GROUND WATER POLLUTION POTENTIAL OF MERCER COUNTY, OHIO

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.

Ground water pollution potential mapping in Mercer County resulted in a map with symbols and colors that illustrate areas of varying ground water contamination vulnerability. Three hydrogeologic settings were identified in Mercer County with computed ground water pollution potential indexes ranging from 91 to 172.

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 Mercer 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 6,000 of these wells exist in Mercer 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 countywide 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 Mercer 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 that 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 Mercer County. Inherent within each hydrogeologic setting are the physical characteristics that 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

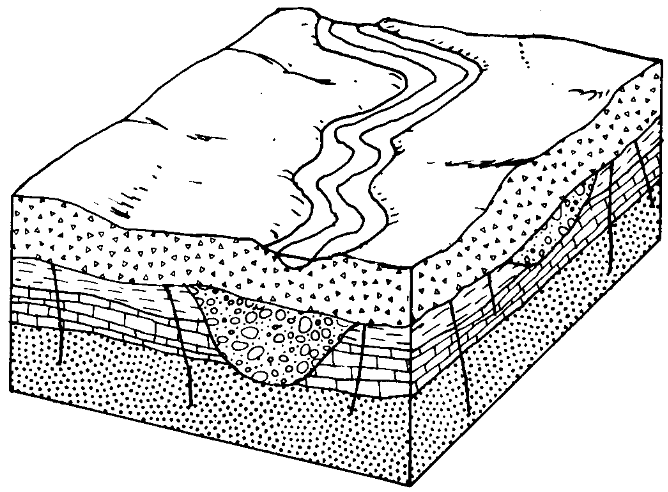
C - Conductivity (Hydraulic) of the Aquifer

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.

<u>Depth to water</u> 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.

<u>Net recharge</u> 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.

<u>Aquifer media</u> 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.



7D Buried Valley

This hydrogeologic setting is characterized by sand and gravel outwash deposits that have been deposited in a former topographic low (a pre-glacial or inter-glacial river valley) by glacial melt waters. Surficial evidence of the buried valley system is absent due to the presence of overlying glacial till. The sand and gravel outwash within the buried valley varies in thickness and areal extent but is generally composed of well sorted coarse material. Static water levels and soil composition within this setting vary greatly. Recharge to the aquifer can be attributed to the infiltration of precipitation. The outwash aquifer is hydraulically connected to the surrounding carbonate aquifer system.

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

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 judgment. 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 for use 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. 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. 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 7 D1 Buried Valley, identified in mapping Mercer 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 143. 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 Mercer County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the three settings identified in the county range from 91 to 172.

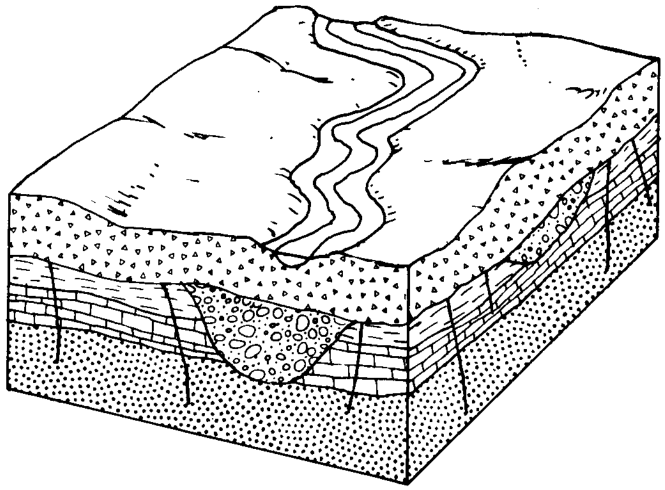
Hydrogeologic settings identified in an area are combined with the pollution potential indexes to create units that can be graphically displayed on maps. Pollution potential mapping in Mercer County resulted in a map with symbols and colors that illustrate areas of ground water vulnerability. The map describing the ground water pollution potential of Mercer 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
143 - defines the relative pollution potential



SETTING 7D1			GENERAL	
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	5-15	5	9	45
Net Recharge	4 - 7	4	6	24
Aquifer Media	sand and gravel	3	7	21
Soil Media	clay loam	2	3	6
Topography	0 - 2	1	10	10
Impact Vadose Zone	silt/clay	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	143

Figure 2. Description of the hydrogeologic setting 7D1 Buried Valley.

Here the first number refers to the major hydrogeologic region and the upper and lower case letters 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 (143) 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 MERCER COUNTY

Mercer County occupies an area of approximately 444 square miles in west-central Ohio (Figure 3). It is bounded on the north by Van Wert County, on the east by Van Wert, Auglaize and Shelby Counties, on the south by Darke County and on the west by the state of Indiana. The county seat is the city of Celina. The population of the county, according to the U.S. Department of Commerce (1987a), was 39,000. Cropland and pasture accounts for 93 percent of the land use in Mercer County, while forest covers approximately 1.74 percent (Ohio Department of Natural Resources, unpublished data).

Physiography

Mercer County lies within the Till Plains section of the Central Lowlands physiographic province (Fenneman, 1938). The county is characterized by gently sloping topography, with the only appreciable elevation changes occurring near glacial moraines and along streams. There are four east-west trending moraines or ridges in Mercer County including the Fort Wayne in northern Dublin and Union Townships; the Wabash, just north of Grand Lake -St. Mary; the St. Johns in Marion, Granville, and Fort Recovery Townships; and the Mississinewa in southern Gibson Township (Goldthwait et al., 1961).

Surface water drainage in Mercer County is divided into two continental watersheds. The Ohio-Erie Divide, from west to east, follows the Wabash Moraine, turns south about midway through Grand Lake-St. Marys, continues south to mid-Marion Township where it turns east and exits the county. North of the divide, surface water flows to Lake Erie by way of the St. Marys River. The extreme northeastern corner of the county drains into the Auglaize River by way of the Maumee River, and then to Lake Erie. South of the Ohio-Erie divide, the majority of the surface water flows into the Wabash River, which eventually empties into the Ohio River. A small area in the southeast corner of the county drains into the Great Miami River, which flows into the Ohio River.

The West Central Region of the state has a fifty-year (1931-1980) average annual precipitation of 36.69 inches (U.S. Department of Commerce, 1987b). Data from the U. S. Weather Bureau Station at Celina showed a 27-year (1957-1983) average annual precipitation of 34.67 inches and a mean temperature of 50.8 degrees Fahrenheit.

Figure 3. Location of Mercer County, Ohio.

Pre-Glacial Drainage

Pleistocene glaciation deposited a layer of drift that destroyed all surficial evidence of any pre-glacial drainage system in Mercer County. Subsurface data indicates the presence of an extensive pre-glacial drainage network that can be traced to the Teays River system. The headwaters of the Teays River were located in the Piedmont region of Virginia and North Carolina. Following a northwestern course, the river entered Ohio near Wheelersburg, Scioto County and exited the state in Black Creek Township, Mercer County.

The main valley of the Teays River, following a western course, enters Mercer County near present day Grand Lake-St. Marys. Before reaching the city of Celina, the river valley turns to a northwestern course for appropriately 10 miles to a point about 3 miles east of the city of Rockford, where the valley follows a western course out of the county. A major tributary of the Teays River entered the county in northern Marion Township and trends in a northwesterly direction, joining the main channel southeast of the city of Celina. The width of the Teays Valley varies from 1 to 2 miles (Stout et al., 1943; Leow (1987a, 1987b). For a more detailed description of the Teays River system in Mercer County, refer to Leow (1987a).

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years ago), at least four episodes of glaciation have occurred in northern North America. In Ohio, evidence exists for two glacial periods; the Illinoian, which occurred at least 120,000 years ago, and the Wisconsinan, which occurred between 70,000 and 10,000 years ago.

All of Mercer County is covered with a mantle of clayey Wisconsinan glacial till deposited directly by glacial ice. Till deposits within Mercer County are composed of poorly sorted clay, silt, sand, and gravel. Occasional thin, lens-shaped bodies of moderately sorted sand and gravel are encountered within the till. A fairly consistent one to two foot zone of sand, gravel, and boulders lies on top of the bedrock surface over much of Mercer County. Drift thickness within the county varies from 20 to 400 feet (Leow, 1987b). Four east-west trending moraines occur in Mercer County, and represent topographic highs or ridges, the result of a localized thickening of the glacial deposits. The till composition within the moraines does not appear to differ substantially from the surrounding till plains. Moraine deposits may represent areas where the glacier stagnated allowing accumulations of till to form a ridge; or they may represent a thickening of the till caused by "stacking" during active ice movement.

Illinoian glaciation is assumed to have occurred within the county because of the presence of Illinoian drift south of the county. Pre-Illinoian glaciation can be linked theoretically to the disruption of ancestral drainage systems within Mercer County.

With the advent of Pleistocene glaciation, the Teays River's northwestern flow was blocked, possibly in Indiana, creating a large finger lake within the river valley. The submerged river valley accumulated clay, silt, sand, and gravel sediments. Valley fill material within the Teays River Valley is normally characterized as silts and clays, but within Mercer County coarse sand and gravel outwash deposits are often encountered. The relative abundance of coarse fill material within the Teays Valley in Mercer County may be related to its close proximity to the leading edge of the ice sheet during deposition.

Subsequent re-advances of glacial ice totally erased any surficial evidence of the Teays River Valley in Mercer County. Clayey, late Wisconsinan till now blankets the area through which the Teays once flowed (Selby, 1978; Forsyth, 1965).

Lake bottom sediments can be found in the southeastern portion of Mercer County along the Darke County line. These sediments were deposited on the bottom of a glacial lake which occupied part of the region between the Mississinewa and St. Johns moraines during late Pleistocene times. In this area the lake sediments are composed of silt and clay and may extend to a depth of six feet. Underlying these deposits is Wisconsinan-age glacial till (Selby, 1978).

Bedrock Geology

The bedrock underlying the glacial till in Mercer County consists of shales and shaley limestones from the Ordovician System, and shales, limestones, and dolomites from the Lower to Upper Silurian System (Table 9). The bedrock formations within the county lie on the western flank of the Cincinnati Arch and have an approximate dip, or slope, of five to ten feet per mile to the northwest (Norris and Fidler, 1973).

In buried valley areas within the county, pre-glacial streams cut down through the Silurian formations and exposed the older Ordovician rocks. The Ordovician System is characterized by soft, calcareous shale, interbedded with thin, hard limestone layers. Within Mercer County, the Ordovician System has an approximate thickness of 1,200 feet (Norris and Fidler, 1973).

The Ordovician units are overlain by the Brassfield Formation. The Brassfield consists of dolomitized, very fine- to coarse-grained limestone. This formation is overlain in turn by sub-Lockport rocks that vary from dolomitized, medium- to coarse-grained limestone to clay-rich, extremely fine-grained dolomite. The combined thickness of the Brassfield Formation and the sub-Lockport rocks is estimated to be between 50 to 70 feet (Janssens, 1977).

<table>
<tr><th>SYSTEM</th><th>SERIES</th><th>GROUP</th><th>FORMATION</th><th>ROCK TYPE</th></tr>
<tr><td rowspan="4">SILURIAN</td><td>Cayugan</td><td>Salina</td><td>Greenfield</td><td>Dolomite</td></tr>
<tr><td rowspan="2">Niagaran</td><td>Lockport</td><td>Undifferentiated Lockport</td><td>Dolomite</td></tr>
<tr><td colspan="2" rowspan="1">Sub-Lockport Silurian</td><td>Limestones and Argillaceous Dolomites</td></tr>
<tr><td>Alexandrian</td><td></td><td>Brassfield</td><td>Limestone</td></tr>
<tr><td>ORDOVICIAN</td><td>Cincinnatian (and below)</td><td>Richmond (and below)</td><td></td><td>Shales and Argillaceous Limestones</td></tr>
</table>

Table 9. Generalized Bedrock Stratigraphy of Mercer County, Ohio (modified from Janssens, 1977)

The Lockport dolomite lies directly above the sub-Lockport rocks and immediately below the glacial drift across most of Mercer County. The Lockport has been described by Janssens (1977) as a white to medium-gray, coarsely crystalline pure dolomite. In Mercer County the Lockport Dolomite reaches thicknesses as great as 250 feet (Norris and Fidler, 1973).

In the northeast corner of Mercer County the Lockport is overlain by the Greenfield dolomite of the Salina Group. The Greenfield is described as a drab, extremely fine-grained dolomite with thin shale layers (Janssens, 1977). The Greenfield typically occurs as 2-6 inch beds, and has an average thickness of 50 feet (Norris and Fidler, 1973).

Hydrogeology

Mercer County was evaluated in terms of a two-aquifer system: the carbonate bedrock, and the outwash sands and gravels that are confined to the buried valley areas. The glacial drift outside of buried valley areas is not considered an aquifer within the county.

The carbonate bedrock aquifer is capable of yielding 100 to 500 gallons per minute to properly designed and constructed drilled wells (Kostelnick, 1982). Most of the domestic wells developed in the carbonate aquifer obtain their supplies from the upper portion of the aquifer (10 to 30 feet) and typically produce 10 to 20 gallons per minute. Yields to wells drilled into the carbonate formations generally rise with increased aquifer penetration; however, ground water quality usually deteriorates with depth.

Within Mercer County the carbonate bedrock aquifer appears to exhibit unconfined to semi-confined characteristics, depending on the nature of the overlying drift. Permeability within the carbonate system is dependent on primary and secondary porosity and the degree of hydraulic connection between the pore spaces.

Primary porosity refers to original void spaces within the rock, while secondary porosity refers to fracturing of the rock and enlargement of open areas through ground water solutioning. Solution activity within this carbonate system is greatest at or near the water table. Fluctuations of the water table over time have produced several distinct zones of increased permeability (Norris and Fidler, 1973).

Outwash sands and gravels are utilized as an aquifer within buried valley areas. Ground water in sand and gravel occurs and moves within the spaces between the individual grains of sand and gravel. In Mercer County, outwash sands and gravels tend to be fairly coarse, have low silt and clay content, and vary in areal extent and thickness. The outwash aquifer is overlain by silts and clays, which normally produce semi-confining conditions. Domestic wells developed in the outwash sands and gravels generally have yields in the 10 to 20 gallon per minute range. Higher ground water yields can be expected from properly designed, large diameter municipal or industrial wells. The Ordovician shales and shaley limestones that underlie the buried valley deposits yield little, if any, ground water.

The potentiometric surface map for Mercer County (Sugar, 1989) indicates a high degree of interconnection between the buried valley aquifer system and the carbonate aquifer system. In addition, static water levels taken from well logs indicate a hydraulic connection between the glacial drift materials and the carbonate bedrock aquifer. Regional ground water flow in Mercer County is to the north with some divergence towards the major river systems.

Streams in Mercer County, particularly the St. Marys River and Wabash River, are areas of ground water discharge. A study using the chemical composition of ground water in southwest Ohio indicates that the eastern third of Mercer County is a discharge area (Norris and Fidler, 1973). Infiltration of precipitation through the glacial till is the principal source of recharge to the regional aquifer system. The composition and thickness of the glacial till plays an important role in the amount of recharge reaching the aquifer.

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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 Ohio Department of Natural Resources, Division of Water. Other important sources of information include data collected for the Southwest Ohio Water Project, Dames & Moore, (1971a: 1971b: 1971c) and data collected for the Northwest Ohio Water Project (Ohio Department of Natural Resources, 1969). In areas with little or no depth to water data, interpretation of surficial geology and topography were used to determine a depth to water rating. Water levels within the moraine areas varied from 30 to 50 feet (5), 50 to 75 feet (3), and 75 to 100 feet (2). Areas outside of moraine areas generally have values for depth to water that range from 5 to 15 feet (9) and 15 to 30 feet (7). The village of Coldwater's municipal wells have caused substantial lowering of the water table. The area affected by this drawdown was given a rating that would correspond to natural conditions for the area, 30 to 50 feet (5).

Net Recharge

Precipitation data for Mercer County indicates that average annual precipitation is 35 inches (Harstine, 1991). This value approximates the state average yearly precipitation. Based on the state average yearly precipitation value, an average statewide value of recharge of 6 inches per year is given by Shindel et al., (1987). This value of recharge was used as a basis for determining net recharge in Mercer County. This typical value was further adjusted by evaluating surface slope, soil type, vadose zone, and depth to water. As slope decreases, runoff from precipitation decreases, leaving more water to infiltrate into the subsurface. Infiltration rates will generally increase as soil and vadose zone composition changes from fine to coarse material. The total depth to water and the character of the vadose zone materials was also considered in evaluating the net recharge. The flood plain areas of the st Marys River and the Wabash River were given a rating of 7 to 10 inches per year (8) due to the high water table and the permeable nature of the soils and vadose zone. Outside of the two river valleys recharge is assumed to fall within the 4 to 7 inch per year (6) range across the county.

Aquifer Media

Determinations about this factor were made using information obtained from Ohio Department of Natural Resources, Division of Water well logs and open files; Kostelnick (1982); Kutz (1977); Stout et al. (1943); OEPA (unpublished); Watkins and Ward (1962); Dayton Testing Laboratory, Inc. (1987); Patzke and DeLorenzo (1988); Norris and Fidler (1973); Dames & Moore (1971a, 1971b, 1971c); Ohio Department of Natural Resources (1969); Leow (1987a, 1987b); and Tate et al. (1973).

In areas where two aquifers are present, the uppermost aquifer was evaluated. Within the buried valley areas in Mercer County, sand and gravel was evaluated as the aquifer. A rating of (7) was assigned to most of the sand and gravel because of the relatively coarse nature of the deposits and the low silt/clay content. In the southern part of the county in Granville Township, a tributary to the main buried valley was assigned a rating of (6) due to the finer nature of the sand and gravel and increasing silt/clay content. Outside the buried valley areas, the carbonate bedrock was evaluated as the aquifer. Due to the presence of highly permeable zones within the carbonate system, and a relatively good hydraulic connection between the zones, a rating of (8) was given to the system.

Soil Media

This factor was evaluated using soil descriptions provided in the *Soil Survey of Mercer County* (Priest, 1979). Each soil was evaluated in terms of textural and organic composition, shrink-swell potential, and permeability. A DRASTIC rating was then assigned to the soil based on these factors. Stream and river valleys are generally rated as a silty loam (4), or as shrinking and/or aggregated clay (7). Outside of the stream and river valleys, the soil was evaluated as a clay loam (3).

Topography

Percentage slope was determined using 7 1/2 minute USGS topographic quadrangle maps. Moraine areas in Mercer County provide the greatest relief within the county and include slopes of 0-2 percent (10), 2-6 percent (9) and 6-12 percent (5). Most slopes within the county range from 0-2 percent (10) and 2-6 percent (9).

Impact of the Vadose Zones Media

Determinations about this factor were made using information obtained from ODNR well log files; Kostelnick (1982); Kutz (1977); Stout et al. (1943); Watkins and Ward (1962); Dayton Testing Laboratory, Inc. (1987); Patzke and Delorenzo (1988); Norris and Fidler (1973); Dames & Moore (1971a, 1971b, 1971c); Ohio Department of Natural Resources (1969); Leow (1987a, 1987b); Tate et al. (1973); and Ohio EPA unpublished file data. The vadose zone materials covering Mercer County are assumed to be composed of varying thicknesses of glacial till. The till is predominantly composed of silt and clay with thin, discontinuous, lens-shaped sand and gravel layers. The composition and permeability of the vadose zone was assumed to be fairly homogeneous over the entire county. Thus, the thickness of the vadose zone was the primary factor used to determine the vadose zone rating. A thick vadose zone received a lower rating, whereas a thin vadose zone received a higher rating. Depth to water was used as a guide in determining vadose zone thickness.

The following depth to water ratings are listed with their corresponding vadose zone ratings: depth to water (9) = vadose zone (5); depth to water (7) = vadose zone (4); depth to water (5) or (3) = vadose zone (3); depth to water (2) = vadose zone (2). The only exceptions to the above list are the flood plains of the St. Marys and Wabash Rivers where the vadose zone is rated as sand and gravel with significant silt and clay (7).

Hydraulic Conductivity

Hydraulic conductivity values were based on Ohio Department of Natural Resources well log files, Dames & Moore (1971a, 1971b, 1971c); Ohio Department of Natural Resources (1969); Leow (1987a, 1987b); Tate et al. (1973); Kostelnick (1982); Freeze and Cherry (1979). Reported hydraulic conductivity values for the carbonate system were assumed to be too low because these values were averaged over the entire aquifer thickness. Permeable zones within the carbonate system would be expected to have much higher hydraulic conductivity values. The carbonate aquifer system was assigned a hydraulic conductivity value of 300 to 700 gallons per day per square foot (4). Hydraulic conductivity values for the sand and gravel aquifers were assigned a value of 300 to 700 gallons per day per square foot (4).

APPENDIX B

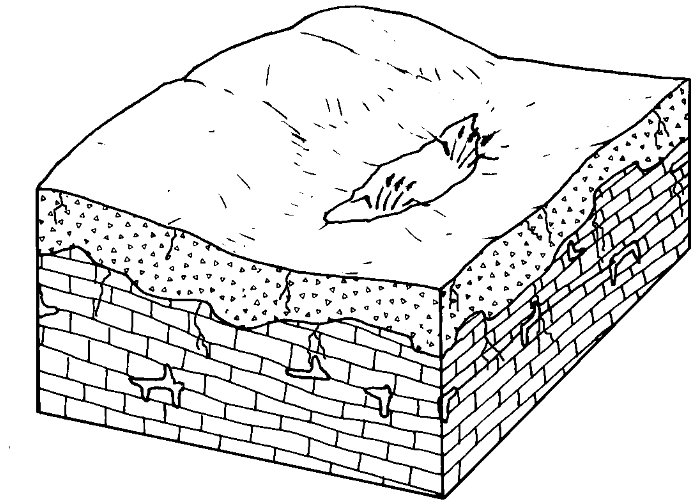
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

In the pollution potential mapping of Mercer County, three hydrogeologic settings within the Glaciated Central Region were identified. The list of these settings, the range of pollution potential index calculations and the number of pollution potential index calculations for each setting are provided in Table 10. Computed pollution potential index values range from 91 to 172.

Table 10. Hydrogeologic Settings Mapped in Mercer County, Ohio

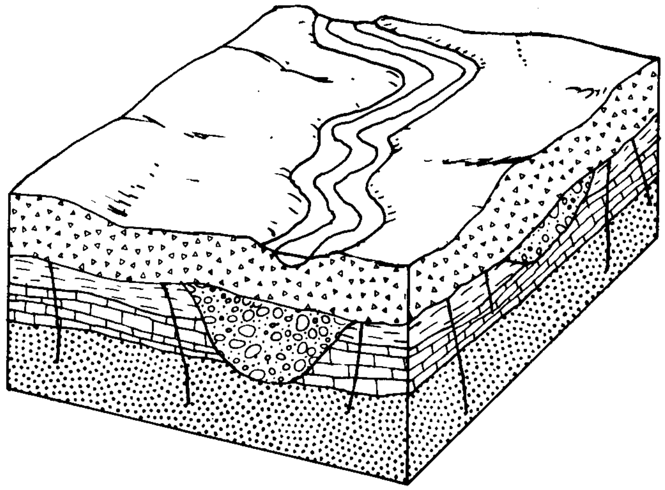
Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Ac Glacial Till Over Limestone	91-154	24
7D Buried Valley	102-172	20
7Ed Alluvium Over Glacial Till	164-172	4

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.



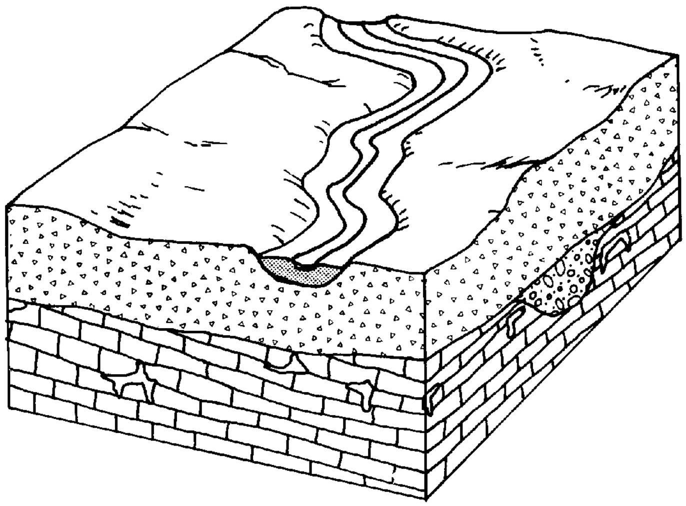
7Ac Glacial Till Over Limestone

This hydrogeologic setting is characterized by low to moderate topography and varying thicknesses of glacial till covering carbonate bedrock. The till consists primarily of clay with varying amounts of silt, sand and gravel. Sand and gravel layers within the till are normally thin or poorly sorted. The carbonate bedrock serves as the aquifer in this setting. Ground water occurs in fractures and solution channels within the bedrock. The bedrock is in direct hydraulic connection with the glacial till and precipitation infiltrating through the till serves as a source of recharge to the aquifer. Depth to water is highly variable depending in part on the thickness of the glacial till. Soils are typically classified as clay loam.



7D Buried Valley

This hydrogeologic setting is characterized by sand and gravel outwash deposits that have been deposited in a former topographic low (a pre-glacial or inter-glacial river valley) by glacial melt waters. Surficial evidence of the buried valley system is absent due to the presence of overlying glacial till. The sand and gravel outwash within the buried valley varies in thickness and areal extent but is generally composed of well-sorted coarse material. Static water levels and soil composition within this setting vary greatly. Recharge to the aquifer can be attributed to the infiltration of precipitation. The outwash aquifer is hydraulically connected to the surrounding carbonate aquifer system.



7Ed Alluvium Over Glacial Till

This hydrogeologic setting is characterized by low topography with surficial deposits of present-day stream-deposited alluvium, confined to valley areas. The alluvium is composed of silt, sand, gravel and clay that is deposited directly over the glacial till. Soils are classified as silty loam or as shrinking and/or aggregated clay. The underlying carbonate bedrock or buried valley sand and gravel deposits serve as the aquifer in this hydrogeologic setting. Depth to water is typically shallow and the overlying stream is usually in hydraulic contact with the deposits. The underlying till deposits and the carbonate bedrock are described in setting 7Ac Glacial Till Over Limestone. This hydrogeologic setting is normally a discharge area for the regional ground-water system. The local ground-water system is recharged through direct infiltration of precipitation.

Table 11. Hydrogeologic Settings, DRASTIC Factors, and Ratings

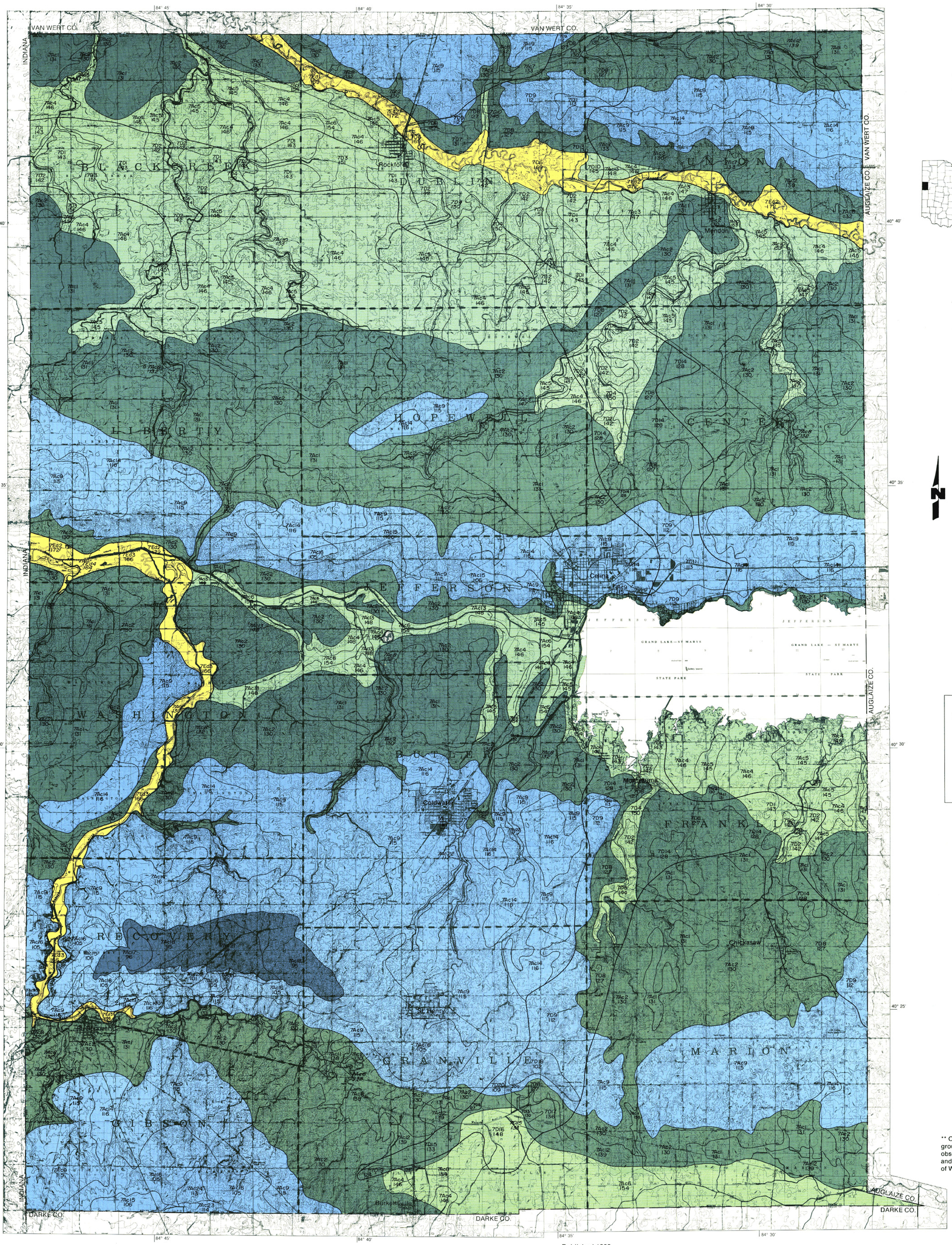
Setting	Depth to Water	Recharge	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ac1	15-30	4-7	limestone	Clay Loam	0-2	silt/clay	300-700	131	152
7Ac2	15-30	4-7	limestone	Clay Loam	2-6	silt/clay	300-700	130	149
7Ac3	5-15	4-7	limestone	Silty Loam	2-6	silt/clay	300-700	147	168
7Ac4	5-15	4-7	limestone	Clay Loam	0-2	silt/clay	300-700	146	166
7Ac5	5-15	4-7	limestone	Clay Loam	2-6	silt/clay	300-700	145	163
7Ac6	5-15	4-7	limestone	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	154	186
7Ac7	15-30	4-7	limestone	Silty Loam	0-2	silt/clay	300-700	133	157
7Ac8	15-30	4-7	limestone	Silty Loam	2-6	silt/clay	300-700	132	154
7Ac9	30-50	4-7	limestone	Clay Loam	2-6	silt/clay	300-700	115	135
7Ac10	5-15	4-7	limestone	Shrinking and/or Aggregated Clay	2-6	silt/clay	300-700	153	183
7Ac11	15-30	4-7	limestone	Shrinking and/or Aggregated Clay	2-6	silt/clay	300-700	138	169
7Ac12	15-30	4-7	limestone	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	139	172
7Ac13	5-15	4-7	limestone	Silty Loam	0-2	silt/clay	300-700	148	171
7Ac14	30-50	4-7	limestone	Clay Loam	0-2	silt/clay	300-700	116	138
7Ac15	50-75	4-7	limestone	Clay Loam	0-2	silt/clay	300-700	106	128
7Ac16	50-75	4-7	limestone	Clay Loam	2-6	silt/clay	300-700	105	125
7Ac17	75-100	4-7	limestone	Clay Loam	0-2	silt/clay	300-700	96	119
7Ac18	75-100	4-7	limestone	Clay Loam	2-6	silt/clay	300-700	95	116
7Ac19	30-50	4-7	limestone	Silty Loam	0-2	silt/clay	300-700	118	143
7Ac20	50-75	4-7	limestone	Clay Loam	6-12	silt/clay	300-700	101	113
7Ac21	75-100	4-7	limestone	Clay Loam	6-12	silt/clay	300-700	91	104
7Ac22	30-50	4-7	limestone	Silty Loam	2-6	silt/clay	300-700	117	140
7Ac23	50-75	4-7	limestone	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	114	148
7Ac24	50-75	4-7	limestone	Shrinking and/or Aggregated Clay	2-6	silt/clay	300-700	113	145
7D1	5-15	4-7	sand and gravel	Clay Loam	0-2	silt/clay	300-700	143	163
7D2	5-15	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	142	160
7D3	5-15	4-7	sand and gravel	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	151	183
7D4	5-15	4-7	sand and gravel	Shrinking and/or Aggregated Clay	2-6	silt/clay	300-700	150	180
7D5	5-15	4-7	sand and gravel	Silty Loam	2-6	silt/clay	300-700	144	165
7D6	5-15	7-10	sand and gravel	Shrinking and/or Aggregated Clay	0-2	sd & gvl w/ sl & cl	300-700	169	199
7D7	15-30	4-7	sand and gravel	Loam	2-6	silt/clay	300-700	131	156
7D8	15-30	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	127	146

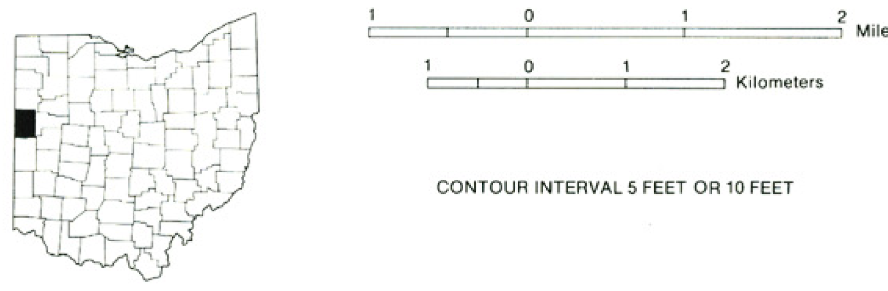
Setting	Depth to Water	Recharge	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D9	30-50	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	112	132
7D10	5-15	4-7	sand and gravel	Silty Loam	0-2	silt/clay	300-700	145	168
7D11	30-50	4-7	sand and gravel	Clay Loam	0-2	silt/clay	300-700	113	135
7D12	15-30	4-7	sand and gravel	Shrinking and/or Aggregated Clay	2-6	silt/clay	300-700	135	166
7D13	15-30	4-7	sand and gravel	Silty Loam	0-2	silt/clay	300-700	130	154
7D14	15-30	4-7	sand and gravel	Clay Loam	0-2	silt/clay	300-700	128	149
7D15	15-30	4-7	sand and gravel	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	133	166
7D16	5-15	4-7	sand and gravel	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	148	180
7D17	15-30	4-7	sand and gravel	Shrinking and/or Aggregated Clay	0-2	silt/clay	300-700	136	169
7D18	50-75	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	102	122
7D19	15-30	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	124	143
7D20	30-50	4-7	sand and gravel	Clay Loam	2-6	silt/clay	300-700	109	129
7Ed1	5-15	7-10	limestone	Silty Loam	2-6	sd & gvl w/ sl & cl	300-700	165	184
7Ed2	5-15	7-10	limestone	Shrinking and/or Aggregated Clay	0-2	sd & gvl w/ sl & cl	300-700	172	202
7Ed3	5-15	7-10	limestone	Silty Loam	0-2	sd & gvl w/ sl & cl	300-700	166	187
7Ed4	5-15	7-10	limestone	Clay Loam	0-2	sd & gvl w/ sl & cl	300-700	164	182

Ground-Water Pollution Potential of MERCER COUNTY

by

David J. Sugar





CONTOUR INTERVAL 5 FEET OR 10 FEET

County Line

Township Line

Incorporated City Limit

Pollution Potential Index Range

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

Description of Map Symbols

Hydrogeologic Region — 7Ad 6 — Hydrogeologic Setting

98 — Relative Pollution Potential

Observation Well Site**

Gravel Pit / Quarry

Hydrogeologic Settings

7D - Buried Valley

7Ac - Glacial Till Over Limestone

7Ed - Alluvium Over Glacial Till

Hydrogeologic Setting Boundary

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 Mercer County Ohio", GWPP Report No. 5 Ohio Dept. of Natural Resources, Division of Water.

** Observation well sites indicate the location of wells used to collect ground-water level information. These wells are part of the State observation well network. Hydrographs of the water levels recorded in these and other State observation wells can be obtained through ODNR-Division of Water.

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