt+clay	300-700	117
7D22	30-50	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	1000-2000	150
7D23	50-75	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	1000-2000	140
7D24	50-75	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	1000-2000	130
7D25	50-75	7-10	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	1000-2000	151
7D26	50-75	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	1000-2000	127
7D27	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	1000-2000	150
7D28	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	700-1000	141
7D29	30-50	4-7	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	300-700	125
7D30	50-75	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	300-700	129
7D31	50-75	4-7	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	300-700	111
7D32	50-75	7-10	sand/gravel	Sand	6-12	sd+gvl/silt+clay	300-700	135
7D33	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	132
7D34	30-50	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	700-1000	163
7D35	15-30	4-7	sand/gravel	Sand	0-2	sd+gvl/silt+clay	300-700	142
7D36	30-50	7-10	sand/gravel	Sandy Loam	2-6	sand + gravel	1000-2000	171
7D37	5-15	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	300-700	144
7D38	30-50	7-10	sand/gravel	Gravel	6-12	sd+gvl/silt+clay	1000-2000	165
7D39	30-50	7-10	sand/gravel	Sand	0-2	sand + gravel	1000-2000	178
7D40	50-75	7-10	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	700-1000	132
7D41	30-50	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	1000-2000	157
7D42	30-50	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	700-1000	148
7D43	30-50	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	700-1000	153
7D44	30-50	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	2000+	166
7D45	5-15	4-7	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	300-700	151
7D46	15-30	4-7	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	300-700	136
7D47	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	132
7D48	30-50	7-10	sand/gravel	Sand	6-12	sd+gvl/silt+clay	1000-2000	163
7D49	30-50	10+	sand/gravel	Gravel	6-12	sd+gvl/silt+clay	1000-2000	169
7D50	30-50	7-10	sand/gravel	Sand	6-12	sd+gvl/silt+clay	700-1000	154
7D51	15-30	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	700-1000	155
7D52	15-30	7-10	sand/gravel	Sand	6-12	sd+gvl/silt+clay	700-1000	164
7D54	30-50	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	2000+	171
7D55	15-30	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	700-1000	173
7D56	30-50	7-10	sand/gravel	Gravel	12-18	sd+gvl/silt+clay	700-1000	154
7D57	30-50	4-7	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	700-1000	135
7D58	30-50	4-7	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	700-1000	130
7D59	15-30	7-10	sand/gravel	Sand	0-2	sd+gvl/silt+clay	1000-2000	178
7D60	15-30	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	1000-2000	164
7D61	30-50	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	700-1000	128
7D62	15-30	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	1000-2000	172
7D63	5-15	7-10	sand/gravel	Muck	0-2	sd+gvl/silt+clay	1000-2000	174
7D64	5-15	7-10	sand/gravel	Loam	0-2	sd+gvl/silt+clay	1000-2000	180
7D65	15-30	7-10	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	2000+	181
7D66	5-15	7-10	sand/gravel	Loam	0-2	sand + gravel	2000+	199
7D67	5-15	7-10	sand/gravel	Muck	0-2	sand + gravel	2000+	193

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7D68	5-15	7-10	sand/gravel	Loam	0-2	sand + gravel	300-700	172
7D69	15-30	7-10	sand/gravel	Sand	0-2	sand + gravel	1000-2000	188
7D70	15-30	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	1000-2000	167
7D71	15-30	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	700-1000	158
7D72	30-50	4-7	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	700-1000	124
7D73	30-50	4-7	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	1000-2000	133
7D74	15-30	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	1000-2000	182
7D75	30-50	7-10	sand/gravel	Clay Loam	6-12	sd+gvl/silt+clay	700-1000	142
7D76	15-30	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	2000+	191
7D77	15-30	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	300-700	164
7D78	15-30	7-10	sand/gravel	Sandy Loam	6-12	sd+gvl/silt+clay	300-700	149
7D79	30-50	7-10	sand/gravel	Sandy Loam	12-18	sd+gvl/silt+clay	700-1000	146
7D80	30-50	7-10	sand/gravel	Sand	12-18	sd+gvl/silt+clay	700-1000	152
7D81	30-50	4-7	sand/gravel	Clay Loam	12-18	sd+gvl/silt+clay	700-1000	122
7D82	30-50	7-10	sand/gravel	Sand	2-6	sd+gvl/silt+clay	700-1000	158
7D83	30-50	7-10	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	300-700	143
7D84	15-30	7-10	sand/gravel	Muck	0-2	sand + gravel	300-700	146
7D85	30-50	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	300-700	154
7D86	5-15	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	300-700	174
7D87	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+gvl/silt+clay	300-700	137
7D88	30-50	7-10	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	700-1000	146
7D89	15-30	4-7	sand/gravel	Clay Loam	0-2	sd+gvl/silt+clay	300-700	130
7D90	30-50	4-7	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	1000-2000	144
7D91	15-30	4-7	sand/gravel	Clay Loam	2-6	sd+gvl/silt+clay	300-700	129
7D92	15-30	4-7	sand/gravel	Shrink-swell (Aggregated) Clay	0-2	silt/clay	1000-2000	151
7D93	15-30	4-7	sand/gravel	Sandy Loam	0-2	sd+gvl/silt+clay	1000-2000	154
7D94	15-30	4-7	sand/gravel	Clay Loam	0-2	sd+gvl/silt+clay	1000-2000	148
7D95	5-15	7-10	sand/gravel	Sand	0-2	sand + gravel	300-700	180
7D96	15-30	4-7	sand/gravel	Sandy Loam	2-6	sd+gvl/silt+clay	300-700	135
7D97	5-15	7-10	sand/gravel	Silty Loam	0-2	sand + gravel	300-700	170
7D98	5-15	7-10	sand/gravel	Sand	0-2	sand + gravel	700-1000	189
7D99	15-30	7-10	sand/gravel	Sand	0-2	sand + gravel	300-700	170
7D100	5-15	7-10	sand/gravel	Sand	0-2	sand + gravel	1000-2000	198
7D101	5-15	7-10	sand/gravel	Sandy Loam	0-2	sand + gravel	700-1000	183



7G Thin Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is characterized by moderate to steep topography and deposits of thin, patchy glacial till overlying alternating layers of fractured sedimentary rock. The till is generally less than 20 feet thick and consists of varying amounts of unsorted clay, silt and sand with some pebbles and cobbles. Ground water is obtained primarily from sandstones and sandy shales, along the bedding planes, and in intersecting vertical fractures. Shale or clay layers can form aquitards, and perched ground water may be developed for domestic water supplies. Strip mines in the glaciated region are included in this setting. In these areas, the natural soils have been removed, and strip mine spoil containing mostly weathered shale and sandstone may randomly occupy the surface. Bedrock is exposed where spoil material is absent. Recharge is moderate due to increased capacity of spoil material to retain and discharge precipitation.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7G1	75-100	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	12-18	interbedded ss/sh/ls/cl/coal	100-300	111
7G2	50-75	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	12-18	interbedded ss/sh/ls/cl/coal	100-300	92
7G3	50-75	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	6-12	interbedded ss/sh/ls/cl/coal	100-300	92
7G4	50-75	2-4	interbedded ss/sh/ls/cl/coal	Sandy Loam	12-18	interbedded ss/sh/ls/cl/coal	100-300	96
7G5	50-75	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	6-12	interbedded ss/sh/ls/cl/coal	100-300	94
7G6	50-75	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	12-18	interbedded ss/sh/ls/cl/coal	100-300	90
7G7	30-50	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	2-6	interbedded ss/sh/ls/cl/coal	100-300	108
7G8	30-50	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	interbedded ss/sh/ls/cl/coal	100-300	106
7G9	50-75	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	interbedded ss/sh/ls/cl/coal	100-300	96

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating
7G10	30-50	2-4	interbedded ss/sh/ls/cl/coal	Sandy Loam	2-6	interbedded ss/sh/ls/cl/coal	100-300	112
7G11	50-75	2-4	interbedded ss/sh/ls/cl/coal	Sandy Loam	6-12	interbedded ss/sh/ls/cl/coal	100-300	98
7G12	50-75	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	6-12	interbedded ss/sh/ls/cl/coal	100-300	118
7G13	50-75	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	12-18	interbedded ss/sh/ls/cl/coal	100-300	116
7G14	30-50	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	6-12	interbedded ss/sh/ls/cl/coal	100-300	104
7G15	50-75	2-4	interbedded ss/sh/ls/cl/coal	Sand	6-12	interbedded ss/sh/ls/cl/coal	100-300	104
7G16	30-50	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	6-12	interbedded ss/sh/ls/cl/coal	100-300	102
7G17	30-50	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	6-12	interbedded ss/sh/ls/cl/coal	100-300	128
7G18	30-50	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	2-6	interbedded ss/sh/ls/cl/coal	100-300	132
7G19	30-50	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	2-6	interbedded ss/sh/ls/cl/coal	1-100	100
7G20	30-50	2-4	interbedded ss/sh/ls/cl/coal	Clay Loam	0-2	interbedded ss/sh/ls/cl/coal	100-300	107
7G21	30-50	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	2-6	interbedded ss/sh/ls/cl/coal	1-100	126
7G22	50-75	2-4	interbedded ss/sh/ls/cl/coal	Silty Loam	18+	interbedded ss/sh/ls/cl/coal	100-300	90
7G23	50-75	4-7	interbedded ss/sh/ls/cl/coal	Thin or Absent	18+	interbedded ss/sh/ls/cl/coal	100-300	114

Ground-Water Pollution Potential of STARK COUNTY

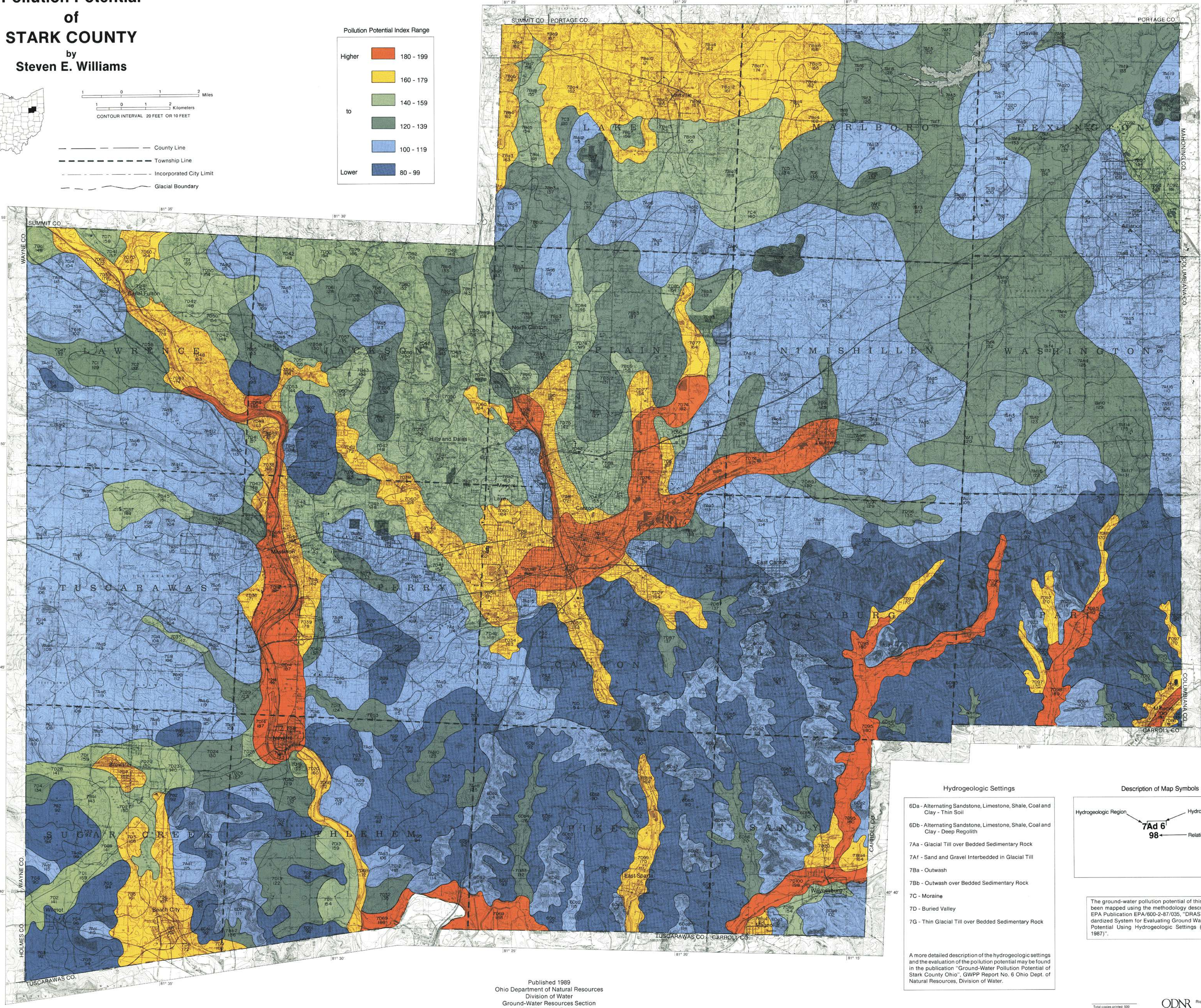
by
Steven E. Williams

1 0 1 2 Miles
1 0 1 2 Kilometers
CONTOUR INTERVAL 20 FEET OR 10 FEET

County Line
Township Line
Incorporated City Limit
Glacial Boundary

Pollution Potential Index Range

Higher	180 - 199
	160 - 179
to	140 - 159
	120 - 139
	100 - 119
Lower	80 - 99



Hydrogeologic Settings

6Da - Alternating Sandstone, Limestone, Shale, Coal and Clay - Thin Soil

6Db - Alternating Sandstone, Limestone, Shale, Coal and Clay - Deep Regolith

7Aa - Glacial Till over Bedded Sedimentary Rock

7Af - Sand and Gravel Interbedded in Glacial Till

7Ba - Outwash

7Bb - Outwash over Bedded Sedimentary Rock

7C - Moraine

7D - Buried Valley

7G - Thin Glacial Till over Bedded Sedimentary Rock

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 Stark County Ohio", GWPP Report No. 6 Ohio Dept. of Natural Resources, Division of Water.

Description of Map Symbols

Hydrogeologic Region → 7Ad 6 ← Hydrogeologic Setting
98 ← Relative Pollution Potential

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)".

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