GROUND WATER POLLUTION POTENTIAL OF RICHLAND COUNTY, OHIO

BY

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ABSTRACT

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

Ground water pollution potential analysis in Richland County resulted in a map with symbols and colors, which illustrate areas of varying ground water pollution potential indexes ranging from 67 to 182.

Richland County lies entirely within the Glaciated Central hydrogeologic setting. A complex network of buried valley systems cross the county. Valleys that were flowing south prior to the advance of ice typically contain fairly coarse, thick sand and gravel outwash deposits that can have maximum yields exceeding 500 gallons per minute (gpm). These coarse deposits may be interbedded with finer-grained alluvial or lacustrine deposits or glacial till particularly in the upper, “headwaters” portion of the valleys. Yields from these finer-grained materials occupying buried valleys seldom exceed 100 gpm. Yields of 5-25 gpm to less than 5 gpm are obtained from thin lenses of sand and gravel interbedded with glacial till and lacustrine sediments along the margins of the buried valleys and in upland areas containing moderately thick drift. The upland areas of northern Richland County include both ground moraine and end moraine.

Thin interbedded sandstones, shales, and siltstones of the Pennsylvanian System are limited to ridge tops in the southeast corner of the county. These rocks commonly have yields of 5-25 gpm. Wells developed from highly fractured, coarse-grained sandstones of the Mississippian Black Hand and Logan Formations yield up to 100 gpm in parts of eastern and southern Richland County. Wells developed in the interbedded shales, fine-grained sandstones, and siltstones of the Mississippian Cuyahoga Group typically yield from 5 to 25 gpm. These units are widespread throughout the county, especially in northern and western Richland County. Rocks of the Cuyahoga Group tend to contain a higher proportion of shale and are lower yielding towards the north central part of the county. Deeper wells in the northern part of the county may encounter low-yielding shales belonging to either the Mississippian Sunbury Shale or Bedford Shale. These units typically yield less than 5 gpm. Deep wells completed into the Mississippian Berea Sandstone in northern Richland County commonly have yields ranging from 5 to 25 gpm.

The ground water pollution potential mapping program optimizes the use of existing data to rank areas with respect to relative vulnerability to contamination. The ground water pollution potential map of Richland 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 area, or to assist in protection, monitoring, and clean-up efforts.

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 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 750,000 rural households depend on private wells; 15,750 of these wells exist in Richland 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 remediation 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 countywide basis in Ohio.

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

A pollution potential map can 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 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.

Individuals in the county who are familiar with specific land use and management problems will recognize other beneficial uses of the pollution potential maps. Planning commissions and zoning boards can use these maps to help make informed decisions about the development of areas within their jurisdiction. Developers proposing projects within ground water sensitive areas may be required to show how ground water will be protected.

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

DRASTIC was developed by the National Ground Water Association for the United States Environmental Protection Agency. This system was chosen for implementation of a ground water pollution potential mapping program in Ohio. 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. 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 that influence ground water pollution potential. The system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system to determine pollution potential.

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area under the assumption that a contaminant with the mobility of water is 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 Richland County. Inherent within each hydrogeologic setting are the physical characteristics that affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

D – Depth to Water

R – Net Recharge

A – Aquifer Media

S – Soil Media

T – Topography

I – Impact of the Vadose Zone Media

C – Conductivity (Hydraulic) of the Aquifer

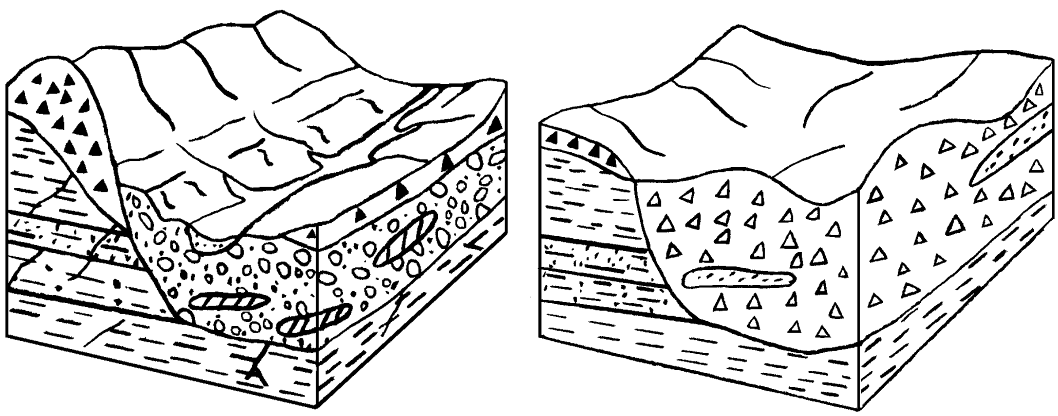
These factors incorporate concepts and mechanisms such as attenuation, retardation, and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms coupled with existing conditions in a setting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

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

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

Soil media refers to the upper six feet of the unsaturated zone that is characterized by significant biological activity. The type of soil media influences 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.



(A) (B)

7D Buried Valley

This hydrogeologic setting is widespread and varies considerably through Richland County. An extensive network of pre-glacial and interglacial rivers created the buried valleys that downcut into the bedrock. Richland County formerly lied on a major drainage divide that was breached and modified extensively by the multiple glacial advances. The greatly differing deposits filling these valleys can be best illustrated by describing the two common forms mapped within Richland County.

The block diagram (A) above shows one common form of buried valley deposit, which is exemplified by Clear Fork between Lexington and Butler, Rocky Fork just southeast of Mansfield, and Black Fork near Charles Mill Reservoir. These valleys are occupied by a modern river and floodplain and contain abundant outwash and kame deposits. The upper portion of these valleys contains 50 to 100 feet of sand and gravel interbedded with alluvium. Depth to water is typically less than 30 feet. Yields over 100 gpm are obtainable from large diameter wells. Soils are typically sandy loams or silt loams. The streams are in direct connection with the aquifer and recharge is typically high. GWPP index values for these settings are usually over 125.

The other common form of buried valley deposit, block diagram (B), is exemplified by the Tinker's Creek buried valley in western Sandusky Township and Sharon Township. The surface topography is commonly rolling and it is difficult to distinguish the buried valley from the surrounding bedrock or ground moraine uplands. Modern streams typically do not overly these deposits. The aquifer is commonly not in direct connection with overlying streams. Recharge is usually moderate to low. The aquifer consists of thinner, less continuous lenses of sand and gravel interbedded with thicker sequences of fine-grained glacial till or lacustrine sediments. Yields are commonly less than 25 gpm. Soils are usually clay loams or silty loams derived from the overlying glacial till.

GWPP index values for the hydrogeologic setting of Buried Valley range from 70 to 182, with the total number of GWPP index calculations equaling 155.

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

Topography refers to the slope of the land expressed as percent slope. The slope of an area affects the likelihood that a contaminant will 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 has a significant impact on the pollution potential of the ground water in an area.

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

Weighting and Rating System

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

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

Pesticide DRASTIC

A special version of DRASTIC was developed for use where the application of pesticides is a concern. The weights assigned to the DRASTIC factors were changed to reflect the processes that affect pesticide movement into the subsurface with particular emphasis on soils. 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**
Shale	1-3	2
Glacial Till	4-6	5
Sandstone	4-9	6
Limestone	4-9	6
Sand and Gravel	4-9	8
Interbedded Ss/Sh/Ls/Coal	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/Absent	10
Gravel	10
Sand	9
Peat	8
Shrink/Swell Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
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
Interbedded Ss/Sh/Ls/Coal	4-8	6
Sand and Gravel with Silt and Clay	4-8	6
Glacial Till	2-6	4
Sand and Gravel	6-9	8
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

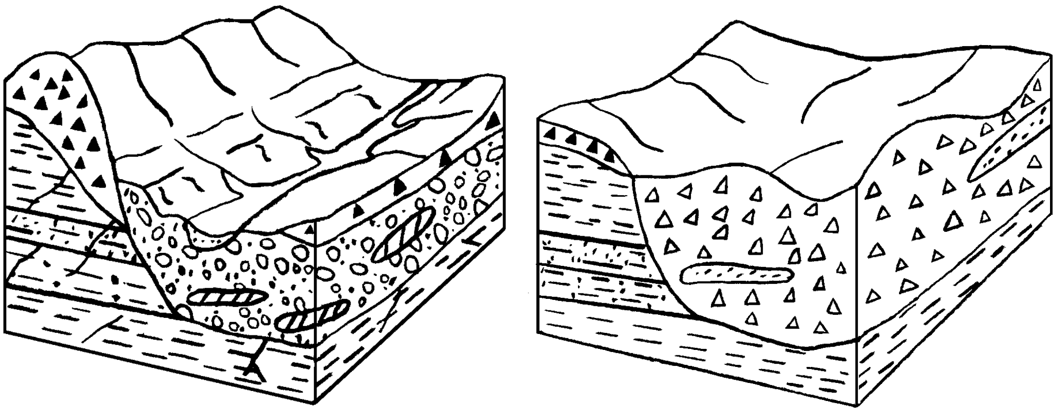
Table 8. Ranges and ratings for hydraulic conductivity

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 7D1, Buried Valley, identified in mapping Richland 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 119. 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 45 to 223. The diversity of hydrogeologic conditions in Richland County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the 10 settings identified in the county range from 67 to 182.

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 Richland 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 Richland County is included with this report.



(A) (B)

SETTING 7D1		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	36	6
Topography	2-6%	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	300-700	3	64	12
		DRASTIC	INDEX	119

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

INTERPRETATION AND USE OF GROUND WATER POLLUTION POTENTIAL MAPS

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

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

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

Here the first number (**7**) refers to the major hydrogeologic region and the upper case letter (**D**) refers 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 (**119**) 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.

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 maps also delineate large man-made and natural features such as lakes, landfills, quarries, and strip mines, but these areas are not rated and therefore are not color-coded.

GENERAL INFORMATION ABOUT RICHLAND COUNTY

Demographics

Richland County occupies approximately 497 square miles in north central Ohio (Figure 3). It is bounded to the west by Crawford County, to the north by Huron County, to the east by Ashland County, to the south by Knox County, and to the southwest by Morrow County.

The approximate population of Richland County, based upon year 2000 census estimates, is 128,852 (Department of Development, Ohio County Profiles, 2002). Mansfield is the largest community and the county seat. Agriculture accounts for roughly 63 percent of the land usage in Richland County. Woodlands, primarily in the southern part of the county, account for approximately 32 percent of the land usage. Urban, industrial, and residential are the other major land uses in the county. Mining, including sand and gravel pits, is a land use in various sections of the county. There are numerous lakes and reservoirs, especially in the southern part of the county. More specific information on land usage can be obtained from the Ohio Department of Natural Resources, Division of Real Estate and Land Management (REALM), Resource Analysis Program (formerly OCAP).

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 49 degrees Fahrenheit for Richland County. The average temperatures decrease towards the east. Harstine (1991) shows that the average precipitation ranges from approximately 37 inches per year for the county with rainfall increasing towards the southeast. The normal annual precipitation at Mansfield is 37.6 inches per year based upon a thirty-year (1971-2000) period (National Oceanic and Atmospheric Administration (NOAA), 2002). The mean annual temperature at Mansfield for the same thirty-year period is 48.7 degrees Fahrenheit (NOAA, 2002).

Physiography and Topography

Northwestern Richland County lies within the Central Till Plains Lowland Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). The remainder of the county lies within the Glaciated Allegheny Plateau Section of the Appalachian Plateau Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). Brockman (1987) and Schiefer (2002) recently re-evaluated the physiography of the entire state and have further subdivided Richland County. Brockman (1998) and Schiefer (2002) indicate that the extreme northwestern corner is part of

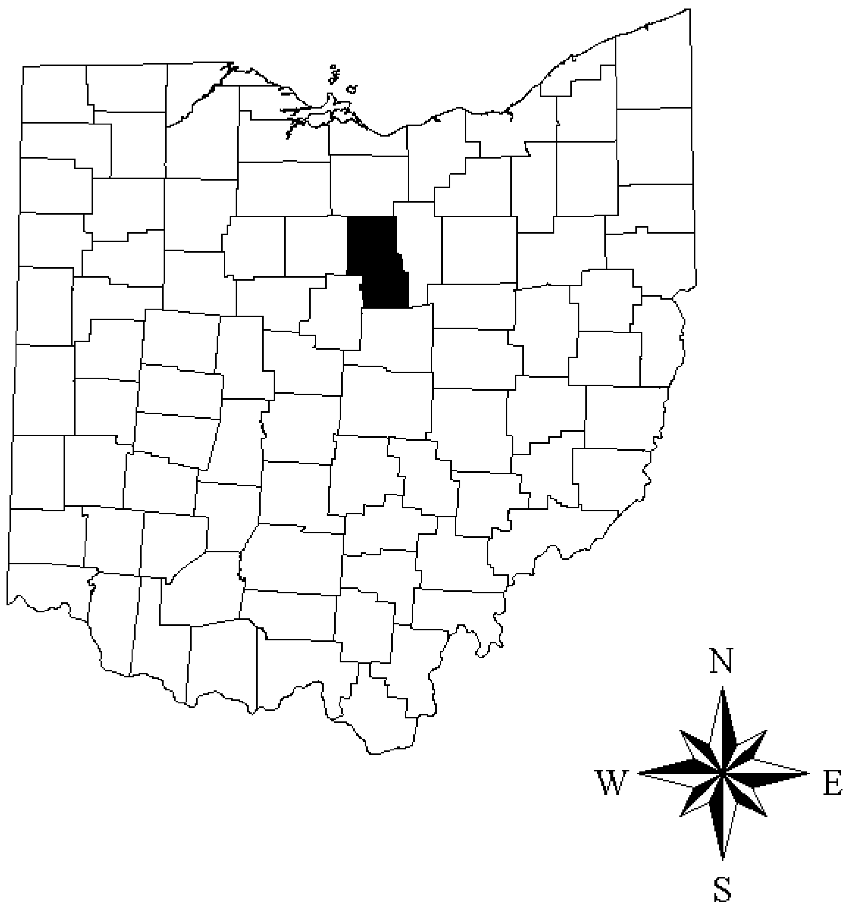


Figure 3. Location map of Richland County, Ohio.

the Central Ohio Clayey Till Plain. The remainder of the northern and northwestern portions of the county is part of the Galion Glaciated Low Plateau. The Berea Escarpment, a relatively steep rise caused by the presence of the underlying, erosion-resistant Berea Sandstone, separate these two regions. Eastern, central, and southwestern Richland County is part of the Killbuck-Glaciated Pittsburgh Plateau. The southeastern corner of the county is part of the Illinoian Glaciated Allegheny Plateau. Highly variable topography and relief are found in Richland County. The southern, central, and eastern portions of the county feature steep, bedrock-controlled ridges separated by broad, flat stream valleys. Relief becomes steeper towards the thinly glaciated southeast corner. Gently rolling ground moraine and hummocky end moraines characterize the northern and western portions of the county.

Modern Drainage

The drainage divide between the Ohio River Basin and the Lake Erie Basin extends across the northern margin of Richland County and also across part of the western margin of the county. The relatively high elevations of the County position it to serve as the headwaters region for many drainage systems. The northwestern corner of the county is drained by the headwaters of the West Branch of the Huron River. The northeastern corner of the county is a source of headwaters for the Vermillion River. Parts of southern Sharon Township, northern Sandusky Township, and western Springfield Township serve as headwaters to the Sandusky River. These streams all drain into the Lake Erie Basin. Black Fork, Rocky Fork, and Clear Fork, the three major tributaries of the Mohican River, drain the majority of the county. Tributaries of the Olentangy River drain southern Sandusky Township. These areas all ultimately drain into the Ohio River Basin.

Pre- and Inter-Glacial Drainage Changes

The drainage patterns of Richland County have changed significantly as a result of the multiple glaciations. The drainage changes are complex and not yet fully understood. More research and data are necessary in both Richland County and adjacent counties. Particularly, well log data for deeper wells that penetrate the entire drift thickness would be helpful in making interpretations.

Prior to glaciation, the drainage in Ohio is referred to as the Teays Stage. The Teays River drained the southern and western two thirds of the state and was the master stream for what is now the upper Ohio River Valley. Other drainages of that age are referred to as Teays Stage even if they did not drain into the Teays or its tributaries. Various theories speculate on the position of Richland County relative to drainage during the Teays Stage.

Stout et al. (1943) inferred that the drainage divides between the Teays River System and northerly drainage towards the present-day Lake Erie Basin was along the Black Hand Escarpment. The Black Hand Escarpment is a discontinuous series of steep resistant sandstone ridges that roughly splits Richland County in half. Stout et al. (1943) proposed that southern Richland County was part of the headwaters of the Groveport River, a major tributary of the Teays River. Totten (1973), summarizing other researchers, placed the divide much further south in Richland County (Figure 4). According to this theory, the vast majority of Richland County drained northwards. As ice advanced through Ohio during the pre-Illinoian (Kansan) glaciations, the northerly drainage ways were blocked. Flow backed-up these numerous tributaries forming several large lakes. These lakes over-topped, creating spillways and cutting new channels. New drainage systems began to evolve (Stout et al., 1943). This downcutting by these new streams was believed to be relatively rapid and, in many places, the new channels were cut over 100 feet deeper than the previous Teays River System valleys. The new drainage system is referred to as the Deep Stage due to this increased downcutting. Stout et al. (1943) proposed that southern (ice-free) Richland County was now drained by the headwaters of the Utica River that had a course similar to that of the Groveport River. Totten (1973) discusses the drainage reversals in detail (Figure 5). The Clear Fork breached a col (a low or saddle in a bedrock ridge) near the present day gorge at Newville. The Black Fork breached a col near Perrysville (Ashland County). The Rocky Fork breached a narrow col east of Lucas that allowed this tributary to merge with Black Fork.

The advance of Illinoian ice caused a continuation of the ice blockage to northerly flowing streams. Totten (1973) proposed that drainage from subsequent ice advances roughly followed the pathways established by the Deep Stage Drainage changes. Totten discusses minor drainage changes that occurred during the Illinoian and Wisconsinan glaciations.

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years before present (Y.B.P.)) several episodes of ice advance occurred in northeastern Ohio. Table 9 summarizes the Pleistocene deposits found in Richland County. Older ice advances, which predate the most recent (Brunhes) magnetic reversal (about 730,000 Y.B.P.), are now commonly referred to as pre-Illinoian (formerly Kansan).

The majority of the glacial deposits fall into four main types: (glacial) till, lacustrine, outwash, and ice-contact sand and gravel (kames). Drift is an older term that collectively refers to the entire sequence of glacial deposits. Buried valleys may contain a mix of all of these types of deposits. Ancestral stream channels filled with glacial/alluvial sediments are referred to as buried valleys. The buried valleys are filled with differing sequences of coarse sand and gravel outwash, glacial till, ice-contact deposits, finer-grained lacustrine (lake) and modern, silty alluvial or floodplain deposits. These deposits vary with the energy level of the streams at that time. Streams leading away from melting glaciers are high energy and deposit coarser outwash. Streams that are blocked by ice or by thick channel deposits tend to be ponded and filled with finer-grained sediments. Such valleys are also typically filled with till from the advancing ice sheets. As the ice sheets melt within the valleys, both outwash and ice-contact features may be deposited. Modern tributaries, which lead into streams overlying the buried valleys, tend to contain variable thicknesses of sand, gravel, and silty alluvium.

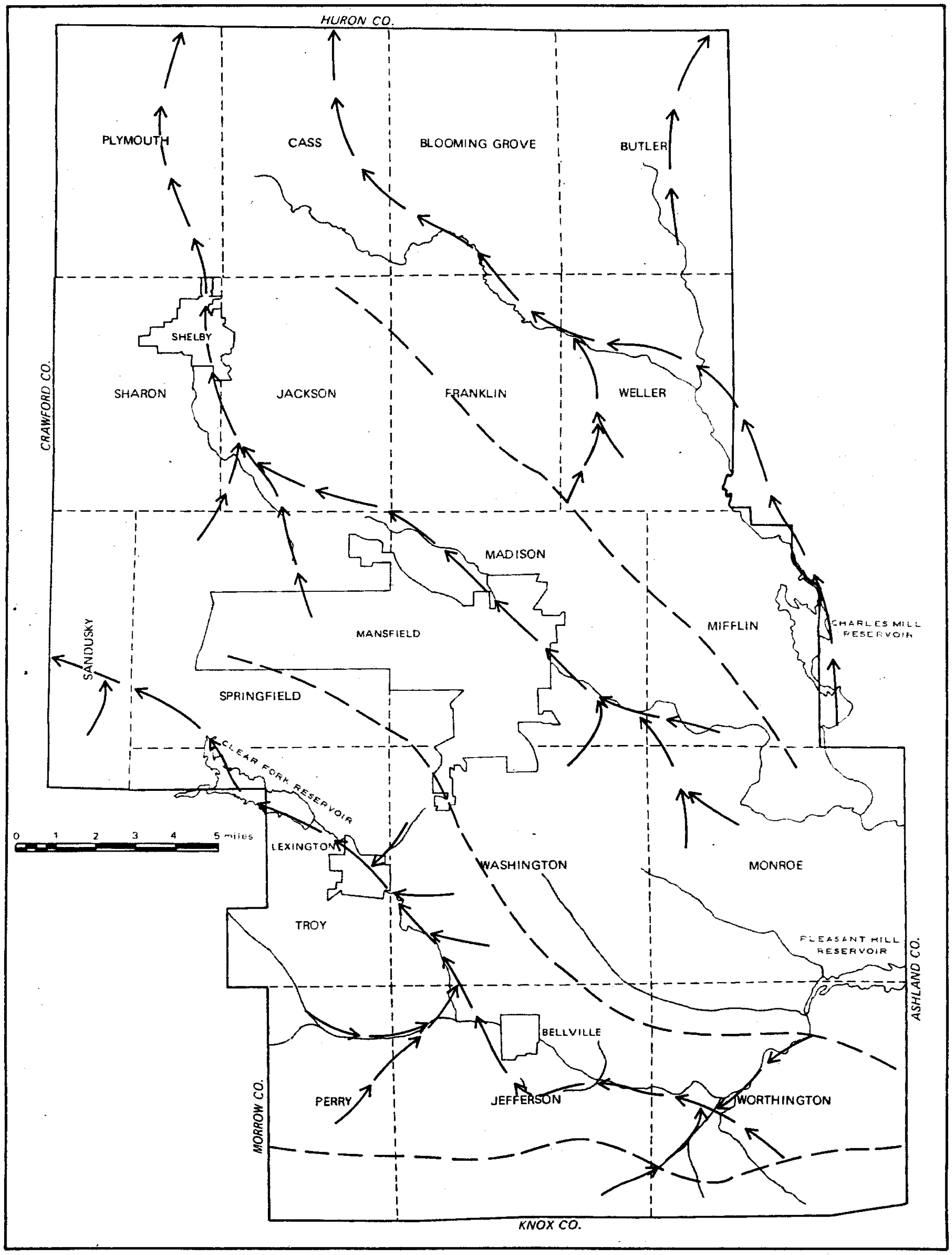


Figure 4. Pre-glacial drainage lines (arrows) and major pre-glacial divides (dashed lines) of the Teays System (after Totten, 1973).

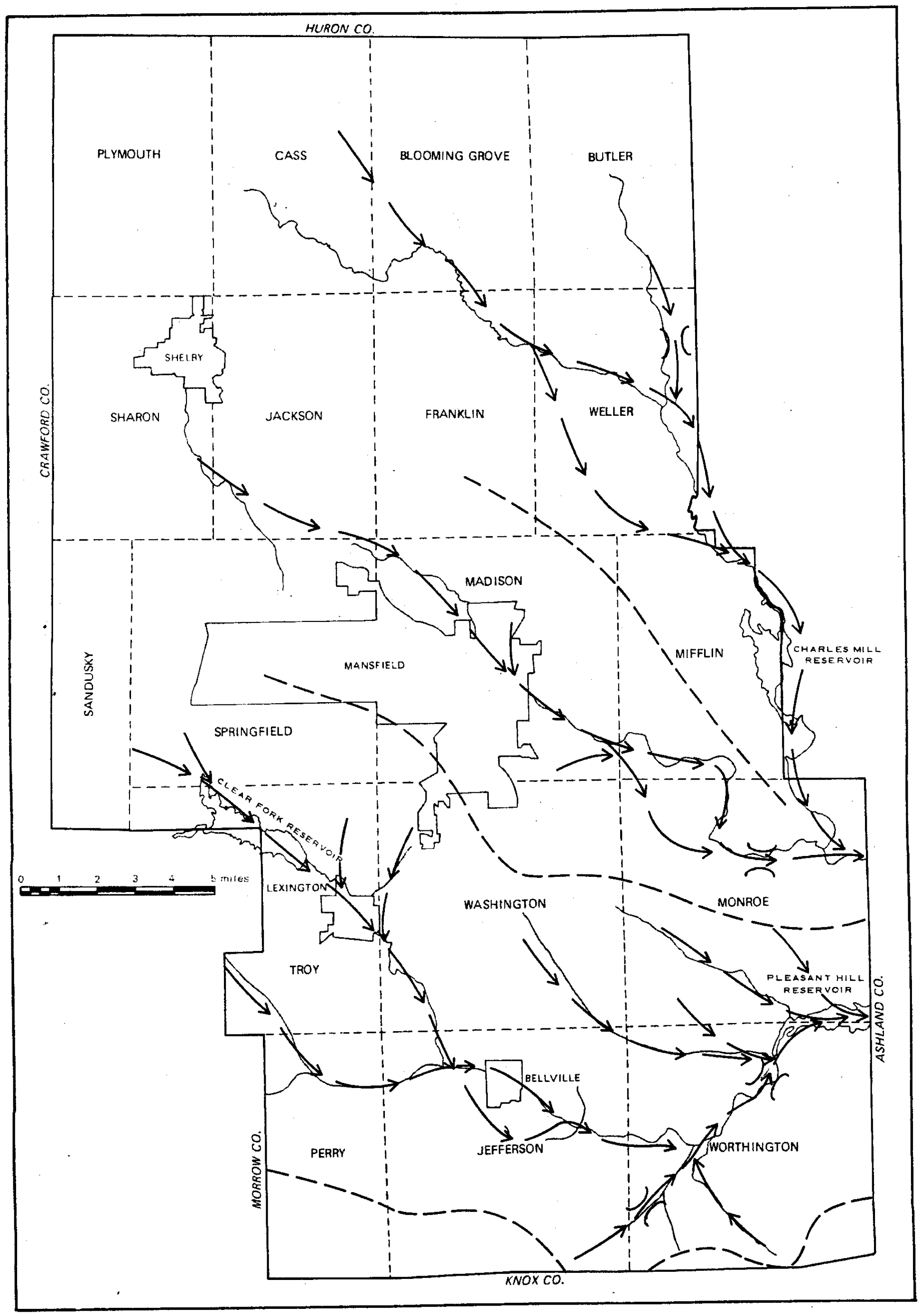


Figure 5. Deep Stage drainage lines (arrows), major divides (dashed lines), and cols (after Totten, 1973).

Table 9. Generalized Pleistocene stratigraphy of Richland County, Ohio

Age In years before present (Y.B.P.)	**Epoch**	**Stage**	**Killbuck Lobe** Northern and eastern Richland Co.	**Scioto Lobe** Southwestern Richland Co.
25,000 to 70,000	Pleistocene	Wisconsinan	Hiram Till Hayesville Till Navarre Till	Centerburg Till Mt. Liberty Till Knox Lake Till
70,000 to 120,000		Sangamonian	Weathered soil	Weathered soil
120,000 to 730,000		Illinoian	Millbrook Till Butler Till	Jelloway Till Butler Till
			Kame deposits	
>730,000		Pre-Illinoian	Deep buried valley deposits	

Till is an unsorted, non-stratified (non-bedded) mixture of sand, gravel, silt, and clay deposited directly by the ice sheet. There are two main types or facies of glacial till. Lodgement till is "plastered-down" or "bulldozed" at the base of an actively moving ice sheet. Lodgement till tends to be relatively dense and compacted and pebbles typically are angular, broken, and have a preferred direction or orientation. "Hardpan" and "boulder-clay" are two common terms used for lodgement till. Ablation or "melt-out" till occurs as the ice sheet melts or stagnates away. Debris bands are laid down or stacked as the ice between the bands melts. Ablation till tends to be less dense, less compacted, and slightly coarser as meltwater commonly washes away some of the fine silt and clay.

Till has relatively low inherent permeability. Permeability in till is in part dependent upon the primary porosity of the till which reflects how fine-textured the particular till is. Vertical permeability in till is controlled largely by factors influencing the secondary porosity such as fractures (joints), worm burrows, root channels, sand seams, etc.(Brockman and Szabo, 2000).

At the land surface, till accounts for two primary landforms: ground moraine and end moraine. Ground moraine (till plain) is relatively flat to gently rolling. End moraines are ridge-like, with terrain that is steeper and more rolling or hummocky. Goldthwait et al. (1961) and Pavey et al. (1999) mapped end moraines regionally across the state. The ODNR, Division of Water Open File, Glacial State Aquifer Map (2000) depicts a generalized version of the more prominent moraines across Richland County. In Richland County, moraines are identifiable north of Mansfield, which approximately equates to being north of the Black Hand Escarpment. South of the Black Hand Escarpment, the steep topography is bedrock controlled and moraines would not be identifiable. Also, once past the Escarpment, the nature of the ice flow may not have been conducive to the formation of end moraines. Totten (1973) maps end moraines in great detail. He shows that many of the moraines have multiple ridges or elements. Among the major end moraines mapped in Richland County by Totten (1973) are (south to north), the Johnstown Moraine, Powell Moraine, Broadway Moraine, Mississinewa Moraine, St. Johns Moraine, and the Wabash Moraine. The end moraines have a tendency to bunch together at places, making separating and naming the ridges difficult.

Pre-Illinoian deposits have not been conclusively identified in Richland County (Totten, 1973). It is possible they may exist in some of the deeper buried valleys. Highly weathered pre-Illinoian deposits may also exist along some of the ridge tops in southeastern Richland County. The thin, patchy drift in southern Worthington Township and Jefferson Township has historically been mapped as Illinoian (Goldthwait et al., 1961 and Pavey et al., 1999). Totten (1973) refers to Illinoian age till in these townships as the Butler Till, named for the village of Butler. Illinoian deposits in Richland County may also include subsurface till, lacustrine, outwash, and kames found in some of the deeper buried valleys in southeastern Richland County. Totten (1973) suggested that many of the extensive sand and gravel deposits found along Clear Fork are probably Illinoian in age. This includes the thick deposits near Bellville and Lexington.

During the Wisconsinan (most recent) ice advance, ice advanced into north central Ohio in two distinct lobes. These lobes extended from the main ice sheet crossing the Lake Erie basin much like fingers extending from a hand. The Killlbuck Lobe extended from the western margin of Summit County into Richland County. The Scioto Lobe extended from western Richland County westward to Bellefontaine and southward to Chillicothe and Hillsboro. Ice movement in the Killbuck Lobe was primarily due south, whereas ice movement in the Scioto Lobe was primarily due east in this region. The boundary between the two lobes passes through southwestern Richland County and is transitional and indistinct (Totten, 1973).

Totten (1973) initially reported that the Millbrook Till and the Jelloway Till were the oldest Wisconsinan age tills in the Killbuck Lobe and Scioto Lobe, respectively. Totten (1973), White et al. (1969), and White (1982) believed that these tills were correlative with the Titusville Till found in the Grand River Lobe of northeastern Ohio and northwestern Pennsylvania. The Titusville Till was proposed as being older than 40,000 Y.B.P. based upon radiocarbon (C^{14}) dates from exposures in northwestern Pennsylvania (White et al., 1969). White et al. (1969) and Totten (1973) referred to these tills as being “early” Wisconsinan and being much older than the other overlying Wisconsinan tills.

Current thinking (Totten, 1987 and Eyles and Westgate, 1987) suggests that there was probably insufficient ice available in North America for a major ice advance into the Great Lakes area until the Late Wisconsinan Woodfordian sub-stage (approximately 25,000 Y.B.P.). The age of deposits previously determined to be early to mid-Wisconsinan in age is therefore being re-evaluated. The Millbrook Till and Jelloway Till are now believed to be Illinoian in age. The Jelloway Till is limited to the southern fringe of Richland County (Totten, 1973). The Millbrook Till is found in the uplands flanking Clear Fork.

The Navarre Till of the Killbuck Lobe and the Knox Lake Till of the Scioto Lobe are the oldest of the Late Wisconsinan Woodfordian tills (Totten, 1973 and White, 1982). These advances occurred about 23,000 Y.B.P. The Knox Lake Till is found in the southwestern corner of the county, southwest of Clear Fork and Mansfield. The Navarre Till roughly lies between Rocky Fork and Clear Fork in southeastern Richland County. The Navarre Till and the Knox Lake Till both are friable (loose), non-compact, sandy, and stony. Sand and gravel lenses are common in these tills. Some of the surficial outwash and kame deposits in the southern part of the county may be associated with the advances that deposited these tills.

Most of the surficial kame and outwash deposits associated with Rocky Fork and Black Fork valleys are believed to be associated with this ice advance (Totten, 1973 and White, 1982).

Following the deposition of the Navarre Till and Knox Lake Till, the late Wisconsinan Woodfordian ice sheet withdrew into the Lake Erie Basin. This local ice-free interval is referred to as the Erie Interstade. Approximately 19,000 YBP, ice began to re-advance into northern Ohio along both lobes. The tills this time are typically much more clayey and silty, contain less rock fragments, and most of the rock fragments are shaley in nature. It is believed that when the ice re-advanced into the Lake Erie basin, it eroded a significant amount of fine shales and previous lacustrine deposits (White, 1982).

The Hayesville Till of the Killbuck Lobe is the surficial till that forms a band around the northern and eastern portions of the Mansfield area. The Hayesville Till is generally the surficial till south of the Powell Moraine; it commonly caps the Johnstown Moraine (Totten, 1973). The Hayesville Till is moderately compact, dense, sparingly to moderately pebbly, and has a clayey-silty texture. The till is commonly thin, patchy, and discontinuous in this area. It is typically highly weathered. The equivalent Mt. Liberty Till is the surficial till found in the vicinity of Cedar Fork , west of Bellville (Totten, 1973). The Mt. Liberty Till is quite similar to the Haysville Till in texture and pebble content. The Mt. Liberty Till is also thin, patchy, and discontinuous.

The Hiram Till is the youngest till encountered in Richland County (Totten, 1973 and White, 1982). It is the surficial till found across northern and central Richland County. The Hiram Till caps the Powell Moraine and extends northward. The Hiram Till is relatively soft, non-compact, and sparingly pebbly and has a silty-clay to clayey texture. The fine texture is probably due to the till eroding and incorporating lacustrine deposits or shale bedrock. The Hiram Till may have been deposited in a fairly wet environment transitional between lacustrine and an ablational environment. The Hiram Till is typically thin; however, it is thicker in areas of lower relief. The Centerburg Till of the Scioto Lobe is very similar to the Hiram Till (Totten, 1973). The Centerburg Till is also patchy and thin. The Centerburg Till may be slightly stonier than the Hiram Till. The occurrence of this till is limited to western Troy Township.

Lacustrine deposits were created as a result of the formation of lakes, particularly within the deeper buried valleys (Totten, 1973). The damming of northerly-flowing streams by the advancing ice sheets typically created the lakes. Smaller, localized lakes could be created along tributaries as they were cut-off from the main trunk streams. Typically, lacustrine deposits are composed of fairly dense, cohesive, uniform silt and clay with minor fine sand. Thin bedding, referred to as laminations, is common in these deposits. Such sediments were deposited in quiet, low-energy environments with little or no current.

Richland County also contains a number of thin but laterally extensive lacustrine deposits that are not associated with buried valleys. These lakes are referred to as intermorainal lakes as they occupy low areas of ground moraine between end moraines. The deposits of these lakes are composed of silty to clayey material. The lakes tend to become somewhat finer-grained near the center of the deposit or lake (Gregory, 1956, House, 1985, Totten, 1986, and Russell, 2002). Lacustrine deposits tend to be laminated (or varved) and contain various proportions of silts and clays. Thin layers of fine sand interbedded with the clayey to silty lacustrine deposits may reflect storm or flood events. Permeability is preferentially horizontal due to the laminations and water-laid nature of these sediments. The inherent vertical permeability is slow; however, secondary porosity features such as fractures, joints, root channels, etc. help increase the vertical permeability. Thin layers of sand typically occupy the margins of the lakes. These sands may reflect minor deltas that started to prograde into the lake, or they may mark the rough beginnings of a beach along the shoreline.

The lakes were created during the recession of the ice sheets. Meltwater was trapped between the receding ice sheet and end moraines. In some areas, meltwater may have been trapped between two end moraines forming a lake. Additional ponding may have resulted from northerly-flowing, run-off fed streams that were blocked by the ice sheets. Run-off in general helped to fill these ponds. Eventually, some of these ponds may have overflowed their margins and began to cut an outlet. House (1985) and Russell (2002) theorized that as one lake overflowed, it would progressively cause the next lower elevation lake to overflow. Alternatively, the headwaters of emerging streams may have cutback and created an outlet for the lakes. As the modern drainage system slowly developed, streams downcut through the series of end moraines, draining the lakes over time. Swampy bog and kettle areas replaced many of the lakes. Many of these features persist today or were recently drained for agriculture.

Glacial Lake Shelby occupies the extensive low area between the St. Johns Moraine and the Mississinewa Moraine north of the town of Shelby and another lake area between the Mississinnewa Moraine and the Broadway Moraine south of Shelby (Totten, 1973 and Russell, 2002). Lake Willard occupies a low area north of the Fort Wayne Moraine in the extreme northwest corner of Richland County (Totten, 1973).

Outwash deposits are created by active deposition of sediments by meltwater streams. These deposits are generally bedded or stratified and are sorted. Outwash deposits in Richland County are commonly associated with buried valleys and are usually adjacent to modern streams. Outwash deposits associated with stream valleys were referred to in earlier literature as valley trains. Sorting and degree of coarseness depend upon the nature and proximity of the melting ice sheet. Braided streams usually deposited the outwash. Such streams have multiple channels, which migrate across the width of the valley floor, leaving behind a complex record of deposition and erosion. As modern streams downcut, the older, now higher elevation, remnants of the original valley floor are called terraces. Totten (1973) has delineated the major terraces in the county. Totten (1973) has inferred that the deposition of these terraces is complex and that there may be multiple episodes of deposition and subsequent erosion over time. Clear Fork, and its tributaries including Cedar Fork, Switzer Creek, and Honey Creek contain thick sequences of outwash. Totten (1973) also speculated that the deeper outwash near Bellville is Illinoian or even pre-Illinoian in age. Thick sequences of outwash are also found along Rocky Fork. Less extensive outwash deposits are found along Black Fork.

Kames and eskers are ice contact features. They are composed of masses of generally poorly sorted sand and gravel with minor till, deposited in depressions, holes, tunnels, or other cavities in the ice. As the surrounding ice melts, a mound of sediment remains behind.

Typically, these deposits may collapse or flow as the surrounding ice melts. These deposits may display high angle, distorted or tilted beds, faults, and folds. In Richland County, the majority of the kames are deposited along the margins or flanks of valleys, particularly within the headwaters of the drainage systems. These kames tend to coalesce together along the valley margins. Such features are referred to as kame terraces. Kame terraces are a linear belt of kames that have a similar appearance and a fairly uniform elevation. They represent deposition of materials between the melting ice sheet and the bedrock and till slopes flanking the ice-filled valleys. Eskers are elongate, sinuous deposits that marked deposition by drainage channels beneath the iced sheet. Crevasse fills are similar except that they occurred at the top of the ice sheet or within the ice sheet.

The kame deposits in some areas are immediately adjacent to outwash deposits. In these areas, the outwash deposits are commonly lower elevation and are flat-lying whereas the kame deposits have their characteristic rolling to hummocky nature. Surficial kame deposits generally lie above the water table whereas the outwash deposits are typically saturated. Although not saturated, the kame deposits are commonly highly permeable and provide conduits for water movement. Buried or lower elevation kames may be saturated.

Abundant kames and kame terraces flank Black Fork, particularly near Charles Mill Reservoir, lower Rocky Fork, and the upper portions of Clear Fork and Cedar Fork. The kames flanking these major stream valleys tend to be at higher elevations and further up the headwaters of tributaries than do outwash deposits. There are also a number of isolated, individual kames that are not obviously associated with streams. Most of these kames are found in uplands nearby Shelby.

Peat and muck are organic-rich deposits associated with low-lying depression areas, bogs, kettles, and swamps. Muck is a dense, fine silt with a high content of organics and a dark black color. Peat is typically brownish and contains pieces of plant fibers, decaying wood, and mosses. The two deposits commonly occur together, along with lacustrine or slack water clays and silts. The majority of these deposits are found along lower-lying portions of valley floors including margins of floodplains and terraces. Minor peat deposits are found in lows amid the kame fields in Clear Fork valley. Small, isolated peat deposits are found in shallow bogs and kettles associated with the intermorainal lakes.

Bedrock Geology

Most of the bedrock exposed at the surface in Richland County belongs to the Mississippian System. Interbedded sandstones, shales, and siltstones of the Pennsylvanian Allegheny and Pottsville Groups are exposed in the extreme southeastern corner of Richland County. Table 10 summarizes the bedrock stratigraphy found in Richland County. The ODNR, Division of Geological Survey, has Open-File Reconnaissance Bedrock Geological Maps done on a 1:24,000 scale USGS topographic map base available for the entire county.

Table 10. Bedrock stratigraphy of Richland County, Ohio

System	Group/Formation (Symbol)	Lithologic Description
Pennsylvanian	Allegheny-Upper Pottsville (Pap)	Thin brown to gray sandstones, siltstones, shale, and coal. Local thickness <100 feet. Poor to moderate aquifer yielding 5-25 gpm. Limited to southeast corner of county.
Mississippian	Logan and Black Hand Formations (Mlb)	The Logan consists of reddish-brown fine-grained sandstones interbedded with siltstones and shales. The Black Hand is a massive, coarse-grained sandstone, yellow to brown in color. Primary aquifers in eastern and southern Richland County. Thickness exceeds 100 feet. Yields range from 5 to 100 gallons per minute.
	Cuyahoga Formation (Mcg)	Gray to brown shale with thin sandstone and siltstone interbeds. Thickness commonly greater than 100 feet. Yields range from 5 to 25 gpm. Widespread aquifer in northern and western Richland County.
	Berea Sandstone (Mb)	Fine- to medium-grained, light greenish-gray to brown sandstone. Thickness is typically <100 feet. Yields average 5-25 gpm. Found near surface in northwestern Richland County and at depth. Found at depth in northern and western Richland County.
	Sunbury Shale (Ms)	The Sunbury Shale is a brownish-black to greenish-gray thin-bedded fissile shale. Encountered at depth in northern and western Richland County. Poor aquifer, yields less than 5 gpm.
	Bedford Shale (Mbd)	Gray to reddish brown shale with minor siltstone. Thickness less than 100 feet. Poor aquifer, yields less than 5 gpm. Limited to valleys in northwestern Richland County.

The ODNR, Division of Water, has Open File Bedrock State Aquifer mapping available for the county also.

The Mississippian Bedford Shale is not known to crop out in Richland County. It is found at depth in the extreme northwest corner of the county. (Totten, 1973 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). The Bedford Shale is a gray to brown or reddish-brown shale with interbedded sandstone and siltstone. It is comprised of very fine-grained silt and clay particles deposited in the outer (distal) margins of a delta.

The Mississippian Berea Sandstone crops out in the northwestern corner of the county near Plymouth (Totten, 1973 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). The Berea is found at depth through the northwestern two-thirds of the county along a line roughly passing east and south of Mansfield. It is a fine- to medium-grained, light greenish-gray to brown sandstone that may contain minor shale interbeds. The thickness seldom exceeds 100 feet. The Berea Sandstone consisted of river channel and bank sediments deposited along the proximal or near-shore edge of a broad delta. The upper part of the Berea Sandstone appears to have been formed as encroaching marine waters submerged the sediments. The sediments were then re-deposited along adjacent shorelines (Rau, 1969).

The Sunbury Shale is a brownish black to greenish gray thin-bedded carbonaceous shale. It is commonly found with carbonate/siderite concretions in the lowermost 50 feet of the formation. The Sunbury Shale is typically fractured and contains a high degree of organic matter, pyrite, petroleum, and is also very mildly radioactive. The Sunbury Shale was deposited in deep oceans that had limited circulation of fresher waters and sediments. Organic material was slow to decompose in the oxygen-starved, stagnant water. The Sunbury Shale is not known to crop out at the surface in Richland County. This unit is common at depth in the subsurface of Richland County and covers roughly the same portions of the county that the underlying Berea Sandstone does.

The Mississippian Cuyahoga Formation is found across northern, western, and southwestern Richland County. It crops out along ridges and valleys and is the uppermost bedrock unit in these areas of the county. The Cuyahoga Formation consists of interbedded sandstones, siltstones, and shales that represent deltaic to fluvial sediments deposited in a rapidly fluctuating, shoreline environment. The Cuyahoga Formation is more shale-rich in the north central portion of the county.

The Mississippian Black Hand and Logan Formation are found in southern, eastern, and central Richland County. These units have numerous exposures, particularly in the thinly glaciated uplands south of Clear Fork. The Logan formation consists of brown to reddish-brown sandstones interbedded with siltstones and shales; in some areas, siltstones and shales may predominate. The Black Hand formation is massive, coarse-grained sandstone, yellow to brown in color. The transition between shales and sandstones reflects the transition between coarser and finer stream deposition. The gradation also reflects the relative position of the shoreline over time, with coarser deposition closer to land and finer-grained sediments more distal from the shore. Drillers commonly refer to these sandstones as the “Big Injun”. These units reflect deposition in a high-energy, near-shore, deltaic environment.

Rocks of the Pennsylvanian System are limited to interbedded dirty sandstones, shales, and siltstones of the Pottsville and Allegheny Groups. These typically thin units occupy steep ridge tops in southeastern Worthington Township (Totten, 1973 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). These rocks were deposited in highly transitional environments including both terrestrial ("land-based") and marine-derived sediments.

Ground Water Resources

Ground water in Richland County is obtained from both unconsolidated (glacial-alluvial) and consolidated (bedrock) aquifers. Glacial aquifers are primarily associated with the buried valleys and thicker upland outwash and kame field deposits. In upland areas where the drift is primarily thick till, water is obtained from sand and gravel lenses interbedded in the glacial till. Such areas include the ground moraine and end moraines of northern Richland County.

Yields exceeding 500 gpm are obtainable from the coarse, well-sorted sand and gravel outwash deposits along Clear Fork between Clear Fork Reservoir and Bellville and for Black Fork in the vicinity of Charles Mill Reservoir (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994). These aquifers have modern, overlying streams that provide recharge to sustain these high yields. Test drilling or geophysical methods are recommended to help locate the higher yielding zones. Proper well construction and development is also needed to insure the high sustainable yields capable from these larger diameter wells. Smaller diameter wells should be suitable for serving domestic/farm needs within this aquifer. Yields of 100 to 500 gpm are obtained from wells completed in coarse, well-sorted outwash deposits. These deposits are found along Clear Fork between Bellville and Butler and nearby Pleasant Hill Reservoir, along Rocky Fork form Ontario through Mansfield, and along Black Fork from Shiloh southward into Ashland County (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000). These high yielding deposits commonly are nearby modern overlying streams or are overlain by permeable kame fields.

Yields of 25 to 100 gpm are obtained from wells drilled in outwash, lacustrine, alluvial, or kame deposits. Typically, these deposits are thinner, less coarse, and are not as clean or well-sorted as the above, higher-yielding aquifers. They also may not have nearby overlying streams. The sand and gravel units may be interbedded with finer-grained silty to clayey lacustrine or alluvial deposits or till. Aquifers yielding 25 to 100 gpm are commonly found along the margins, in the headwaters, or along tributaries leading toward the higher-yielding buried valley deposits in the county (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994).

Yields of 5 to 25 gpm are obtained from thin lenses of sand and gravel interbedded with glacial till where the drift is of adequate thickness. This includes areas of ground moraine and end moraine in northern and western Richland County. In many portions of eastern and southern Richland County, the drift is too thin to be utilized as an aquifer and the presence of a good, underlying sandstone aquifers helps minimize the number of wells completed in the drift found in these locales (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994).

Yields from the consolidated, bedrock aquifers throughout the county are variable. The highest-yielding bedrock aquifers are the coarse, highly fractured zones of the Mississippian Black Hand Sandstone and the Logan Formation. (ODNR, Division of Water, Bedrock State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994). These erosion-resistant units form the steep, higher-relief ridges in the southern and eastern portions of the county and typically yield 25 to 100 gpm (ODNR, Division of Water Open File, Bedrock State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994). Yields ranging from 5 to 25 gpm are associated with the interbedded shales, fine-grained sandstones, and siltstones of the Cuyahoga Formation. These aquifers are widespread across northern, central, and western Richland County (ODNR, Division of Water Open File, Bedrock State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994).

The dirty sandstones, shales, and siltstones of the Pennsylvanian Allegheny-Pottsville Groups in the southeastern part of Worthington Township are too thin and fine-grained to be good aquifers. Wells typically are drilled through these formations and are completed in the underlying sandstones (ODNR, Division of Water, Open File, Bedrock State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994).

Yields of 5 to 25 gpm are obtained from the Berea Sandstone in much of the western, northern and central portion of the county (ODNR, Division of Water, Bedrock State Aquifer Map, 2000, Schmidt, 1979, and Haiker, 1994). The Berea Sandstone is found at depth underlying shaley portions of the Cuyahoga Formation. Yields less than 5 gpm are obtained from shaley portions of the Cuyahoga Formation, the Bedford Shale, and the Sunbury Shale in portions of north central and northeastern Richland County. Typically, yields from these units are marginal for even domestic needs and may require extra storage. Water quality from these deep, shaley aquifers also tends to be quite poor.

The yield in any particular area is dependent upon the number and type of formations through which the well is drilled. Wells drilled in bedrock often encounter several aquifers or water-producing zones. Sandstones and conglomerates tend to be better water-bearing units than shales or siltstones. Water tends to "perch" or collect on top of lower permeability units (e.g. shale) and move laterally along the base of an overlying unit with higher permeability (e.g. sandstone). Springs and seeps mark where these contacts meet the slope or land surface. The number of fractures and bedding planes intersected by the well also influences yields. The amount of fracturing tends to increase along hill slopes and valleys. Fracturing is also an influence on the direction of ground water flow (Schubert, 1980) and affects the amount of recharge.

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APPENDIX A
DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

This factor was primarily evaluated using information from water well log records on file at the Ohio Department of Natural Resources (ODNR), Division of Water, Water Resources Section (WRS). Approximately 15,750 water well log records are on file for Richland County. Data from roughly 6,100 located water well log records were analyzed and plotted on U.S.G.S. 7-1/2 minute topographic maps during the course of the project. Static water levels and information as to the depths at which water was encountered were taken from these records. The *Ground Water Resources of Richland County* (Schmidt, 1979 and Haiker, 1994) provided generalized depth to water information throughout the county. Depth to water trends mapped in adjoining Crawford County (Angle and Russell, 2003), Huron County (Powers, et al., 2003), and Knox County (Aller and Ballou, 1990) were used as a guideline.

Depths to water of 0 to 5 feet (10) were assigned to the headwaters of some minor tributaries in northwestern Richland County. Depths to water of 5 to 15 feet (9) were typical of areas associated with floodplains of major streams. Depths of 5-15 feet (9) were also chosen for certain areas of ground moraine and end moraine in northern and western Richland County. Depths of 15 to 30 feet (7) were used for stream terraces adjacent to major streams and along smaller tributaries. Depths to water of 15 to 30 feet were also common in areas of ground moraine and end moraine in north central Richland County. Depths of 30 to 50 feet (5) were utilized for upland areas with lower relief and for margins of buried valleys that are not in close proximity to modern streams. Depths to water of 50 to 75 feet (3) were utilized for steeper slopes and moderate ridge tops in the uplands and in deeper buried valleys, which lack modern surficial streams. Depths to water of 75 to 100 feet (2) and greater than 100 feet (1) were selected for steep slopes and ridge tops associated with the resistant sandstones of southeastern Richland County.

Net Recharge

This factor was evaluated using many criteria, including depth to water, topography, soil type, surface drainage, vadose zone material, aquifer type, and annual precipitation. General estimates of recharge provided by Pettyjohn and Henning (1979) and Dumouchelle and Schiefer (2002) proved to be helpful. Recharge is the precipitation that reaches the aquifer after evapotranspiration and run-off. Recharge ratings from adjoining Crawford County (Angle and Russell, 2003) and Knox County (Aller and Ballou, 1990) were used as a guideline.

Recharge values of 7 to 10 inches per year (8) were assigned to floodplains adjacent to modern streams overlying outwash buried valley deposits. These areas contain highly permeable soils, vadose, and aquifer materials, have shallow depths to water, gentle slopes, and surficial streams. These areas are limited to terraces and floodplains underlain by coarse-grained outwash deposits. Values of 4 to 7 inches per year (6) were used for areas with moderate recharge. These areas include margins of buried valleys and uplands. Such areas also tend to have moderately shallow depths to water and lower permeability soils, or areas with moderate depths to water and moderately permeable soils, vadose, and aquifers. The majority of these areas are located in northern Richland County. Values of 2 to 4 inches per year (3) were utilized for steep slopes and ridge tops in uplands associated with resistant sandstone bedrock. Greater depths to water, lower permeability soils, and steep slopes with high runoff characterize these areas of lower recharge. Values less than 2 inches per year (1) were used in the 7G-Thin till over bedded sedimentary rock hydrogeologic setting. These settings tend to lack soil and have very high run-off rates, steep slopes, and fairly great depths to water.

Aquifer Media

Information on evaluating aquifer media was obtained from the reports and maps of Schmidt, 1979, Totten, 1973, Haiker, 1994, and Golder Associates, 1997. Open File Bedrock Reconnaissance Maps and Open File Bedrock Topography Maps, based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) were an important source of aquifer data. Aquifer media data from adjoining Crawford County (Angle and Russell, 2003), Huron County (Powers et al., 2003), and Knox County (Aller and Ballou, 1990) were used as a guideline. Water well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

An aquifer rating of (8) was designated for the high-yielding sand and gravel outwash deposits underlying portions of Clear Fork extending from the Reservoir to Butler and by Pleasant Hill Reservoir, Rocky Fork from Ontario through southeastern Mansfield, and Black Fork in the vicinity of Charles Mill Reservoir. An aquifer rating of (7) was assigned to thinner, less continuous sand and gravel outwash deposits associated with portions of Clear Fork, Cedar Fork, Rocky Fork south of Mansfield and Black Fork in the vicinity of Shiloh. These outwash deposits also tend to be somewhat finer-grained and less well sorted. An aquifer rating of (7) was also utilized for ice-contact deposits such as kames and eskers. An aquifer rating of (6) was used for some thinner sand and gravel deposits associated with tributaries and margins of the major buried valleys. The aquifer rating of (6) was also used for many of the end moraine settings found in northwestern Richland County. An aquifer rating of (5) was used for the thin sand and gravel lenses interbedded with thick sequences of fined-grained glacial till in uplands and areas of ground moraine and end moraine in northeastern and central Richland County. An aquifer rating of (5) was used for thin sand and gravel lenses interbedded with fine-grained till or lacustrine materials found in the headwaters of tributaries to buried valleys in southwestern Richland County.

Sandstone was designated for the aquifer primarily in wells in which sandstone was encountered. These areas are associated with the Mississippian Black Hand and Logan Formations throughout southeastern Richland County. An aquifer rating of (5) was used for these aquifers. Wells that encounter both sandstone and shale were common in northern and western Richland County. The aquifer in these areas was evaluated as being interbedded sandstone and shale even if the majority of the yield was probably derived from the sandstone. These areas are associated with the Mississippian Cuyahoga Formation. An aquifer rating of (5) was utilized for portions of the Cuyahoga Formation in southwestern and northeastern Richland County. In these areas the Cuyahoga Formation contained a higher proportion of sandstone or was associated with steeper ridge tops that are more extensively fractured. An aquifer rating of (4) was assigned to more shaley portions of the Cuyahoga Formation in northwestern Richland County. Shale was evaluated as the aquifer for wells completed in shale in which sandstone was absent or not encountered in nearby well logs. Shale aquifers were limited to areas adjacent to Huron County where relatively thin, clayey end moraine deposits overlie very shale-rich units of the Cuyahoga Formation. An aquifer rating of (2) was utilized for shale aquifers.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Richland County* (Redmond et al., 1975). Each soil type was evaluated and given a rating for soil media. Evaluations were based upon the texture, permeability, and shrink-swell potential for each soil material. The soils of Richland County showed a high degree of variability. This is a reflection of the parent material. Table 11 is a list of the soils, parent materials, setting, and corresponding DRASTIC values for Richland County.

Soils were considered to be Thin/Absent (10) along many steep, prominent ridge tops and slopes where bedrock was exposed. These soils are common in southeastern Richland County. Soils were rated as being a peat (8) for limited organic soils in depressions or kettles on floodplains. These areas overlie buried valleys and the largest occurrence of these soils is found along Black Fork south of Shiloh. Shrink-swell (aggregated) clays (7) were evaluated for limited shale-rich ridge tops associated with Pennsylvanian Allegheny-upper Pottsville Formations in the southeastern corner of Richland County. Locally, these fine-grained shales weather into thin, very clay-rich soils Sandy loams (6) were selected for soils overlying outwash terraces, plains, and kames overlying buried valleys. Sandy loam soils (6) were also selected for steep, residual sandstone ridges that flank buried valleys in southeastern Richland County. Loam soils (5) were designated for soils derived from coarser, ablational glacial till that caps portions of end moraines along the Huron County border. Silt loam (4) soils were evaluated for loamy glacial till found in much of southern Richland County. Silt loam (4) was also selected for silty alluvial and lacustrine deposits on floodplains. Clay loam (3) soils were evaluated for areas with clay-rich glacial till, primarily in central and northern Richland County.

The Rittman-Wadsworth Soils, which are associated with the Hayesville till in much of northern Richland County, the Ravenna-Canfield-Frenchtown-Wooster soils, which are associated with the Knox Lake and Navarre Tills in southern and western Richland County, and the Gresham-Hanover-Titusville soils, which are weathered from the Illinoian tills in far southern Richland County, contain fragipans. A fragipan is a dense, impermeable zone found within certain loamy, till-derived soils. Fragipans may notably restrict the downward

Table 11. Richland County soils

Soil Name	Parent Material or Setting	DRASTIC Rating	Soil Media
Alexandria	Silty Till	3	Clay loam
Algiers	Alluvium, floodplain	4	Silt loam
Belmore	Outwash, kame	6	Sandy loam
Bennington	Clayey till	3	Clay loam
Berks	Shale-fine sandstone	10	Thin/Absent
Bogart	Outwash, kames	6	Sandy loam
Canfield*	Loamy till	4	Silt loam
Cardington	Silty till	3	Clay loam
Carlisle	Bogs, depressions	8	Peat
Chili	Outwash, kames	6	Sandy loam
Conotton	Coarse outwash	10	Gravel
Condit	Clayey till	3	Clay loam
Digby	Outwash	6	Sandy loam
Fitchville	Silty lacustrine terrace	4	Silt loam
Frenchtown*	Loamy till	4	Silt loam
Glenford	Silty lacustrine	4	Silt loam
Gresham*	Illinoian till	3	Clay loam
Haney	Kames, outwash deposits	6	Sandy loam
Hanover*	Illinoian till	3	Clay loam
Holly	Coarse alluvium	6	Sandy loam
Landes	Coarse alluvium	9	Sand
Latham	Shale/siltstone	7	Shrink-swell clay
Linwood	Bogs, depressions	2	Muck
Lobdell	Alluvium, floodplain	4	Silt loam
Lordstown	Sandstone	10	Thin/Absent
Loudonville	Sandstone bedrock	10	Thin/Absent
Luray	Silty lacustrine	4	Silt loam
Mentor	Alluvial, slackwater	4	Silt loam
Orrville	Alluvium, floodplain	4	Silt loam
Pewamo	Clayey till	3	Clay loam
Ravenna*	Loamy till	4	Silt loam
Rittman*	Silty till	3	Clay loam
Schaffenaker	Sandstone outcrops	10	Thin/Absent
Sebring	High lacustrine terraces	3	Clay loam
Shoals	Alluvium, floodplain	4	Silt loam
Sloan	Alluvium, floodplain	4	Silt loam
Tiro	Lacustrine over till	3	Clay loam
Titusville*	Illinoian till	3	Clay loam
Wadsworth*	Silty till	3	Clay loam
Walkill	kettle, depression	8	Peat
Wheeling	High lacustrine terraces	4	Silt loam
Wooster*	Loamy till	4	Silt loam

* denotes soils containing a fragipan

movement of water (Ritchie et al., 1974 and Williams, 1991). The net effect of the fragipan is to reduce the overall permeability of a soil within a given textural range (Aller et al., 1987). Hence, a soil with a loam (5) texture would be evaluated as a silt loam (4), and a soil with a silt loam (4) texture would be evaluated as a clay loam (3) due to the presence of a fragipan (see Table 11).

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Richland County* (Redmond et al., 1975).

Slopes of 0 to 2 percent (10) and 2 to 6 percent (9) were selected for flat-lying floodplains, valley floors, and terraces. Slopes of 0 to 2 (10) and 2 to 6 percent (9) were also used for flat lying ground moraine or till plain areas on the uplands. Slopes of 6 to 12 percent (5) were used for less steep bedrock-controlled topography, for steeper kame features, and for areas of end moraines. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were selected for steeper slopes in higher relief, upland areas. These areas have bedrock-controlled topography and drift is Thin/Absent. These steep areas are common in southern Richland County and along isolated ridge tops in northeastern Richland County.

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained from the reports and maps of Schmidt, 1979, Totten, 1973, Haiker, 1994, Bowser-Morner (1986), and Hull and Associates (1989, 1991, 1992, 1993, 1994). Vadose zone media data from adjoining Crawford County (Angle and Russell, 2003), Huron County (Powers et al., 2003), and Knox County (Aller and Ballou, 1990) proved useful as a guideline for evaluating vadose zone materials. Open File Bedrock Reconnaissance Maps based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were important sources of vadose zone media data. Information on parent materials derived from the *Soil Survey of Richland County* (Redmond et al., 1975), also proved useful in evaluating vadose zone materials. Water well log records on file at the ODNR, Division of Water, were the primary source of information on vadose zone media for the county.

Vadose zone media was given ratings of (6), and (7) for sand and gravel interbedded with silt and clay layers for outwash terraces, kames, and coarse alluvium overlying buried valleys. Vadose zone media ratings of (5) and (6) were selected for sand and gravel interbedded with silt and clay layers for deposits overlying buried valleys and alluvium. These ratings depend upon the proportion of coarse, well-sorted outwash to the finer-grained alluvial and lacustrine deposits. Silt and clay with ratings of (3), (4), and (5) were selected for vadose zone media for floodplains and alluvial deposits associated with minor tributaries and the headwaters of streams throughout Richland County. Silt and clay (3) was also chosen as the vadose zone media for the areas of intermorainal lakes found in western Richland

County. Silt and clay (3) was assigned as the vadose zone media along the border of Huron County as the till in this area was very highly-clayey Hiram till in this area.

Till with a rating of (5) was utilized for loamy glacial tills associated with the Knox Lake and Navarre in the southern part of the county. Till was also given a rating of (5) where the till was relatively thin, weathered, and presumably fractured through much of its extent. Till with a rating of (5) was also used in some areas where till had incorporated large amounts of sand from sandstone outcrops. Till with a rating of (4) was used for more clayey-textured tills and for tills of significant thickness in which the majority of the till would be unweathered and fractured to a lower degree. Till with a rating of (4) was used for silty to clayey tills associated with the Hayesville Till, Mt. Liberty Till, and Hiram Till in western, central, and northern Richland County. Till with a rating of (4) was also used for till which had incorporated large amounts of fine-grained shale in the northern part of the county. A vadose zone media rating of (3) was selected for till interbedded with fine lacustrine sediments in a deep buried valley in the southeastern corner of the county.

A vadose zone media rating of (5) was selected for sandstone associated with the Mississippian Black Hand Sandstone and Logan Formation and some sandstone-rich units of the Cuyahoga Formation. A vadose zone media rating of (5) was chosen for interbedded sandstone and shale of the Cuyahoga Formation that capped uplands in northeastern and southwestern Richland County. A rating of (4) was selected for interbedded sandstone and shale for a shale-rich area of the Cuyahoga Formation in north central Richland County.

<u>Hydraulic Conductivity</u>

Published data for hydraulic conductivity for Richland County included the reports of Golder Associates, 1997, Bowser-Morner, 1986, and Hull and Associates (1989, 1991, 1992, 1993, 1994). Mapping in adjoining Crawford County (Angle and Russell, 2003), Huron County (Powers et al., 2003), and Knox County (Aller and Ballou, 1990) were used as a guideline for determining the range of hydraulic conductivity values. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) proved valuable. Water well log records on file at the ODNR, Division of Water, were the primary sources of information. Textbook tables (Freeze and Cherry, 1979, Fetter, 1980, and Driscoll, 1986) were useful in obtaining estimated values for hydraulic conductivity in a variety of sediments.

Values for hydraulic conductivity correspond to aquifer ratings; i.e., the more highly rated aquifers have higher values for hydraulic conductivity. For sand and gravel aquifers with an aquifer rating of (8), hydraulic conductivity values of 1,000-2,000 gallons per day per square foot (gpd/ft^2) (8) or 700-1,000 gpd/ft^2 (6) were selected. These high values were limited to the clean outwash and kame deposits associated with buried valleys underlying Clear Fork, Rocky Fork, and Black Fork. For sand and gravel deposits associated with buried valleys with an aquifer media rating of (7), hydraulic conductivities of 700-1000 gpd/ft^2 (6) and 300-700 gpd/ft^2 (4) were chosen. These ratings vary upon how coarse, clean (free of fines), and well-sorted the permeable deposits are. For sand and gravel deposits with an aquifer rating of

(6), hydraulic conductivity values ranged from 300-700 gpd/ft^2 (4). For sand and gravel deposits with an aquifer rating of (5), hydraulic conductivity values ranged from 300-700 gpd/ft^2 (4) or 100-300 gpd/ft^2 (2). In these deposits, thin sand and gravel lenses are interbedded with thicker sequences of finer-grained materials.

Sandstone aquifers with an aquifer rating of (5) have been assigned a hydraulic conductivity rating of 300-700 gpd/ft^2 (4) for a few limited areas that had very high yields, presumably due to the intersection of localized fracture systems. Typically, sandstone aquifers with an aquifer rating of (5) are assigned hydraulic conductivity values of 100-300 gpd/ft^2 (2). These rocks tend to be relatively coarse-grained, porous, and highly fractured. Interbedded sandstone and shales with aquifer ratings of (5) or (4) were given hydraulic conductivity ratings of 1-100 gpd/ft^2 (1). All of the shale aquifers with an aquifer rating of (2) were given a hydraulic conductivity rating of 1-100 gpd/ft^2 (1) due to the low permeability of these rocks.

APPENDIX B

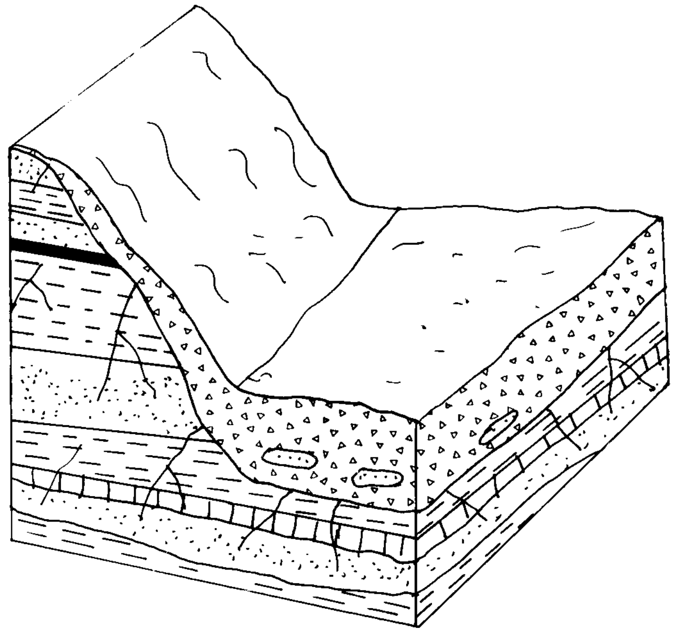
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Richland County resulted in the identification of 10 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 Richland County range from 67 to 182.

Table 12. Hydrogeologic settings mapped in Richland County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa-Glacial till over bedded sedimentary rocks	67-128	53
7Ad-Glacial till over sandstone	69-122	42
7Af-Sand and gravel interbedded in glacial till	91-140	20
7Bb-Outwash over bedded sedimentary rock	106-131	5
7C-Moraine	88-140	37
7D-Buried valley	70-182	155
7Ec-Alluvium over bedded sedimentary rock	112-133	11
7Ed-Alluvium over glacial till	129-145	9
7Fc-Intermorainal lake deposits	90-111	8
7G-Thin glacial till over bedded sedimentary rock	73-108	20

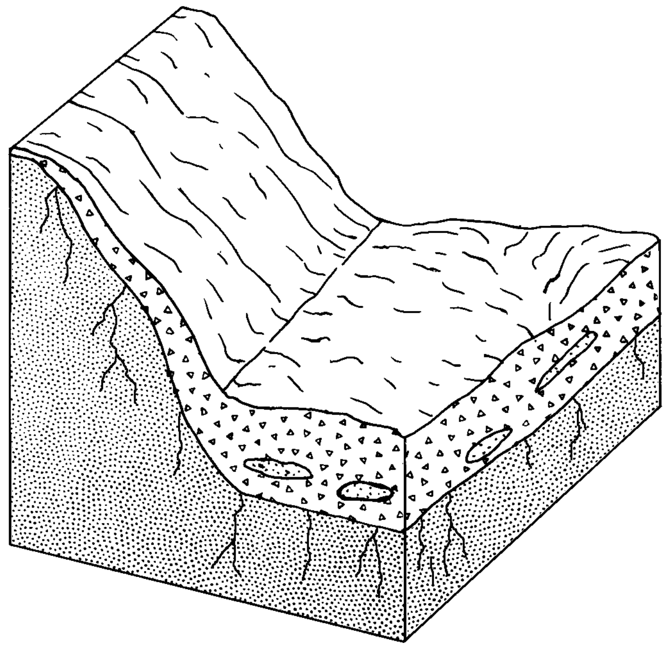
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide 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 variable and is common in north central and southwestern Richland County. This setting is associated with upland areas and commonly features bedrock-controlled topography. Topography varies from rolling, moderate relief areas with moderately thick till cover to steeper, higher relief areas associated with bedrock ridges. Well log data indicates that wells in this setting encounter both sandstone and shale sequences. The aquifer typically consists of thin interbedded shales, sandstones, and siltstones of the Mississippian Cuyahoga Formation. Yields range from 5 to 25 gpm for wells completed in these rocks. The thickness of glacial till typically overlying the aquifer is highly variable. The various till units commonly weather into either silty loams or clay loams. Where the till was thin and depths to water greater, the interbedded sandstone and shale were inferred as being the vadose zone media. The depth to water is variable, ranging from 15 feet to up to 100 feet. The depth to water is significantly higher for the steeper ridge tops. Recharge is typically low to moderated due to low permeability soils, thickness of the till cover, and depth to water.

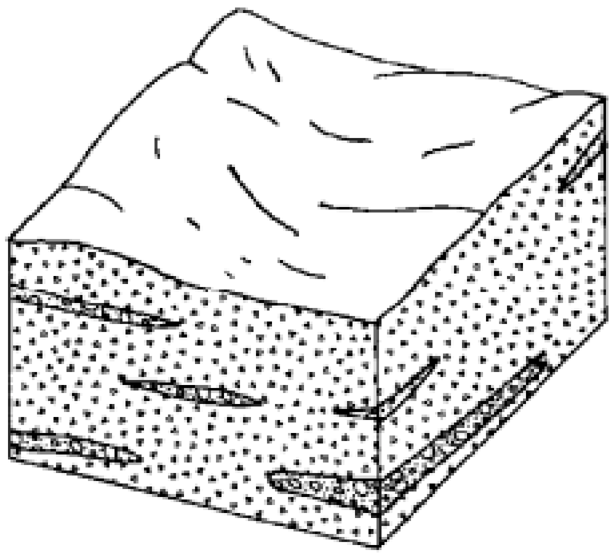
GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rocks range from 67 to 128, with the total number of GWPP index calculations equaling 53.



7Ad Glacial Till over Sandstone

This hydrogeologic setting is common in southeastern Richland County. It is typically associated with resistant, steep-sided ridges with moderately broad, flat ridge tops. The topography varies from gently rolling to relatively steep. Depths to water vary from moderate to deep. Soils are clay loams or silt loams derived from tills. The vadose zone varies from glacial till to sandstone depending upon the drift thickness. The aquifer consists of the Mississippian Black Hand and Logan Formations. Yields range from 5 to 100 gpm depending upon the various sandstone units present. Recharge is commonly moderate to low due to low permeability soils and vadose, variable depths to water, and moderately steep slopes.

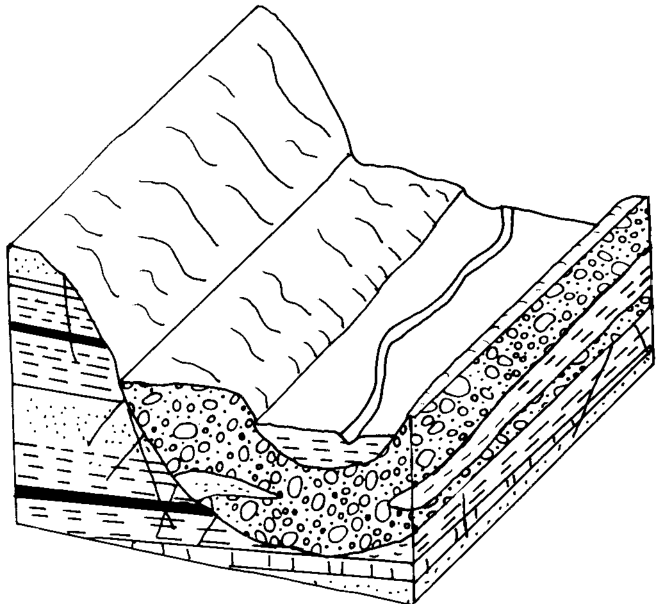
GWPP index values for the hydrogeologic setting of glacial till over sandstone ranges from 69 to 122, with the total number of GWPP index calculations equaling 42.



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting occurs in north central Richland County. The setting encompasses areas where sand and gravel lenses interbedded within till are the aquifer. It is associated with relatively thick sequences of glacial till associated with areas of ground moraine. The setting is characterized by relatively flat-lying to rolling topography. The total thickness of drift in these areas is substantially less than that found in the 7D - Buried Valley hydrogeologic setting and somewhat less than in the 7C-Moraine hydrogeologic setting. Drift is commonly thicker than in adjacent settings with bedrock aquifers. Soils are usually clay loams or silt loams derived from the weathering of glacial tills. The sand and gravel aquifers are typically thin, discontinuous, lenses. Yields average from 5 to 25 gpm and are adequate for domestic purposes. Till is the vadose zone media. Depth to water is commonly shallow to moderate depending upon how deep the sand and gravel lenses are. Recharge is moderate due to the low relief, moderate depths to the water table, moderate thickness of the till, and low permeability soils.

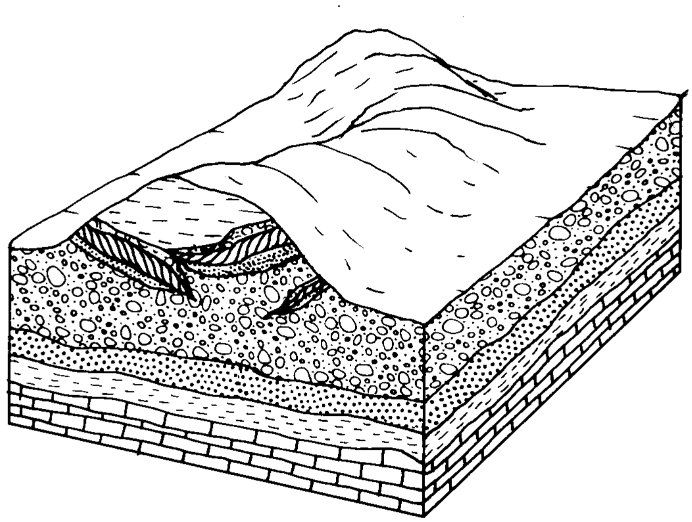
GWPP index values for the hydrogeologic setting of sand and gravel interbedded in glacial till range from 91 to 140, with the total number of GWPP index calculations equaling 20.



7Bb Outwash over Bedded Sedimentary Rock

This hydrogeologic setting consists of relatively small, high-level outwash terraces that set on top of bedrock benches. These terraces are limited to the margins or tributaries to the buried valleys. The total thickness of drift is not adequate to be considered buried valleys. Relief is rolling to moderately steep depending upon the amount of local stream dissection. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with finer alluvial deposits. Soils are usually sandy loams. The outwash terraces are not thick enough to comprise the aquifer; underlying fractured sandstone serves as the aquifer. In a few limited areas wells are completed in the very top of the sandstone; the aquifer is realistically the sand and gravel and the bedrock was drilled for use as a "screen" by the driller. Yields average 10 to 25 gpm. The overlying terraces are typically in direct contact with the underlying bedrock aquifer. Depth to water is typically shallow to moderate and is usually less than 50 feet. Recharge is moderately high due to the relatively permeable soils and vadose, moderate to shallow depth to water, and the moderately steep topography.

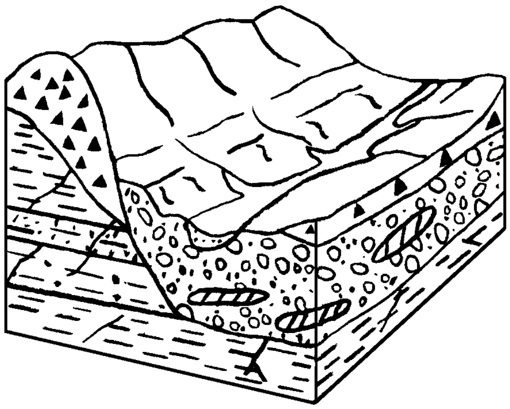
GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rocks range from 106 to 131, with the total number of GWPP index calculations equaling 5.

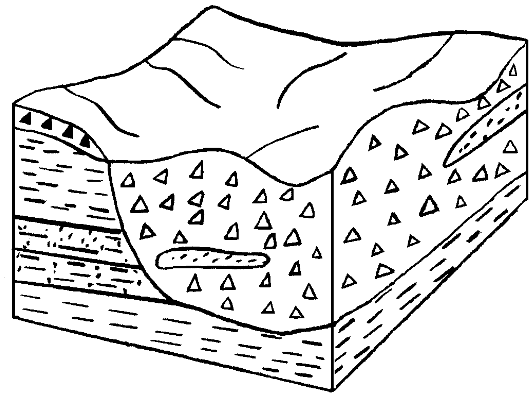


7C-Moraine

This hydrogeologic setting consists of segments of the numerous end moraines that cross Richland County. This setting is characterized by hummocky to rolling topography. Relief tends to become steeper near the margins of the moraine, especially if enhanced by the downcutting of an adjacent stream. The aquifer consists of relatively thin sand and gravel lenses interbedded with glacial till within the moraine. These sand and gravel deposits differ as to lateral extent and thickness and are found at variable depths. Yields range from the 5 to 25 gpm. If sand and gravel lenses are not encountered or if they are too thin, wells are completed in the underlying sandstone or shale bedrock. The vadose zone is composed of loamy to clayey glacial till. The till may be fractured or jointed, particularly in areas where it is predominantly thin and weathered. Depth to water is variable and depends primarily upon how deep the underlying aquifer is. Soils are commonly clay loams. Recharge is moderately high due to the proximity of sand and gravel lenses to the surface and the amount of weathering and fracturing in the till. The end moraines are the primary local sources of recharge.

GWPP index values for the hydrogeologic setting of Moraine range from 88 to 140, with the total number of GWPP index calculations equaling 37.





(A) (B)

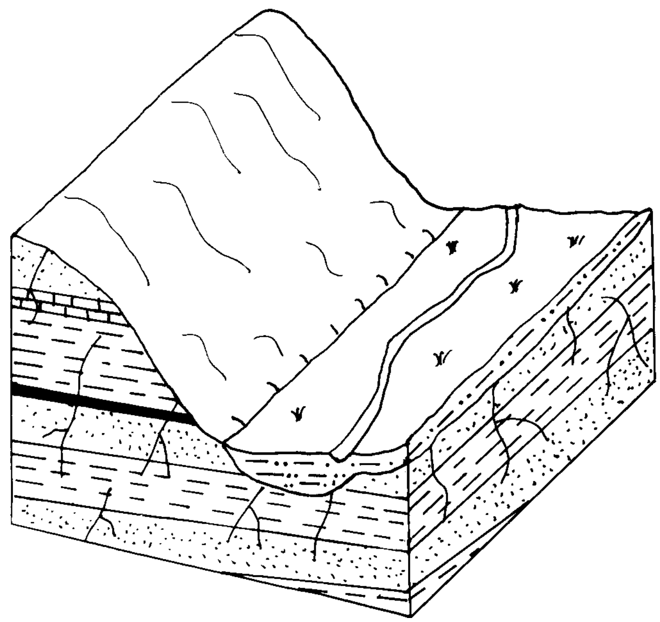
7D Buried Valleys

This hydrogeologic setting is widespread and varies considerably through Richland County. An extensive network of pre-glacial and interglacial rivers created the buried valleys that downcut into the bedrock. Richland County formerly lied on a major drainage divide that was breached and modified extensively by the multiple glacial advances. The greatly differing deposits filling these valleys can be best illustrated by describing the two common forms mapped within Richland County.

The block diagram (A) above shows one common form of buried valley deposit, which is exemplified by Clear Fork between Lexington and Butler, Rocky Fork just southeast of Mansfield, and Black Fork near Charles Mill Reservoir. These valleys are occupied by a modern river and floodplain and contain abundant outwash and kame deposits. The upper portion of these valleys contains 50 to 100 feet of sand and gravel interbedded with alluvium. Depth to water is typically less than 30 feet. Yields over 100 gpm are obtainable from large diameter wells. Soils are typically sandy loams or silt loams. The streams are in direct connection with the aquifer and recharge is typically high. GWPP index values for these settings are usually over 125.

The other common form of buried valley deposit, block diagram (B), is exemplified by the Tinker's Creek buried valley in western Sandusky Township and Sharon Township. The surface topography is commonly rolling and it is difficult to distinguish the buried valley from the surrounding bedrock or ground moraine uplands. Modern streams typically do not overly these deposits. The aquifer is commonly not in direct connection with overlying streams. Recharge is usually moderate to low. The aquifer consists of thinner, less continuous lenses of sand and gravel interbedded with thicker sequences of fine-grained glacial till or lacustrine sediments. Yields are commonly less than 25 gpm. Soils are usually clay loams or silty loams derived from the overlying glacial till.

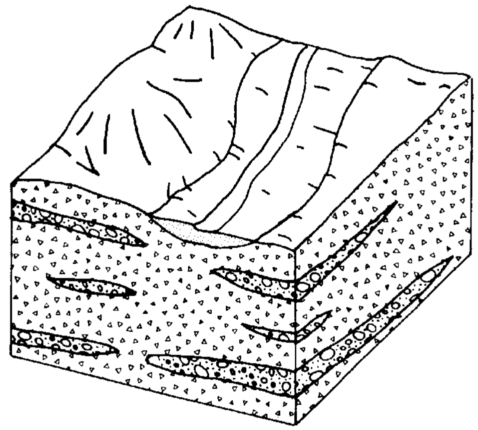
GWPP index values for the hydrogeologic setting of Buried Valley range from 70 to 182, with the total number of GWPP index calculations equaling 155.



7Ec Alluvium Over Bedded Sedimentary Rock

This hydrogeologic setting is found in upland areas throughout Richland County. This setting consists of the headwaters of small tributary streams in upland areas with thin glacial cover. The setting is characterized by narrow, flat-bottomed stream valleys, which are flanked by rolling to steep bedrock-controlled uplands. The aquifer consists of fractured, interbedded sandstone and shale of the Mississippian Cuyahoga Formation or sandstones of the Mississippian Black Hand and Logan Formations. Yields developed from wells intersecting fractures and bedding planes of the bedrock range from 10 to 25 gpm. Soils vary but are usually silty loams. Vadose zone media is typically silty, fine-grained alluvium. The depth to water is commonly shallow, averaging from 10 to 35 feet. The alluvium is commonly in direct hydraulic connection with the underlying aquifer. Recharge is moderately high due to the shallow depth to water, flat-lying topography, proximity of modern streams, and the moderately low permeability of the soils, alluvium, and bedrock.

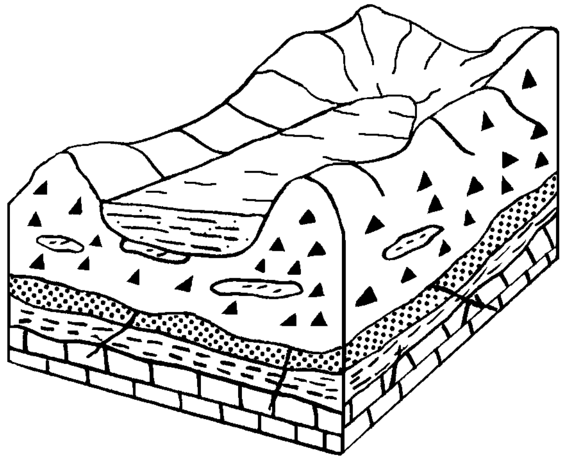
GWPP index values for the hydrogeologic setting of alluvium over bedded sedimentary rocks ranges from 112 to 133, with the total number of GWPP index calculations equaling 11.



<u>7Ed Alluvium Over Glacial Till</u>

This hydrogeologic setting is comprised of flat-lying floodplains and stream terraces containing thin to moderate thicknesses of modern alluvium. This setting is similar to the 7Af - Sand and Gravel Interbedded in Glacial Till setting except for the presence of the modern stream and related deposits. The setting is similar to the 7Ec Alluvium over Bedded Sedimentary Rocks except that the drift is thicker. This setting is found in upland areas of northern Richland County and as tributaries to the major buried valleys in southern Richland County. The stream may or may not be in direct hydraulic connection with the underlying sand and gravel lenses, which constitute the aquifer. The surficial, silty alluvium is typically more permeable than the surrounding till. The alluvium is too thin to be considered the aquifer. Soils are silt loams. Yields commonly range from 10 to 25 gpm. Depth to water is typically shallow with depths averaging less than 30 feet. Recharge is moderate due to the shallow depth to water, flat-lying topography, and the moderate permeability of the glacial till and alluvium.

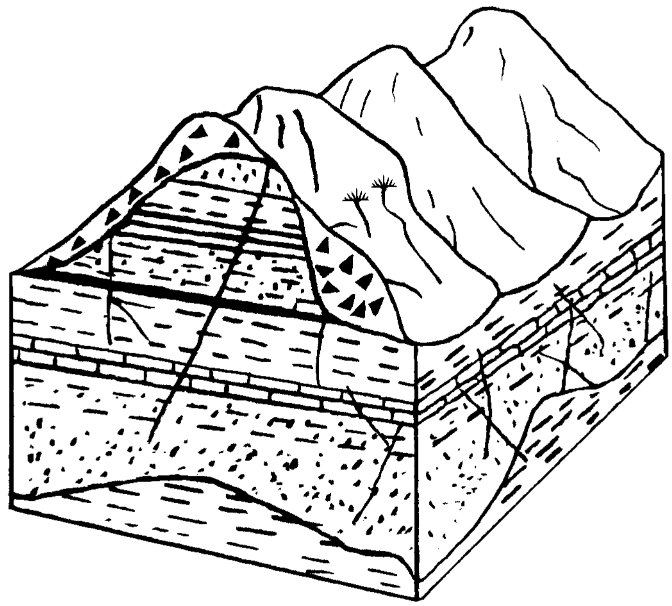
GWPP index values for the hydrogeologic setting Alluvium Over Glacial Till range from 129 to 145, with the total number of GWPP index calculations equaling 9.



7Fc-Intermorainal Lake Deposits

This hydrogeologic setting is characterized by flat-lying topography and varying thicknesses of fine-grained lacustrine sediments. Surficial drainage is typically very poor; ponding is very common after rains. These sediments were deposited in shallow lakes formed between end moraines and the retreating ice sheets before the modern drainage system evolved. This setting occupies isolated low-lying areas in far western Richland County. The vadose zone media consists of silty to clayey lacustrine sediments that overlie glacial till. The aquifer consists of thin sand and gravel lenses interbedded in the underlying till or the underlying bedrock. Yields average 5 to 25 gpm for the sand and gravel lenses and 5 to 25 gpm for the interbedded sandstone and shale. Depth to water is commonly shallow. Soils are clay loams derived from clayey lacustrine sediments. Recharge in this setting is low due to the relatively low permeability soils and vadose.

GWPP index values for the hydrogeologic setting of Intermorainal Lake Deposits range from 90 to 111, with the total number of GWPP index calculations equaling 8.



<u>7G Thin Glacial Till Over Bedded Sedimentary Rock</u>

This hydrogeologic setting is found in upland areas of southeast Richland County. The setting is characterized by rolling to steep bedrock-controlled topography and deposits of thin, patchy glacial till overlying layers of fractured sedimentary rock. The rock is typically resistant sandstone, but also includes shale. The till is commonly less than 5 feet thick and consists of varying amounts of unsorted clay, silt, and sand with minor pebbles and cobbles. Due to its thin nature, the till is probably weathered and fractured. The till may be absent in some areas along steep slopes. Due to the thin nature of the tills and soil, fractured bedrock is the vadose zone media. All of Richland County is within the glacial margin. The majority of the area covered with Illinoian-age till falls within this hydrogeologic setting. Ground water is obtained from the underlying, fractured Mississippian bedrock. Depth to water is usually relatively deep, especially along ridge tops. Soils are evaluated as Thin/Absent, especially along steeper slopes and rock outcrops. Recharge is low due to depth to water, relatively steep slopes, and the high runoff due to the lack of a thick, permeable soil layer.

GWPP index values for the hydrogeologic setting of Thin Glacial Till Over Bedded Sedimentary Rock range from 73 to 108, with the total number of GWPP index calculations equaling 20.

Table 13. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7Aa01	5-15	2-4	interbedded ss + sh	Clay Loam	0-2	till	1-100	108	132
7Aa02	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	114	135
7Aa03	15-30	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	115	138
7Aa04	5-15	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	125	148
7Aa05	5-15	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	124	145
7Aa06	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	107	128
7Aa07	30-50	4-7	interbedded ss + sh	Clay Loam	6-12	till	1-100	103	116
7Aa08	50-75	2-4	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	85	106
7Aa09	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	107	128
7Aa10	100+	2-4	interbedded ss + sh	Silty Loam	2-6	interbedded ss + sh	1-100	77	101
7Aa11	100+	2-4	interbedded ss + sh	Silty Loam	12-18	interbedded ss + sh	1-100	71	83
7Aa12	50-75	2-4	interbedded ss + sh	Clay Loam	2-6	till	1-100	80	102
7Aa13	50-75	2-4	interbedded ss + sh	Silty Loam	12-18	interbedded ss + sh	1-100	81	93
7Aa14	30-50	4-7	interbedded ss + sh	Silty Loam	6-12	till	1-100	105	121
7Aa15	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	104	125
7Aa16	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	99	121
7Aa17	100+	2-4	interbedded ss + sh	Clay Loam	2-6	till	1-100	67	89
7Aa18	50-75	2-4	interbedded ss + sh	Clay Loam	2-6	till	1-100	77	99
7Aa19	50-75	2-4	interbedded ss + sh	Clay Loam	12-18	interbedded ss + sh	1-100	79	88
7Aa20	30-50	4-7	interbedded ss + sh	Clay Loam	6-12	interbedded ss + sh	1-100	95	109
7Aa21	30-50	4-7	interbedded ss + sh	Clay Loam	6-12	till	1-100	100	113
7Aa22	50-75	2-4	interbedded ss + sh	Clay Loam	6-12	interbedded ss + sh	1-100	73	87
7Aa23	50-75	2-4	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	77	99
7Aa24	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	109	131
7Aa25	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	117	138

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7Aa26	30-50	4-7	interbedded ss + sh	Clay Loam	6-12	interbedded ss + sh	1-100	103	116
7Aa27	15-30	4-7	interbedded ss + sh	Clay Loam	6-12	interbedded ss + sh	1-100	113	126
7Aa28	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	117	138
7Aa29	15-30	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	118	141
7Aa30	15-30	2-4	interbedded ss + sh	Clay Loam	0-2	till	1-100	98	122
7Aa31	30-50	2-4	interbedded ss + sh	Clay Loam	0-2	till	1-100	88	112
7Aa32	5-15	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	128	151
7Aa33	5-15	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	127	148
7Aa34	30-50	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	108	131
7Aa35	100+	2-4	interbedded ss + sh	Clay Loam	0-2	till	1-100	71	95
7Aa36	30-50	4-7	interbedded ss + sh	Silty Loam	2-6	till	1-100	109	133
7Aa37	100+	2-4	interbedded ss + sh	Silty Loam	2-6	till	1-100	72	97
7Aa38	50-75	2-4	interbedded ss + sh	Silty Loam	6-12	interbedded ss + sh	1-100	83	99
7Aa39	50-75	2-4	interbedded ss + sh	Silty Loam	2-6	till	1-100	82	107
7Aa40	50-75	2-4	interbedded ss + sh	Silty Loam	6-12	till	1-100	78	95
7Aa41	100+	2-4	interbedded ss + sh	Silty Loam	6-12	till	1-100	68	85
7Aa42	100+	2-4	interbedded ss + sh	Silty Loam	6-12	interbedded ss + sh	1-100	73	89
7Aa43	75-100	2-4	interbedded ss + sh	Silty Loam	2-6	till	1-100	77	102
7Aa44	30-50	4-7	interbedded ss + sh	Silty Loam	2-6	interbedded ss + sh	1-100	109	133
7Aa45	75-100	2-4	interbedded ss + sh	Silty Loam	6-12	interbedded ss + sh	1-100	78	94
7Aa46	50-75	2-4	interbedded ss + sh	Silty Loam	2-6	interbedded ss + sh	1-100	87	111
7Aa47	75-100	2-4	interbedded ss + sh	Silty Loam	6-12	till	1-100	73	90
7Aa48	50-75	2-4	interbedded ss + sh	Silty Loam	12-18	till	1-100	76	89
7Aa49	30-50	2-4	interbedded ss + sh	Clay Loam	12-18	interbedded ss + sh	1-100	89	98
7Aa50	100+	2-4	interbedded ss + sh	Clay Loam	2-6	interbedded ss + sh	1-100	75	96
7Aa51	50-75	2-4	interbedded ss + sh	Clay Loam	12-18	till	1-100	74	84
7Aa52	100+	2-4	interbedded ss + sh	Clay Loam	2-6	till	1-100	70	92

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7Aa53	50-75	2-4	interbedded ss + sh	Clay Loam	6-12	till	1-100	76	90
7Ad01	30-50	4-7	sandstone	Silty Loam	6-12	sandstone	100-300	108	123
7Ad02	15-30	4-7	sandstone	Silty Loam	2-6	till	100-300	122	145
7Ad03	30-50	4-7	sandstone	Silty Loam	2-6	till	100-300	112	135
7Ad04	100+	2-4	sandstone	Silty Loam	2-6	sandstone	100-300	80	103
7Ad05	100+	2-4	sandstone	Silty Loam	6-12	sandstone	100-300	76	91
7Ad06	100+	2-4	sandstone	Silty Loam	2-6	till	100-300	75	99
7Ad07	30-50	4-7	sandstone	Silty Loam	6-12	till	100-300	108	123
7Ad08	30-50	4-7	sandstone	Clay Loam	2-6	sandstone	100-300	110	130
7Ad09	50-75	2-4	sandstone	Silty Loam	2-6	sandstone	100-300	90	113
7Ad10	30-50	4-7	sandstone	Clay Loam	2-6	till	100-300	110	130
7Ad11	50-75	2-4	sandstone	Clay Loam	2-6	till	100-300	83	104
7Ad12	100+	2-4	sandstone	Clay Loam	2-6	till	100-300	73	94
7Ad13	100+	2-4	sandstone	Clay Loam	2-6	sandstone	100-300	78	98
7Ad14	30-50	4-7	sandstone	Clay Loam	6-12	till	100-300	101	114
7Ad15	30-50	4-7	sandstone	Clay Loam	6-12	sandstone	100-300	106	118
7Ad16	50-75	2-4	sandstone	Clay Loam	2-6	sandstone	100-300	88	108
7Ad17	50-75	2-4	sandstone	Clay Loam	6-12	till	100-300	79	92
7Ad18	50-75	2-4	sandstone	Clay Loam	6-12	sandstone	100-300	84	96
7Ad19	100+	2-4	sandstone	Clay Loam	6-12	till	100-300	69	82
7Ad20	100+	2-4	sandstone	Clay Loam	6-12	sandstone	100-300	74	86
7Ad21	50-75	2-4	sandstone	Silty Loam	6-12	sandstone	100-300	86	101
7Ad22	50-75	2-4	sandstone	Silty Loam	6-12	till	100-300	81	97
7Ad23	100+	2-4	sandstone	Silty Loam	12-18	sandstone	100-300	74	85
7Ad24	100+	2-4	sandstone	Silty Loam	6-12	till	100-300	71	87
7Ad25	50-75	0-2	sandstone	Silty Loam	6-12	till	100-300	73	89
7Ad26	50-75	2-4	sandstone	Clay Loam	12-18	till	100-300	77	86
7Ad27	50-75	2-4	sandstone	Silty Loam	2-6	till	100-300	85	109
7Ad28	100+	2-4	sandstone	Silty Loam	12-18	till	100-300	69	81
7Ad29	75-100	2-4	sandstone	Clay Loam	0-2	till	100-300	79	102
7Ad30	50-75	2-4	sandstone	Silty Loam	12-18	till	100-300	79	91
7Ad31	50-75	2-4	sandstone	Clay Loam	0-2	till	100-300	84	107
7Ad32	75-100	2-4	sandstone	Clay Loam	2-6	till	100-300	78	99
7Ad33	75-100	2-4	sandstone	Clay Loam	2-6	sandstone	100-300	83	103
7Ad34	15-30	4-7	sandstone	Clay Loam	2-6	till	100-300	120	140
7Ad35	30-50	4-7	sandstone	Clay Loam	0-2	till	100-300	111	133
7Ad36	15-30	4-7	sandstone	Clay Loam	2-6	sandstone	100-300	120	140
7Ad37	100+	2-4	sandstone	Clay Loam	0-2	till	300-700	80	101
7Ad38	75-100	2-4	sandstone	Silty Loam	2-6	till	100-300	80	104
7Ad39	30-50	4-7	sandstone	Clay Loam	2-6	till	300-700	116	134

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7Ad40	30-50	4-7	sandstone	Silty Loam	2-6	sandstone	100-300	112	135
7Ad41	50-75	2-4	sandstone	Silty Loam	12-18	sandstone	100-300	84	95
7Ad42	30-50	4-7	sandstone	Silty Loam	12-18	till	100-300	106	117
7Af01	5-15	4-7	sand+gravel	Clay Loam	0-2	silt + clay	300-700	138	159
7Af02	50-75	2-4	sand+gravel	Silty Loam	2-6	till	300-700	91	113
7Af03	5-15	2-4	sand+gravel	Clay Loam	0-2	till	300-700	123	144
7Af04	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	130	150
7Af05	5-15	4-7	sand+gravel	Clay Loam	0-2	till	300-700	140	160
7Af06	5-15	4-7	sand+gravel	Clay Loam	2-6	till	300-700	139	157
7Af07	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	129	147
7Af08	30-50	4-7	sand+gravel	Silty Loam	2-6	till	300-700	118	139
7Af09	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	126	144
7Af10	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	127	147
7Af11	5-15	4-7	sand+gravel	Clay Loam	2-6	till	300-700	136	154
7Af12	5-15	4-7	sand+gravel	Clay Loam	0-2	till	300-700	137	157
7Af13	5-15	2-4	sand+gravel	Clay Loam	0-2	till	100-300	114	137
7Af14	5-15	4-7	sand+gravel	Clay Loam	0-2	till	100-300	131	153
7Af15	15-30	4-7	sand+gravel	Clay Loam	0-2	till	100-300	121	143
7Af16	15-30	2-4	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	300-700	116	137
7Af17	15-30	4-7	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	300-700	134	164
7Af18	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	116	134
7Af19	50-75	4-7	sand+gravel	Clay Loam	2-6	till	300-700	104	123
7Af20	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	119	137
7Bb1	30-50	4-7	sandstone	Sandy Loam	2-6	sd + gvl w/silt +clay	100-300	121	149
7Bb2	15-30	4-7	sandstone	Sandy Loam	2-6	sd + gvl w/silt +clay	100-300	131	159
7Bb3	15-30	4-7	interbedded ss + sh	Sandy Loam	2-6	sd + gvl w/silt +clay	1-100	128	157
7Bb4	50-75	4-7	sandstone	Sandy Loam	2-6	sd + gvl w/silt +clay	100-300	106	135
7Bb5	30-50	4-7	sandstone	Sandy Loam	2-6	sd + gvl w/silt +clay	100-300	116	145
7C01	5-15	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	125	148
7C02	15-30	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	115	138
7C03	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	114	135
7C04	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	129	147
7C05	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	119	137

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7C06	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	104	125
7C07	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	130	150
7C08	15-30	4-7	sand+gravel	Clay Loam	0-2	till	100-300	121	143
7C09	5-15	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	124	145
7C10	5-15	4-7	sand+gravel	Clay Loam	2-6	till	100-300	130	150
7C11	5-15	4-7	sand+gravel	Clay Loam	2-6	till	300-700	139	157
7C12	5-15	4-7	sand+gravel	Clay Loam	0-2	till	300-700	140	160
7C13	15-30	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	117	138
7C14	30-50	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	107	128
7C15	15-30	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	118	141
7C16	30-50	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	108	131
7C17	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	126	144
7C17	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	126	144
7C18	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	127	147
7C19	30-50	4-7	sand+gravel	Clay Loam	0-2	till	300-700	117	137
7C20	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	116	134
7C21	30-50	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	105	128
7C22	5-15	4-7	sand+gravel	Clay Loam	2-6	till	300-700	136	154
7C23	5-15	4-7	sand+gravel	Clay Loam	0-2	till	300-700	137	157
7C24	5-15	4-7	sand+gravel	Clay Loam	0-2	till	100-300	131	153
7C25	15-30	4-7	sand+gravel	Sandy Loam	6-12	sd + gvl w/silt +clay	300-700	129	149
7C26	15-30	2-4	sandstone	Silty Loam	2-6	silt + clay	100-300	100	125
7C27	15-30	4-7	sand+gravel	Loam	2-6	silt + clay	300-700	126	152
7C28	15-30	2-4	sandstone	Clay Loam	2-6	silt + clay	100-300	98	120
7C29	5-15	4-7	shale	Clay Loam	2-6	silt + clay	1-100	108	131
7C30	15-30	2-4	shale	Silty Loam	2-6	silt + clay	1-100	88	114
7C31	5-15	4-7	shale	Silty Loam	2-6	silt + clay	1-100	110	136
7C32	5-15	4-7	shale	Clay Loam	0-2	silt + clay	1-100	109	134
7C33	5-15	4-7	sand+gravel	Silty Loam	2-6	silt + clay	300-700	134	157
7C34	5-15	4-7	sand+gravel	Clay Loam	2-6	silt + clay	300-700	132	152
7C35	5-15	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	127	148
7C36	5-15	4-7	interbedded ss + sh	Clay Loam	0-2	till	1-100	128	151
7C37	50-75	4-7	interbedded ss + sh	Clay Loam	2-6	till	1-100	97	118
7D001	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	119	137

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7D002	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	172	191
7D003	5-15	7-10	sand+gravel	Peat	0-2	sd + gvl w/silt +clay	700-1000	175	207
7D004	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	141	156
7D005	5-15	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	700-1000	162	179
7D006	5-15	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	700-1000	163	181
7D007	5-15	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	1000-2000	181	202
7D008	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	1000-2000	155	167
7D009	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	1000-2000	168	185
7D010	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	164	184
7D011	30-50	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	144	164
7D012	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	144	159
7D013	15-30	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	700-1000	155	172
7D014	15-30	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	700-1000	152	169
7D015	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	154	174
7D016	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	1000-2000	173	191
7D017	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	147	167
7D017	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	147	167
7D018	30-50	4-7	sandstone	Clay Loam	2-6	till	100-300	105	126
7D019	50-75	2-4	sandstone	Clay Loam	2-6	till	100-300	83	104
7D020	5-15	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	1000-2000	171	186
7D021	30-50	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	700-1000	143	161
7D022	30-50	4-7	sand+gravel	Silty Loam	6-12	till	300-700	117	130
7D023	15-30	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	129	152
7D024	30-50	4-7	sand+gravel	Silty Loam	2-6	till	300-700	118	139
7D025	100+	2-4	sand+gravel	Silty Loam	12-18	till	300-700	75	85
7D026	15-30	4-7	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	300-700	133	162
7D027	15-30	4-7	sand+gravel	Clay Loam	0-2	silt + clay	300-700	127	147
7D028	5-15	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	139	162
7D029	30-50	4-7	sand+gravel	Silty Loam	6-12	sd + gvl w/silt +clay	300-700	114	127

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7D030	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	700-1000	165	188
7D031	30-50	4-7	sand+gravel	Clay Loam	2-6	till	300-700	116	134
7D032	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	135	152
7D033	5-15	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	300-700	156	175
7D034	5-15	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	300-700	148	168
7D035	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	129	147
7D036	15-30	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	142	159
7D037	15-30	4-7	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	139	159
7D038	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	155	177
7D039	15-30	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	145	162
7D040	30-50	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	124	141
7D041	15-30	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	159	173
7D042	5-15	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	147	169
7D043	30-50	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	127	144
7D044	15-30	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	151	166
7D045	5-15	7-10	sand+gravel	Silty Loam	0-2	silt + clay	300-700	150	173
7D046	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	158	180
7D047	5-15	7-10	sand+gravel	Peat	0-2	silt + clay	700-1000	167	200
7D048	5-15	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	142	165
7D049	15-30	4-7	sand+gravel	Clay Loam	2-6	till	300-700	126	144
7D050	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	130	150
7D051	15-30	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	156	170
7D052	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	146	160
7D053	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	159	178
7D054	15-30	7-10	sand+gravel	Peat	0-2	silt + clay	300-700	151	186
7D055	15-30	7-10	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	300-700	146	165
7D056	5-15	7-10	sand+gravel	Peat	0-2	silt + clay	300-700	161	196
7D057	15-30	4-7	sand+gravel	Peat	0-2	silt + clay	300-700	135	171
7D058	5-15	7-10	sand+gravel	Peat	0-2	silt + clay	300-700	153	189
7D059	30-50	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	119	142
7D060	15-30	7-10	sand+gravel	Peat	0-2	silt + clay	700-1000	157	190

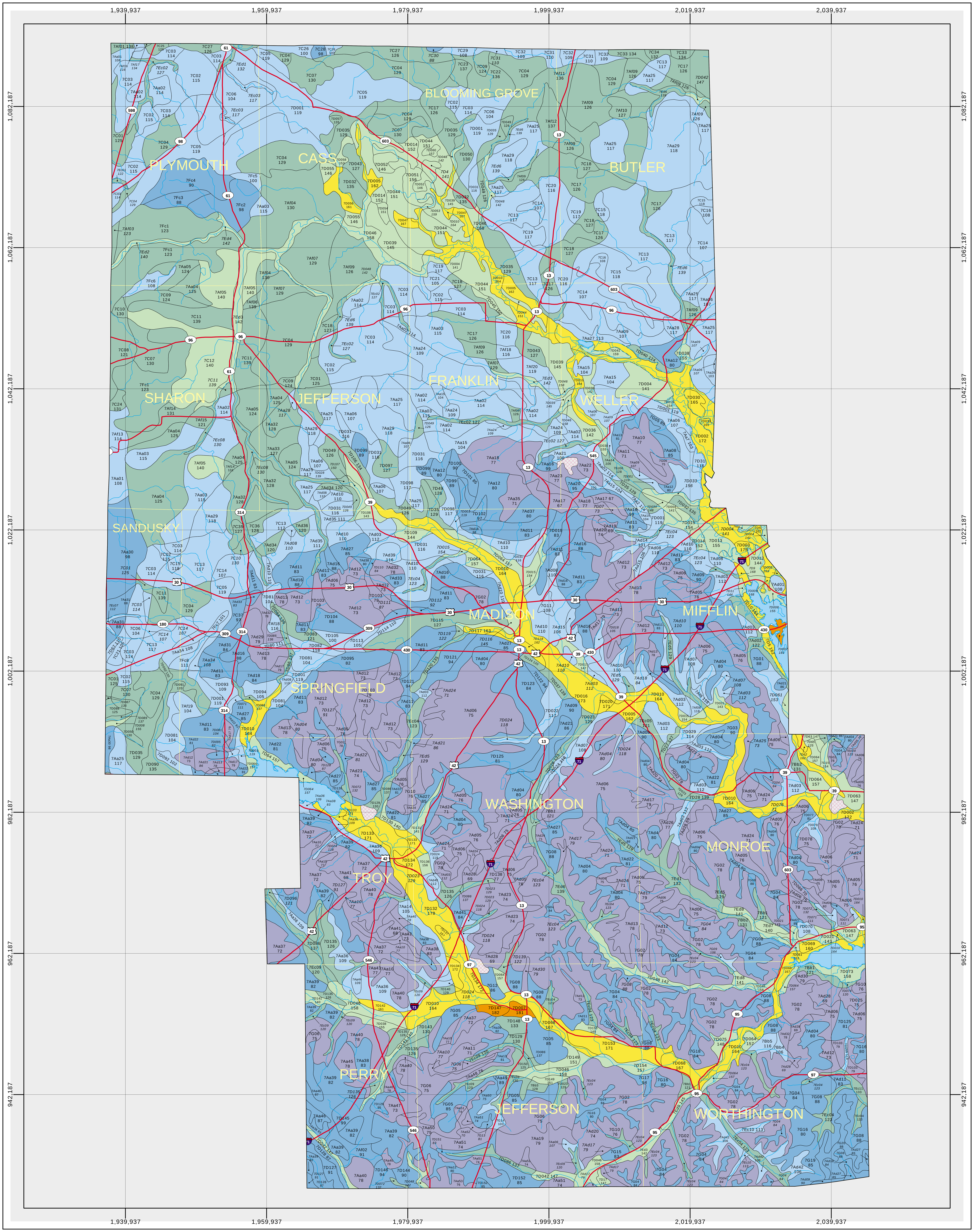
Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7D061	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	700-1000	153	171
7D062	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	162	181
7D063	30-50	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	700-1000	147	171
7D064	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	700-1000	157	181
7D065	50-75	4-7	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	700-1000	125	143
7D066	100+	2-4	sandstone	Silty Loam	2-6	till	100-300	70	95
7D067	30-50	4-7	sand+gravel	Clay Loam	0-2	till	300-700	115	136
7D068	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	167	187
7D069	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	700-1000	160	184
7D070	50-75	4-7	sand+gravel	Silty Loam	2-6	till	300-700	108	129
7D071	50-75	4-7	sand+gravel	Silty Loam	2-6	till	300-700	111	132
7D072	15-30	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	132	155
7D073	15-30	7-10	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	700-1000	158	184
7D074	50-75	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	120	146
7D075	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	148	174
7D076	100+	2-4	sandstone	Silty Loam	6-12	till	100-300	71	87
7D077	50-75	2-4	sandstone	Silty Loam	6-12	till	100-300	81	97
7D078	100+	2-4	sandstone	Silty Loam	2-6	till	100-300	75	99
7D079	30-50	4-7	sandstone	Silty Loam	6-12	till	100-300	108	123
7D080	30-50	4-7	sandstone	Clay Loam	0-2	till	100-300	111	133
7D081	50-75	4-7	sand+gravel	Clay Loam	2-6	till	300-700	104	123
7D082	50-75	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	118	134
7D083	50-75	4-7	sand+gravel	Clay Loam	2-6	till	700-1000	121	137
7D084	30-50	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	139	159
7D085	30-50	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	136	156
7D086	15-30	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	137	159
7D087	5-15	4-7	sand+gravel	Clay Loam	0-2	till	300-700	135	156
7D088	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	125	146
7D089	5-15	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	137	161
7D090	5-15	4-7	sand+gravel	Clay Loam	0-2	silt + clay	300-700	135	156
7D091	30-50	4-7	sand+gravel	Clay Loam	0-2	till	300-700	120	140
7D092	50-75	4-7	sand+gravel	Silty Loam	6-12	till	300-700	102	116
7D093	50-75	4-7	sand+gravel	Clay Loam	2-6	till	300-700	109	127

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7D094	50-75	4-7	sand+gravel	Clay Loam	6-12	till	300-700	105	115
7D095	100+	2-4	sand+gravel	Clay Loam	2-6	till	300-700	82	101
7D095	100+	2-4	sand+gravel	Clay Loam	2-6	till	300-700	82	101
7D096	30-50	4-7	sand+gravel	Silty Loam	2-6	till	300-700	121	142
7D097	15-30	4-7	sand+gravel	Clay Loam	0-2	till	300-700	127	147
7D098	30-50	4-7	sand+gravel	Clay Loam	0-2	till	300-700	117	137
7D099	50-75	2-4	sand+gravel	Clay Loam	2-6	till	300-700	89	108
7D100	50-75	2-4	sand+gravel	Clay Loam	0-2	till	300-700	90	111
7D101	75-100	2-4	sand+gravel	Clay Loam	0-2	till	300-700	85	106
7D102	50-75	2-4	sand+gravel	Clay Loam	2-6	till	300-700	97	115
7D103	100+	2-4	sand+gravel	Clay Loam	2-6	till	300-700	79	98
7D104	100+	2-4	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	300-700	88	108
7D105	100+	2-4	sand+gravel	Clay Loam	0-2	sd + gvl w/silt +clay	700-1000	100	118
7D106	15-30	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	134	151
7D107	5-15	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	150	172
7D108	15-30	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	700-1000	143	158
7D109	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	144	164
7D110	75-100	2-4	sand+gravel	Clay Loam	2-6	till	300-700	84	103
7D111	75-100	2-4	sand+gravel	Clay Loam	2-6	till	300-700	87	106
7D112	50-75	2-4	sand+gravel	Clay Loam	2-6	till	300-700	92	111
7D113	100+	2-4	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	1000-2000	105	119
7D114	75-100	2-4	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	1000-2000	110	124
7D115	50-75	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	1000-2000	127	141
7D116	30-50	7-10	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	1000-2000	145	159
7D117	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	1000-2000	163	181
7D118	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	1000-2000	162	178
7D119	30-50	4-7	sand+gravel	Clay Loam	2-6	sd + gvl w/silt +clay	300-700	122	140
7D120	15-30	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	135	158
7D121	50-75	2-4	sand+gravel	Clay Loam	2-6	till	300-700	94	112
7D122	100+	2-4	sand+gravel	Silty Loam	6-12	sd + gvl w/silt +clay	700-1000	94	105
7D123	100+	2-4	sand+gravel	Silty Loam	2-6	till	300-700	84	106
7D124	50-75	4-7	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	700-1000	120	139
7D125	100+	2-4	sand+gravel	Silty Loam	2-6	till	300-700	81	103

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7D126	50-75	2-4	sand+gravel	Silty Loam	6-12	sd + gvl w/silt +clay	300-700	95	108
7D127	50-75	2-4	sand+gravel	Silty Loam	2-6	till	300-700	91	113
7D128	50-75	2-4	sand+gravel	Silty Loam	6-12	till	300-700	87	101
7D129	30-50	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	130	156
7D130	15-30	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	140	166
7D131	15-30	4-7	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	300-700	141	169
7D132	5-15	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	1000-2000	178	195
7D133	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	1000-2000	171	192
7D134	15-30	7-10	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	1000-2000	172	195
7D135	30-50	4-7	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	126	146
7D136	15-30	7-10	sand+gravel	Clay Loam	0-2	silt + clay	1000-2000	156	172
7D137	15-30	7-10	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	1000-2000	167	182
7D138	100+	2-4	sand+gravel	Silty Loam	6-12	till	300-700	77	91
7D139	30-50	4-7	sand+gravel	Silty Loam	0-2	till	300-700	122	145
7D140	30-50	4-7	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	129	149
7D141	15-30	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	140	162
7D142	5-15	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	161	187
7D143	30-50	4-7	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	300-700	130	152
7D144	50-75	2-4	sand+gravel	Silty Loam	6-12	till	300-700	90	104
7D145	50-75	2-4	sand+gravel	Silty Loam	2-6	sd + gvl w/silt +clay	300-700	99	120
7D146	50-75	2-4	sand+gravel	Silty Loam	2-6	till	300-700	94	116
7D147	5-15	7-10	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	1000-2000	182	205
7D148	30-50	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	133	159
7D149	15-30	7-10	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	151	177
7D150	30-50	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	125	152
7D151	50-75	2-4	sand+gravel	Clay Loam	12-18	till	300-700	83	90
7D152	50-75	2-4	sand+gravel	Clay Loam	6-12	till	300-700	85	96
7D153	5-15	7-10	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	700-1000	171	197
7D154	15-30	7-10	sand+gravel	Silty Loam	0-2	sd + gvl w/silt +clay	700-1000	157	177
7D155	15-30	7-10	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	300-700	149	177

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7Ec01	5-15	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	122	149
7Ec02	5-15	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	127	153
7Ec03	15-30	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	117	143
7Ec04	15-30	4-7	sandstone	Silty Loam	0-2	silt + clay	100-300	123	148
7Ec05	15-30	4-7	sandstone	Clay Loam	0-2	silt + clay	100-300	121	143
7Ec06	5-15	4-7	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	128	151
7Ec07	15-30	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	112	139
7Ec08	5-15	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	130	156
7Ec09	15-30	4-7	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	120	146
7Ec10	30-50	4-7	sandstone	Silty Loam	0-2	silt + clay	100-300	113	138
7Ec11	5-15	4-7	sandstone	Silty Loam	0-2	silt + clay	100-300	133	158
7Ed1	15-30	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	132	155
7Ed2	0-5	4-7	sand+gravel	Clay Loam	0-2	silt + clay	300-700	140	161
7Ed3	5-15	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	142	165
7Ed4	0-5	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	142	166
7Ed5	15-30	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	129	152
7Ed6	5-15	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	139	162
7Ed7	15-30	4-7	sand+gravel	Sandy Loam	2-6	sd + gvl w/silt +clay	300-700	140	166
7Ed8	15-30	4-7	sand+gravel	Sandy Loam	0-2	sd + gvl w/silt +clay	300-700	141	169
7Ed9	5-15	4-7	sand+gravel	Silty Loam	0-2	silt + clay	300-700	145	168
7Fc1	5-15	2-4	sand+gravel	Clay Loam	0-2	silt + clay	300-700	123	144
7Fc2	15-30	2-4	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	98	122
7Fc3	30-50	2-4	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	88	112
7Fc4	30-50	2-4	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	90	117
7Fc5	15-30	2-4	interbedded ss + sh	Silty Loam	0-2	silt + clay	1-100	100	127
7Fc6	5-15	2-4	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	108	132
7Fc7	15-30	2-4	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	101	125
7Fc8	5-15	2-4	interbedded ss + sh	Clay Loam	0-2	silt + clay	1-100	111	135
7G01	100+	2-4	sandstone	Thin/Absent	6-12	sandstone	100-300	88	121
7G02	100+	0-2	sandstone	Thin/Absent	12-18	sandstone	100-300	78	107

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating_
7G03	50-75	0-2	sandstone	Thin/Absent	6-12	sandstone	100-300	90	123
7G04	100+	0-2	sandstone	Thin/Absent	2-6	sandstone	100-300	84	125
7G05	50-75	0-2	interbedded ss + sh	Thin/Absent	12-18	interbedded ss + sh	1-100	85	115
7G06	100+	0-2	interbedded ss + sh	Thin/Absent	12-18	interbedded ss + sh	1-100	75	105
7G07	100+	0-2	interbedded ss + sh	Thin/Absent	2-6	interbedded ss + sh	1-100	73	116
7G08	50-75	0-2	sandstone	Thin/Absent	12-18	sandstone	100-300	88	117
7G09	30-50	2-4	sandstone	Thin/Absent	12-18	sandstone	100-300	106	135
7G10	100+	0-2	sandstone	Thin/Absent	18+	sandstone	100-300	76	101
7G11	30-50	2-4	sandstone	Thin/Absent	6-12	sandstone	100-300	108	141
7G12	50-75	0-2	sandstone	Thin/Absent	18+	sandstone	100-300	86	111
7G13	100+	0-2	interbedded ss + sh	Thin/Absent	2-6	interbedded ss + sh	1-100	81	123
7G14	30-50	2-4	interbedded ss + sh	Thin/Absent	12-18	interbedded ss + sh	1-100	103	133
7G15	75-100	0-2	sandstone	Thin/Absent	12-18	sandstone	100-300	83	112
7G16	100+	0-2	sandstone	Thin/Absent	6-12	sandstone	100-300	80	113
7G17	50-75	0-2	sandstone	Thin/Absent	2-6	sandstone	100-300	94	135
7G18	100+	2-4	sandstone	Sandy Loam	2-6	sandstone	100-300	84	113
7G19	75-100	0-2	sandstone	Thin/Absent	6-12	sandstone	100-300	85	118
7G20	50-75	0-2	sandstone	Shrink-swell clay	2-6	sandstone	100-300	88	120

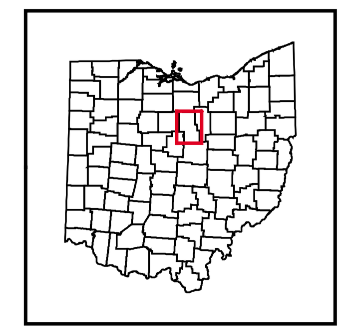


Ground Water Pollution Potential of Richland County

by

Michael P. Angle

Ohio Department of Natural Resources



Ground Water Pollution Potential maps are designed to evaluate the susceptibility of ground water to contamination from surface sources. These maps are based on the DRASTIC system developed for the USEPA (Aller et al., 1987). The DRASTIC system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and a relative rating system for determining the ground water pollution potential within a hydrogeologic setting. The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. The evaluation of pollution potential of an area assumes that a contaminant with the mobility of water is introduced at the surface and is flushed into the ground water by precipitation. DRASTIC is not designed to replace specific on-site investigations.

In DRASTIC mapping, hydrogeologic settings form the basis of the system and incorporate the major hydrogeologic factors that affect and control ground water movement and occurrence. The relative rating system is based on seven hydrogeologic factors: Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone media, and hydraulic Conductivity. These factors form the acronym DRASTIC. The relative rating system uses a combination of weights and ratings to produce a numerical value called the ground water pollution potential index. Higher index values indicate higher susceptibility to ground water contamination. Polygons (outlined in black on the map at left) are regions where the hydrogeologic setting and the pollution potential index are combined to create a mappable unit with specific hydrogeologic characteristics, which determine the region's relative vulnerability to contamination. Additional information on the DRASTIC system, hydrogeologic settings, ratings, and weighting factors is included in the report.

Description of Map Symbols

Hydrogeologic Region → 7D24 ← Hydrogeologic Setting

170 ← Relative Pollution Potential

Legend

Colors are used to depict the ranges in the pollution potential indexes shown below. Warm colors (red, orange, yellow) represent areas of higher vulnerability (higher pollution potential indexes), while cool colors (green, blue, violet) represent areas of lower vulnerability to contamination (lower pollution potential indexes).

- Roads
- Streams
- Lakes
- Townships

Index Ranges

- Not Rated
- Less Than 79
- 80 - 99
- 100 - 119
- 120 - 139
- 140 - 159
- 160 - 179
- 180 - 199
- Greater Than 200

N

Black grid represents the State Plane South Coordinate System (NAD27, feet).

0 1 2 3 4 5
Miles

0 1 2 4 6 8
Kilometers

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2003