GROUND WATER POLLUTION POTENTIAL OF DEFIANCE COUNTY, OHIO

BY

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ABSTRACT

A ground water pollution potential map of Defiance 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 Defiance County resulted in a map with symbols and colors, which illustrate areas of varying ground water pollution potential indexes ranging from 82 to 171.

Defiance County lies entirely within the Glaciated Central hydrogeologic setting. Limestones and dolomites of the Devonian System and Silurian System compose the aquifer for the eastern third of the county. Yields in the uppermost carbonate aquifers in this area typically range from 5 to 25 gallons per minute (gpm). Yields over 100 gpm are possible from large diameter wells drilled deep into the limestone in the southeast corner of the county. Shale of the Devonian System composes the aquifer in limited areas of the northeast corner of the county. Yields from the shale are poor, typically yielding less than 5 gpm.

Sand and gravel lenses interbedded in the glacial till serve as aquifers throughout the western half of the county. The sand and gravel lenses become relatively thick and more laterally extensive to the west and north. The coarsest deposits are found in the extreme northwest corner of the county. Yields in these areas can range from 100 to 500 gpm. As these deposits thin to the east, the yields drop, and typical well yields range from 5 to 100 gpm. The sand and gravel lenses may lie directly on top of the shale or limestone bedrock and serve as the aquifer or provide additional recharge to the underlying bedrock. The sand and gravel lenses are utilized more frequently by wells in areas where the underlying bedrock is low-yielding shale instead of the higher-yielding limestones and dolomite.

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 Defiance County has been prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring, and clean-up efforts.

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

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. Approximately 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; 4430 of these wells exist in Defiance 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 Defiance 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 Defiance 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

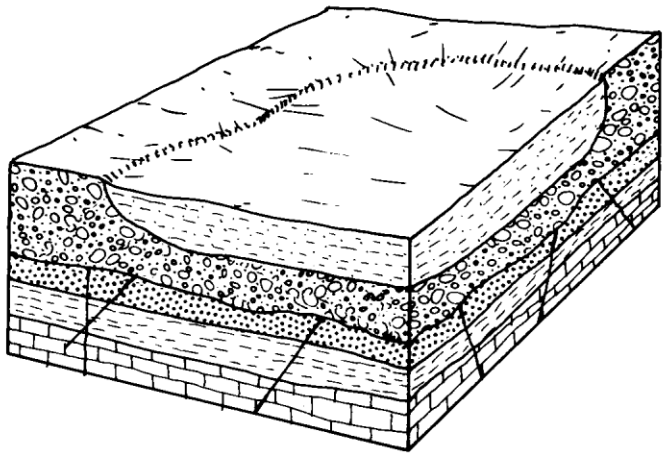
These factors incorporate concepts and mechanisms such as attenuation, retardation, and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms coupled with existing conditions in a setting 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.



7F Glacial Lake Plain Deposits

This hydrogeologic setting occupies most of west-central, central, and southeastern Defiance County. It is characterized by flat-lying topography and varying thickness of fine-grained lacustrine sediments. These sediments were deposited in lakes by a sequence of ancestral lakes. The vadose zone media consists of clayey lacustrine sediments that overlie glacial till. Wells are completed in the underlying Silurian and Devonian limestone and dolomite in the southeastern part of the county. Yields greater than 100 gpm are possible from the Silurian Lockport, Tymochtee, Greenfield and Salina Groups. In the west-central and part of the central portion of the county the wells are completed in sand and gravel lenses in the till and lacustrine deposits. Yields from these wells can range up to 500 gpm where the lenses are the thickest. There is a narrow band trending northeast-southwest in the east-central portion of the county where the Devonian Antrim Shale is the aquifer. Yields from the Devonian Antrim Shale are poor, averaging less than 5 gpm. Depth to water is variable and seems to be dependent upon the overall thickness of the glacial drift and the depth to the aquifer in which the wells are completed. Soils are shrink-swell (aggregated) clays. The presence of shrink-swell clay soils is important; desiccation cracks in these soils form during prolonged dry spells. These cracks serve as conduits for contaminants to move through these normally low permeability soils. The vadose zone is comprised of fine-grained lacustrine sediments overlying till in some areas. Recharge in this setting is moderate to low depending upon the depth to water and the thickness of the fine-grained lacustrine sediments and till.

The GWPP index values for the hydrogeologic setting of Glacial Lake Plains Deposits range from 82 to 156, with the total number of GWPP index calculations equaling 157.

Figure 1. Format and description of the hydrogeologic setting – 7F Glacial Lake Plain Deposits.

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

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

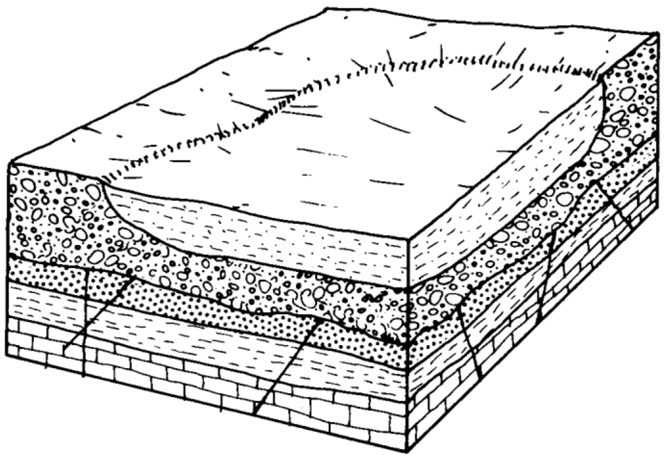
Table 8. Ranges and ratings for hydraulic conductivity

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 7F1, Glacial Lake Plain Deposits, identified in mapping Defiance 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 152. 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 Defiance County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the nine settings identified in the county range from 82 to 171.

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 Defiance 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 Defiance County is included with this report.



SETTING 7F1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and gravel	3	7	21
Soil Media	Shrink-swell Clay	2	7	14
Topography	0-2%	1	10	10
Impact of Vadose Zone	Silt and Clay	5	4	20
Hydraulic Conductivity	700-1000	3	6	18
		DRASTIC	INDEX	152

Figure 2. Description of the hydrogeologic setting – 7F1 Glacial Lake Plain Deposits.

INTERPRETATION AND USE OF GROUND WATER POLLUTION POTENTIAL MAPS

The application of the DRASTIC system to evaluate an aquifer's vulnerability to contamination produces hydrogeologic settings with corresponding pollution potential indexes. The susceptibility to contamination is 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:

7F1 - defines the hydrogeologic region and setting
152 - defines the relative pollution potential

The first number (**7**) refers to the major hydrogeologic region and the upper case letter (**F**) 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 (**152**) 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 DEFIANCE COUNTY

Demographics

Defiance County occupies approximately 412 square miles (Flesher, 1984) in northwestern Ohio (Figure 3). Defiance County is bounded to the north by Williams County, to the east by Henry County, to the south by Paulding and Putnam Counties, and to the west by Indiana.

The approximate population of Defiance County, based upon year 2006 estimates, is 39,091 (Department of Development, Ohio County Profiles, 2007). The city of Defiance is the largest community and the county seat. Agriculture accounts for roughly 81 percent of the land usage in Defiance County. Crops are the primary agricultural land usage. Forest, industry, and residential are the other major land uses in 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.

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 49 degrees Fahrenheit for Defiance County. Harstine (1991) shows that precipitation averages approximately 33 inches per year for most of the county, with the exception of the northeast and southwest corners, which average 35 inches per year. The mean annual precipitation for Defiance is 35.6 inches per year based upon a thirty-year (1971-2000) period (National Oceanographic and Atmospheric Administration (NOAA), 2002). The mean annual temperature at Defiance for the same thirty-year period is 50.1 degrees Fahrenheit (NOAA, 2002).

Physiography and Topography

All of Defiance County lies within two sections of the Central Lowlands Province (Brockman, 1998). The northwest corner of the county lies within the Till Plains Section, while the rest of the county lies within the Huron-Erie Lake Plains Section. The Paulding Clay Bottom, which occupies about ¼ of the area in east-central Defiance County, was believed to be the deepest portion of the ancestral Lake Maumee basin and is characterized by exceptionally clayey, flat-lying sediments. Most of Defiance County is characterized by very flat, lake plain topography. The northwest corner of the county has more rolling topography due to the presence of the Fort Wayne moraine. Portions of the flat-lying lake plain are comprised of ground moraine that was heavily wave-eroded.

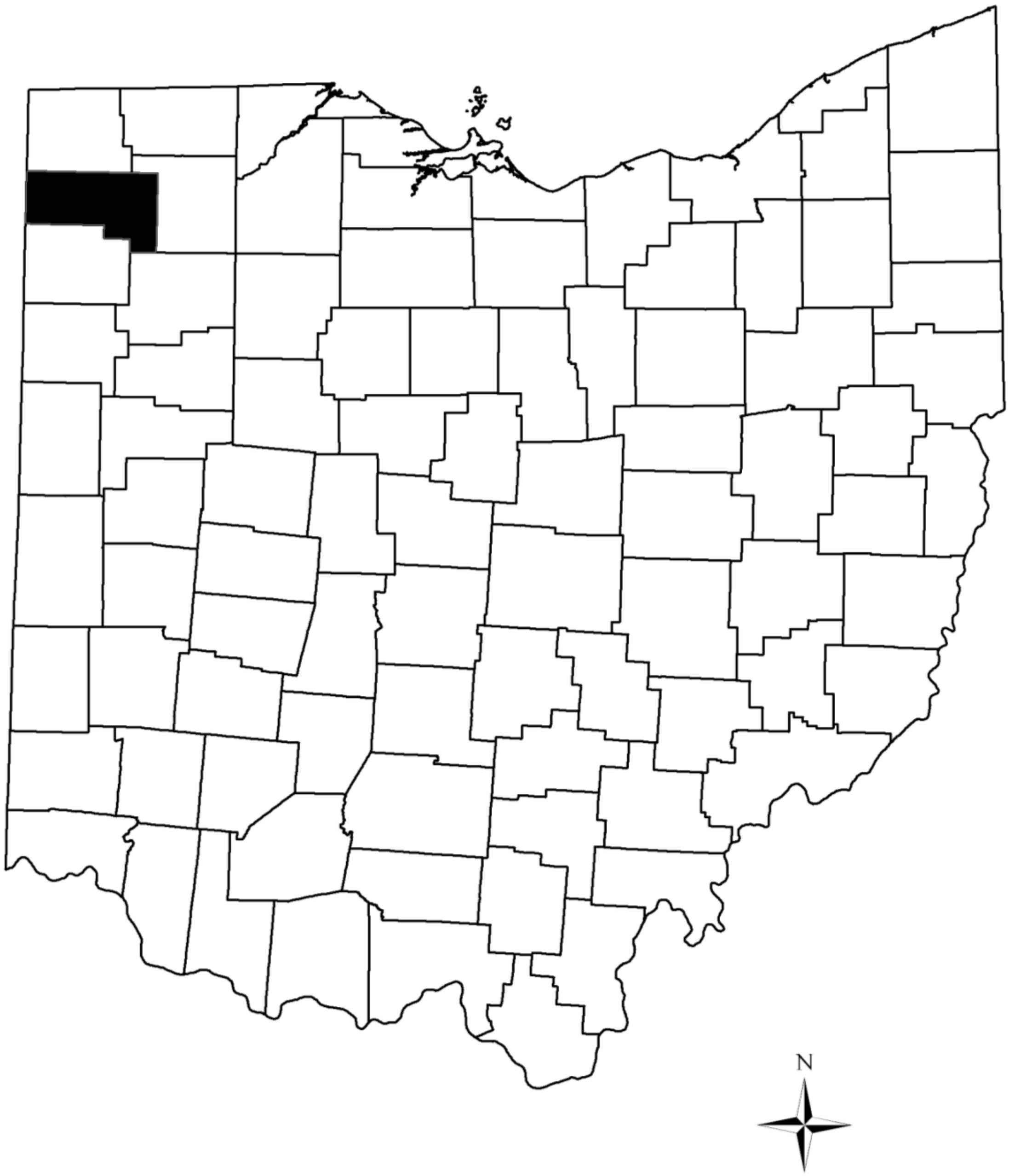


Figure 3. Location map of Defiance County, Ohio.

Modern Drainage

Defiance County lies north of the major drainage divide crossing north central Ohio; all of Defiance County drains toward Lake Erie. The northern two-thirds of the county are drained by the Tiffin River and its tributaries including Buckskin Creek, Lick Creek, Lost Creek, and Mud Creek. The Tiffin River then drains into the Maumee River in the area of Defiance. The southeastern third of the county is drained by the Auglaize River and by its tributary Powell Creek. The Auglaize River then joins the Maumee River at Defiance as well.

Pre- and Inter-Glacial Drainage Changes

The drainage patterns of Defiance 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 Defiance County and adjacent counties. Particularly, well log data for deeper wells that penetrate the entire drift thickness would be helpful in making interpretations. This would allow a more accurate reconstruction of the system of buried valleys and former drainage channels for the county.

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. The Teays River ran to the south of Defiance County, extending across northern Mercer County. Stout et al. (1943) mapped a rough drainage divide running through eastern Defiance County (see Figure 4). Drainage in the western ¾ of Defiance County was to the west, towards westerly-flowing tributaries of the Teays River in Indiana (Stout et al., 1943). Drainage in the eastern part of Defiance County was to the northeast, towards an ancestor of the Maumee River referred to as the Napoleon River.

As ice advanced through Ohio during the pre-Illinoian (Kansan) glaciations, drainage ways to the north and west were blocked. The pre-existing channels and valleys created by the Teays River drainage system were overrun by the advancing glaciers and filled with glacial till from the advancing ice sheets. Subsequent ice advances during the Illinoian and Wisconsinan ice advances further filled these former channels. These sediment-filled ancestral valleys are referred to as buried valleys. Modern bedrock topography data (Open File Bedrock Topography Maps, ODNR Division of Geological Survey) shows a minor buried valley system underlying extreme northwestern Defiance County. This buried valley lies beneath the modern day St. Joseph River valley. Buried valleys representing major tributaries of the Teays River lie to the south in Van Wert County and Allen County.

Slowly the drainage patterns of Defiance County evolved and drainage shifted towards the north and east during ice-free intervals. The modern drainage reflects the nature of landforms deposited during, and immediately following, the Wisconsinan advances, particularly the lake plain associated with Lake Maumee.

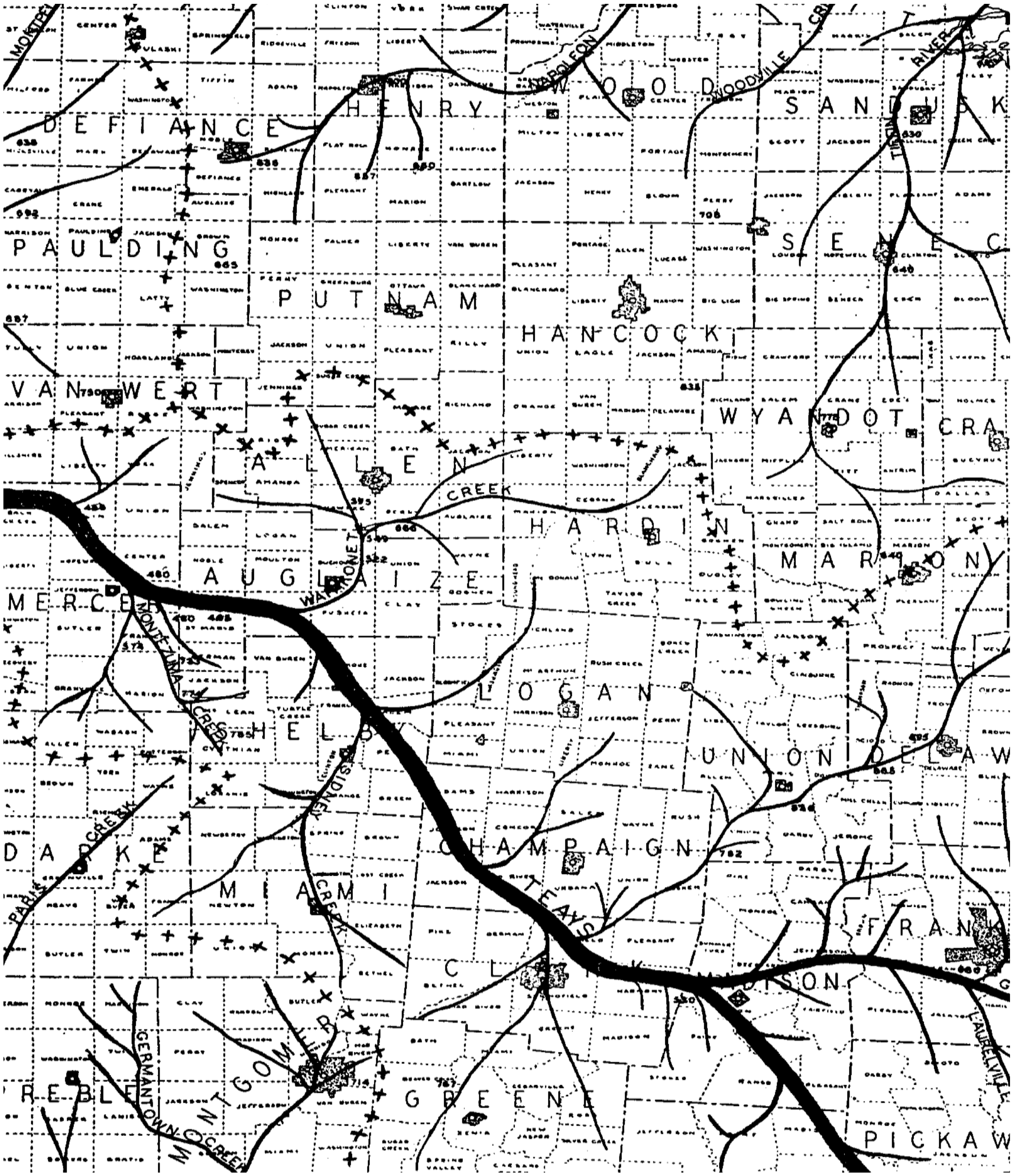


Figure 4. Teays Stage drainage in western Ohio (after Stout et al., 1943).

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years before present (Y.B.P.)) several episodes of ice advance occurred in northwestern Ohio. Older ice advances that predate the most recent (Brunhes) magnetic reversal (about 730,000 Y.B.P.) are now commonly referred to as pre-Illinoian (formerly Kansan). Goldthwait et al. (1961) and Pavey et al. (1999) report that the last advance, the Late Wisconsinan Ice Sheet, deposited the surficial till in Defiance County. Evidence for the earlier glaciations is lacking or obscured.

The unconsolidated (glacial) deposits in Defiance County fall into four main types: (glacial) till, lacustrine deposits, beach/deltaic/dune deposits, and alluvial (river) deposits. Alluvium consists of both ancestral and relatively modern sediments deposited by rivers. Drift is an older term that collectively refers to the entire sequence of glacial deposits. In Defiance County, drift thins to the south and east areas of the county, and thickens to the north and west. Drift is thickest in the northwest corner of the county bordering Williams County (ODNR, Division of Geological Survey, Open File Bedrock Topography and ODNR, Division of Water, Glacial State Aquifer Map, 2000, Mohd-Nurin, 1986).

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 and ablation tills. 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 or 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.

There is evidence that most of the till in Defiance County was deposited in a water-rich environment. These types of tills are associated with ancestral Lake Maumee and are common in the eastern two-thirds of Defiance County. The till is covered by a thick layer of lacustrine sediment in the central portion of the county. These types of tills would be deposited when a relatively thin ice sheet would alternately float and ground depending on the water level of the lake and thickness of the ice sheet. Such tills may more closely resemble lacustrine deposits (Forsyth, 1965). Wave activity in the shallow areas from these ancestral lakes had the effect of eroding or “planing” existing till or lacustrine deposits. The net effect of the planning is typically an enhanced flattening in areas of low relief.

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 and Haefner, 2000). Fractures may also interconnect sand and gravel lenses. The number of sand and gravel lenses interbedded within the glacial till tends to increase to the north and west, particularly in the northwestern corner. In some areas, there are multiple zones of sand and gravel lenses in the vertical sequence. The sand and gravel lenses may “stack” in places, creating another possible window for contaminant migration. The thickness and lateral extent of these lenses also increases to the north and west. The sand and gravel lenses become coarser-grained and better sorted, making the lenses better local aquifers. The sand and gravel lenses may directly overlie the bedrock and provide additional recharge.

Alluvial deposits are sediments deposited by either the floodplain or channel of rivers and streams. As modern streams downcut, the older, now higher elevation remnants of the original valley floor are called terraces. Terraces in Defiance County tend to be relatively low elevation and are at elevations just above the current floodplain. The majority of the alluvium in Defiance County is very fine-grained and is more clayey than silty. This reflects the very clayey nature of the till and lacustrine sediments in this area. Also, many of these streams have a very low gradient and cannot carry coarse sediments except following major storm or flood events.

The Lake Plains region of Ohio was flooded immediately upon the melting of glacial ice due to its basin-like topography. River flow into the basin also contributed to the formation of these lakes. Various drainage outlets in Indiana, Michigan, and New York controlled lake levels over time.

This series of lakes, from ancestral Lake Maumee to modern Lake Erie, had a profound influence on the surficial deposits and geomorphology of the area. Shallow wave activity had a beveling affect on the topography. The resulting land surface is flat, gently sloping towards the Maumee River and Lake Erie. Clayey to silty lacustrine sediments were deposited into deeper, quieter waters. In shallower areas, beaches and bars were deposited. Some of the beach ridge sand and gravel was deposited by insitu erosion (Anderhalt et al., 1984); the remainder of the sediment was transported in by local rivers and then re-deposited by wave activity. Coarser sand and gravel was deposited at the shoreline (strandline). Progressively offshore, finer sands, then silts, and then clay were deposited. This accounts for the variable soil types which progress from sands, to sandy loams, to silty loams, to either clays or shrink-swell clays. Lacustrine deposits tend to be laminated or "varved" and contain various proportions of silts and clays. Thin layers of fine sand 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.

The highest elevation in Defiance County lies north of Hicksville on the Fort Wayne Moraine at 874 feet above mean sea level (msl) (Mohd-Nurin, 1986). Lacustrine deposits that comprise the 7F-Glacial Lake Plain Deposits hydrogeologic setting are found at the surface through most of eastern and central Defiance County. All of these deposits tend to be very clayey, are poorly drained, and pond water after precipitation events.

Beach ridge and related deposits are found in eastern Defiance County, and in western Defiance County along the eastern edge of the Fort Wayne moraine. The sequence of ancestral lake levels and elevations of beaches in Defiance County are listed in Table 9.

Table 9. Sequence of ancestral lake levels and beaches in Defiance County (after Forsyth, 1959 and 1973)

Lake Stage	Age (Years B.P)	Elevation (ft.)	Outlet	Found in Defiance County
Erie (modern)	4,000	573	Niagara	No
Algonquin	> 12,000	605	Grand River, Mi or Mohawk River, N.Y.	No
Lundy	>12,200	?	Grand River, Mi or Mohawk River, N.Y.	No
(Elkton)		615	Grand River, Mi or Mohawk River, N.Y.	No
(Dana)		620	Grand River, Mi or Mohawk River, N.Y.	No
(Grassmere)		640	Grand River, Mi	No
Lower Warren		675	Grand River, Mi or Mohawk River, N.Y.	No
Wayne		655-660	Grand River, Mi or Mohawk River, N.Y.	No
Upper Warren	<13,000	685-690	Grand River, Mi.	No
Whittlesey	>13,000	735	Grand River, Mi	Yes
Lower Arkona		700-705	Grand River, Mi	No
Upper Arkona		715-720	Grand River, Mi	No
Middle Maumee	14,000	775-780	Wabash River, In	Yes
Lower Maumee		755	Grand River, Mi	No
Upper Maumee		800	Wabash River, In	No

Forsyth (1959 and 1973) gives a detailed discussion of the beach levels and lake history in northwestern Ohio. Well-developed beach features in Defiance County occur at elevations of 735 feet msl which corresponds with Lake Whittlesey. Lake Whittlesey commonly has relatively strong beach development; east of Defiance it has assumed a V-shaped pattern. This pattern marks the area where the Defiance moraine was breached and the beach deposits formed on each side of it. Other beach ridges occur along the eastern flank of the Fort Wayne Moraine, and correspond to Middle Maumee lake levels (Mohd-Nurin, 1986).

Historically, this area was very poorly drained due to the clayey soils and flat topography. During the time of early settlement, most of Defiance County was within the Great Black Swamp (Kaatz, 1955). Settlement and transportation were limited to the well-drained beaches and dunes. The remaining areas were not inhabited until the swamp was drained artificially in the 1870's.

Bedrock Geology

Bedrock underlying the surface of Defiance County consists of shale, limestone, and dolomite (carbonates) of the Silurian and Devonian System. Along the northern two-thirds of the county, Devonian shale is the uppermost bedrock unit, overlying the limestone. Table 10 summarizes the bedrock stratigraphy found in Defiance County. The ODNR, Division of Geological Survey has Open-File Reconnaissance Bedrock Geological Maps completed at a 1:24,000 scale on USGS topographic map bases available for the entire county. The ODNR, Division of Water has Open File Bedrock State Aquifer maps available for the county also.

The youngest unit encountered is the Devonian Antrim shale that is found over the northern two-thirds of the county. The Antrim Shale is dark brown to black, marine, fissile to platy shale. The Antrim shale may contain abundant pyrite, organic matter, and locally, natural gas pockets. These fine sediments were deposited in a deep, quiet environment, under reducing conditions with little circulation of waters.

Table 10. Bedrock stratigraphy of Defiance County.

System	Group/Formation (Symbol)	Lithologic Description
Devonian	Antrim Shale (Da)	Thick, brown to black, fissile to platy shale. Carbonaceous, contains pyrite, hydrogen sulfide, and pockets of methane gas. Poor aquifer with meager yields and poor water quality.
	Traverse Group Dundee Limestone Detroit River Group (Dtddr)	Interbedded brown limestones and dolomites. Contains sandy, shale-rich, cherty, evaporate, and fossiliferous zones. Unit underlies entire county except for northern 1/3. Moderate aquifer, yields average 5 to 25 gpm. Water quality may be poor where overlain by the Antrim Shale.
Silurian	Undifferentiated Salina Dolomite (Sus)	Gray to brown, thin-bedded, argillaceous dolomite. Thin evaporite zones common. This unit is typically greater than 100 feet in thickness, and average yields range from 5 to 25 gallons per minute. Underlies the Dtddr where it exists as the uppermost bedrock unit.
	Tymochtee and Greenfield Dolomites (Stg)	Thin- to massive-bedded, olive-gray to yellowish-brown. The Tymochtee contains shale partings. The Greenfield has a laminated dolomite lithology. Underlies the Sus, and thickness usually exceeds 100 feet. Yields range from 25 to 100 gpm.
	Lockport Dolomite (Sl)	White to medium gray, medium- to massive-bedded dolomite. Commonly contains cavernous solution zones. Thickness >100 feet. Yields can exceed 100 gpm, especially in cavernous or solution zones. Found in the subsurface where overlain by Stg.

The next youngest unit is the Devonian Traverse Group, Dundee Limestone, and Detroit River Group that are mapped together as a single unit. These rocks are brown limestones and dolomites and are somewhat variable. They contain units with sandy pockets, shale-rich zones, and sections with chert, evaporates, and fossiliferous zones. These units underlie all but the northern third of the county, and a small area in the extreme southeast corner. These units get thinner toward the southeast.

The uppermost Silurian unit is the Salina Undifferentiated Group. The Salina Undifferentiated Group consists of dolomites, fine-grained limestones, and some minor evaporite deposits such as gypsum. These rocks were deposited in warm, shallow tidal areas. Units of the Salina Undifferentiated Group underlie the units of the Traverse Group, Dundee Limestone, and Detroit River Group in areas where they are the uppermost bedrock unit. The thickness of the Salina Undifferentiated Group remains consistent throughout the county.

Underlying the Salina Undifferentiated Group are rocks of the Silurian Tymochtee and Greenfield Formations, which were also deposited in warm, shallow seas. These two formations maintain their thickness across the county.

The oldest unit typically encountered by water wells is the Silurian Lockport Group. Rocks of the Lockport are commonly found in the subsurface in areas where the Traverse Group, Dundee Limestone, and Detroit River Group are the uppermost bedrock units. The Lockport Group rocks were associated with tidal reefs deposited in warm, high-energy shallow seas.

Ground Water Resources

Ground water in Defiance County is obtained from both consolidated (bedrock) and unconsolidated (sand and gravel) aquifers. Shale is utilized as an aquifer in a northeast-southwest-trending band that runs from southeast of Sherwood and widens northeast. The area includes Evansport on the west and enters Henry County on the east just northwest of Okolona. Wells in the eastern third of the county are developed in the limestone and dolomite aquifer. Sand and gravel aquifers dominate the western half of the county.

Over an area ranging from the Indiana border east to a northeast-southwest trending line running just west of Ney and Mark Center, numerous thick sand and gravel lenses exist. The sand and gravel within these lenses tends to be coarse-grained, clean, and well-sorted. Properly designed and constructed large diameter wells completed in these intervals may be capable of yielding up to 500 gpm (Schmidt, 1982, ODNR, Division of Water, Glacial State Aquifer Map, 2000). This area of higher-yielding sand and gravel deposits forms the leading edge of a thick wedge of interbedded, sand-and-gravel-rich till that extends south into Paulding (Raab, 1986) and north into Williams County (Haiker, 1996, Angle et al., 1993).

Yields of 3 to 10 gpm are possible from wells completed in sand and gravel lenses interbedded within the glacial till or lacustrine units just east of the area of high-yielding wells (Schmidt, 1982). These wells are suitable for domestic and farm purposes. In some areas, there may be multiple layers of sand and gravel lenses in the vertical sequence. The sand and gravel lenses may directly overlie the shale or limestone bedrock, providing additional recharge to these units. It is common in many older wells for the drilling contractor to have drilled only a few feet into the bedrock to use it as a “screen” for immediately overlying sand and gravel deposits. Sand and gravel wells are much more common in areas where the underlying bedrock is low-yielding shale instead of the better-yielding limestones and dolomites.

The Devonian Antrim Shale is a very poor aquifer, typically yielding less than 5 gpm. It provides a meager supply of water, suitable for limited domestic use, in an area confined to a northeast-southwest trending band through the central portion of the county that widens into the northeast corner of the county. Also, the water quality is typically objectionable due to hydrogen sulfide, high iron, and natural gas.

The carbonate bedrock aquifer is an important regional aquifer for most of northwestern and north central Ohio and underlies all of Defiance County (ODNR, Div. of Water, 1970 and Schmidt, 1982). However, in the northern third of the county, the carbonate units are not considered aquifers due to their depth beneath the Antrim Shale, and the resulting poor water quality (ODNR, Division of Water, Open File, Bedrock State Aquifer Map, 2000, and ODNR, Division of Water, 1970, and Schmidt, 1982). Completed water wells typically penetrate multiple bedrock units.

The eastern third of the county primarily utilizes the carbonate aquifers. There is a limited area east of Defiance and extending to the county border where the wells penetrate the Antrim Shale to reach the carbonate aquifer. These wells produce enough for domestic use, but usually do not have the high yields more characteristic of the carbonate aquifers. Water quality in the Devonian carbonates may be poor where they directly underlie or are adjacent to the Antrim Shale. The Devonian Traverse Group, Dundee Limestone, and Detroit River Group are the uppermost carbonate units found in the eastern part of the county. Yields in these units are commonly lower than in the underlying Silurian rocks and average 5 to 25 gpm. Yields exceeding 100 gpm are available from deep, large diameter wells drilled into the underlying Silurian Salina Group, the Tymochtee and Greenfield Dolomites, and the Lockport Dolomite (ODNR, Div. of Water, Open File, Bedrock State Aquifer Map, 2000, ODNR, Div. of Water, 1970, and Schmidt, 1982). However, the assumption that a deeper well will always produce higher yields is a generalization. The amount of fracturing, solution, and vuggy (porous) zones has great local importance. Deeper wells are more likely to contain highly mineralized water and have objectionable water quality.

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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 4430 water well log records are on file for Defiance County. Data from roughly 1179 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 Defiance County* (Schmidt, 1982) provided generalized depth to water information throughout the county. Generalized regional depth to water information was obtained from the ODNR, Division of Water (1970) report. Depth to water trends mapped in adjoining Putnam County (Angle, 2006), Paulding County (Angle, 2007), Williams County (Angle, et. al., 2003), and Henry County (Miller and Angle, 2002) were used as a guideline. Topographic and geomorphic trends were utilized in areas where other sources of data were lacking.

Depths of 5 to 15 feet (9) were selected for the northwestern corner of Defiance County in the area mapped as 7D-Buried Valley and 7AF-Glacial Till over Shale. Depths of 5 to 15 feet, as well as 15 to 30 (7) feet, are also found in the eastern and central areas of the county mapped as 7Ea-River Alluvium with Overbank Deposits, 7Ec-Alluvium over Sedimentary Rock, and 7Ed-Alluvium over Glacial Till. Depths of 0 to 5 (10), 5 to 15, and 15 to 30 feet are found in the west-central part of the county that is mapped as 7F-Glacial Lake Plain Deposits. The aquifer in this area is sand and gravel. In the areas of this hydrogeologic setting where the aquifer is limestone or shale, typically the east-central part of the county, the depth to water increases to 30 to 50 feet. The 7H-Beaches, Beach Ridges, and Sand Dunes hydrogeologic setting is found in the eastern part of the county, and depths to water of 30 to 50 feet are common because the aquifers are the limestone or shale bedrock. Areas mapped as 7C-Moraine also include depths to water of 30 to 50 feet. Depths to water of 50 to 75 (3) are found in this setting as well due to the thickness of glacial deposits. This setting is mapped in the northwest corner of the county.

Net Recharge

Recharge is the precipitation that reaches the aquifer. 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 ratings from neighboring Putnam County (Angle, 2006) Paulding County (Angle, 2007), Williams County (Angle, et. al., 2003), and Henry County (Miller and Angle, 2002) were used as a guideline.

Values of 7 to 10 inches per year (8) were used for the area of outwash deposits overlying the St. John's River valley in the northwest corner of the county. The shallow depth to water, flat topography, and coarseness of the deposits contributed to this determination. Values of 4 to 7 inches per year (6) were used in the area of the 7C-Moraine setting, all of alluvial settings, and some areas mapped with the 7F-Glacial Lake Plain Deposits setting. These areas tend to have moderate depths to water and moderately permeable soils. Values of 2 to 4 inches per year (3) were used for the rest of the Glacial Lake Plain Deposits settings, the 7Ae-Glacial Till Over Shale settings, and the 7Af-Sand and Gravel Interbedded in Glacial Till settings. These are areas of ground moraine and lake plain. They have clayey, low permeability soils and vadose zone materials and represent semi-confining conditions.

Aquifer Media

Information on evaluating aquifer media was obtained from the *Ground-Water Resources of Defiance County* (Schmidt, 1982). 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. Aquifer ratings from neighboring Putnam County (Angle, 2006) Paulding County (Angle, 2007), Williams County (Angle, et. al., 2003), and Henry County (Miller and Angle, 2002) were used as a guideline. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) were an important source of aquifer data. The *Glacial Map of Ohio* (Goldthwait et al., 1961) and the *Quaternary Geology of Ohio* (Pavey et al., 1999) provided useful information on the nature of the glacial aquifers and the delineation of the hydrogeologic settings. Additional information on limestone aquifers was obtained from a report (Division of Water, 1970) on carbonate rocks in northwestern Ohio. Well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

All of the bedrock and most of the interbedded lenses of sand and gravel are semi-confined or leaky; however, for the purposes of DRASTIC, they have been evaluated as being unconfined (Aller et al., 1987). Limestone was evaluated as the aquifer for the southeastern corner of Defiance County. A rating of (7) was applied to all of the Silurian and Devonian limestone aquifers in the county.

Sand and gravel was evaluated as the aquifer for the western half of the county. In these areas, sand and gravel lenses interbedded in the underlying till or lacustrine deposits were used as the aquifer. These sand and gravel lenses tended to become thicker, more numerous, and coarser-grained in the northwestern corner of the county. An aquifer rating of (8) was applied to the sand and gravel aquifers in the northwest corner due to their greater thickness and yields to wells. The remainder of the sand and gravel aquifers were rated (7).

Shale was evaluated as the aquifer for a limited area in northeastern Defiance County, and along a narrow, northeast-southwest trending band extending from an area west of Defiance southwest to the border with Paulding County. Shale was encountered in well logs throughout these areas. In some instances, sand and gravel deposits directly overlie the shale and the wells were completed 1 or 2 feet into the shale, essentially using the shale as a "well screen”. In these cases, yields were good and sand and gravel was evaluated as the aquifer. In a limited number of wells, the well was drilled through thin shale and into the underlying limestone. In these cases, limestone was evaluated as the aquifer. Shale was only evaluated as an aquifer where the well penetrated a reasonable thickness of the shale and there was no directly overlying sand and gravel or underlying limestone present in the well log record. Aquifer ratings of (2) for more massive shale, or (3) for fractured shale, were applied to the shale aquifers due to their poor aquifer characteristics.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Defiance County* (Flesher, 1984), as well as data from the United States Department of Agriculture Natural Resource Conservation Service’s Soil Data Mart (2007). 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. Special emphasis is placed upon determining the most restrictive layer. The soils of Defiance 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 Defiance County.

Shrink-swell (non-aggregated) clays (7) were selected for the highly clayey soils found at the surface of the 7F-Glacial Lake Plain Deposits settings. These soils were formed on the water-eroded till and lacustrine sediments associated with ancestral Lake Maumee, and are found mainly in eastern and central Defiance County. Shrink-swell clay (7) was also selected for some fine-grained alluvial deposits. Sand (9) was also utilized in the 7F-Glacial Lake Plain deposits setting for a few isolated locations that probably consisted of fine-grained dune sand overlying a low beach ridge feature. Sandy loam (6) soils were associated with sandy sediments found in the 7H-Beaches, Beach Ridges, and Sand Dunes setting. Loam (5) soils were selected for a number of areas where the surficial deposits had an intermediate texture soil. These areas included thin layers of fine sand that had been eroded off beach ridges and in areas with coarser alluvial deposits. Silt loam (4) was designated for silty, finer-grained alluvial and floodplain deposits. The loam (5) and silt loam (4) alluvial deposits were usually associated with the main trunk of the Maumee, Tiffin, and Auglaize Rivers, whereas the tributary streams more likely contained the shrink-swell clay (7) soils.

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Defiance County* (Flesher, 1984). Defiance County has exceptionally flat-lying terrain and low relief. Slopes of 0 to 2 percent (10) are common across the entire county and were selected for almost all hydrogeologic settings mapped in the county. Slopes of 2 to 6 percent (9) were limited to areas where there was some moderately steep stream dissection along the banks of rivers. Slopes of 2 to 6 percent (9) are also associated with some beach ridges capped by dunes.

Table 11. Defiance County soils

Soil Symbol	Soil Name	Parent Material/ Setting	DRASTIC Rating	Soil Media
Bmb	Belmore	Beach ridge	6	Sandy loam
BhA	Bixler	Thin beach over lacustrine	6	Sandy loam
BnA	Blount	Till	3	Clay loam
Bp	Bono	Lacustrine, till	7	Shrink/swell clay
BsB	Boyer	Beach ridge or terrace	6	Sandy loam
BrB	Bronson	Beach ridge	6	Sandy loam
BvE, BwC3	Broughton	Lacustrine	7	Shrink/swell clay
Ca	Carlisle	Peat, muck	8	Peat
Cm	Colwood	Deltaic	5	Loam
Db	Defiance	Clayey alluvium	3	Clay loam
DdA, DeA, DfA	Del Rey	Lacustrine	3	Clay loam
DgA	Del Rey	Lacustrine	4	Silty loam
DmA	Digby	Beach, deltaic	5	Loam
Ee	Eel	Alluvium	4	Silty loam
Fc	Flatrock	Alluvium	4	Silty loam
FrA, FsA, FtA, FuA, FuB, FvA	Fulton	Lacustrine	7	Shrink/swell clay
Ge	Genessee	Alluvium	4	Silty loam
Gf	Gilford	Beach, deltaic, outwash	6	Sandy loam
GwB, GwB2, GwC2, GwD2	Glynwood	Till	3	Clay loam
Gx	Granby	Beach, dune, deltaic	6	Sandy loam
HaB, HbA	Haney	Beach ridge	5	Loam
HnA	Haskins	Thin beach over till	3	Clay loam
HhA, HkA, HmA, HpA	Haskins	Beach sand over till	5	Sandy loam
Ho, Hs, Ht, Hv	Hoytville	Wave-planed till	7	Shrink/swell clay
KfA	Kibbie	Deltaic	5	Loam
Kn	Knoxdale	Coarse alluvium	5	Loam
Lb	Landes	Alluvial terraces	6	Sandy loam
Lc	Latty	Lacustrine	7	Shrink/swell clay
Lf	Lenawee	Silty lacustrine	3	Clay loam
LwB, LwC2, LwD2	Lucas	Clayey lacustrine	7	Shrink/swell clay
Mc	Medway	Alluvium	4	Silt loam
Md	Mermill	Beach, deltaic	5	Sandy loam
Me	Mermill	Thin beach ,deltaic over till	3	Clay loam
Mg, Mh	Millgrove	Beach, deltaic, thin outwash	5	Loam
MrD2	Morley	Eroded till	3	Clay loam
NmA, NmB, NnA, NpA, NrA	Nappanee	Water-modified till	7	Shrink/swell clay
OsB, OrC	Oshtemo	Beach deposits	6	Sandy Loam
Pa	Paulding	Lacustrine	7	Shrink/swell clay
Pm	Pewamo	Till in depressions	3	Clay loam
Pt	Pitts, gravel	Not rated	NR	NR

Soil Symbol	Soil Name	Parent Material/ Setting	DRASTIC Rating	Soil Media
RkC, RmB, RmC	Rawson	Thin beach sand over till/lacustrine	5	Loam
RnA, RoA, RpA	Rimer	Beach over till/lacustrine	6	Sandy loam
RrA, RsA, RtA, RtB, RvA, RwA, RwB	Roselms	Clayey lacustrine	7	Shrink/swell clay
Ru	Ross	Alluvium	4	Silty loam
SaB, SbB2, SbC2, SbE, ScD3, ScE3, SfE3, SfF3	St. Clair	Lacustrine or water-modified till	7	Shrink/swell clay
SdB, SeB	Seward	Thin delta, beach	5	Sandy loam
Sh	Shoals	Alluvium	4	Silty loam
So	Sloan	Alluvium	4	Silty loam
TdA	Tedrow	Dunes, beach ridge	9	Sand
Tn, To	Toledo	Lacustrine	7	Shrink/swell clay
TsB, TtC2	Tuscola	Deltaic, fine beach ridge	5	Sandy loam
Ud	Udorthents	NR	NR	NR
Ur	Urban land	NR	NR	NR
W	Water	NR	NR	NR
Wa	Wabasha	Clayey alluvium	7	Shrink/swell clay
Wc, Wd	Wallkill	Peat, depressions, kettles	8	Peat
Wf	Wauseon	Thin beach over till/lacustrine	5	Sandy loam

Table 11. Defiance County soils (continued from page 30)

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained primarily from the *Ground Water Resources of Defiance County* (Schmidt, 1982) and water well log records on file at the ODNR, Division of Water. 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. Vadose zone media ratings from neighboring Putnam County (Angle, 2006) Paulding County (Angle, 2007), Williams County (Angle, et. al., 2003), and Henry County (Miller and Angle, 2002) were used as a guideline.The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) were important sources of vadose zone media data. The *Soil Survey of Defiance County* (Flesher, 1984) provided valuable information on parent materials. The *Glacial Map of Ohio* (Goldthwait et al., 1961) and the *Quaternary Geology of Ohio* (Pavey et al., 1999) were useful in delineating vadose zone media.

The vadose zone media is a critical component of the overall DRASTIC rating in Defiance County. The rating varies with the restrictive properties of the various glacial materials. The higher the proportion of silt and clay and the greater the compaction (density) of the sediments, the lower the permeability and the lower the vadose zone media are rated.

A vadose zone media rating of (6) was chosen for sand and gravel with significant silt and clay for the 7H-Beaches, Beach Ridges, and Sand Dunes hydrogeologic settings in eastern Defiance County, and the 7D-Buried Valley setting in the northwest corner of the county. Sand and gravel with significant silt and clay with a rating of (5) was chosen for some of the alluvial settings across the county. Silt and clay with a vadose zone media rating of (5) was selected for alluvial settings in the county containing moderately fine-grained alluvium that weathers into silt loam or clay loam soils. Silt and clay with a rating of (4) was applied to fine-grained alluvium that weathers into shrink-swell clay associated with the some of the streams in Defiance County. Silt and clay with a rating of (4) was chosen for clayey lacustrine sediments that had weathered into shrink-swell clay soils in central and east-central Defiance County.

Silt and clay with till (4) was used for select locations in the 7F-Glacial Lake Plain Deposits for areas of exceptionally fine-grained till containing pockets of lacustrine silt and clay. The 7F-Glacial Lake Plain Deposits forms a broad belt across the central portion of Defiance County. Till with a rating of (5) was use for the 7C-Moraine setting and the 7Af-Sand and Gravel Interbedded in Glacial Till setting due to the higher percentage of sand and gravel lenses found in these deposits. These settings are found in the northwest corner of the county. It is also found in the 7F-Glacial Lake Plain Deposits setting in the west central and southeast corner areas of the county. Till and water-modified till with a rating of (4) was used for areas of west central Defiance County near the Ft. Wayne Moraine.

<u>Hydraulic Conductivity</u>

Information on evaluating the hydraulic conductivity was obtained from the maps and report of the ODNR, Div. of Water, (1970), Norris and Fidler (1973), and the *Ground-Water Resources of Defiance County* (Schmidt, 1982). 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. Hydraulic conductivity ratings from neighboring Putnam County (Angle, 2006) Paulding County (Angle, 2007), Williams County (Angle, et. al., 2003), and Henry County (Miller and Angle, 2002) were used as a guideline. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) were important sources of hydraulic conductivity data. Mohd-Nurin (1986) was also a valuable source of information. Water well log records on file at the ODNR, Division of Water, were used to help determine hydraulic conductivity, and textbook tables (Freeze and Cherry, 1979, Fetter, 1980, and Driscoll, 1986) were helpful in obtaining estimated values for hydraulic conductivity in a variety of aquifers.

Values for hydraulic conductivity correspond to aquifer ratings; i.e., the more highly rated aquifers have higher values for hydraulic conductivity. The limited shale aquifers were assigned a hydraulic conductivity range of 1-300 gallons per day per foot squared (gpd/ft^2) (1). All limestone aquifers were assigned a hydraulic conductivity range of 300-700 gpd/ft^2 (4). The majority of the sand and gravel aquifers were given a hydraulic conductivity range of 300-700 gpd/ft^2 (4). A limited number of higher-yielding sand and gravel aquifers in the northwestern corner of the county were given a hydraulic conductivity range of 700-1000 gpd/ft^2 (6).

APPENDIX B

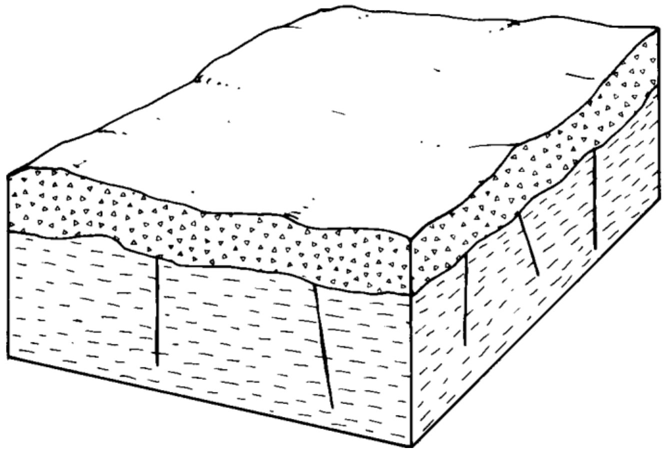
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Defiance County resulted in the identification of nine hydrogeologic settings within the Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 12. Pollution potential indexes for Defiance County range from 82 to 171.

Table 12. Hydrogeologic settings mapped in Defiance County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7 Ae-Glacial till over shale	82-99	11
7 Af-Sand and gravel interbedded in glacial till	114-140	17
7 C-Moraine	121-142	16
7 D-Buried valley	165-171	5
7 Ea-River alluvium with overbank deposits	106-123	3
7 Ec-Alluvium over sedimentary rock	104-151	29
7 Ed-Alluvium over glacial till	130-151	15
7 F-Glacial lake plain deposits	82-156	157
7 H-Beaches, beach ridges, and sand dunes	103-144	16

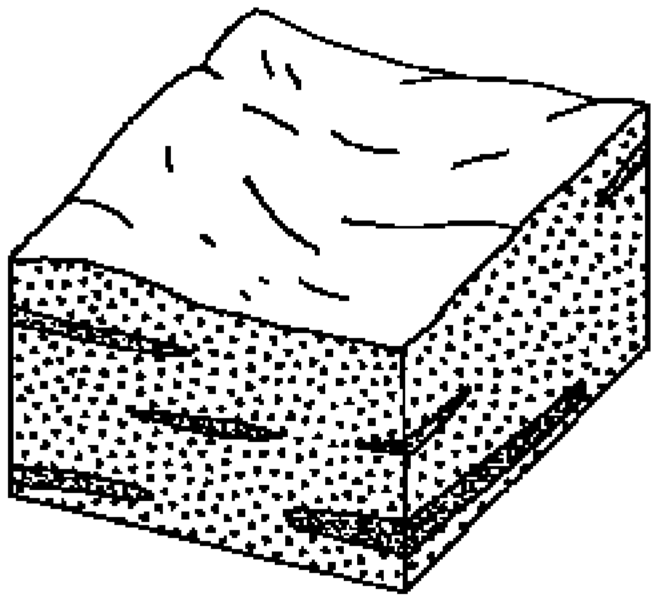
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide 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.



7Ae-Glacial Till over Shale

This hydrogeologic setting is common in the northeastern corner of Defiance County. The area is characterized by flat-lying topography and very low relief. The vadose zone is composed of loamy to clayey glacial till and clayey to silty lacustrine deposits. The till and clayey lacustrine sediments may be fractured or jointed, particularly in areas where it is predominantly thin and weathered. Depth to water is typically moderate. Soils are generally shrink-swell (aggregated) clays. The aquifer is fractured, massive black Devonian-age shale. In some areas, wells are completed in thin lenses of dirty, shale–rich gravel that directly overly the shale. Yields from the shale are typically less than 5 gpm and range from 5 to 25 gpm for the shaley gravel lenses. Recharge is generally low due to the thick and clayey vadose zone and soils and the depth to water.

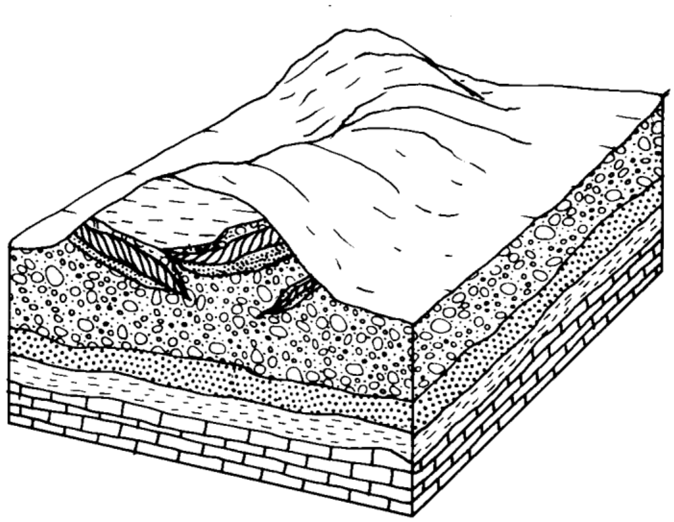
GWPP index values for the hydrogeologic setting of Glacial Till over Shale range from 82 to 99 with the total number of GWPP index calculations equaling 11.



7Af-Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is commonly associated with areas of ground moraine throughout Defiance County. The area is characterized by flat-lying topography and very low relief. The vadose zone is composed of silty 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 usually shallow to moderate, averaging less than 60 feet. Soils are commonly clay loams. The aquifer consists of lenses of sand and gravel interbedded in the glacial till. Ground water yields range up to 500 gpm for properly constructed, large diameter wells. Recharge is moderate to low due to the relatively shallow to moderate depth to water, flatter topography, and the relatively low permeability of the clayey soils and vadose materials.

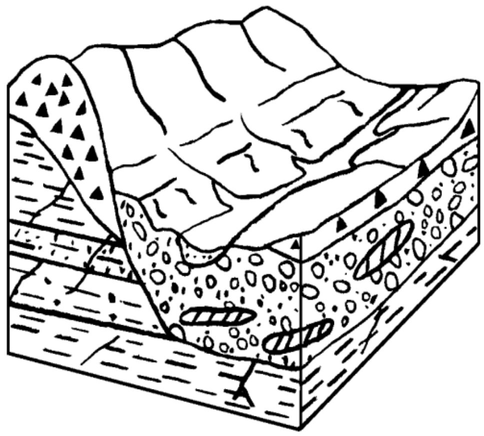
GWPP index values for the hydrogeologic setting of Sand and Gravel Interbedded in Glacial Till range from 114 to 140 with the total number of GWPP index calculations equaling 17.



7C-Moraine

This hydrogeologic setting consists of segments of the Fort Wayne Moraine in northwestern Defiance County. This setting is characterized by hummocky to rolling topography and low relief. The aquifer consists of relatively thick and continuous sand and gravel outwash deposits interbedded with glacial till underlying or within the moraine. These sand and gravel deposits are variable as to lateral extent and thickness and are found at variable depths. Maximum yields range up to 500 gpm. Test drilling may be necessary to locate higher-yielding areas. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with varying thicknesses of glacial till. Depth to water is moderate to deep and is a function of the thickness of the till overlying the sand and gravel lenses. 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.

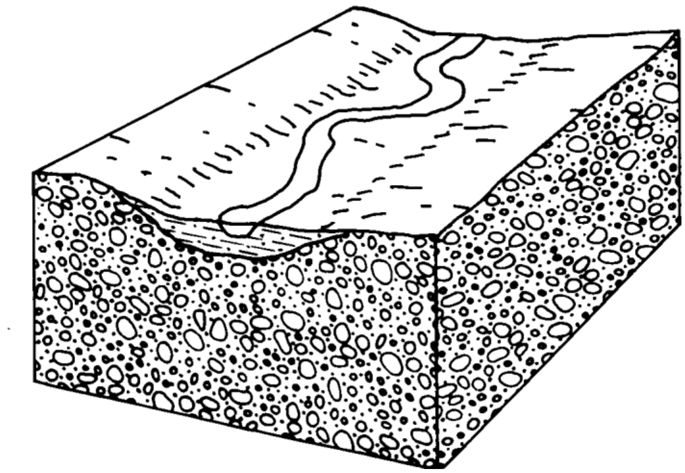
GWPP index values for the hydrogeologic setting of Moraine range from 121 to 142 with the total number of GWPP index calculations equaling 16.



7D-Buried Valley

This hydrogeologic setting follows the St. Joseph River and some of its major tributaries through northwestern Defiance County. The low-lying terraces and floodplains adjacent to the river characterize the setting. The block diagram above characterizes the St. Joseph River buried valley. Depths to water are commonly shallow and yields over 500 gpm are possible from properly-developed, large diameter wells. Soils are variable depending upon whether the parent material is outwash terrace or finer-grained floodplain deposits. Vadose zone media consists of zones of clean sand and gravel lenses interbedded with finer-grained alluvial deposits and thin till. The overlying streams may be in direct hydraulic connection with the sand and gravel outwash in some areas. Recharge is typically high due to the shallow depth to water, flat topography, presence of nearby modern streams, and the highly permeable soils, vadose, and aquifer materials.

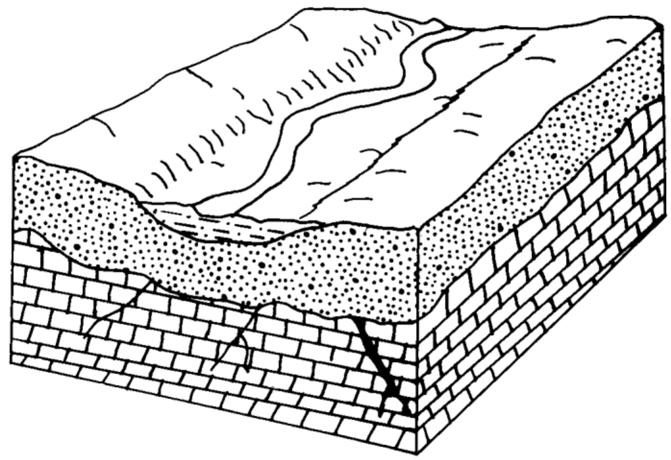
GWPP index values for the hydrogeologic setting of Buried Valley range from 165 to 171, with the total number of GWPP index calculations equaling 5.



7Ea-River Alluvium with Overbank Deposits

This hydrogeologic setting is associated with some of the floodplains and terraces flanking the Tiffin River and its tributaries. Relatively broad, flat-lying floodplains and low terraces characterize this setting. Vadose zone materials vary from clayey to silty floodplain deposits to sandy and loamy materials in the terraces. The setting is similar to the 7Ed Alluvium over Glacial Till except that wells are completed in shale bedrock instead of sand and gravel lenses interbedded in the glacial till. Yields vary from less than 5 gpm to 25 gpm. Soils are generally silt loams. The depth to water is typically shallow, averaging less than 30 feet. Depth to water typically increases in the headwaters of tributaries. Recharge is typically moderate due to shallow depth to water, flat topography, presence of nearby streams, and low to moderate permeability soils and vadose zone materials.

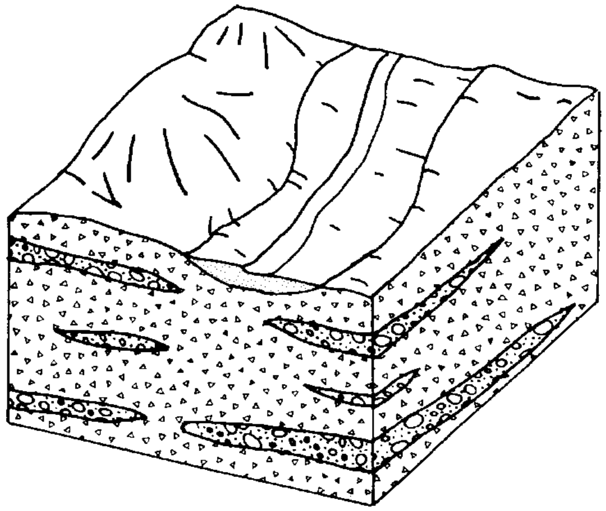
GWPP index values for the hydrogeologic setting of River Alluvium with Overbank Deposits range from 106 to 123, with the total number of GWPP index calculations equaling 3.



7Ec-Alluvium over Sedimentary Rock

This hydrogeologic setting is common along the Auglaize River and its tributaries, a portion of the Maumee River starting from just west of Defiance east to the border with Henry County, and a portion of the Tiffin River starting just south of the Williams County border. It is comprised of flat-lying floodplains and stream terraces containing thin to moderate thicknesses of modern alluvium. The aquifers mainly consist of Silurian and Devonian limestones and dolomites; however, just west of Defiance the aquifer is the Antrim Shale. The vadose zone consists of silty to clayey alluvial deposits overlying thin glacial till. Soils are variable due to the varying texture of the alluvial materials and are usually silt loams. Depth to water is commonly shallow, typically no deeper than 30 feet. The alluvium may be in direct hydraulic connection with the underlying bedrock or there may be a varying thickness of thin till or lacustrine deposits in between. Ground water yields average 5 to 25 gpm, though yields of 100 gpm or more are possible by drilling deeper into the Silurian limestones and dolomites. Recharge is typically moderate due to the flat-lying topography, shallow depth to water, the moderate permeability of the soils and vadose zone media, and the relatively high permeability of the underlying bedrock.

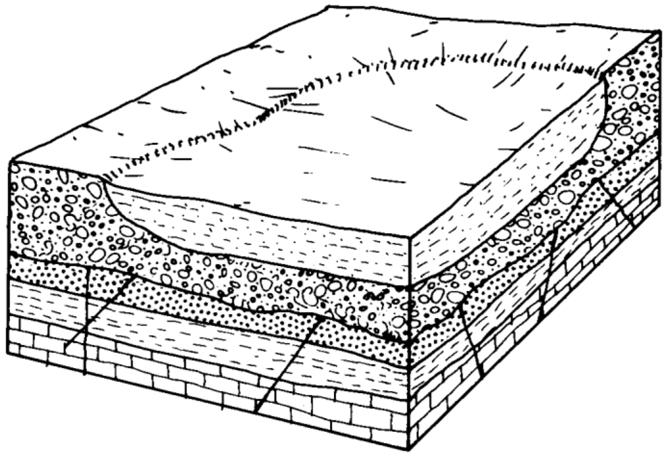
The GWPP index values for the hydrogeologic setting Alluvium over Sedimentary Rocks range from 104 to 151, with the total number of GWPP index calculations equaling 29.



<u>7Ed-Alluvium over Glacial Till</u>

This hydrogeologic setting is comprised of flat-lying floodplains and stream terraces associated with the Maumee River and its tributaries west of Defiance, Lick Creek and Little Lick Creek. These deposits consist of thin to moderate thicknesses of modern alluvium. The setting is similar to the 7Ec-Alluvium over Sedimentary Rock except that the underlying till is thicker and contains sand and gravel lenses. The stream may or may not be in direct hydraulic connection with the underlying sand and gravel lenses that constitute the aquifer. The surficial, silty to sandy alluvium is typically more permeable than the underlying till. The alluvium is too thin to be considered the aquifer. The vadose zone consists of the sandy to silty to clayey alluvial deposits. Soils are variable and depend upon the texture of the alluvium. Ground water yields average 5 to 100 gpm for the wells completed in the underlying sand and gravel lenses; the yield is dependent upon the thickness of the sand and gravel lenses. Depth to water is typically shallow with depths averaging less than 20 feet. Recharge is moderately high due to the shallow depth to water, flat-lying topography, and the moderate permeability of the glacial till and alluvium.

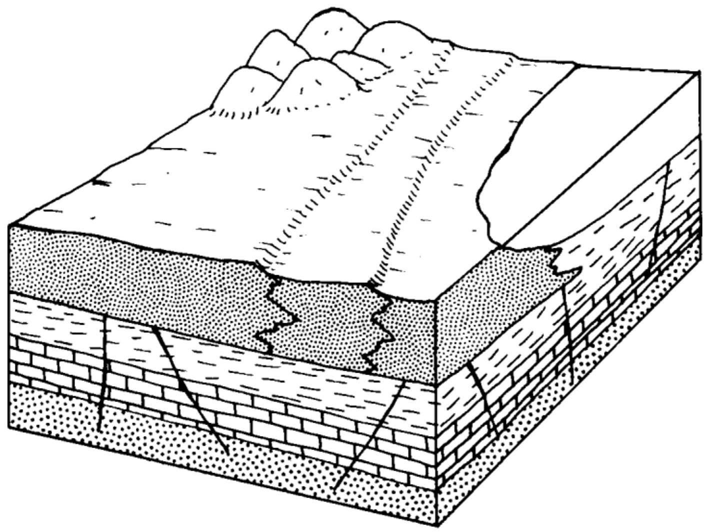
The GWPP index values for the hydrogeologic setting Alluvium over Glacial Till range from 130 to 151, with the total number of GWPP index calculations equaling 15.



7F-Glacial Lake Plain Deposits

This hydrogeologic setting occupies most of west-central, central, and southeastern Defiance County. It is characterized by flat-lying topography and varying thickness of fine-grained lacustrine sediments. These sediments were deposited in lakes by a sequence of ancestral lakes. The vadose zone media consists of clayey lacustrine sediments that overlie glacial till. Wells are completed in the underlying Silurian and Devonian limestone and dolomite in the southeastern part of the county. Yields greater than 100 gpm are possible from the Silurian Lockport, Tymochtee, Greenfield and Salina Groups. In the west-central and part of the central portion of the county the wells are completed in sand and gravel lenses in the till and lacustrine deposits. Yields from these wells can range up to 500 gpm where the lenses are the thickest. There is a narrow band trending northeast-southwest in the east-central portion of the county where the Devonian Antrim Shale is the aquifer. Yields from the Devonian Antrim Shale are poor, averaging less than 5 gpm. Depth to water is variable and seems to be dependent upon the overall thickness of the glacial drift and the depth to the aquifer in which the wells are completed. Soils are shrink-swell (aggregated) clays. The presence of shrink-swell clay soils is important; desiccation cracks in these soils form during prolonged dry spells. These cracks serve as conduits for contaminants to move through these normally low permeability soils. The vadose zone is comprised of fine-grained lacustrine sediments overlying till in some areas. Recharge in this setting is moderate to low depending upon the depth to water and the thickness of the fine-grained lacustrine sediments and till.

The GWPP index values for the hydrogeologic setting of Glacial Lake Plain Deposits range from 82 to 156, with the total number of GWPP index calculations equaling 157.



7H-Beaches, Beach Ridges, and Sand Dunes

This hydrogeologic setting is characterized by narrow, elongate, low-lying ridges of sand overlying the lacustrine plain or wave-planed till uplands. This setting is found in the eastern third of Defiance County. The vadose zone media is composed of thin, clean, fine-grained quartz sand that has moderately high permeability and low sorptive capability. These thin sands overlie clayey lacustrine deposits and water-modified till. Wells are completed in the Devonian shale or Silurian limestone and dolomite bedrock that underlies the till and lacustrine sediments. Maximum ground water yields greater than 100 gpm are possible from the Silurian Lockport, Tymochtee, Greenfield and Salina Groups. Depth to water is variable and seems to be dependent upon the overall thickness of the glacial drift and the depth to the aquifer in which the wells are completed. Soils are loams, sandy loams, or sand depending upon how fine-grained the beach deposits are. Recharge is moderately high due to shallow depth to water and highly permeable soils and vadose material.

GWPP index values for the hydrogeologic setting of Beaches, Beach Ridges, and Sand Dunes range from 103 to 144, with the total number of GWPP index calculations equaling 16.

Table 13. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ae1	30-50	2-4	shale	Shrink/swell clay	0-2	till	1-100	95	130
7Ae2	30-50	2-4	shale	Loam	0-2	till	1-100	91	120
7Ae3	30-50	2-4	shale	Clay Loam	0-2	till	1-100	87	110
7Ae4	30-50	2-4	shale	Sandy Loam	0-2	till	1-100	93	125
7Ae5	30-50	2-4	shale	Sand	0-2	till	1-100	99	140
7Ae6	30-50	2-4	shale	Silty Loam	2-6	till	1-100	88	112
7Ae7	30-50	2-4	shale	Loam	0-2	till	1-100	86	116
7Ae8	30-50	2-4	shale	Sandy Loam	0-2	till	1-100	88	121
7Ae9	30-50	2-4	shale	Shrink/swell clay	0-2	till	1-100	90	126
7Ae10	30-50	2-4	shale	Clay Loam	0-2	till	1-100	82	106
7Ae11	30-50	2-4	shale	Sand	0-2	till	1-100	94	136
7Af1	15-30	2-4	sand & gravel	Silty Loam	0-2	till	700-1000	132	153
7Af2	15-30	2-4	sand & gravel	Loam	0-2	till	700-1000	134	158
7Af3	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	till	700-1000	138	168
7Af4	15-30	2-4	sand & gravel	Clay Loam	0-2	till	700-1000	130	148
7Af5	15-30	2-4	sand & gravel	Peat	0-2	till	700-1000	140	173
7Af6	15-30	2-4	sand & gravel	Sandy Loam	0-2	till	700-1000	136	163
7Af7	15-30	2-4	sand & gravel	Sandy Loam	2-6	till	700-1000	135	160
7Af8	15-30	2-4	sand & gravel	Silty Loam	2-6	till	700-1000	131	150
7Af9	15-30	2-4	sand & gravel	Clay Loam	2-6	till	700-1000	129	145
7Af10	15-30	2-4	sand & gravel	Peat	2-6	till	700-1000	139	170
7Af11	30-50	2-4	sand & gravel	Clay Loam	0-2	till	300-700	114	134
7Af12	15-30	2-4	sand & gravel	Clay Loam	2-6	till	300-700	123	141
7Af13	15-30	2-4	sand & gravel	Silty Loam	2-6	till	300-700	125	146
7Af14	15-30	2-4	sand & gravel	Sandy Loam	0-2	till	300-700	130	159
7Af15	15-30	2-4	sand & gravel	Clay Loam	0-2	till	300-700	124	144
7Af16	15-30	2-4	sand & gravel	Silty Loam	0-2	till	300-700	126	149
7Af17	15-30	2-4	sand & gravel	Loam	0-2	till	300-700	128	154

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7C1	30-50	4-7	sand & gravel	Clay Loam	0-2	till	700-1000	132	150
7C2	30-50	4-7	sand & gravel	Silty Loam	0-2	till	700-1000	134	155
7C3	30-50	4-7	sand & gravel	Clay Loam	2-6	till	700-1000	131	147
7C4	30-50	4-7	sand & gravel	Loam	0-2	till	700-1000	136	160
7C5	30-50	4-7	sand & gravel	Shrink/swell clay	0-2	till	700-1000	140	170
7C6	30-50	4-7	sand & gravel	Silty Loam	2-6	till	700-1000	133	152
7C7	30-50	4-7	sand & gravel	Peat	0-2	till	700-1000	142	175
7C8	50-75	4-7	sand & gravel	Peat	0-2	till	700-1000	132	165
7C9	50-75	4-7	sand & gravel	Shrink/swell clay	0-2	till	700-1000	130	160
7C10	50-75	4-7	sand & gravel	Clay Loam	2-6	till	700-1000	121	137
7C11	50-75	4-7	sand & gravel	Clay Loam	0-2	till	700-1000	122	140
7C12	30-50	4-7	sand & gravel	Sandy Loam	0-2	till	700-1000	138	165
7C13	30-50	4-7	sand & gravel	Shrink/swell clay	2-6	till	700-1000	139	167
7C14	30-50	4-7	sand & gravel	Peat	2-6	till	700-1000	141	172
7C15	50-75	4-7	sand & gravel	Peat	2-6	till	700-1000	131	162
7C16	30-50	4-7	sand & gravel	Loam	2-6	till	700-1000	135	157
7D1	5-15	7-10	sand & gravel	Sandy Loam	0-2	sand & gravel w/silt &clay	700-1000	171	197
7D2	5-15	7-10	sand & gravel	Loam	0-2	sand & gravel w/silt &clay	700-1000	169	192
7D3	5-15	7-10	sand & gravel	Clay Loam	0-2	sand & gravel w/silt &clay	700-1000	165	182
7D4	5-15	7-10	sand & gravel	Silty Loam	0-2	sand & gravel w/silt &clay	700-1000	167	187
7D5	5-15	7-10	sand & gravel	Sandy Loam	2-6	sand & gravel w/silt &clay	700-1000	170	194
7Ea1	5-15	4-7	shale	Silty Loam	0-2	silt & clay	1-100	121	147
7Ea2	5-15	4-7	shale	Loam	0-2	silt & clay	1-100	123	152
7Ea3	15-30	4-7	shale	Silty Loam	0-2	silt & clay	1-100	106	133
7Ec1	15-30	4-7	shale	Silty Loam	0-2	silt & clay	1-100	106	133
7Ec2	15-30	4-7	shale	Shrink/swell clay	0-2	silt & clay	1-100	112	148
7Ec3	15-30	4-7	shale	Sandy Loam	0-2	silt & clay	1-100	110	143

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ec4	15-30	4-7	shale	Silty Loam	2-6	silt & clay	1-100	105	130
7Ec5	15-30	4-7	shale	Shrink/swell clay	2-6	silt & clay	1-100	111	145
7Ec6	15-30	4-7	shale	Loam	0-2	silt & clay	1-100	108	138
7Ec7	15-30	4-7	shale	Clay Loam	0-2	silt & clay	1-100	104	128
7Ec8	15-30	4-7	limestone	Silty Loam	0-2	sand & gravel w/silt &clay	300-700	135	158
7Ec9	15-30	4-7	limestone	Silty Loam	2-6	sand & gravel w/silt &clay	300-700	134	155
7Ec10	15-30	4-7	limestone	Loam	0-2	sand & gravel w/silt &clay	300-700	137	163
7Ec11	15-30	4-7	limestone	Shrink/swell clay	2-6	sand & gravel w/silt &clay	300-700	140	170
7Ec12	15-30	4-7	shale	Silty Loam	0-2	sand & gravel w/silt &clay	1-100	114	140
7Ec13	15-30	4-7	shale	Shrink/swell clay	0-2	sand & gravel w/silt &clay	1-100	120	155
7Ec14	15-30	4-7	shale	Shrink/swell clay	2-6	sand & gravel w/silt &clay	1-100	119	152
7Ec15	5-15	4-7	limestone	Silty Loam	0-2	silt & clay	300-700	145	168
7Ec16	5-15	4-7	limestone	Loam	0-2	silt & clay	300-700	147	173
7Ec17	5-15	4-7	limestone	Sandy Loam	0-2	silt & clay	300-700	149	178
7Ec18	5-15	4-7	limestone	Shrink/swell clay	0-2	silt & clay	300-700	151	183
7Ec19	5-15	4-7	limestone	Shrink/swell clay	2-6	silt & clay	300-700	150	180
7Ec20	5-15	4-7	limestone	Shrink/swell clay	0-2	silt & clay	300-700	146	179
7Ec21	5-15	4-7	limestone	Clay Loam	0-2	silt & clay	300-700	138	159
7Ec22	5-15	4-7	limestone	Silty Loam	0-2	silt & clay	300-700	140	164
7Ec23	5-15	4-7	limestone	Shrink/swell clay	2-6	silt & clay	300-700	145	176
7Ec24	15-30	4-7	shale	Loam	0-2	sand & gravel w/silt &clay	1-100	113	142
7Ec25	15-30	4-7	limestone	Shrink/swell clay	0-2	sand & gravel w/silt &clay	300-700	141	173
7Ec26	15-30	4-7	limestone	Clay Loam	0-2	sand & gravel w/silt &clay	300-700	133	153
7Ec27	15-30	4-7	limestone	Sandy Loam	0-2	sand & gravel w/silt &clay	300-700	139	168
7Ec28	15-30	4-7	limestone	Loam	2-6	sand & gravel w/silt &clay	300-700	136	160
7Ec29	15-30	4-7	limestone	Sandy Loam	2-6	sand & gravel w/silt &clay	300-700	138	165
7Ed1	5-15	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	140	164
7Ed2	5-15	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	146	179
7Ed3	15-30	4-7	sand & gravel	Silty Loam	0-2	sand & gravel w/silt &clay	300-700	135	158

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ed4	5-15	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	145	168
7Ed5	5-15	4-7	sand & gravel	Loam	0-2	silt & clay	300-700	147	173
7Ed6	5-15	4-7	sand & gravel	Sandy Loam	0-2	silt & clay	300-700	149	178
7Ed7	5-15	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	151	183
7Ed8	5-15	2-4	sand & gravel	Silty Loam	0-2	sand & gravel w/silt &clay	300-700	140	163
7Ed9	5-15	2-4	sand & gravel	Clay Loam	0-2	sand & gravel w/silt &clay	300-700	138	158
7Ed10	5-15	2-4	sand & gravel	Shrink/swell clay	0-2	sand & gravel w/silt &clay	300-700	146	178
7Ed11	15-30	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	132	155
7Ed12	15-30	4-7	sand & gravel	Clay Loam	0-2	silt & clay	300-700	130	150
7Ed13	15-30	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	138	170
7Ed14	15-30	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	141	173
7Ed15	5-15	4-7	sand & gravel	Shrink/swell clay	2-6	silt & clay	300-700	150	180
7F1	5-15	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	700-1000	152	183
7F2	15-30	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay w/till	700-1000	142	173
7F3	15-30	4-7	sand & gravel	Clay Loam	0-2	silt & clay w/till	700-1000	134	153
7F4	5-15	4-7	sand & gravel	Silty Loam	0-2	silt & clay	700-1000	146	168
7F5	5-15	4-7	sand & gravel	Loam	0-2	silt & clay	700-1000	148	173
7F6	5-15	4-7	sand & gravel	Clay Loam	0-2	silt & clay	700-1000	144	163
7F7	5-15	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	137	170
7F8	5-15	2-4	sand & gravel	Loam	0-2	silt & clay	300-700	133	160
7F9	5-15	2-4	sand & gravel	Clay Loam	0-2	silt & clay	300-700	129	150
7F10	5-15	2-4	sand & gravel	Sandy Loam	0-2	silt & clay	300-700	135	165
7F11	5-15	2-4	sand & gravel	Silty Loam	0-2	silt & clay	300-700	131	155
7F12	15-30	2-4	sand & gravel	Sandy Loam	0-2	silt & clay w/till	300-700	125	155
7F13	15-30	2-4	sand & gravel	Loam	0-2	silt & clay w/till	300-700	123	150
7F14	15-30	2-4	sand & gravel	Clay Loam	0-2	silt & clay w/till	300-700	119	140

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7F15	15-30	2-4	sand & gravel	Silty Loam	0-2	silt & clay w/till	300-700	121	145
7F16	15-30	2-4	sand & gravel	Sandy Loam	0-2	till	300-700	130	159
7F17	15-30	2-4	sand & gravel	Silty Loam	0-2	till	300-700	126	149
7F18	15-30	2-4	sand & gravel	Clay Loam	0-2	till	300-700	124	144
7F19	15-30	2-4	sand & gravel	Loam	0-2	till	300-700	128	154
7F20	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay w/till	300-700	127	160
7F21	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	till	300-700	132	164
7F22	15-30	2-4	sand & gravel	Loam	2-6	till	300-700	127	151
7F23	15-30	2-4	sand & gravel	Clay Loam	2-6	till	300-700	123	141
7F24	15-30	2-4	sand & gravel	Silty Loam	2-6	till	300-700	125	146
7F25	15-30	2-4	sand & gravel	Sandy Loam	2-6	till	300-700	129	156
7F26	15-30	2-4	sand & gravel	Sand	0-2	till	300-700	136	174
7F27	15-30	2-4	sand & gravel	Sand	0-2	silt & clay w/till	300-700	131	170
7F28	5-15	2-4	sand & gravel	Sand	0-2	silt & clay	300-700	141	180
7F29	15-30	4-7	sand & gravel	Silty Loam	0-2	silt & clay w/till	700-1000	136	158
7F30	15-30	4-7	sand & gravel	Loam	0-2	silt & clay w/till	700-1000	138	163
7F31	5-15	4-7	sand & gravel	Loam	0-2	silt & clay	700-1000	148	173
7F32	5-15	4-7	sand & gravel	Sandy Loam	0-2	silt & clay	700-1000	150	178
7F33	5-15	4-7	sand & gravel	Clay Loam	0-2	silt & clay	700-1000	144	163
7F34	5-15	4-7	sand & gravel	Sand	0-2	silt & clay	700-1000	156	193
7F35	5-15	2-4	sand & gravel	Clay Loam	0-2	water-modified till	300-700	129	150
7F36	5-15	2-4	sand & gravel	Shrink/swell clay	0-2	water-modified till	300-700	137	170
7F37	5-15	2-4	sand & gravel	Loam	0-2	water-modified till	300-700	133	160
7F38	5-15	2-4	sand & gravel	Silty Loam	0-2	water-modified till	300-700	131	155
7F39	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	water-modified till	300-700	127	160
7F40	15-30	2-4	sand & gravel	Clay Loam	0-2	water-modified till	300-700	119	140
7F41	5-15	2-4	sand & gravel	Shrink/swell clay	0-2	till	300-700	134	167

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7F42	5-15	2-4	sand & gravel	Loam	0-2	till	300-700	130	157
7F43	15-30	4-7	sand & gravel	Clay Loam	0-2	silt & clay	300-700	128	149
7F44	15-30	4-7	sand & gravel	Loam	0-2	silt & clay	300-700	132	159
7F45	15-30	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	136	169
7F46	5-15	4-7	sand & gravel	Clay Loam	0-2	silt & clay	300-700	138	159
7F47	5-15	4-7	sand & gravel	Loam	0-2	silt & clay	300-700	142	169
7F48	5-15	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	146	179
7F49	30-50	4-7	sand & gravel	Clay Loam	0-2	silt & clay	300-700	118	159
7F50	30-50	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	120	179
7F51	30-50	4-7	sand & gravel	Loam	0-2	silt & clay	300-700	122	139
7F52	30-50	4-7	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	126	173
7F53	15-30	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	130	144
7F54	5-15	4-7	sand & gravel	Silty Loam	0-2	silt & clay	300-700	140	149
7F55	5-15	2-4	sand & gravel	Sandy Loam	0-2	water-modified till	300-700	135	159
7F56	5-15	2-4	sand & gravel	Clay Loam	0-2	till	300-700	126	154
7F57	5-15	2-4	sand & gravel	Sandy Loam	0-2	till	300-700	132	164
7F58	5-15	2-4	sand & gravel	Sand	0-2	till	300-700	138	165
7F59	5-15	4-7	sand & gravel	Silty Loam	0-2	till	300-700	140	147
7F60	5-15	4-7	sand & gravel	Shrink/swell clay	0-2	till	300-700	146	177
7F61	15-30	2-4	sand & gravel	Silty Loam	0-2	till	300-700	118	164
7F62	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	till	300-700	124	179
7F63	15-30	4-7	sand & gravel	Clay Loam	0-2	till	300-700	128	142
7F64	15-30	4-7	sand & gravel	Silty Loam	0-2	till	300-700	130	157
7F65	15-30	4-7	sand & gravel	Shrink/swell clay	0-2	till	300-700	136	149
7F66	15-30	4-7	sand & gravel	Shrink/swell clay	2-6	silt & clay	300-700	135	154
7F67	15-30	4-7	limestone	Silty Loam	2-6	silt & clay	300-700	129	163
7F68	15-30	4-7	limestone	Shrink/swell clay	0-2	silt & clay	300-700	136	179
7F69	30-50	4-7	shale	Silty Loam	2-6	silt & clay	1-100	98	149

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7F70	30-50	4-7	shale	Silty Loam	0-2	silt & clay	1-100	99	169
7F71	30-50	4-7	shale	Loam	0-2	silt & clay	1-100	101	123
7F72	30-50	4-7	shale	Sandy Loam	0-2	silt & clay	1-100	103	126
7F73	30-50	4-7	shale	Shrink/swell clay	0-2	silt & clay	1-100	105	131
7F74	30-50	4-7	shale	Sand	0-2	silt & clay	1-100	109	136
7F75	30-50	4-7	shale	Clay Loam	0-2	silt & clay	1-100	94	141
7F76	30-50	4-7	shale	Silty Loam	0-2	silt & clay	1-100	96	151
7F77	30-50	4-7	shale	Silty Loam	2-6	silt & clay	1-100	95	118
7F78	30-50	4-7	shale	Shrink/swell clay	2-6	silt & clay	1-100	101	123
7F79	30-50	4-7	shale	Shrink/swell clay	0-2	silt & clay	1-100	102	120
7F80	30-50	4-7	sand & gravel	Silty Loam	2-6	silt & clay	300-700	119	135
7F81	30-50	4-7	sand & gravel	Sandy Loam	0-2	silt & clay	300-700	124	138
7F82	30-50	4-7	sand & gravel	Sand	0-2	silt & clay	300-700	130	141
7F83	5-15	2-4	sand & gravel	Sand	0-2	till	300-700	141	154
7F84	5-15	2-4	sand & gravel	Sand	0-2	water-modified till	300-700	141	169
7F85	5-15	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay	100-300	125	180
7F86	0-5	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay	100-300	130	180
7F87	0-5	2-4	sand & gravel	Loam	0-2	silt & clay	100-300	126	160
7F88	0-5	2-4	sand & gravel	Clay Loam	0-2	silt & clay	100-300	122	165
7F89	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay	300-700	124	155
7F90	15-30	2-4	sand & gravel	Sandy Loam	0-2	silt & clay	300-700	122	145
7F91	15-30	2-4	sand & gravel	Loam	0-2	silt & clay	300-700	120	157
7F92	15-30	2-4	sand & gravel	Silty Loam	0-2	silt & clay	300-700	118	152
7F93	15-30	2-4	sand & gravel	Clay Loam	0-2	silt & clay	300-700	116	147
7F94	15-30	2-4	sand & gravel	Clay Loam	0-2	silt & clay	100-300	107	170
7F95	15-30	2-4	sand & gravel	Loam	0-2	silt & clay	100-300	111	126
7F96	15-30	2-4	sand & gravel	Silty Loam	0-2	silt & clay	100-300	109	131
7F97	15-30	2-4	sand & gravel	Sandy Loam	0-2	silt & clay	100-300	113	136
7F98	15-30	2-4	sand & gravel	Shrink/swell clay	0-2	silt & clay	100-300	115	141
7F99	15-30	2-4	sand & gravel	Sand	0-2	silt & clay	100-300	119	151

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7F100	15-30	2-4	shale	Shrink/swell clay	0-2	silt & clay	1-100	100	118
7F101	15-30	2-4	shale	Silty Loam	0-2	silt & clay	1-100	94	123
7F102	15-30	2-4	shale	Loam	0-2	silt & clay	1-100	96	120
7F103	15-30	2-4	shale	Sandy Loam	0-2	silt & clay	1-100	98	135
7F104	5-15	2-4	shale	Silty Loam	0-2	silt & clay	1-100	104	138
7F105	5-15	2-4	shale	Shrink/swell clay	0-2	silt & clay	1-100	110	141
7F106	15-30	2-4	shale	Loam	0-2	silt & clay	1-100	96	154
7F107	5-15	4-7	shale	Silty Loam	0-2	silt & clay	1-100	121	169
7F108	30-50	2-4	shale	Clay Loam	0-2	silt & clay	1-100	82	180
7F109	30-50	2-4	shale	Silty Loam	0-2	silt & clay	1-100	84	180
7F110	30-50	2-4	shale	Loam	0-2	silt & clay	1-100	86	160
7F111	30-50	2-4	shale	Silty Loam	2-6	silt & clay	1-100	83	165
7F112	5-15	4-7	shale	Loam	0-2	silt & clay	1-100	123	155
7F113	15-30	4-7	shale	Silty Loam	0-2	silt & clay	1-100	106	145
7F114	15-30	4-7	shale	Loam	0-2	silt & clay	1-100	108	157
7F115	30-50	2-4	shale	Clay Loam	0-2	silt & clay	1-100	82	152
7F116	30-50	2-4	shale	Silty Loam	2-6	silt & clay	1-100	83	147
7F117	30-50	2-4	shale	Silty Loam	0-2	silt & clay	1-100	84	142
7F118	30-50	2-4	shale	Loam	0-2	silt & clay	1-100	86	137
7F119	30-50	2-4	shale	Sandy Loam	0-2	silt & clay	1-100	88	145
7F120	30-50	2-4	shale	Shrink/swell clay	2-6	silt & clay	1-100	89	150
7F121	30-50	2-4	shale	Shrink/swell clay	0-2	silt & clay	1-100	90	160
7F122	15-30	4-7	sand & gravel	Silty Loam	2-6	silt & clay	300-700	129	136
7F123	15-30	2-4	shale	Shrink/swell clay	2-6	silt & clay	1-100	99	121
7F124	30-50	2-4	limestone	Shrink/swell clay	0-2	silt & clay	300-700	114	126
7F125	30-50	2-4	limestone	Shrink/swell clay	2-6	silt & clay	300-700	113	131
7F126	30-50	2-4	limestone	Silty Loam	0-2	silt & clay	300-700	108	131
7F127	30-50	2-4	limestone	Silty Loam	2-6	silt & clay	300-700	107	146
7F128	30-50	2-4	limestone	Loam	0-2	silt & clay	300-700	110	126
7F129	30-50	4-7	shale	Shrink/swell clay	2-6	silt & clay	1-100	104	147
7F130	15-30	4-7	limestone	Clay Loam	0-2	silt & clay	300-700	128	106
7F131	15-30	4-7	limestone	Silty Loam	0-2	silt & clay	300-700	130	111
7F132	15-30	4-7	limestone	Shrink/swell clay	2-6	silt & clay	300-700	135	116
7F133	15-30	4-7	sand & gravel	Shrink/swell clay	2-6	silt & clay	300-700	135	108
7F134	15-30	4-7	limestone	Loam	0-2	silt & clay	300-700	132	152
7F135	15-30	4-7	limestone	Sand	0-2	silt & clay	300-700	140	133

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7F136	15-30	4-7	limestone	Sandy Loam	0-2	silt & clay	300-700	134	138
7F137	30-50	4-7	limestone	Shrink/swell clay	0-2	silt & clay	300-700	126	106
7F138	15-30	2-4	limestone	Shrink/swell clay	0-2	silt & clay	300-700	124	108
7F139	15-30	2-4	limestone	Silty Loam	0-2	silt & clay	300-700	118	111
7F140	30-50	2-4	limestone	Shrink/swell clay	0-2	silt & clay	300-700	109	116
7F141	30-50	2-4	limestone	Shrink/swell clay	2-6	silt & clay	300-700	108	121
7F142	30-50	2-4	limestone	Clay Loam	0-2	silt & clay	300-700	106	123
7F143	30-50	2-4	limestone	Clay Loam	2-6	silt & clay	300-700	105	126
7F144	30-50	2-4	limestone	Sandy Loam	0-2	silt & clay	300-700	112	151
7F145	30-50	2-4	limestone	Sand	0-2	silt & clay	300-700	118	133
7F146	30-50	2-4	limestone	Loam	2-6	silt & clay	300-700	109	147
7F147	30-50	2-4	limestone	Sand	2-6	silt & clay	300-700	117	144
7F148	30-50	2-4	limestone	Loam	0-2	silt & clay	300-700	105	132
7F149	30-50	2-4	limestone	Loam	0-2	till	300-700	115	129
7F150	30-50	2-4	limestone	Sandy Loam	2-6	till	300-700	116	137
7F151	30-50	2-4	limestone	Sandy Loam	0-2	till	300-700	117	138
7F152	30-50	2-4	limestone	Shrink/swell clay	0-2	till	300-700	119	149
7F153	30-50	2-4	limestone	Clay Loam	0-2	till	300-700	111	154
7F154	30-50	2-4	limestone	Silty Loam	2-6	till	300-700	112	166
7F155	30-50	2-4	limestone	Shrink/swell clay	2-6	till	300-700	118	166
7F156	30-50	2-4	limestone	Sand	0-2	till	300-700	123	159
7F156	30-50	2-4	limestone	Loam	2-6	till	300-700	114	179
7F157	30-50	2-4	limestone	Silty Loam	0-2	till	300-700	113	164
7H1	15-30	4-7	limestone	Sandy loam	0-2	sand & gravel w/silt & clay	300-700	144	159
7H2	15-30	4-7	limestone	Sandy loam	2-6	sand & gravel w/silt & clay	300-700	143	157
7H3	15-30	4-7	limestone	Loam	2-6	sand & gravel w/silt & clay	300-700	141	130
7H4	30-50	4-7	limestone	Sandy Loam	2-6	sand & gravel w/silt & clay	300-700	133	140
7H5	30-50	4-7	limestone	Shrink/swell clay	0-2	sand & gravel w/silt & clay	300-700	136	135
7H6	30-50	4-7	limestone	Sandy Loam	0-2	sand & gravel w/silt & clay	300-700	134	145
7H7	30-50	4-7	limestone	Loam	0-2	sand & gravel w/silt & clay	300-700	132	150
7H8	30-50	4-7	limestone	Sand	0-2	sand & gravel w/silt & clay	300-700	140	160
7H9	30-50	4-7	limestone	Clay Loam	0-2	sand & gravel w/silt & clay	300-700	128	136

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7H10	30-50	4-7	shale	Sandy Loam	0-2	sand & gravel w/silt & clay	1-100	110	121
7H11	30-50	4-7	shale	Loam	0-2	sand & gravel w/silt & clay	1-100	108	126
7H12	30-50	4-7	shale	Shrink/swell clay	0-2	sand & gravel w/silt & clay	1-100	112	131
7H13	30-50	4-7	shale	Clay Loam	0-2	sand & gravel w/silt & clay	1-100	104	131
7H14	30-50	4-7	shale	Sandy Loam	0-2	sand & gravel w/silt & clay	1-100	105	146
7H15	30-50	4-7	shale	Loam	0-2	sand & gravel w/silt & clay	1-100	103	126
7H16	30-50	4-7	shale	Shrink/swell clay	0-2	sand & gravel w/silt & clay	1-100	107	147

Ground Water Pollution Potential of Defiance County

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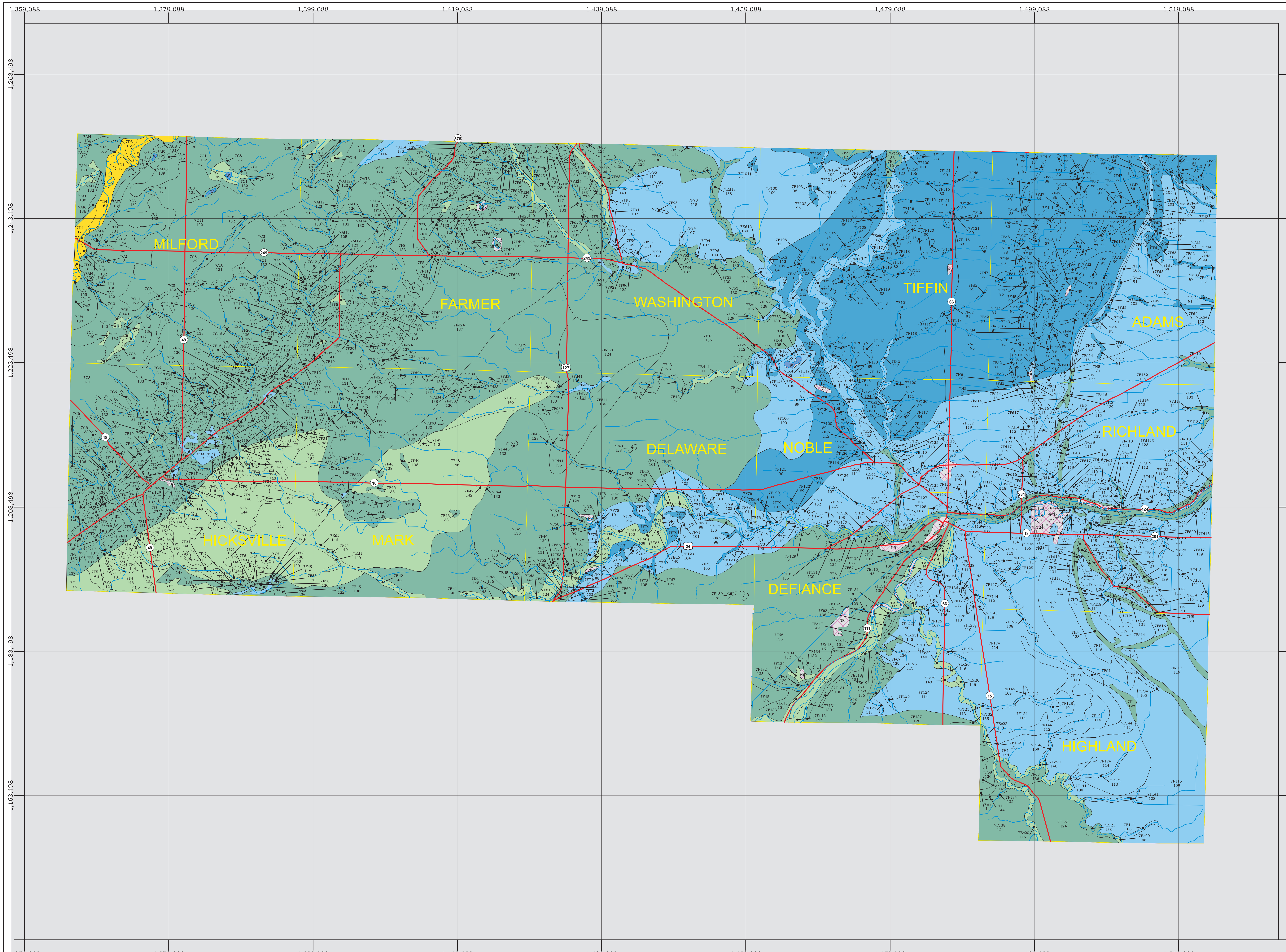
Division of Soil and Water Resources



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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