GROUND WATER POLLUTION POTENTIAL OF MIAMI COUNTY, OHIO

BY

PAUL N. SPAHR

GROUND WATER POLLUTION POTENTIAL REPORT NO. 27

OHIO DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER

WATER RESOURCES SECTION

OCTOBER, 1995

ABSTRACT

A ground water pollution potential map of Miami County has been prepared 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.

Miami County lies within the Glaciated Central hydrogeologic region. The county is covered by variable thicknesses of glacial till, lacustrine deposits, and outwash. These unconsolidated glacial deposits are underlain by limestone, shale, and shaley limestone bedrock. Ground water yields are dependent on the type of aquifer and vary greatly throughout the county. Pollution potential indexes are relatively low to moderate in areas of till or lacustrine cover over bedrock. Buried valleys containing sand and gravel aquifers, and areas covered by outwash have moderate to high vulnerabilities to contamination.

Ground water pollution potential analysis in Miami County resulted in a map with symbols and colors which illustrate areas of varying ground water contamination vulnerability. Eleven hydrogeologic settings were identified in Miami County with computed ground water pollution potential indexes ranging from 75 to 190.

The ground water pollution potential analysis program optimizes the use of existing data to rank areas with respect to relative vulnerability to contamination. The ground water pollution potential map of Miami 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.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Number Page

ACKNOWLEDGEMENTS

The preparation of the Miami County Ground Water Pollution Potential report and map involved the contribution and work of a number of individuals in the Division of Water. Grateful acknowledgement is given to the following individuals for their technical review and map production, text authorship, report editing, and preparation:

Map preparation and review:	Paul Spahr Mike Angle Michael Hallfrisch
Map print production and review:	Xiaoning Jiang Michael Hallfrisch David Orr
Report production and review:	Paul Spahr Michael Hallfrisch Mike Angle
Report editing:	Rebecca Petty Michael Hallfrisch Paul Spahr J. Mc Call-Neubauer
Desktop publishing and report design:	David Orr Denise L. Spencer

INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 percent of Ohio citizens rely on ground water for drinking and household use 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 4,000 of these wells exist in Miami 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, 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 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 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 Miami 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 assisting 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.

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

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 sensitive ground water 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 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 100 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 15 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 Miami County. Inherent within each hydrogeologic setting are the physical characteristics which affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

D - Depth to Water

R - Net Recharge

A - Aquifer Media

S - Soil Media

T - Topography

I - Impact of the Vadose Zone Media

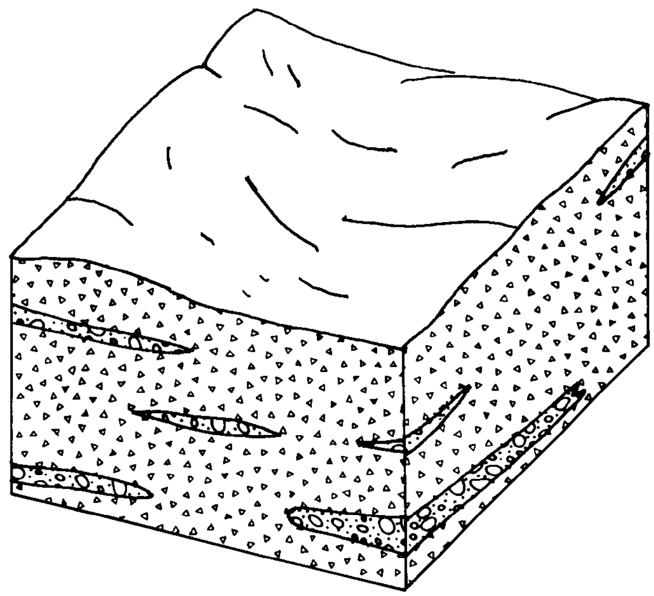
C - Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is characterized by sand and gravel interbedded within glacial till. The till is composed of clay, silt, and sand and gravel in varying amounts. The sand and gravel deposits vary from small isolated lenses to large areally extensive deposits. Sand and gravel serves as the principal aquifer in this setting. Recharge occurs from infiltration of precipitation through the glacial till. Depth to water is highly variable. Soils are typically classified as clay loam.

Figure 1. Format and description of the hydrogeologic setting - 7Af Sand and Gravel Interbedded in Glacial Till.

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

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

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 differs significantly. 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	

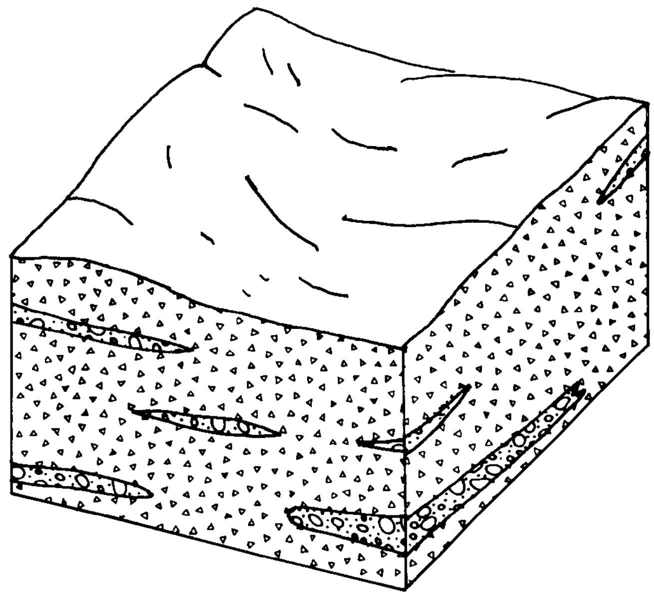
TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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 7Af1, Sand and Gravel Interbedded in Glacial Till, identified in mapping Miami 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 109. 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 Miami County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the eleven settings identified in the county range from 75 to 190.

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 analysis in Miami 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 Miami County is included with this report.



SETTING 7Af1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	6	18
Soil Media	Clay Loam	2	3	6
Topography	0-2%	1	10	10
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	100-300	3	2	6
		DRASTIC	INDEX	109

Figure 2. Description of the hydrogeologic setting - 7Af1 Sand and Gravel Interbedded in Glacial Till.

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:

7Af1 - defines the hydrogeologic region and setting
109 - defines the relative pollution potential

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (Af) refer to a specific hydrogeologic setting. The following number (1) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (109) 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 location of a selected observation well. Available information on this observation well 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 MIAMI COUNTY

Miami County occupies approximately 407 square miles in west-central Ohio. The county is divided into 12 townships and is bordered on the west by Darke County, on the north by Shelby County, on the east by Clark County, and on the south by Montgomery County (Figure 3). The county seat is the city of Troy. The population of Miami County was estimated to be 93,152 in 1990 (U.S. Department of Commerce, 1990).

Physiography

Miami County lies within the Till Plains section of the Central Lowlands physiographic province (Fenneman, 1938). The topography of the county is characterized by level to gently rolling terrain dissected by modern drainages. The surficial features of the county are predominantly glacial in origin with the exception of bedrock outcrops throughout the county. The maximum relief in the county is approximately 390 feet.

Climate

The thirty-year (1961-1990) annual average temperature for the region including Miami County, as recorded in Dayton Ohio, is 53.4 degrees Fahrenheit (U.S. Department of Commerce, 1992). January, the coldest month, has a thirty-year monthly average of 27.3 degrees Fahrenheit. July is the warmest month with a thirty-year monthly average of 76.6 degrees Fahrenheit (Table 9).

The precipitation for Miami County has been recorded at stations in Piqua, Pleasant Hill, and Tipp City. The thirty-year (1961-1990) average annual precipitation for these locations are 37.50 inches, 36.26 inches, and 37.89 inches, respectively (U.S. Department of Commerce, 1992). The wettest month is typically May and the driest month is January (Table 9).

Modern Drainage

Miami County lies within the Great Miami River Basin (Ohio Department of Natural Resources, 1985). Major sub-basins of the Great Miami River Basin in Miami County include the Stillwater River Basin (Walker, 1960a), the Miami River Basin (Middle Portion) (Walker, 1960b, c), and the Lower Mad River Basin (Walker, 1960c). Figure 4 is a generalized map of Miami County showing the modern drainage system and accompanying basins.

Figure 3. Location of Miami County

Table 9. Monthly 30 Year Average for Precipitation and Temperature (United States Department of Commerce, 1992)

Month	Precipitation (inches)			Temperature (degrees Fahrenheit)
	Piqua	Pleasant Hill	Tipp City	Dayton
January	2.15	1.97	2.02	27.3
February	2.23	1.95	2.16	30.6
March	3.34	3.19	3.38	41.5
April	3.76	3.40	3.64	52.8
May	3.90	4.12	4.25	63.6
June	3.93	3.59	4.00	72.7
July	3.58	3.72	4.04	76.6
August	3.12	3.28	3.31	74.7
September	2.57	2.53	2.72	68.0
October	2.66	2.64	2.56	55.7
November	3.22	2.94	2.97	44.5
December	3.04	2.93	2.84	32.8
Annual	**37.50**	**36.26**	**37.89**	**53.4**

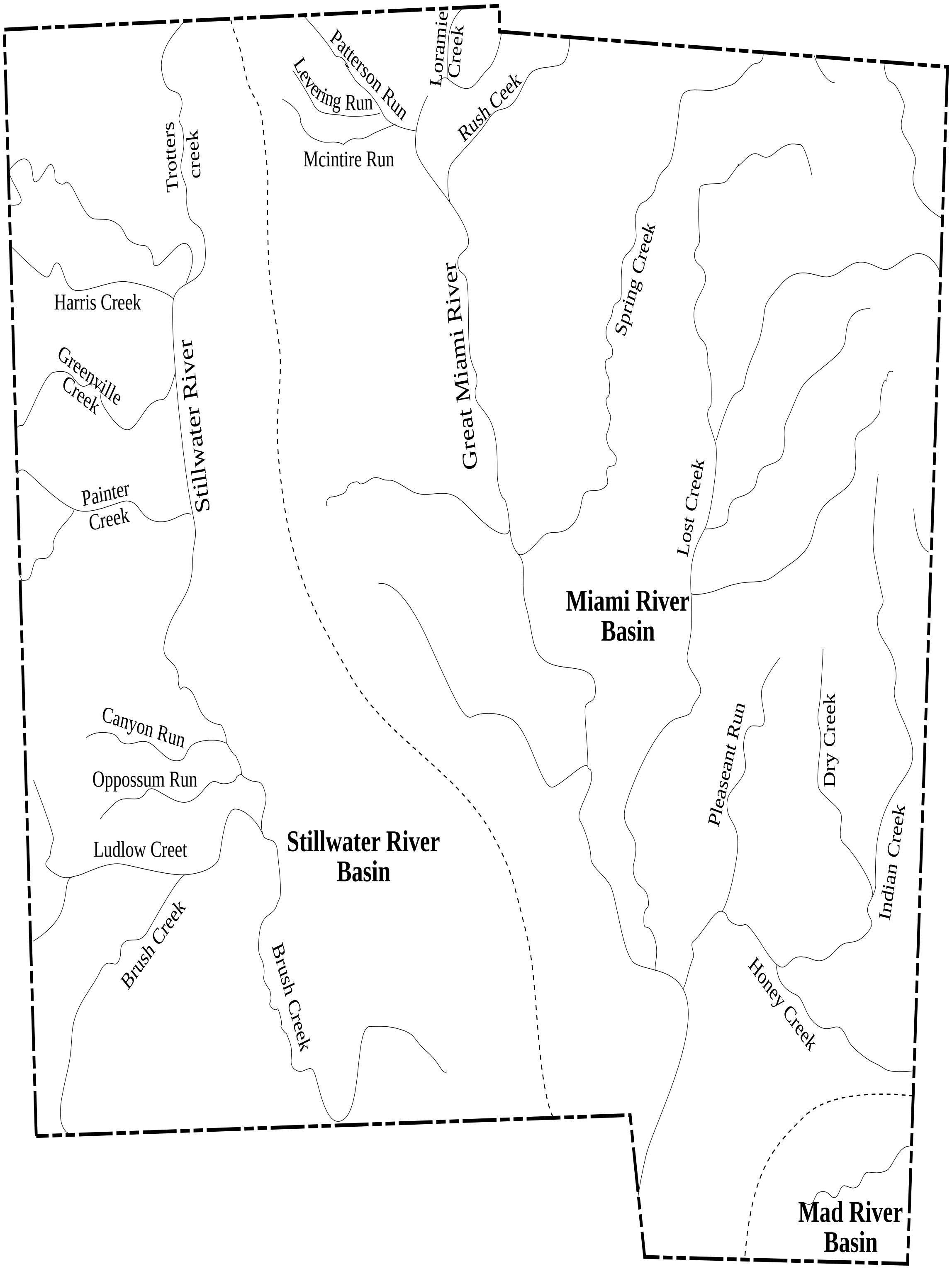


Figure 4. Generalized Modern Drainage Map (modified from Ohio Department of Natural Resources, Division of Water, 1985)

The Stillwater River Basin in Miami County is drained by the southerly flowing Stillwater River and its tributaries. The portion of this basin that lies in Miami County occupies approximately the western third of the county. The average daily discharge for a gauging station on the Stillwater River at Pleasant Hill from 1917 to 1992 is 447 cubic feet per second (U.S. Geological Survey, 1992). The largest tributary to the Stillwater River is Greenville Creek. Average discharge for a 61 year period at a gauging station for Greenville Creek, near Bradford Ohio, is 176 cubic feet per second (U.S. Geological Survey, 1992). Minor tributaries to the Stillwater River include Trotters Creek, Harris Run, Painter Creek, Canyon Run, Opossum Run, Rocky Run, Brush Creek, and Jones Run (Figure 4).

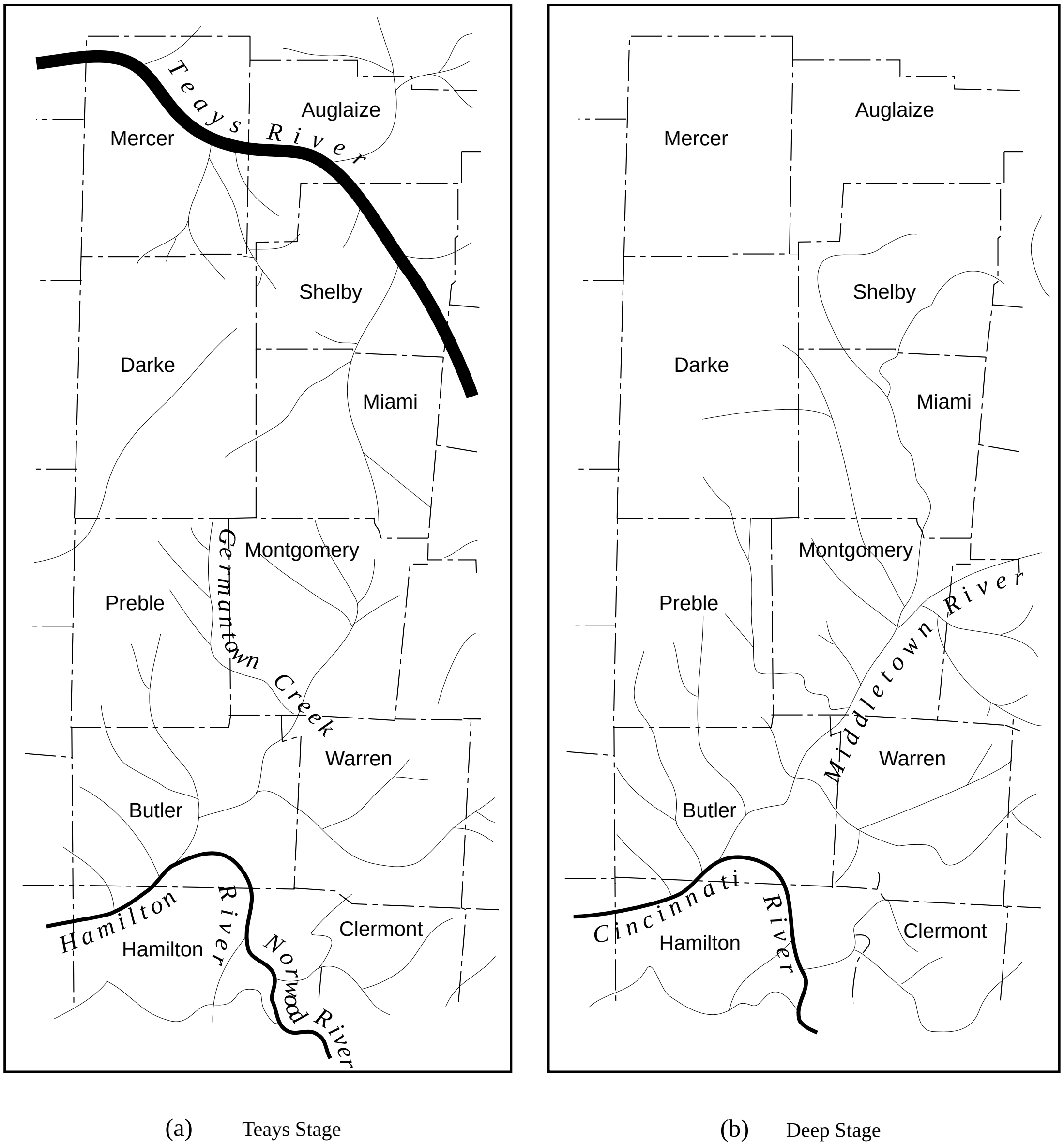
The Miami River Basin (Middle Portion) is drained by the Great Miami River and its tributaries. The portion of this basin that is present in Miami County occupies the approximate eastern two thirds of the county. The Great Miami River is the largest river in the county. Average daily discharge for a gauging station at Troy from 1963 to 1992 is 814 cubic feet per second (U.S. Geological Survey, 1992). The largest tributaries to the Great Miami River in Miami County include Spring Creek, Lost Creek, and Honey Creek (Figure 4).

A small portion of the Lower Mad River Basin is present in southeastern Miami County. Surficial drainages that are part of this basin are limited to small ephemeral tributaries to Mud Creek (Figure 4).

Ancestral Drainage and Bedrock Topography

Pre-glacial (Teays Stage) drainage in Miami County was to the north (Stout et al., 1943) (Figure 5). Teays Stage drainage was blocked by advancing glaciers during the Pre-Illinoian glacial period. The blockage of the Teays Stage drainage resulted in the formation of a new southerly drainage pattern. This new drainage pattern is referred to as Deep Stage drainage. (Figure 5).

During the Illinoian and Wisconsinan glacial periods, many geomorhphological changes resulted in subsequent changes in drainage patterns in Miami County. Glacial drift of varying thickness was deposited over the remnants of the ancestral drainage patterns. The bedrock topography of Miami County is depicted in maps by Cummins (1959), Clinch (1991), Clinch and Vormelker (1991a, b), Swinford and Brockman (1992a, b, c, d) and Vormelker (1991a, b, c, d, e, f). These maps show the configuration of the buried valley system for Miami County.



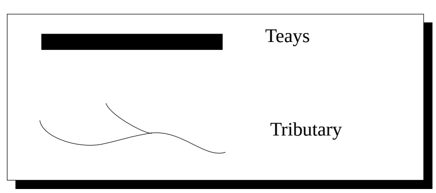


Figure 5. Teays and Deep Stage Drainage in Western Ohio (modified from Stout et al., 1943)

Glacial Geology

During the Pleistocene Epoch at least four stages of glaciation occurred in North America. Evidence for glaciation during the Wisconsinan, Illinoian, and Pre-Illinoian (Kansan) stages exist in southwestern Ohio. Surficial glacial drift throughout Miami County was deposited during the Wisconsinan stage (Goldthwait et al., 1961). Drift was deposited in the form of ice-laid (end moraines, ground moraines) and water-laid deposits (kames, outwash).

Drift deposits range in thickness from 0 to approximately 400 feet in Miami County. The thickest deposits of drift are typically located beneath end moraines or filling valleys that have been buried by glacial deposits. The thickest deposit of drift can be found in the northeastern section of the county, to the north of the Village of Lena. At this location an end moraine overlies a buried valley. Drift, composed of sand and gravel lenses interbedded in till, is approximately 400 feet thick at this site. There are many locations in Miami County where drift is absent and bedrock is exposed. Areas in which the till cover is less than 10 feet have been mapped as Thin Till over Limestone (7Gb) or as Thin Till over Bedded Sedimentary Rocks (7G).

Portions of three end moraines are present in Miami County (Goldthwait et al, 1961; Ohio Department of Natural Resources, Division of Geological Survey, 1993). End moraines are belts of hummocky terrain that are generally higher than the adjoining land and are composed of till. Till is predominantly unsorted, unconsolidated, and unstratified drift composed of a heterogeneous mixture of clay, silt, sand, and coarser rocks. End moraines are classically described as forming along the margins of a glacier where the ice was stagnant or retreating. The Bloomer and Union City End Moraines are located in the northwestern corner of Miami County. The Farmersville End Moraine is located on the eastern side of the county.

Associated with the Union City and Farmersville moraines are an anomalously high concentration of boulders referred to as the Boulder Belt (Goldthwait et al., 1961). The concentration of boulders in this area is in the range of 10 to 100 per acre. The majority of boulders are usually crystalline rocks of Canadian origin. Field observations in 1991 revealed a high concentration of boulders lining fences in Sections 23 and 29 of Elizabeth Township. These were apparently moved to the fence line by farmers in the area during agricultural operations.

Most of the surficial glacial deposits of Miami County are in the form of ground moraine. Ground moraine are extensive, broad, flat-surfaced deposits of till. The till was deposited discontinuously by ice advancing over bedrock or over older glacial deposits. Ground moraine covers most of the county. Till thicknesses in ground moraine are typically less than adjacent end moraines.

Extensive deposits of outwash are present in Miami County. Outwash is well sorted, highly stratified, commonly crossbedded deposits of sand and gravel. The sand and gravel was deposited by meltwater streams that flowed in front of the glacier. Most of the outwash in Miami County was deposited as outwash fans or as valley trains. Some of the outwash may be covered by a thin layer of recent alluvium or loess. Lenses of till and silt are common within the outwash deposits. Outwash, of various thicknesses, is found in most of the Great Miami River Valley with the exception of a narrow part of the river valley between Piqua and Farrington (Norris and Speiker, 1961). Outwash is also present in the vicinity of major portions of the Stillwater River Valley and in areas adjacent to Honey Creek (Ohio Department of Natural Resources, Division of Geological Survey, 1993).

Kames are high, steep hummocks composed of bedded sand and gravel deposited by water flowing through channels, tubes, or pits in the melting glacier. Crossbedding, dipping beds, and channel structures are common (Goldthwait et al, 1961). A high percentage of kames are found adjacent to Honey Creek in Elizabeth and Bethel Townships (Ohio Department of Natural Resources, Division of Geological Survey, 1993).

Bedrock Geology

The bedrock of Miami County is composed of upper Ordovician to upper Silurian age sedimentary rocks (Table 10). The bedrock units consist of undifferentiated Ordovician age interbedded limestone and shales overlain by Silurian age Sub Lockport, Lockport, and undifferentiated Salina limestones and dolomites. These formations lie on the western flank of the Cincinnati Arch and have an approximate dip of five to ten feet per mile to the northwest (Norris and Fidler, 1973). The configuration of the bedrock geology of Miami County can be seen in the Bedrock Geology maps of Schumacher (Schumacher, 1991a, b, c, d, e, f, g, h).

The upper Ordovician in Miami County consists of shale with minor limestone and dolomite. The shale portion is described as gray, calcareous to dolomitic, locally silty, thinly to thickly bedded, and sparsely to abundantly fossiliferous. The limestone portion is gray, micritic, thin to medium irregular wavy to planar bedded, has a rare vuggy to intergranular porosity, and is fossiliferous. The dolomite is gray, finely to coarsely crystalline, has a rare vuggy porosity and rare vertical fractures, and is laminated to medium bedded (Schumacher, 1993).

Table 10. Bedrock Stratigraphy of Miami County, Ohio. (After Schumacher, 1993)

SYSTEM	SERIES	STRATIGRAPHIC UNIT
QUATERNARY	Holo-cene	Quaternary undifferentiated
	Pleistocene	
SILURIAN	Cayugan	Salina undifferentiated
	Niagaran	Lockport Dolomite
	Alexandrian	sub-Lockport undifferentiated
ORDOVICIAN	Cincinnatian	Ordovician undivided

The Lower Silurian in Miami County consist of undiferentiated sub-Lockport dolomite and minor shale, and Lockport dolomite with rare chert and shale. The sub-Lockport dolomite is described as light gray to brown, micro to coarsely crystalline, has open vertical fractures, thin to thick irregular to planar bedding, and is sparsely fossiliferous. The minor shale portion of the sub Lockport is described as greenish-gray, dolomitic, with laminated to thin irregular to wavy bedding (Schumacher, 1993). The Lockport dolomite is described as white to gray, micro to coarsely crystalline, vuggy, with fractures perpendicular to massive to thick beds, and is commonly fossiliferous (Schumacher, 1993).

The upper Silurian bedrock in Miami County is composed of undifferentiated Salina dolomite and rare shale. The undifferentiated Salina is gray, microcrystaline to fine grained, intergranular to vuggy porosity, with open vertical fractures, laminated to thinly bedded and sparsely fossiliferous (Schumacher, 1993).

There are several locations in Miami County in which the bedrock is exposed or outcrops at the ground surface. Bedrock outcrops are found in the uplands, adjacent to the Stillwater River, near West Milton, Ludlow Falls, Pleasant Hill, and Covington. Bedrock outcrops are located in the uplands, adjacent to the Great Miami River floodplain, in the vicinity of Piqua, Troy, and Tipp City. Waterfalls on Greenville Creek and Ludlow Creek flow directly over the bedrock which outcrops on the adjacent banks of these creeks. Several limestone quarries in the county have fresh exposures of bedrock (Weisgarber, 1992). Gregory Stone (Union Township), Piqua Mineral Division (Spring Creek Township), and C.F. Poppelman, Inc. (Newberry Township) are located in areas where the bedrock is close to the surface.

Hydrogeology

An aquifer is a saturated permeable geologic unit that can transmit significant quantities of water under hydraulic gradients to yield economic amounts of water to wells (Freeze and Cherry, 1979). Aquifer media in Miami County can be classified as consolidated (bedrock) and unconsolidated (sand and gravel) formations. Consolidated aquifers in Miami County include the undifferentiated Ordovician age interbedded limestone and shales, and the Silurian age limestones and dolomites. Unconsolidated aquifers in the county are composed of sand and gravel deposits of varying extent, thickness and composition. These sand and gravel aquifers were deposited as "lenses" within till or as outwash filling buried valleys.

The undifferentiated Ordovician interbedded limestone and shale aquifer system is typically found below elevations of 875 feet in Miami County (Schumacher, 1991a, b, c, d, e, f, g, h). The Ordivician aquifer outcrops in some areas in Miami County but is typically found in the buried valleys where it is covered with varying thicknesses of drift. The Ordovician age interbedded limestone and shale is a poor aquifer due to the low permeability of the interbedded limestone and shale formations. It is usually considered a lower confining unit relative to more permeable overlying aquifers that are typically present. Well Log and Drilling Reports show that wells are developed in this aquifer only when no significant overlying aquifer of higher permeability is present. Yields from domestic wells are meager and usually less than two gallons per minute (gpm) (Schmidt, 1984).

The Silurian limestone and dolomite aquifer system is present throughout the county at elevations usually greater than 875 feet (Schumacher, 1991a, b, c, d, e, f, g, h). The permeability of this aquifer system is variable and is primarily dependent on the amount of joints, fractures, and solution openings, and the degree of interconnection between them. This aquifer system exhibits unconfined to semi-confined conditions depending on the amount and composition of any overlying unconsolidated deposits. Wells developed in this aquifer system are highly variable and yields range from 5 to 75 gpm (Schmidt, 1984).

The unconsolidated sand and gravel aquifers in Miami County occurring as "lenses" interbedded within till are found throughout the county. Well Log and Drilling Reports show that these sand and gravel aquifers show a wide range of variability in their vertical and horizontal extent, degree of sorting, and texture. Norris and Speiker (1961) state, "Locally, the deposits may consist of clean well-sorted coarse sand and gravel, ideally suited to the development of wells, but elsewhere they may be clayey, or made up chiefly of fine sand, making well development difficult or impractible". These variations are reflected in the yields obtained from the sand and gravel aquifers. Domestic wells developed in sand and gravel interbedded in till typically yield 3 to 10 gpm (Schmidt, 1984). Well Logs and Drilling Reports for this type of aquifer show that occasional yields of up to 50 gpm can be obtained with a properly constructed well in thicker, well sorted sand and gravel lenses.

Outwash sand and gravel deposits within buried valleys are the highest yielding aquifers in Miami County. Regionally extensive, thick deposits of sand and gravel adjacent to the Great Miami River are capable of producing in excess of 1000 gpm (Schmidt, 1984). Outwash deposits overlying buried valleys adjacent to Honey Creek and the Stillwater River are capable of producing up to 500 gpm (Schmidt, 1984). Well Logs and Drilling Reports for wells located within the buried valleys show a high degree of variability in the composition of the sand and gravel aquifers within the buried valleys.

Related Studies

A report prepared by the Miami Valley Regional Planning Commission entitled "A Protection Strategy for the Miami Valley Region" contains a composite data map for the Miami County area (MVRPC, 1990). Data presented on the map of the Upper Great Miami River Basin include: basin boundaries, planning area boundaries, sensitivity units, hydrodynamic divides, surface waters, community public drinking water supply sites, Priority 1 and 2 DWPA boundaries, wastewater treatment plants, industrial dischargers, package plants, water treatment plants, on-site system concentrations, sludge disposal sites, land disposal sites, municipal lagoons, industrial lagoons, agricultural lagoons, and other potential pollutant sites. The mapping of sensitivity units are somewhat similar to the DRASTIC map. The sensitivity unit descriptions on the map are divided into buried valley aquifer and upland aquifer areas. These two aquifer areas are further subdivided into units that have hydrogeologic descriptions similar to those contained in the Pollution Potential Map of Miami County. Although the sensitivity units are not given a numerical value, they are listed in order as "most sensitive" to "least sensitive" regarding vulnerability of the aquifers to contamination.

REFERENCES

Aller, L.T., Bennett, J.H. Lehr, R.J. Petty and G. Hackett, 1987. DRASTIC: A standardized system for evaluation of ground water pollution potential using hydrogeologic settings. U.S. Environmental Protection Agency, EPA / 600 / 2-87-035, 622 pp.

CH2M Hill, 1986. Final remedial investigation report, Volume 1 of 2, Miami County Incinerator, Ohio. WA113.5LHI.0

Clinch, J.M., 1991. Bedrock topography mapping of southwest Ohio: Procedures, results and a few speculations on the Teays problem. Ohio Journal of Science, Vol. 91, April Program Abstracts, p. 35.

Clinch, J.M. and Vormelker, J.D., 1991a. Bedrock topography of the Gettysburg quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5A4, 1 map.

Clinch, J.M. and Vormelker, J.D., 1991b. Bedrock topography of the Versailles quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5B4, 1 map.

Cummins, J.W., 1959. Probable surfaces of bedrock underlying the glaciated area in Ohio. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory, Water Inventory Report 10, 3 pp. 2 maps.

Dames and Moore, 1971a. Hydrologic survey of ground water potential in southwest Ohio, Province XVI, Greenville Creek. Unpublished Report Prepared for the Ohio Department of Natural Resources, Division of Water, 23 pp.

_________________, 1971b. Hydrogeologic survey of ground water potential in southwest Ohio, Province XII, Upper Great Miami River. Unpublished Report Prepared for the Ohio Department of Natural Resources, Division of Water, 31 pp.

_________________, 1971c. Hydrogeologic survey of ground water potential in southwest Ohio, Province XIV, Stillwater River. Unpublished Report Prepared for the Ohio Department of Natural Resources, Division of Water, 40 pp.

Eagon, H.B., 1973. Report of ground water investigation, well capacity tests, rest areas 23 and 24, I-75, Miami County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, 5 pp.

Eastman, J.A., 1989. Progress report, Willow Run Wellfield. Lockwood, Jones and Beals, Inc.

Fenneman, N.M., 1938. Physiography of the eastern United States. McGraw-Hill Book Co., New York, New York, 714 pp.

Forsyth, J.L., 1965. Contribution of soils to the mapping and interpretation of Wisconsinan tills in western Ohio. Ohio Division of Geologic Survey, Ohio Journal of Science, Volume 65, No. 4, 9 pp.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater. Prentice-Hall Inc., Englewood Cliffs, New Jersey, 604 pp.

Goldthwait, R.P., G.W. White, and J.L. Forsyth, 1961. Glacial geology of Ohio. Ohio Department of Natural Resources, Division of Water and Geologic Survey, 1 map.

Hallfrisch, M.P and M.P. Angle., in progress. Ground water pollution potential of Montgomery County, Ohio. Ohio Department of Natural Resources, Division of Water.

Heath, R.C., 1984. Ground water regions of the United States. U.S. Geological Survey, Water Supply Paper 2242, 78 pp.

Horvath, A.L. and D. Sparling, 1967. Guide to the forty second annual field conference of the section of geology of the Ohio academy of science, Silurian geology of western Ohio. Unpublished Guide, 25 pp.

Klaer, F.H. and Associates, 1966. Potential ground water supply, Miami and Erie canal area, city of Piqua, Ohio. Report prepared for Bonhan, Grant and Brundage, Consulting Engineers, Columbus, Ohio. 13 pp.

Klaer, F.H. and Associates, 1970. Report on pumping tests, Grayson area, Great Miami River Valley, Miami County, Ohio. Prepared for the Miami Conservancy District, Dayton, Ohio.

Lehman, S.F., and Bottrell, G.D., 1978. Soil survey of Miami County Ohio. United States Department of Agriculture, Soil Conservation Service, 100 pp., 59 maps.

Miami Valley Regional Planning Commission, 1990. A groundwater protection strategy for the Miami valley region. Draft report, volume three, Upper Great Miami River Basin, Management Units Plans: BV-1 and UL-1.

Norris, S.E. and R.E. Fiddler, 1973. Availability of water from Limestone and Dolomite aquifers in southwest Ohio and the relation of water quality to the regional flow system. U.S. Geological Survey, Water Resource Investigations 17-73, 42 pp.

Norris, S.E. and A.M. Speiker, 1961. Geology and hydrology of the Piqua area, Ohio. United States Geological Survey, Geological Survey Bulletin 1133-A, 33 pp.

Norris, S.E. and A.M. Speiker, 1966. Ground water resources of the Dayton, area, Ohio. United States Geological Survey, Geological Survey Water-Supply Paper 1808, 167 pp, 9 plates.

Ohio Department of Natural Resources, 1985. Principal streams and their drainage areas, Division of Water, 1 map.

Ohio Department of Natural Resources, 1993. Quaternary geology of Ohio. Division of Geological Survey, open file maps quadrangles, Muncie and Cincinnati quadrangles, 1:250,000.

Ohio Environmental Protection Agency, 1986. Ohio ground water protection and management strategy. 67 pp.

Pettyjohn, W.A., and R. Henning, 1979. Preliminary estimate of ground water recharge rates, related streamflow and water quality in Ohio. U.S. Department of the Interior, Office of Water Research and Technology, Project A-051-Ohoi, 323 pp.

Schmidt, J.J., 1984. Ground water resources of Miami County, Ohio. Ohio Department of Natural Resources, Division of Water, 1 map.

Schmidt, R.G. and Associates, 1987. A source protection program for the water supply system of the city of Troy, Ohio, final report.

Schumacher, G.A., 1991a. Preliminary bedrock geology of the Troy, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5A2, 1 map.

_________________, 1991b. Preliminary bedrock geology of the Gettysburg, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5A4, 1 map.

_________________, 1991c. Preliminary bedrock geology of the Piqua West, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5B3, 1 map.

_________________, 1991d. Preliminary bedrock geology of the Pleasant Hill, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5A3, 1 map.

_________________, 1991e. Preliminary bedrock geology of the Piqua East, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5B2, 1 map.

_________________, 1991f. Preliminary bedrock geology of the Christianburg, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5A1, 1 map.

_________________, 1991g. Preliminary bedrock geology of the Fletcher, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5B1, 1 map.

_________________, 1991h. Preliminary bedrock geology of the Versailles, Ohio quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map BG-C5B4, 1 map.

Schumacher, G.A., 1993. Regional bedrock geology of the Ohio portion of the Piqua, Ohio-Indiana 30 x 60-minute quadrangle. Ohio Division of Geological Survey Map, No. 6. Ohio Department of Natural Resources, Division of Geological Survey, 1 map.

Spahr, P.N., 1991, Ground water pollution potential of Darke County, Ohio. Ohio Department of Natural Resources, Division of Water, Ground Water Pollution Potential Report No. 25, 99 pp., 1 map.

Stout, W., VerSteeg, K., and Lamb, G.F., 1943. Geology of water in Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 44, 69 pp., 8 maps.

Swinford, E.M. and C.S. Brockman, 1992a. Bedrock topography of the Laura quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map B5H4, 1 map.

__________________, 1992b. Bedrock topography of the New Carlisle quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File MapB5H1, 1 map.

__________________ , 1992c. Bedrock topography of the Tipp city quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map B5H2, 1 map.

__________________ , 1992d. Bedrock topography of the west Milton quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Open File Map B5H3, 1 map.

URS Consultants, 1991. Unpublished Report on the west Milton water study

U.S. Department of Commerce, 1990. Ohio population by governmental unit. Bureau of Census, Current Population Reports

U.S. Department of Commerce, 1992. Monthly station normals of temperature, precipitation and heating and cooling degree days 1961-1990 Ohio. National Oceanic and Atmospheric Administration, National Climatic Data Center, Climatology of the United States, No. 81 (by State) 28 pp.

U.S. Geological Survey, 1992, Water resources data for Ohio, water year 1991, volume 1. Ohio River Basin excluding project data. U.S. Geological Survey, Water Resources Division, 440 pp.

Vormelker, J.D., 1991a. The Bedrock topography of the Fletcher quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5B1, 1 map.

Vormelker, J.D., 1991b. The Bedrock topography of the Christianburg quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5A1, 1 map.

Vormelker, J.D., 1991c. The Bedrock topography of the Pleasant Hill quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5A3.

Vormelker, J.D., 1991d. The Bedrock topography of the Piqua West quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5B3, 1 map.

Vormelker, J.D., 1991e. The Bedrock topography of the Piqua East quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5B2, 1 map.

Vormelker, J.D., 1991f. The Bedrock topography of the Troy quadrangle. Ohio Department of Natural Resources, Division of Geologic Survey, Open File Map BT-C5A2, 1 map.

Walker, A.C.,1960a. Stillwater River Basin underground water resources. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory, File Index H 6 and 7, 1 map.

Walker, A.C., 1960b. A portion of the Miami River Basin (Loramie and Mosquito Creek area) underground water resources. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory, File Index H 2, 1 map.

Walker, A.C., 1960c (reprinted 1978). Miami River Basin (part of middle portion) and Lower Mad River Basin underground water resources. Ohio Department of Natural Resources, Division of Water, Ohio Water Plan Inventory, File Index H 4 and H-5, 1 map.

Weisgarber, S.L., 1992. 1991 Report on Ohio mineral industries. Ohio Department of Natural Resources, Division of Geological Survey, 138 pp., 1 map.

UNPUBLISHED DATA

Ohio Department of Natural Resources, Division of Water, Water Resources Section, Well Log and Drilling Reports for Miami County.

APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Depth to water data were evaluated and mapped depending on which aquifer medium was being evaluated and the depth of the aquifer from the land surface. This factor was primarily evaluated using Well Log and Drilling Reports for Miami County on file at the Ohio Department of Natural Resources, Division of Water. Additional depth to water data were obtained from the U.S. Geological Survey (1992), Spahr (1991), Hallfrisch and Angle (in progress), Norris and Speiker (1961), Norris and Speiker (1966), Dames and Moore (1971a, 1971b, 1971c). In areas with little or no data for depth to water, supplemental values were estimated based on an interpretation of the geomorphology.

The aquifers of Miami County were interpreted as being unconfined to semi-confined. Aquifers which are present at the ground surface and are not overlain by a geologic unit of significant lower permeability were considered to be unconfined. Unconfined aquifers in Miami County included major portions of the aquifers underlying the Great Miami and Stillwater River valleys. Aquifers in which the depth to the bedrock aquifer from the ground surface was less than 10 feet were also considered to be unconfined. An aquifer overlain (and underlain) by a confining geologic unit of lower permeability than the aquifer, but allowing water to travel downward into the aquifer, was assumed to be semi-confined. The depth to water for the unconfined and semi-confined aquifers in Miami County was considered to be the distance from the land surface to the surface below the ground where all of the pore spaces are filled with water.

Depth to water in the bedrock aquifers was evaluated as belonging to either the Silurian limestone or dolomite aquifer or the Ordovician interbedded limestone and shale aquifer. Water level data from Well Log and Drilling Reports varied according to the depth of the well. Depth to water in the bedrock aquifers for Miami County ranged from 5 to 50 feet below the land surface and were given DRASTIC ratings of (9) to (5).

Depth to water in the sand and gravel aquifers was evaluated using data obtained from wells that were believed to be completed in the same regionally extensive aquifer and at the same depth. The depth to water in areas in which wells penetrate different sand and gravel aquifers at different depths showed a wide range of values. For example, the buried valley to the east of Piqua in Spring Creek Township has several aquifers at different depths. Water level data from Well Log and Drilling Reports show a high degree of variability in the depth to water. A well completed in a sand and gravel aquifer at 16 to 23 feet below the land surface had a static water level of 9 feet below the land surface resulting in a DRASTIC rating of (9). Another well, located less than a half mile away is developed in a sand and gravel aquifer from 210 to 234 feet below the land surface. The static water level in this well was 80 feet below the land surface resulting in a DRASTIC rating of (2). In scenarios such as these, if the shallow aquifer was regionally extensive, the shallower depth to water was generally used for the DRASTIC rating.

Depth to water values for the sand and gravel aquifers in Miami County ranged from 5 to 100 feet below the land surface and were given DRASTIC ratings of (9) to (2). Depth to water for sand and gravel aquifers adjacent to the floodplains of modern drainage systems ranged from 5 to 30 feet below the land surface which correspond to a DRASTIC rating of (9) to (7). Depth to water in areas with deep wells and significant till cover typically had deeper depths to water. Areas mapped as buried valleys (7D) have the broadest range of depth to water values. Depth to water ranged from 5 to 100 feet (DRASTIC rating of (9) to (2)) in this hydrogeologic setting.

Net Recharge

As used in the DRASTIC methodology, net recharge is defined as the total quantity of precipitation, in inches per year, applied to the ground surface that infiltrates to the aquifer (Aller et al, 1987). Net recharge values were derived from data and information provided in Pettyjohn and Henning (1979), Hallfrisch and Angle (in progress), Spahr (1991), Lehman and Bottrell (1978), and Well Log and Drilling Reports for wells located in Miami County, Ohio.

The average annual precipitation for Miami County is approximately 37 inches per year. Only a portion of the 37 inches infiltrates the aquifer. The remainder is lost through evaporation, transpiration, and surficial runoff. The amount of recharge reaching the aquifer is dependent on and influenced by DRASTIC parameters such as topography, vadose zone material, and soil type. As the slope of the land surface becomes steeper, the amount of runoff increases. Therefore, net recharge would be less in steeper areas relative to flatter regions. The amount of recharge to an aquifer system is also influenced by the amount of coarse to fine material found in the soil and vadose zone. Coarser deposits are more permeable than finer deposits and will therefore allow a higher percentage of precipatation to infiltrate the aquifer system.

Areas in Miami County that have a clay loam soil, a significant thick till as a vadose zone, and the Ordovician interbedded limestone and shale as an aquifer were evaluated as receiving 2 to 4 inches per year of recharge to the aquifer (DRASTIC rating of (3)). This value was common in portions of Miami County mapped as Till over Shale (7Aa). A DRASTIC rating of (3) was given to portions of the Thin Till Over Shale (7G) hydrogeologic setting located adjacent to the Stillwater and Great Miami Rivers. This setting typically has a steep slope of interbedded limestone and shale of low permeability.

A large portion of various hydrogeologic settings in Miami County was estimated to receive 4 to 7 inches per year (DRASTIC rating of (6)) of recharge to the underlying aquifers. This rating was also given to settings located in flat areas with a clay loam soil and a till vadose zone. A DRASTIC rating of (6) was given to all of the Sand and Gravel Interbedded in Till (7Af) and Till Over Limestone (7Ac) hydrogeologic settings. A DRASTIC rating of (6) was given to portions of the Till over Shale (7Aa) settings. These areas are flat and have a thin layer of till as a vadose zone.

A net recharge of 7 to 10 inches per year (DRASTIC rating of (8)) was given to flat areas in Miami County with permeable soils and a coarse vadose zone of sand and gravel with significant amounts of silt and clay. Areas adjacent to modern drainages were given a DRASTIC recharge value of (8). These areas included large portions of the Buried Valley (7D) setting, Alluvium over Bedded Sedimentary Rock (7Ec) setting, and the Alluvium over Till (7Ed) setting. Outwash over Limestone (7Bc), Outwash over Bedded Sedimentary Rock (7Bb), and Outwash over Till (7Bd) were given a DRASTIC recharge value of (8). Areas mapped as Thin Till over Limestone (7Gb) were generally given a DRASTIC rating of (8). These areas have less than ten feet of till over fractured limestone. The tills in this setting were assumed to be fractured and more permeable than those with greater than ten feet of till.

Aquifer Media

Aquifer media is defined as the consolidated or unconsolidated rock that yields sufficient quantities of water for use (Aller et al., 1987). This parameter was evaluated using data obtained from field observations by the author, Well Log and Drilling Reports for Miami County on file at the Ohio Department of Natural Resources, and from the following reports and maps: Dames and Moore (1971a, b, c), Hallfrisch and Angle (in progress), Spahr (1991), Schmidt (1984), Schumacher (1991a, b, c, d, e, f, g, h), Norris and Fidler (1973), Norris and Speiker (1961), Horvath and Sparling (1967) and Stout et al., (1943).

DRASTIC ratings are assigned to aquifer media based on the degree of fracturing and bedding planes of consolidated bedrock aquifers, and on the degree of sorting and the amount of fine material present in the unconsolidated sand and gravel aquifers. Similar to the rating of depth to water, in areas where there is more than one aquifer present, the shallower aquifer is evaluated. The aquifers in Miami County were assumed to be semi-confined to unconfined.

The consolidated bedrock aquifers of Miami County consist of Silurian limestone and Ordivician interbedded limestones and shales. The Silurian limestone aquifer was given a DRASTIC rating of (6) The less permeable Ordovician interbedded limestone and shale aquifer was given a DRASTIC rating of (3). Bedrock was evaluated as the aquifer media in areas of the county where the overlying material did not contain sufficient amounts of sand and gravel to supply water to domestic wells. The type of aquifer media present was delineated using the bedrock geology maps of Shcumacher (1991a, b, c, d, e, f, g, h), the ground water resource map of Schmidt (1984), and Well Log and Drilling Reports on file at the Ohio Department of Natural Resources.

Limestone was evaluated as the aquifer media for all of the Till Over Limestone (7Ac) and the Thin Till over Limestone (7Gb) hydrogeologic settings. Portions of the Outwash Over Till (7Bd) setting and Alluvium Over Bedded Sedimentary Rock (7Ec) setting were rated as having limestone as the aquifer media.

The interbedded limestone and shale aquifer was evaluated as the media for the Thin Till over Bedded Sedimentary Rocks (7G) and the Till Over Shale (7Aa) hydrogeologic setting. Portions of the Alluvium Over Bedded Sedimentary Rocks (7Ec) and Outwash Over Till (7Bd) settings were evaluated as having interbedded limestone and shale aquifer media.

The unconsolidated sand and gravel aquifers of Miami were given DRASTIC ratings of (6), (7), or (8) depending on the degree of sorting, coarseness, and the composition of the deposit. Sand and gravel aquifers in Miami County are located within buried valleys as valley train deposits, interbedded in glacial till, and as outwash. The sand and gravel aquifers adjacent to most reaches of the Stillwater River, the Great Miami River, and Honey Creek generally were given higher ratings in comparison to other parts of the county.

Soil Media

This parameter was evaluated using the soil survey of Miami County, Ohio (Lehman and Bottrell, 1978). Each soil was evaluated and given a DRASTIC rating for soil media (Table 11). Evaluations were based on the texture, permeability, and shrink swell potential of each soil unit. DRASTIC ratings for soil media are lower for soils in which the parent material is till than soils in which parent material is outwash or alluvium.

Table 11. MIAMI COUNTY SOILS (after Lehman and Bottrell, 1978)

Soil Name	DRASTIC Rating	Soil Media
Algiers	4	clay loam
Blount	3	clay loam
Brookston	3	clay loam
Celina	3	clay loam
Corwin	3	clay loam
Crosby	3	clay loam
Edwards	2	muck
Eel	5	loam
Eldean	5	loam
Eldean-Casco	5	loam
Eldean-Miamian	5	loam
Genessee	5	loam
Glynwood	3	clay loam
Linwood	2	muck
Lorenzo-Rodman	9	sand
Martinsville	5	clay loam
Medway	3	clay loam
Miamian	3	clay loam
Millsdale	7	shrink, swell
Milton	3	clay loam
Montgomery	3	clay loam
Ockley	4	silt loam
Odell	3	clay loam
Pewamo	3	clay loam
Randolph	7	shrink, swell
Ritchey	10	thin, absent
Ross	4	silt loam
Ross (variant)	10	thin, absent
Shoals	4	silt loam
Shoals (variant)	10	loam
Sleeth	3	clay loam
Stonelick	6	sandy loam
Walkill	4	silt loam
Warsaw	5	loam
Wea	4	clay loam
Westland	6	sandy loam

Topography

Topography, or percent slope, was evaluated using USGS 7.5 minute quadrangle maps and the soil survey of Miami County, Ohio (Lehman and Bottrell, 1978). DRASTIC ratings for topography ranged from (3) to (10) (12-18 percent to 0-2 percent).

Impact of the Vadose Zone Media

Vadose zone media in Miami County consisted of till, sand and gravel with significant silt and clay, sand and gravel, silt and clay, limestone, and interbedded limestone and shale. Numerical DRASTIC ratings were given based on composition, thickness, and permeability of the vadose zone deposits. This parameter was evaluated using information obtained from Hallfrisch and Angle (in progress), Spahr (1991), Forsyth (1965), Lehman and Bottrell (1978), Dames and Moore (1971a,b,c), Well Log and Drilling Reports on file at the Ohio Department of Natural Resources, and field observations made by the author.

DRASTIC values for vadose zone media in Miami County ranged from (3) to (8). Till, where evaluated as a vadose zone media, was given a DRASTIC rating of (3) for areas to the northeast of Greenville Creek. A rating of (4) was given to the till vadose zone for the remainder of the county. These ratings were given because the till northeast of Greenville Creek and associated with the Union City and Bloomer Moraines are more clay-rich and therefore less permeable than till in the remainder of the county. Sand and gravel with significant silt and clay and silt and clay were evaluated as the vadose for areas that contained outwash and recent modern alluvium deposits. These areas were generally adjacent to the Great Miami River, Honey Creek, Greenville Creek, Ludlow Creek, and the Stillwater River. DRASTIC ratings for areas evaluated as having sand and gravel with significant silt and clay ranged from (5) to (7). Silt and clay deposits were given a rating of (4) or (5). Sand and gravel as a vadose zone media was generally evaluated in areas that contain coarse outwash deposits. A DRASTIC rating of (8) was generally given to these deposits. In areas that had a small amount of unconsolidated material over the bedrock, limestone or interbedded limestone and shale was evaluated as the vadose zone media. Limestone was given a DRASTIC rating of (6) and the interbedded limestone and shale was given a rating of (3) for vadose zone.

Hydraulic Conductivity

This parameter was evaluated using data obtained from Dames and Moore (1971a, b, c), Klaer and Associates (1966), Klaer and Associates (1970), URS Consultants (1991), Eastman (1989), Eagon (1973), Norris and Fidler (1973), Norris and Speiker (1961), Norris and Speiker (1966), Schmidt (1987), CH2M Hill (1986), Miami Valley Regional Planning Commission (1990), Spahr (1991), and Hallfrisch and Angle (in progress).

Hydraulic conductivity, the ability of the aquifer media to transmit water, is dependent on the properties of water and the aquifer. Hydraulic conductivity values for Miami County were highly variable due to the anisostropy and heterogeneity of the aquifer systems. The lowest hydraulic conductivities of aquifer media are in the Ordivician interbedded limestone and shale aquifer. The Ordivician interbedded limestone and shale aquifer was evaluated as having hydraulic conductivity values ranging from 1 to 100 gallons per day per square foot (gpd/Ft^2). This corresponds to a DRASTIC rating of (1). The Silurian limestone aquifer was evaluated as having hydraulic conductivity values ranging from 100 to 300 gpd/Ft^2 (DRASTIC rating of (2)). The sand and gravel aquifers of Miami County have a much higher degree of variability in hydraulic conductivity values. Values ranged from 100 to over 2000 gpd/Ft^2. Drastic values assigned to these aquifers ranged from (2) to (10). Values for the hydraulic conductivity varied depending on the degree of sorting, coarseness, thickness, and the amount of fine material within the sand and gravel aquifer.

APPENDIX B

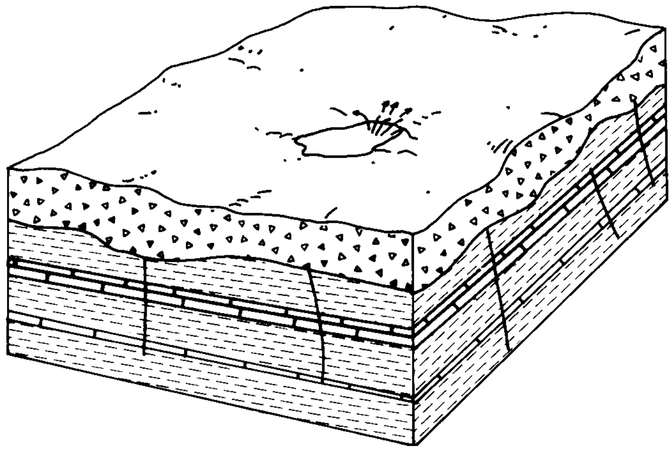
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Miami County resulted in the identification of eleven hydrogeologic settings within the Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 12. Computed pollution potential indexes for Miami County range from 75 to 190.

Table 12. Hydrogeologic Settings Mapped in Miami County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa - Glacial Till Over Bedded Sedimentary Rock	92 - 107	8
7Ac - Glacial Till Over Solution Limestone	99 - 151	23
7Af - Sand & Gravel Interbedded in Glacial Till	107 - 138	28
7Bb - Outwash over Bedded Sedimentary Rock	160 - 171	3
7Bc - Outwash Over Limestone	159 - 169	2
7Bd - Outwash Over Glacial Till	116 - 157	10
7D - Buried Valley	102 - 190	85
7Ec - Alluvium Over Sedimentary Rock	129 - 161	11
7Ed - Alluvium Over Glacial Till	128 - 155	9
7G - Thin Till Over Bedded Sedimentary Rocks	75 - 112	11
7Gb - Thin Till Over Limestone	126 - 155	20

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

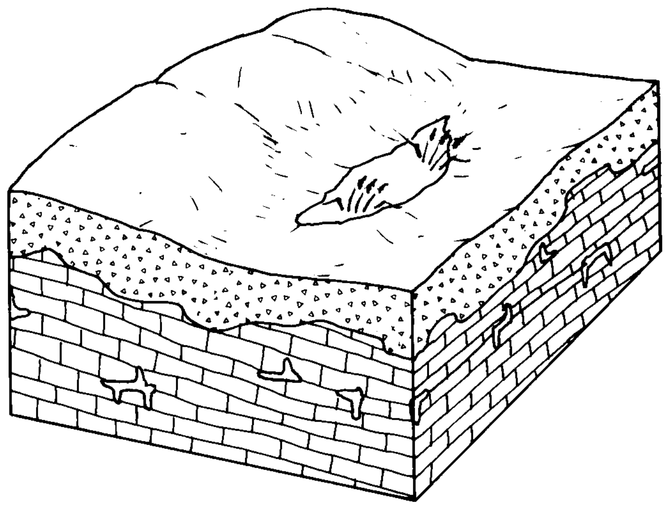


7Aa Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is characacterized by relatively flat-lying, fractured sedimentary rocks covered by more than ten feet of glacial till. The fractured bedrock consists of interbedded limestone and shale. The till consists primarily of clay with varying amounts of silt, sand, and gravel. Sand and gravel deposits within the till are extremely thin or nonexistent. Small supplies of ground water are obtained from the upper weathered portion of the bedrock and from intersecting fractures and bedding planes. Soils in this setting are typically clay or silt loams. Recharge is moderate to low because of low permeability of the overlying till and soils. Relief in this setting is moderate to steep. Depth to water is variable, ranging between 5 and 50 feet, but averages around 30 feet.

GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rock range from 92 to 107 with the total number of GWPP index calculations equaling 8.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topogr aphy	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa1	15-30	2-4	limestone/shale	Clay Loam	2-6	till	1-100	94	116
7Aa2	15-30	4-7	limestone/shale	Clay Loam	0-2	till	1-100	107	131
7Aa3	30-50	4-7	limestone/shale	Clay Loam	6-12	till	1-100	92	106
7Aa4	15-30	4-7	limestone/shale	Clay Loam	2-6	till	1-100	106	128
7Aa5	5-15	2-4	limestone/shale	Clay Loam	0-2	till	1-100	105	129
7Aa6	15-30	4-7	limestone/shale	Clay Loam	6-12	till	1-100	102	116
7Aa7	15-30	4-7	limestone/shale	Clay Loam	12-18	till	1-100	100	110
7Aa8	15-30	4-7	limestone/shale	Silty Loam	6-12	till	1-100	104	121



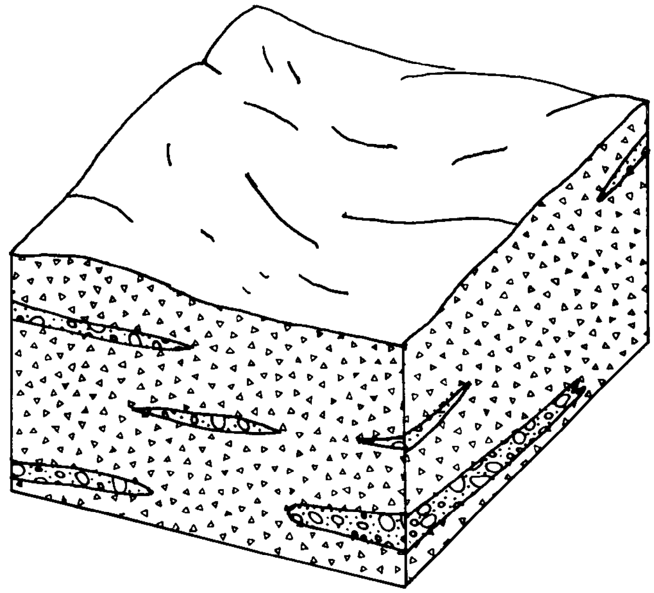
7Ac Glacial Till Over Limestone

This hydrogeologic setting is characterized by low to moderate relief and limestone or dolomite bedrock covered by more than ten feet of glacial till. The till consists of clay with varying amounts of silt, sand, and gravel. Sand and gravel layers within the till are thin or nonexistent. Surficial deposits have usually weathered to a clay loam soil. Although ground water occurs in the glacial deposits, the limestone bedrock serves as the principal aquifer in this setting. Ground water is obtained from fractures and solution channels, usually within the first several feet of the limestone. The limestone is in direct hydraulic connection with the glacial till, and precipitation infiltrating through the till serves as a source of recharge for the underlying limestone. Recharge is moderate because of the relatively lower permeability of the overlying till. Depth to water is extremely variable, depending in part on the thickness of the glacial till and the depth of the well.

GWPP index values for the hydrogeologic setting of glacial till over limestone range from 99 to 151 with the total number of GWPP index calculations equaling 23.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topograp hy	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ac1	5-15	4-7	limestone	Clay Loam	0-2	till	100-300	129	152
7Ac2	5-15	4-7	limestone	Silty Loam	0-2	till	100-300	131	157
7Ac3	15-30	4-7	limestone	Clay Loam	0-2	till	100-300	119	142
7Ac4	15-30	4-7	limestone	Clay Loam	6-12	till	100-300	114	127
7Ac5	30-50	4-7	limestone	Clay Loam	0-2	till	100-300	109	132
7Ac6	15-30	4-7	limestone	Clay Loam	2-6	till	100-300	118	139
7Ac7	30-50	4-7	limestone	Clay Loam	12-18	till	100-300	102	111
7Ac8	15-30	4-7	limestone	Loam	0-2	till	100-300	123	152
7Ac9	5-15	4-7	limestone	Clay Loam	2-6	till	100-300	128	149
7Ac10	15-30	4-7	limestone	Clay Loam	6-12	till	100-300	109	123
7Ac11	15-30	4-7	limestone	Clay Loam	0-2	till	100-300	114	138
7Ac12	5-15	4-7	limestone	Clay Loam	2-6	till	100-300	123	145
7Ac13	5-15	4-7	limestone	Loam	2-6	till	100-300	127	155
7Ac14	15-30	4-7	limestone	Loam	6-12	till	100-300	118	137
7Ac15	30-50	4-7	limestone	Clay Loam	6-12	till	100-300	99	113
7Ac16	30-50	4-7	limestone	Clay Loam	0-2	till	100-300	104	128
7Ac17	15-30	4-7	limestone	Silty Loam	0-2	till	100-300	116	143
7Ac18	5-15	4-7	limestone	Loam	0-2	till	100-300	133	162

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ac19	15-30	7-10	limestone	Loam	0-2	sand and gravel w/silt and clay	100-300	141	168
7Ac20	5-15	7-10	limestone	Loam	0-2	sand and gravel w/silt and clay	100-300	151	178
7Ac21	5-15	7-10	limestone	Silty Loam	0-2	sand and gravel w/silt and clay	100-300	149	173
7Ac22	5-15	4-7	limestone	Silty Loam	2-6	till	100-300	130	154
7Ac23	5-15	4-7	limestone	Loam	2-6	till	100-300	132	159



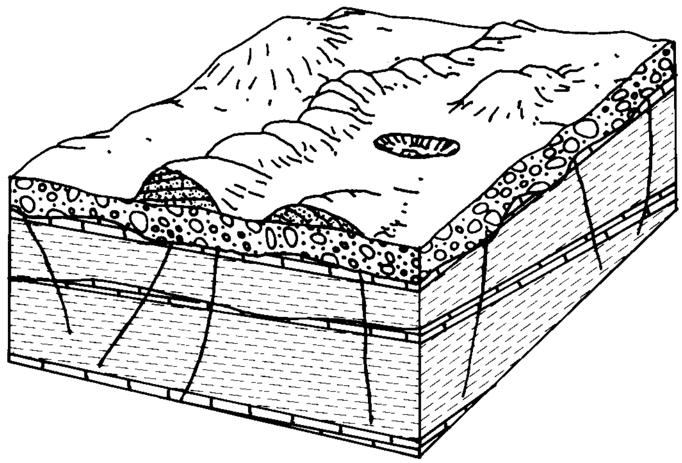
7Af Sand and Gravel Interbedded in Glacial Till

This setting is characterized by low relief and sand and gravel deposits interbedded in glacial till. The till is composed primarily of clay with varying amounts of unsorted silt, sand, and gravel. The sand and gravel may be relatively thin and discontinuous, lens-shaped bodies, or thick layers which are areally extensive. The thick units are commonly confined to common horizons within the till. Ground water occurs in both the till and the sand and gravel; however, the sand and gravel serves as the aquifer. Recharge to the sand and gravel is primarily due to infiltration of precipitation through the till. Recharge is moderate for this hydrogeologic setting. Depth to water is highly variable. Soils are typically clay loams.

GWPP index values for the hydrogeologic setting of sand and gravel interbedded in glaical till range from 107 to 138 with the total number of GWPP index calculations equaling 29.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af1	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	109	132
7Af2	15-30	4-7	sand and gravel	Loam	0-2	till	100-300	123	152
7Af3	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	119	142
7Af4	5-15	4-7	sand and gravel	Clay Loam	0-2	till	100-300	129	152
7Af5	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	117	141
7Af6	5-15	4-7	sand and gravel	Clay Loam	0-2	till	100-300	132	155
7Af7	5-15	4-7	sand and gravel	Loam	0-2	till	100-300	136	165
7Af8	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	107	131
7Af9	15-30	4-7	sand and gravel	Clay Loam	6-12	till	100-300	112	126
7Af10	15-30	4-7	sand and gravel	Silty Loam	0-2	till	100-300	119	146
7Af11	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	112	135
7Af12	5-15	4-7	sand and gravel	Clay Loam	6-12	till	100-300	127	140
7Af13	5-15	4-7	sand and gravel	Silty Loam	0-2	till	100-300	134	160
7Af14	15-30	4-7	sand and gravel	Clay Loam	6-12	till	100-300	117	130
7Af15	5-15	4-7	sand and gravel	Silty Loam	0-2	till	100-300	129	156
7Af16	15-30	4-7	sand and gravel	Clay Loam	2-6	till	100-300	121	142
7Af17	5-15	4-7	sand and gravel	Clay Loam	2-6	till	100-300	131	152
7Af18	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	122	145

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af19	15-30	4-7	sand and gravel	Silty Loam	0-2	till	100-300	124	150
7Af21	5-15	4-7	sand and gravel	Clay Loam	0-2	till	300-700	138	159
7Af22	15-30	4-7	sand and gravel	Clay Loam	0-2	till	300-700	128	149
7Af23	30-50	4-7	sand and gravel	Clay Loam	0-2	till	300-700	118	139
7Af24	30-50	4-7	sand and gravel	Clay Loam	2-6	till	300-700	117	136
7Af25	50-75	4-7	sand and gravel	Clay Loam	0-2	till	300-700	108	129
7Af26	30-50	4-7	sand and gravel	Clay Loam	6-12	till	300-700	113	124
7Af27	15-30	4-7	sand and gravel	Clay Loam	12-18	till	100-300	112	121
7Af28	15-30	4-7	sand and gravel	Clay Loam	2-6	till	300-700	127	146
7Af29	15-30	4-7	sand and gravel	Loam	0-2	sand and gravel w/silt and clay	300-700	137	163

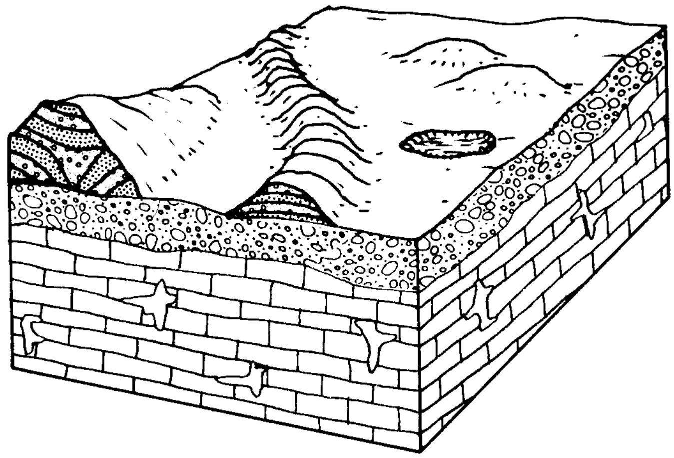


7Bb Outwash Over Bedded Sedimentary Rock

This setting is characterized by flat lying sedimentary rocks consisting of interbedded limestone and shales covered by outwash deposits. The outwash of this setting consists primarily of sand and gravel occasionally containing interbedded deposits of till or lacustrine clays. Ground water is obtained from the outwash deposits. Infiltration of precipitation serves as the primary source of recharge to the sand and gravel aquifer. Recharge is moderate to high. Depth to water is variable and depends in part on the thickness of the outwash. Soils are variable but typically permeable, ranging from loam to sandy loam. Relief is also variable ranging from low to steep. In Miami County, this setting is similar to the Outwash Over Limestone setting (7Bc) except for the underlying bedrock.

GWPP index values for the hydrogeologic setting of outwash over bedded sedimentary rock range from 160 to 171 with the total number of GWPP index calculations equaling 4.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Bb1	5-15	7-10	sand and gravel	Loam	0-2	sand and gravel w/silt and clay	700-1000	171	193
7Bb2	15-30	7-10	sand and gravel	Sandy Loam	0-2	sand and gravel w/silt and clay	300-700	160	187
7Bb4	15-30	7-10	sand and gravel	Loam	2-6	sand and gravel w/silt and clay	700-1000	163	183

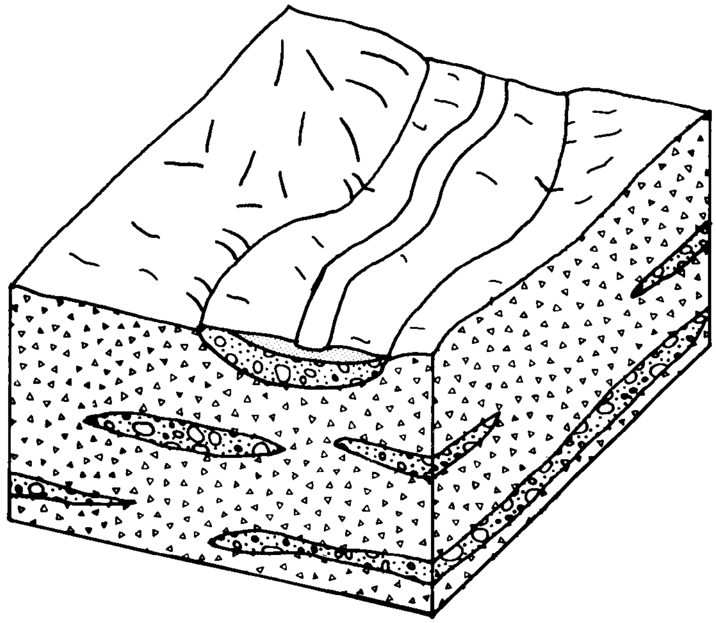


7Bc Outwash Over Limestone

This setting is characterized by flat lying limestone covered by outwash deposits. The outwash of this setting consist of sand and gravel occasionally interbedded with till or lacustrine clays. Ground water is obtained from the outwash deposits. Infiltration of precipitation serves as the primary source of recharge to the sand and gravel aquifer. Recharge is moderate to high. Depth to water is variable and depends in part on the thickness of the outwash. Soils are variable but permeable, and are typically a loam. Relief is moderate. In Miami County, this setting is similar to the Outwash over Bedded Sedimentary Rock (7Bb) setting except for the underlying bedrock.

GWPP index values for the hydrogeologic setting of outwash over limestone range from 159 to 169 with the total number of GWPP index calculations equaling 2.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Bc1	5-15	7-10	sand and gravel	Loam	0-2	sand and gravel w/silt and clay	700-1000	169	192
7Bc2	15-30	7-10	sand and gravel	Loam	0-2	sand and gravel w/silt and clay	700-1000	159	182

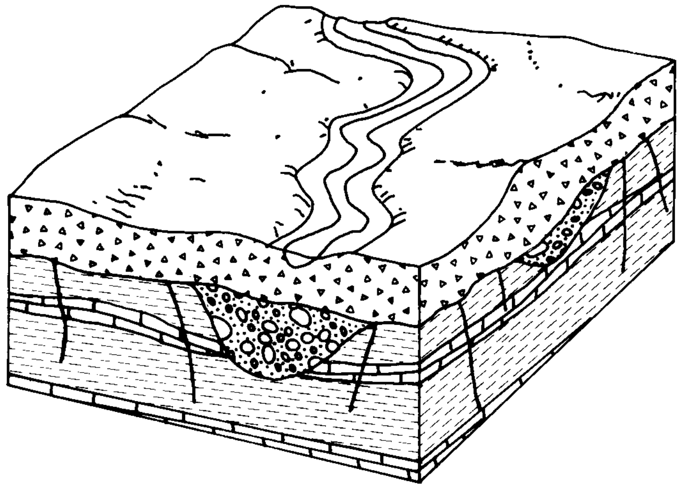


7Bd Outwash Over Glacial Till

This hydrogeologic setting is characterized by low relief and varying thickness of outwash sand and gravel deposited over glacial till. Streams fed by water from melting ice cut channels in the till, and left behind relatively clean sand and gravel deposits. Present day streams flowing with these channels are in hydraulic contact with the outwash deposits. A thin layer of alluvium may overlie these deposits at some locations. Where the outwash is thick, drilled wells may yield several hundred gallons per minute. Where the outwash is thin, wells are developed in the underlying limestone or interbedded limestone and shale. Surficial deposits of soil range from silt loam to sandy loam. Water levels are variable in depth.

GWPP index values for the hydrogeologic setting of outwash over glacial till range from 116 to 157 with the total number of GWPP index calculations equaling 10.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Bd1	15-30	7-10	limestone/shale	Loam	0-2	sand and gravel w/silt and clay	1-100	124	153
7Bd2	15-30	7-10	sand and gravel	Loam	2-6	sand and gravel w/silt and clay	100-300	138	164
7Bd3	15-30	7-10	limestone	Loam	2-6	sand and gravel w/silt and clay	100-300	135	161
7Bd4	5-15	7-10	limestone	Loam	0-2	sand and gravel w/silt and clay	100-300	146	174
7Bd5	15-30	7-10	limestone	Loam	6-12	sand and gravel w/silt and clay	100-300	136	153
7Bd6	5-15	7-10	sand and gravel	Loam	0-2	sand and gravel w/silt and clay	100-300	149	177
7Bd7	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand and gravel w/silt and clay	100-300	151	182
7Bd8	5-15	7-10	sand and gravel	Silty Loam	0-2	sand and gravel w/silt and clay	100-300	147	172
7Bd9	15-30	7-10	sand and gravel	Sandy Loam	0-2	sand and gravel w/silt and clay	300-700	157	184
7Bd10	30-50	4-7	sand and gravel	Loam	6-12	sand and gravel w/silt and clay	100-300	116	134



7D Buried Valley

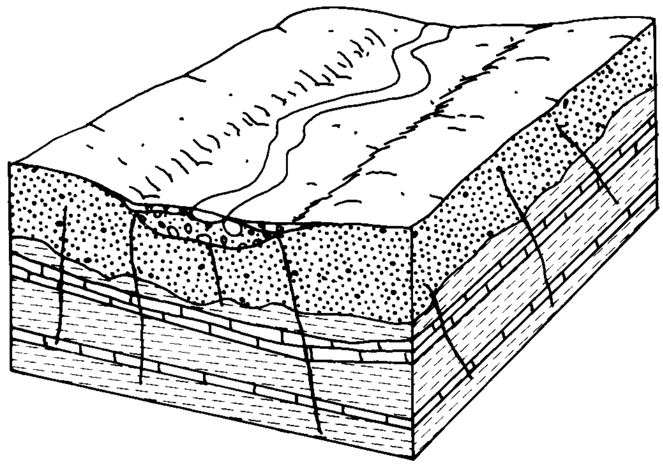
This hydrogeologic setting is characterized by sand and gravel that has been deposited in a former topographic low (usually a pre-glacial or inter-glacial river valley) by glacial meltwaters. These outwash (valley train) deposits are capable of yielding large quantities of ground water. Commonly, the more continuous, thicker sand and gravel deposits are located within the main "trunk" valleys. Sand and gravel deposits along valley margins and in tributary valleys may not be as productive. These deposits typically underlie present day rivers; however, the degree of hydraulic connection between streams and the underlying aquifers is variable. Till and lacustrine clays often separate the surficial deposits from underlying sand and gravel aquifers. The sand and gravel aquifers tend to be several times more permeable than the adjacent bedrock. Depth to water for this setting is highly variable and ranges from 5 to over 100 feet below the land surface. Soil types are highly variable. Buried valley deposits may or may not underlie a present day stream and may or may not be in hydraulic contact with that stream.

GWPP index values for the hydrogeologic setting of buried valley range from 102 to 190 with the total number of GWPP index calculations equaling 87.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D1	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	109	132
7D2	30-50	4-7	sand and gravel	Clay Loam	0-2	till	1000-2000	130	147
7D3	15-30	4-7	sand and gravel	Clay Loam	6-12	till	1000-2000	135	142
7D4	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	1000-2000	165	184
7D5	15-30	4-7	sand and gravel	Clay Loam	0-2	till	300-700	128	149
7D6	15-30	4-7	sand and gravel	Clay Loam	0-2	till	1000-2000	140	157
7D7	15-30	4-7	sand and gravel	Clay Loam	12-18	till	1000-2000	133	136
7D8	15-30	4-7	sand and gravel	Clay Loam	12-18	till	300-700	121	128
7D9	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	2000+	186	204
7D10	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	2000+	184	199
7D11	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand & gravel w/silt & clay	2000+	188	209
7D12	15-30	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	2000+	176	194
7D13	5-15	7-10	sand and gravel	Gravel	0-2	sand & gravel w/silt & clay	1000-2000	190	225
7D14	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	1000-2000	178	195

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D15	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand & gravel w/silt & clay	1000-2000	182	205
7D16	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	180	200
7D17	30-50	4-7	sand and gravel	Clay Loam	2-6	till	700-1000	123	140
7D18	15-30	4-7	sand and gravel	Clay Loam	2-6	till	700-1000	133	150
7D19	30-50	4-7	sand and gravel	Clay Loam	0-2	till	300-700	118	139
7D20	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	300-700	165	189
7D21	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand & gravel w/silt & clay	300-700	167	194
7D22	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	300-700	158	180
7D23	15-30	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	700-1000	164	186
7D24	15-30	7-10	sand and gravel	Loam	0-2	till	100-300	134	163
7D25	5-15	4-7	sand and gravel	Clay Loam	2-6	till	100-300	131	152
7D26	30-50	4-7	sand and gravel	Clay Loam	6-12	till	300-700	113	124
7D27	75-100	4-7	sand and gravel	Clay Loam	0-2	till	700-1000	112	131
7D28	50-75	4-7	sand and gravel	Clay Loam	0-2	till	700-1000	117	136
7D29	5-15	4-7	sand and gravel	Clay Loam	0-2	till	100-300	132	155
7D30	30-50	4-7	sand and gravel	Clay Loam	0-2	till	700-1000	127	146
7D31	5-15	4-7	sand and gravel	Clay Loam	0-2	till	300-700	138	159
7D32	15-30	4-7	sand and gravel	Clay Loam	0-2	till	700-1000	137	156
7D33	5-15	4-7	sand and gravel	Silty Loam	0-2	till	100-300	131	157
7D34	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	119	142
7D35	15-30	4-7	sand and gravel	Clay Loam	2-6	till	100-300	118	139
7D36	15-30	4-7	sand and gravel	Clay Loam	6-12	till	100-300	114	127
7D37	15-30	4-7	sand and gravel	Clay Loam	12-18	till	100-300	112	121
7D38	15-30	4-7	sand and gravel	Clay Loam	2-6	till	300-700	127	146
7D39	50-75	4-7	sand and gravel	Clay Loam	0-2	till	300-700	108	129
7D40	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	122	145
7D42	15-30	4-7	sand and gravel	Clay Loam	6-12	till	1000-2000	138	145
7D43	15-30	4-7	sand and gravel	Clay Loam	0-2	till	1000-2000	143	160
7D44	5-15	4-7	sand and gravel	Clay Loam	0-2	till	1000-2000	153	170
7D45	15-30	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	160	182
7D47	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand & gravel w/silt & clay	700-1000	176	201
7D48	15-30	7-10	sand and gravel	Loam	2-6	sand & gravel w/silt & clay	700-1000	163	183
7D49	15-30	4-7	sand and gravel	Loam	6-12	sand & gravel w/silt & clay	700-1000	143	156
7D50	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	1000-2000	175	192
7D51	5-15	7-10	sand and gravel	Muck	0-2	sand & gravel w/silt & clay	1000-2000	161	174
7D52	30-50	7-10	sand and gravel	Gravel	12-18	sand and gravel	1000-2000	165	185
7D53	5-15	7-10	sand and gravel	Clay Loam	0-2	sand & gravel w/silt & clay	1000-2000	173	187
7D54	30-50	7-10	sand and gravel	Loam	2-6	sand & gravel w/silt & clay	1000-2000	156	174
7D55	30-50	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	157	177
7D56	30-50	7-10	sand and gravel	Loam	6-12	sand & gravel w/silt & clay	1000-2000	152	162
7D57	15-30	7-10	sand and gravel	Loam	2-6	sand & gravel w/silt & clay	1000-2000	166	184
7D58	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	177	197
7D59	5-15	7-10	sand and gravel	Sandy Loam	0-2	sand & gravel w/silt & clay	1000-2000	179	202
7D60	30-50	7-10	sand and gravel	Clay Loam	12-18	sand & gravel w/silt & clay	700-1000	140	142
7D61	15-30	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	300-700	143	166
7D62	30-50	4-7	sand and gravel	Clay Loam	2-6	till	100-300	111	132
7D63	30-50	4-7	sand and gravel	Loam	12-18	till	300-700	115	128
7D64	15-30	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	170	190
7D65	15-30	7-10	sand and gravel	Loam	2-6	sand & gravel w/silt & clay	100-300	143	168
7D66	15-30	7-10	sand and gravel	Loam	2-6	sand & gravel w/silt & clay	1000-2000	169	187
7D67	15-30	4-7	sand and gravel	Clay Loam	2-6	till	700-1000	136	153
7D68	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	112	135

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D69	15-30	4-7	sand and gravel	Clay Loam	0-2	till	300-700	128	149
7D70	5-15	4-7	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	1000-2000	162	184
7D71	30-50	4-7	sand and gravel	Clay Loam	2-6	till	700-1000	126	143
7D72	15-30	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	700-1000	154	178
7D73	30-50	4-7	sand and gravel	Clay Loam	0-2	till	100-300	107	131
7D74	15-30	4-7	sand and gravel	Clay Loam	6-12	till	100-300	112	126
7D75	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	117	141
7D76	30-50	4-7	sand and gravel	Clay Loam	6-12	till	100-300	102	116
7D77	15-30	4-7	sand and gravel	Clay Loam	2-6	till	100-300	116	138
7D78	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	300-700	160	185
7D79	15-30	4-7	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	100-300	136	163
7D80	15-30	4-7	sand and gravel	Clay Loam	6-12	till	100-300	109	123
7D81	5-15	7-10	sand and gravel	Loam	0-2	sand & gravel w/silt & clay	100-300	151	178
7D82	5-15	7-10	sand and gravel	Silty Loam	0-2	sand & gravel w/silt & clay	100-300	149	173
7D83	15-30	4-7	sand and gravel	Clay Loam	0-2	till	300-700	123	145
7D84	15-30	4-7	sand and gravel	Clay Loam	2-6	till	300-700	122	142
7D85	15-30	4-7	sand and gravel	Clay Loam	0-2	till	100-300	114	138
7D86	15-30	4-7	sand and gravel	Clay Loam	6-12	till	300-700	118	130
7D87	75-100	4-7	sand and gravel	Clay Loam	0-2	till	300-700	103	124

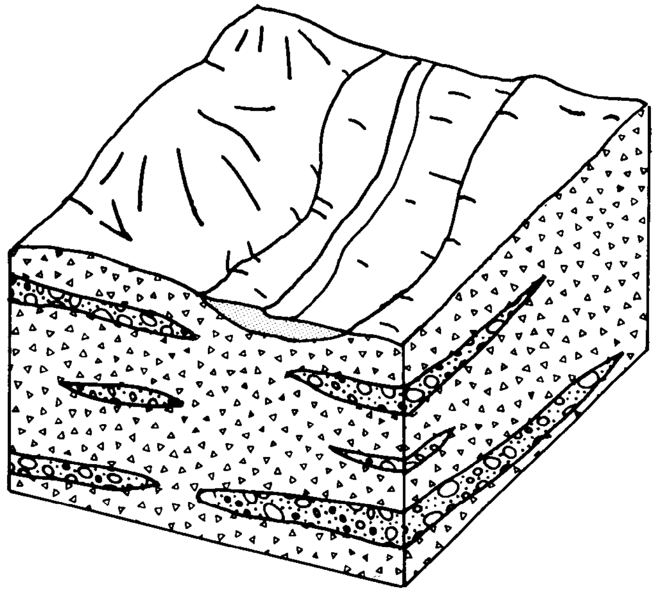


7Ec Alluvium Over Sedimentary Rock

This hydrogeologic setting is characterized by low relief with thin to moderate thicknesses of modern, stream-deposited alluvium. The alluvium is composed of silt, sand, gravel, and clay. Depth to water is shallow, and the stream is usually in hydraulic contact with the alluvial deposits. The alluvium is underlain by interbedded Ordovician limestone and shale or Silurian limestone. Usually the upper portion of the bedrock serves as the aquifer in this setting. Infiltration of precipitation or induced infiltration of stream waters serve as a source of recharge to the bedrock. Recharge is moderately high due to the highly permeable soils and the relatively shallow depth to water. Soils range from silt loam to sandy loam.

GWPP index values for the hydrogeologic setting of alluvium over sedimentary rock range from 129 to 161 with the total number of GWPP index calculations equaling 11.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ec1	5-15	7-10	limestone	Loam	0-2	sand and gravel w/silt and clay	100-300	146	174
7Ec2	5-15	7-10	limestone	Silty Loam	0-2	sand and gravel w/silt and clay	100-300	144	169
7Ec3	5-15	7-10	limestone	Thin or Absent	0-2	limestone	100-300	161	203
7Ec4	5-15	7-10	limestone	Loam	6-12	limestone	100-300	146	163
7Ec5	5-15	7-10	limestone	Loam	0-2	limestone	100-300	151	178
7Ec6	5-15	7-10	limestone	Sandy Loam	0-2	sand and gravel w/silt and clay	100-300	153	183
7Ec7	5-15	7-10	limestone	Loam	0-2	sand and gravel w/silt and clay	100-300	151	178
7Ec8	5-15	7-10	limestone	Silty Loam	0-2	sand and gravel w/silt and clay	100-300	149	173
7Ec9	5-15	7-10	shale	Silty Loam	0-2	sand and gravel w/silt and clay	1-100	132	158
7Ec10	5-15	4-7	limestone	Silty Loam	0-2	till	100-300	131	157
7Ec11	5-15	4-7	limestone	Clay Loam	0-2	till	100-300	129	152

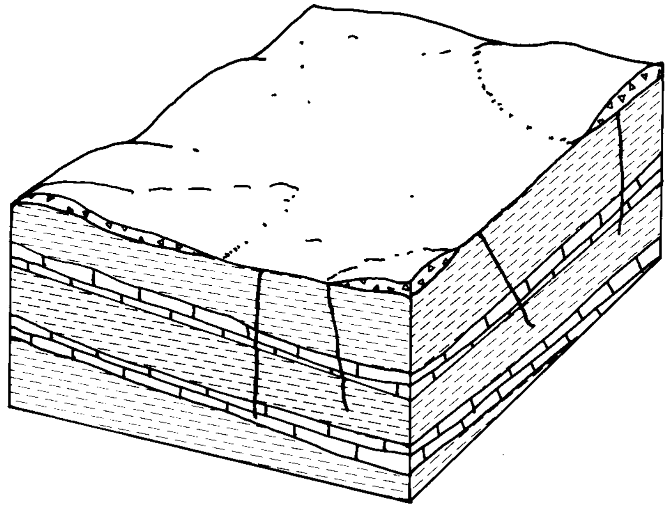


7Ed Alluvium Over Glacial Till

This hydrogeologic setting is characterized by low relief with thin to moderate thickness of modern, stream-deposited alluvium overlying glacial till. The alluvium is composed of silt, sand, gravel, and clay. The underlying sand and gravel lenses within the till serve as the aquifer. The depth to the water table is shallow, and the stream is usually in hydraulic connection with the alluvial deposits. Soils range from clay loams to loams. Infiltration of precipitation or induced infiltration of stream water serve as a source of recharge to the sand and gravel lenses within the till. Recharge is moderately high.

GWPP index values for the hydrogeologic setting of alluvium over glacial till range from 128 to 155 with the total number of GWPP index calculations equaling 9.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ed1	15-30	4-7	sand and gravel	Silty Loam	0-2	sand and gravel w/silt and clay	300-700	135	158
7Ed2	15-30	4-7	sand and gravel	Clay Loam	0-2	silt/clay	300-700	128	149
7Ed3	5-15	7-10	sand and gravel	Loam	0-2	silt/clay	300-700	155	181
7Ed4	5-15	7-10	sand and gravel	Silty Loam	0-2	silt/clay	300-700	153	176
7Ed5	15-30	4-7	sand and gravel	Loam	0-2	silt/clay	300-700	137	163
7Ed6	5-15	7-10	sand and gravel	Silty Loam	0-2	till	100-300	142	168
7Ed7	5-15	7-10	sand and gravel	Loam	0-2	till	100-300	144	173
7Ed8	5-15	7-10	sand and gravel	Clay Loam	0-2	till	100-300	140	163
7Ed9	15-30	4-7	sand and gravel	Clay Loam	0-2	sand and gravel w/silt and clay	300-700	133	153

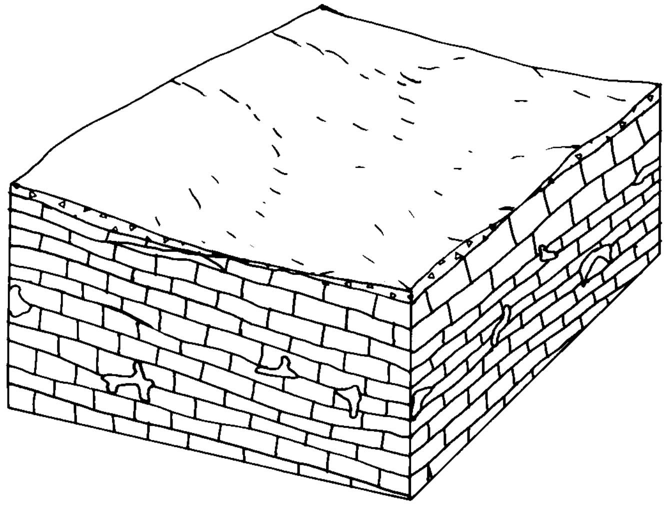


7G Thin Till Over Bedded Sedimentary Rocks

This hydrogeologic setting is characterized by moderate to steep relief with thin deposits of glacial till overlying interbedded layers of limestone and shale. The till and soil are usually very thin or absent in areas of steep relief. The till consists of clay with little, if any, sand and gravel and does not serve as a source of water. Till thicknesses are usually less than ten feet for this setting. The till is typically weathered and fractured. Small supplies of ground water are obtained from the upper weathered portion of the bedrock or from the intersection of fractures and bedding planes. Recharge is moderate. Depth to water is variable. This setting is similar to the Thin Till Over Limestone (7Gb) setting except for the underlying bedrock.

GWPP index values for the hydrogeologic setting of thin till over bedded sedimentary rocks range from 75 to 112 with the total number of GWPP index calculations equaling 12.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7G1	30-50	2-4	limestone/shale	Clay Loam	6-12	limestone/shale	1-100	75	90
7G2	15-30	2-4	limestone/shale	Clay Loam	12-18	limestone/shale	1-100	83	94
7G3	30-50	2-4	limestone/shale	Clay Loam	6-12	limestone/shale	1-100	75	90
7G4	15-30	2-4	limestone/shale	Thin or Absent	6-12	limestone/shale	1-100	99	135
7G5	30-50	2-4	limestone/shale	Thin or Absent	12-18	limestone/shale	1-100	87	119
7G7	30-50	2-4	limestone/shale	Loam	6-12	limestone/shale	1-100	79	100
7G8	5-15	2-4	limestone/shale	Silty Loam	2-6	limestone/shale	1-100	101	127
7G9	15-30	2-4	limestone/shale	Clay Loam	6-12	limestone/shale	1-100	85	100
7G10	5-15	2-4	limestone/shale	Shrink-swell (Aggregated) Clay	2-6	till	1-100	112	146
7G11	5-15	2-4	limestone/shale	Shrink-swell (Aggregated) Clay	2-6	till	1-100	112	146
7G12	5-15	2-4	limestone/shale	Clay Loam	2-6	till	1-100	104	126



7Gb Thin Till Over Limestone

This hydrogeologic setting is characterized by low relief with thin deposits of glacial till overlying limestone bedrock. The till and soil are usually thin to absent in areas of steep relief. The till consists of clay with little, if any, sand and gravel and does not serve as a source of water. Till thicknesses are usually less than ten feet for this setting. Ground water is obtained from the limestone bedrock. Recharge is moderate to high. Depth to water is variable. This setting is similar to the Thin Till Over Bedded Sedimentary Rock (7G) setting except for the underlying bedrock.

GWPP index values for the hydrogeologic setting of thin till over limestone range from 126 to 155 with the total number of GWPP index calculations equaling 20.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Gb1	5-15	7-10	limestone	Clay Loam	0-2	till	100-300	137	160
7Gb2	5-15	7-10	limestone	Shrink-swell (Aggregated) Clay	0-2	till	100-300	145	180
7Gb3	15-30	7-10	limestone	Clay Loam	2-6	limestone	100-300	136	155
7Gb4	15-30	7-10	limestone	Clay Loam	0-2	limestone	100-300	137	158
7Gb5	15-30	7-10	limestone	Shrink-swell (Aggregated) Clay	0-2	limestone	100-300	145	178
7Gb6	30-50	7-10	limestone	Clay Loam	0-2	limestone	100-300	127	148
7Gb7	30-50	7-10	limestone	Shrink-swell (Aggregated) Clay	0-2	limestone	100-300	135	168
7Gb8	15-30	7-10	limestone	Thin or Absent	0-2	limestone	100-300	151	193
7Gb9	15-30	7-10	limestone	Loam	0-2	limestone	100-300	141	168
7Gb10	15-30	7-10	limestone	Shrink-swell (Aggregated) Clay	2-6	limestone	100-300	144	175
7Gb11	15-30	7-10	limestone	Thin or Absent	6-12	limestone	100-300	146	178
7Gb12	30-50	7-10	limestone	Clay Loam	2-6	limestone	100-300	126	145
7Gb13	5-15	7-10	limestone	Shrink-swell (Aggregated) Clay	0-2	limestone	100-300	155	188
7Gb14	5-15	7-10	limestone	Clay Loam	0-2	limestone	100-300	147	168
7Gb15	15-30	7-10	limestone	Shrink-swell (Aggregated) Clay	6-12	limestone	100-300	140	163
7Gb16	15-30	7-10	limestone	Clay Loam	6-12	limestone	100-300	132	143
7Gb17	5-15	7-10	limestone	Shrink-swell (Aggregated) Clay	2-6	till	100-300	144	177
7Gb18	5-15	7-10	limestone	Clay Loam	2-6	till	100-300	136	157
7Gb19	15-30	7-10	limestone	Thin or Absent	2-6	limestone	100-300	150	190
7Gb20	5-15	7-10	limestone	Clay Loam	2-6	limestone	100-300	146	165

ERRATA SHEET
September 2005

MIAMI COUNTY
Ground Water Pollution Potential Report No. 27

The following settings have been omitted from the setting tables and do not appear on the map.

7Af20; 7Bb3; 7D41, 7D46; 7G6.

Ground Water Pollution Potential of MIAMI COUNTY

by
Paul N. Spahr

Hydrogeologic Settings

7Aa	-	Glacial Till Over Interbedded Limestones and Shales
7Ac	-	Glacial Till Over Limestone
7Af	-	Sand and Gravel Interbedded in Till
7Bb	-	Outwash Over Interbedded Limestones and Shales
7Bc	-	Outwash Over Limestone
7Bd	-	Outwash Over Till
7D	-	Buried Valley
7Ec	-	Alluvium Over Bedded Sedimentary Rocks
7Ed	-	Alluvium Over Till
7Gb	-	Thin Till Over Limestone
7G	-	Thin Till Over Interbedded Limestones and Shales

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 Miami County", GWPP Report No. 27, Ohio Department of Natural Resources, Division of Water.

Pollution Potential Index Range

Higher	180 - 199
	160 - 179
	140 - 159
to	120 - 139
	100 - 119
	80 - 99
Lower	< 79

County Line

Township Line

Incorporated City Limit

N

Description of Map Symbols

Hydrogeologic Region — Hydrogeologic Setting

7Ad6

98 — Relative Pollution Potential

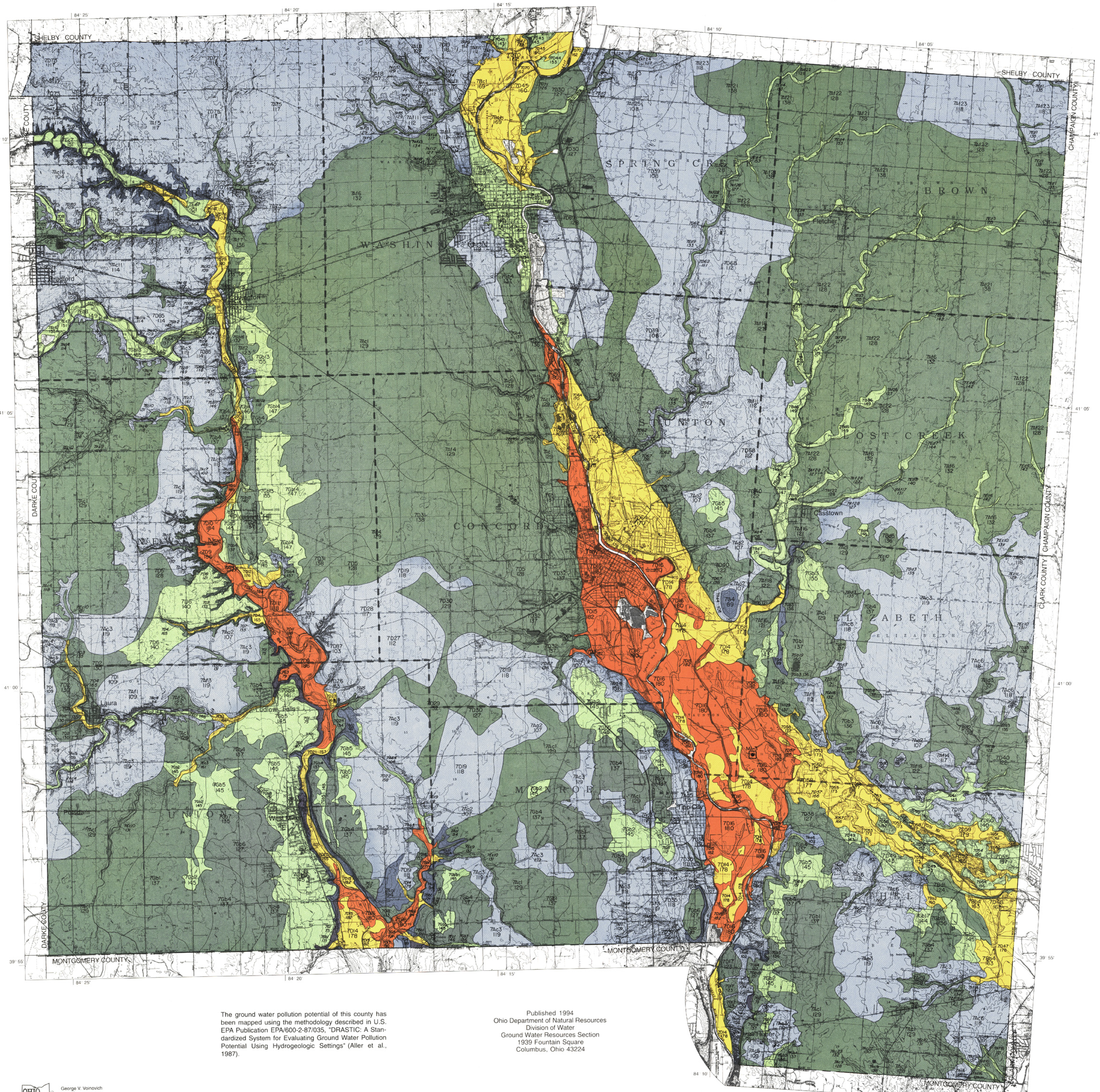
Observation Well Site *

Gravel Pit / Quarry

Miles

Kilometers

CONTOUR INTERVAL 5 OR 10 FEET



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).

Published 1994
Ohio Department of Natural Resources
Division of Water
Ground Water Resources Section
1939 Fountain Square
Columbus, Ohio 43224

George V. Voinovich
Governor
Frances S. Buchholzer
Director

Xiaoning Jiang, Cartographer