GROUND WATER POLLUTION POTENTIAL OF HARRISON COUNTY, OHIO

BY

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ABSTRACT

A ground water pollution potential map of Harrison 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 Harrison County resulted in a map with symbols and colors that illustrate areas of varying ground water contamination vulnerability. Five hydrogeologic settings were identified in Harrison County with computed ground water pollution potential indexes ranging from 53 to 145.

Harrison County lies within the Nonglaciated Central hydrogeologic setting. Sand and gravel deposits are limited and provide yields less than 25 gallons per minute (gpm). Smaller tributaries contain only thin, fine-grained alluvial/lacustrine deposits commonly yielding less than 10 gpm.

Interbedded dirty sandstones, shales, thin limestones, coals, and claystones of the Pennsylvanian and Permian Systems comprise the aquifer for the majority of Harrison County. These consolidated aquifers are poor aquifers and yields are commonly less than 5 gpm.

The ground water pollution potential mapping program optimizes the use of existing data to rank areas with respect to relative vulnerability to contamination. The ground water pollution potential map of Harrison County has been prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate area, or to assist in protection, monitoring, and clean-up efforts.

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. 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; 2765 of these wells exist in Harrison County.

The characteristics of the many aquifer systems in the state make ground water highly vulnerable to contamination. Measures to protect ground water from contamination usually cost less and create less impact on ground water users than clean up of a polluted aquifer. Based on these concerns for protection of the resource, staff of the Division of Water conducted a review of various mapping strategies useful for identifying vulnerable aquifer areas. They placed particular emphasis on reviewing mapping systems that would assist in state and local protection and management programs. Based on these factors and the quantity and quality of available data on ground water resources, the DRASTIC mapping process (Aller et al., 1987) was selected for application in the program.

Considerable interest in the mapping program followed successful production of a demonstration county map and led to the inclusion of the program as a recommended initiative in the Ohio Ground Water Protection and Management Strategy (Ohio EPA, 1986). Based on this recommendation, the Ohio General Assembly funded the mapping program. A dedicated mapping unit has been established in the Division of Water, Water Resources Section to implement the ground water pollution potential mapping program on a 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 Harrison 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 Harrison 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:

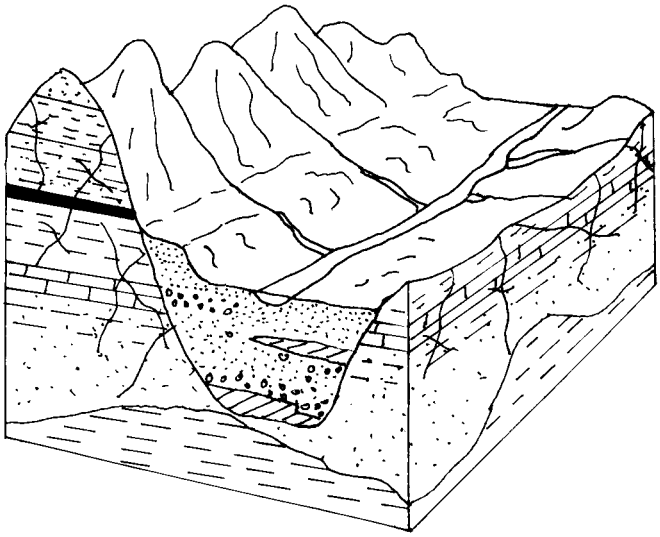
D – Depth to Water
R – Net Recharge
A – Aquifer Media
S – Soil Media
T – Topography
I – Impact of the Vadose Zone Media
C – Conductivity (Hydraulic) of the Aquifer

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.



7D Buried Valley

This setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a pre-glacial river valley) by glacial meltwater. Many of the buried valleys in Harrison County underlie the broad, flat lying floodplains of modern rivers. The boundary between the buried valley and the adjacent bedrock upland is usually prominent. The buried valleys contain substantial thicknesses of permeable sand and gravel that serve as the aquifer. The aquifer is typically in hydraulic connection with the modern rivers. The vadose zone is typically composed of sand and gravel but significant amounts of silt and clay can be found in discrete areas. Silt loams, loams, and sandy loams are the typical soil types for this setting. Depth to water is typically less than 30 feet for areas adjacent to modern rivers, and between 30 to 50 feet for terraces that border the bedrock uplands. Recharge is generally high due to permeable soils and vadose zone materials, shallow depth to water, and the presence of surface streams.

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

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

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. The higher the

DRASTIC index, the greater the vulnerability to contamination. The index generated provides only a relative evaluation tool and is not designed to produce absolute answers or to represent units of vulnerability. Pollution potential indexes of various settings should be compared to each other only with consideration of the factors that were evaluated in determining the vulnerability of the area.

Pesticide DRASTIC

A special version of DRASTIC was developed for use where the application of pesticides is a concern. The weights assigned to the DRASTIC factors were changed to reflect the processes that affect pesticide movement into the subsurface with particular emphasis on soils. Where other agricultural practices, such as the application of fertilizers, are a concern, general DRASTIC should be used to evaluate relative vulnerability to contamination. The process for calculating the Pesticide DRASTIC index is identical to the process used for calculating the general DRASTIC index. However, general DRASTIC and Pesticide DRASTIC numbers should not be compared because the conceptual basis in factor weighting and evaluation differs significantly. Table 1 lists the weights used for general and pesticide DRASTIC.

Table 1. Assigned weights for DRASTIC features

Feature	**General DRASTIC Weight**	**Pesticide DRASTIC Weight**
Depth to Water	5	5
Net Recharge	4	4
Aquifer Media	3	3
Soil Media	2	5
Topography	1	3
Impact of the Vadose Zone Media	5	4
Hydraulic Conductivity of the Aquifer	3	2

Table 2. Ranges and ratings for depth to water

Depth to Water (feet)	
Range	**Rating**
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	Pesticide Weight: 5

Table 3. Ranges and ratings for net recharge

Net Recharge (inches)	
Range	**Rating**
0-2	1
2-4	3
4-7	6
7-10	8
10+	9
Weight: 4	Pesticide Weight: 4

Table 4. Ranges and ratings for aquifer media

Aquifer Media		
Range	**Rating**	**Typical Rating**
Shale	1-3	2
Glacial Till	4-6	5
Sandstone	4-9	6
Limestone	4-9	6
Sand and Gravel	4-9	8
Interbedded Ss/Sh/Ls/Coal	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

Table 5. Ranges and ratings for soil media

Soil Media	
Range	**Rating**
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrink/Swell Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Clay	1
Weight: 2	Pesticide Weight: 5

Table 6. Ranges and ratings for topography

Topography (percent slope)	
Range	**Rating**
0-2	10
2-6	9
6-12	5
12-18	3
18+	1
Weight: 1	Pesticide Weight: 3

Table 7. Ranges and ratings for impact of the vadose zone media

Impact of the Vadose Zone Media		
Range	**Rating**	**Typical Rating**
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
Limestone	2-7	6
Sandstone	4-8	6
Interbedded Ss/Sh/Ls/Coal	4-8	6
Sand and Gravel with Silt and Clay	4-8	6
Glacial Till	2-6	4
Sand and Gravel	6-9	8
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

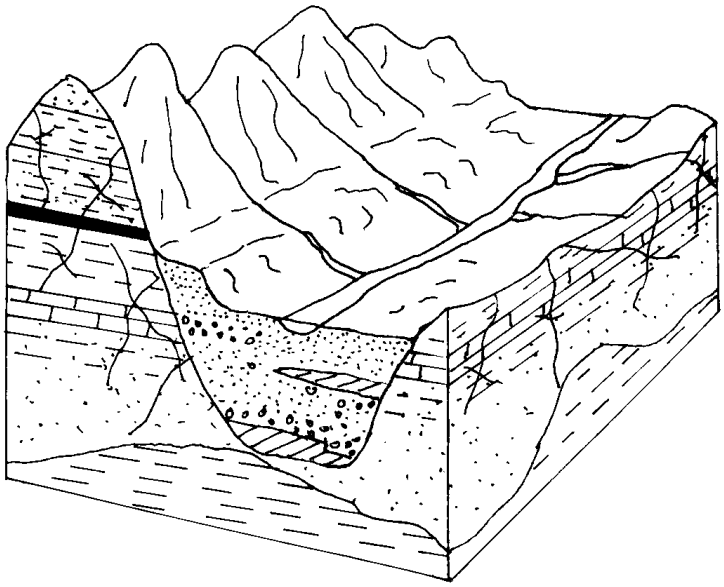
Table 8. Ranges and ratings for hydraulic conductivity

Hydraulic Conductivity (GPD/FT^2)	
Range	**Rating**
1-100	1
100-300	2
300-700	4
700-1000	6
1000-2000	8
2000+	10
Weight: 3	Pesticide Weight: 2

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1, Buried Valley, identified in mapping Harrison 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 137. 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 Harrison County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the 5 settings identified in the county range from 53 to 145.

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 Harrison 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 Harrison County is included with this report.



SETTING 7D1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	8	24
Soil Media	Silt Loam	2	4	8
Topography	2-6%	1	9	9
Impact of Vadose Zone	Silt/Clay	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		DRASTIC	INDEX	137

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

INTERPRETATION AND USE OF GROUND WATER POLLUTION POTENTIAL MAPS

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

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

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

Here the first number (**7**) refers to the major hydrogeologic region and the upper and lower case letters (**D**) refer to a specific hydrogeologic setting. The following number (**1**) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (**137**) 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. Large man-made features such as landfills, quarries, or strip mines have also been marked on the map for reference.

GENERAL INFORMATION ABOUT HARRISON COUNTY

Demographics

Harrison County occupies approximately 410 square miles in the east-central portion of Ohio (Figure 3). Harrison County is bounded to the west by Tuscarawas County, to the southwest by Guernsey County, to the south by Belmont County, to the east by Jefferson County, and to the north by Carroll County.

The approximate population of Harrison County, based upon 1998 estimates, is 16,097 (Department of Development, Ohio County Profiles, 1999). Cadiz is the largest community in Harrison County. Most modern growth is occurring in the corridor adjacent to U.S. Route 250. Woodland is a major land use in the county. Agriculture is also an important land use, accounting for approximately 42% of the land area. Strip mining and underground mining has historically been an important land use in the eastern part of the county. More specific information on land usage can be obtained from the Ohio Department of Natural Resources, Division of Real Estate and Land Management (REALM), Resource Analysis Program (formerly OCAP).

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 51 degrees Fahrenheit for Harrison County. The average temperature is higher through the central section of the county. Harstine (1991) shows that precipitation averages 38 to 40 inches per year for the county. The mean annual precipitation increases toward the southwest portion of Harrison County. The mean annual precipitation for Cadiz is 37.41 inches per year based upon a thirty-year (1961-1990) period (Owenby and Ezell, 1992). The mean annual temperature at Cadiz for the same thirty-year period is 50.2 degrees Fahrenheit (Owenby and Ezell, 1992).

Physiography and Topography

Harrison County lies within the Unglaciated Allegheny Plateau section of the Appalachian Plateau Province (Frost, 1931 and Fenneman, 1938). Relatively high relief and rugged topography, featuring narrow ridges, steep slopes, and a high degree of stream dissection characterize the county. Slopes are particularly steep in the eastern part of the county. Ridge tops tend to be broader and less steep in the western portion of the county. The highest elevation in the county is 1,366 ft. above sea level, in German Township. The lowest elevation is 861 ft, in Washington Township.

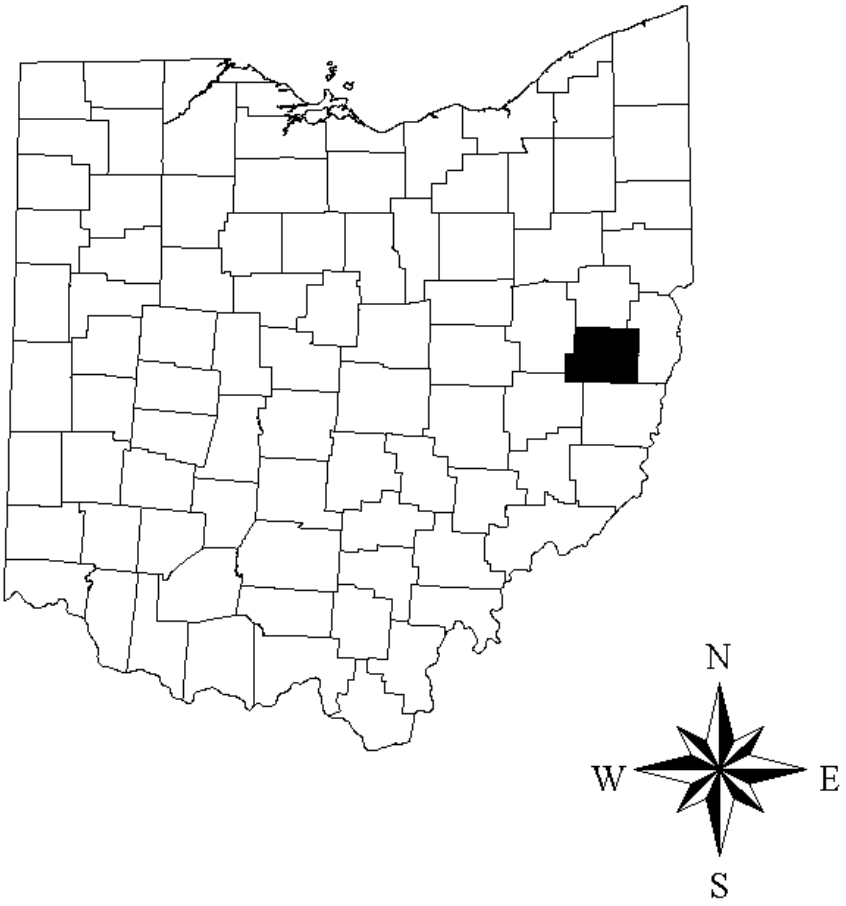


Figure 3. Location of Harrison County, Ohio.

Modern Drainage

Situated in the eastern fourth of the county is a major bedrock ridge, referred to as the Flushing Escarpment by Stout et al. (1943). It serves as a major drainage divide, separating the stream flow east to the Ohio River and west to the Tuscarawas River. In Harrison County, the Flushing Escarpment starts north east of Jewett. The escarpment continues south along U.S. Highway 22 past the western margin of Cadiz Township. The divide then extends along County Highway 29 south, west of New Athens Township. The two primary tributaries draining the eastern portion of the county to the Ohio River are (from north to south), Cross Creek and Short Creek. To the west there are three major tributaries: Conotton Creek, Little Stillwater Creek, and Stillwater Creek. Conotton Creek flows west through Jewett to the Tuscarawas River. Just northeast of Cadiz Township, Little Stillwater Creek drains westward into the Tappan Reservoir. West of New Athens, Clendening Lake empties into Stillwater Creek, which drains into the Tuscarawas River.

Pre- and Inter-Glacial Drainage Changes

Harrison County lies entirely beyond the glacial boundary; however, the drainage patterns of the county were influenced by the multiple glaciations. The drainage changes are complex and not yet fully understood. More research and data are necessary in Harrison County and surrounding counties. Particularly, well log data for deeper wells that penetrate the entire drift thickness would be helpful in making further interpretations.

Prior to glaciation, the Flushing Escarpment divided Harrison County down the east-central section (Figure 4). The western portion of Harrison County was drained into the northerly-flowing Dover River (Stout et al., 1943). The Dover River roughly followed the course of present day Stillwater Creek to Midvale and ran the course of present-day Tuscarawas River northward into Tuscarawas County. East of the Flushing Escarpment, Harrison County drained into the Steubenville River. Headwaters of the Steubenville River were to the south in Monroe County. The northern portion of Harrison County drained into Zoar Creek, which followed the course of present day Conotton Creek, which emptied downstream into the Dover River. The Dover River flowed northward, roughly following the course of present day Tuscarawas River in Tuscarawas County.

As ice advanced through Ohio and northwestern Pennsylvania during the pre-Illinoian (Kansan) glaciation, the Steubenville River became blocked by ice. Flow backed-up in the main trunk of the Steubenville River as well as in many tributaries, forming several large lakes. These lakes over-topped, creating spillways and cutting new channels. New drainage systems began to evolve (Stout et al., 1943). This down cutting by these new streams was believed to be relatively rapid and, in many places, the new channels were cut over 100 feet deeper than the previous valleys. The new drainage system is referred to as the Deep Stage due to this increased down cutting. The ponded water overtopped and cut a new channel in

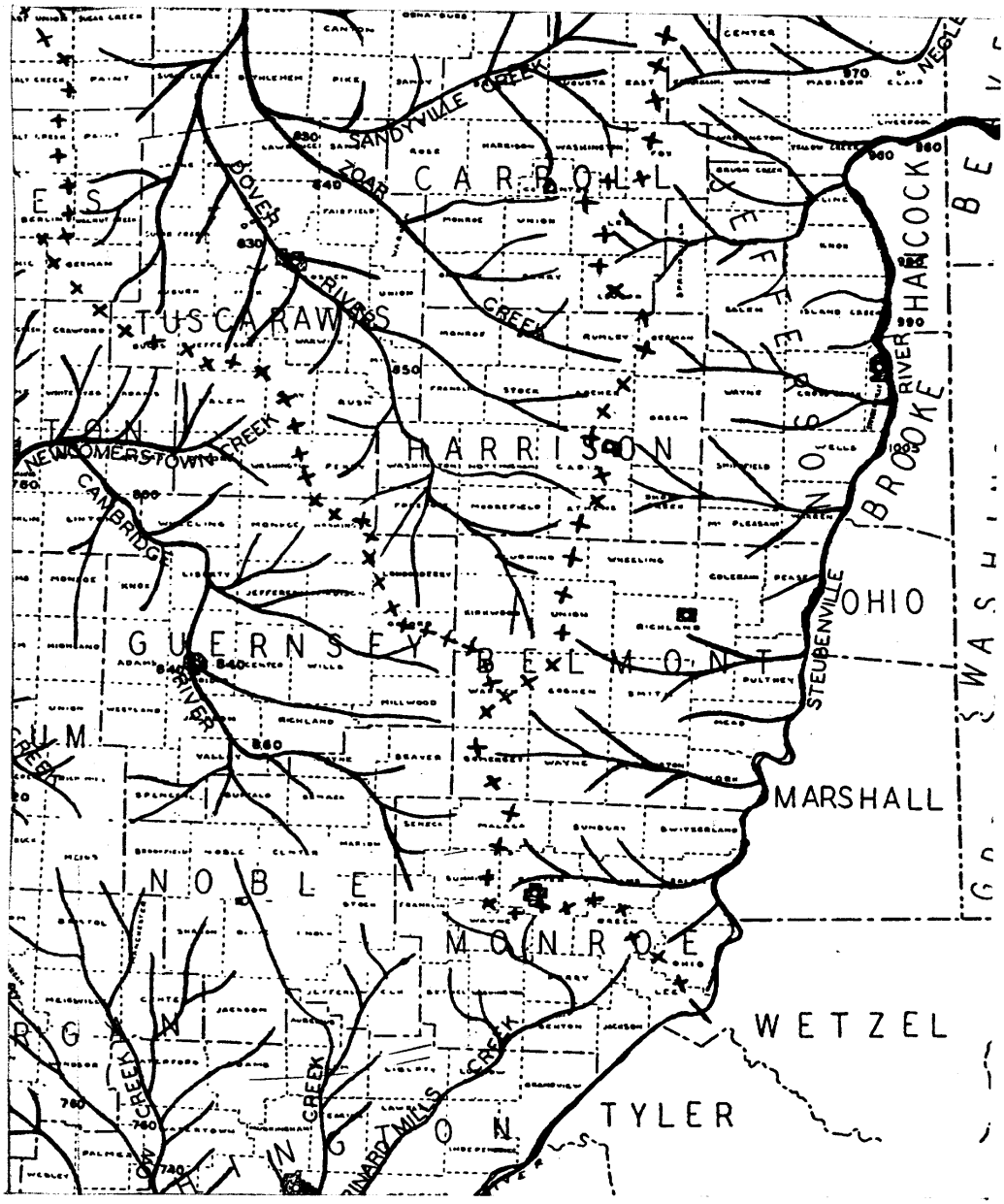


Figure 4. Pre-glacial (Teays Stage) drainage in eastern Ohio. The line of x's in Harrison County indicate the Flushing Escarpment (after Stout et al., 1943).

the divide in Monroe County and drainage reversed, changing to southward flow. The newly created river was referred to as the Pomeroy River (Stout et al., 1943). It was at this time that the ancestral channel of the Ohio River was primarily created (Figure 5).

During the time that many of the stream valleys east of the Flushing Escarpment were ponded, abundant sediments were deposited into these streams. The deposits were typically clayey to silty with thin layers of fine-grained sand (Stout et al., 1943). These fine-grained deposits have been referred to as the Minford Silts.

Drainage systems west of the Flushing Escarpment also experienced change due to the pre-Illinoian ice advance. The advancing ice sheet blocked the northerly flowing Dover River (Stout et al., 1943 and Lamborn, 1956). Water in the blocked river rose and breached a new channel draining toward the southwest referred to as the Newark River (Figure 5). The Newark River replaced the Dover River as it downcut and eroded eastward. The headwaters of the Newark River drainage system extended into Harrison County. Sherodsville Creek, which roughly followed the course of present day Conotton Creek, drained northern Harrison County. The Urichsville River closely followed the course of modern Stillwater Creek and drained southwestern Harrison County. Sherodsville Creek was a major tributary of the Newark River. Fine-grained lacustrine and silty alluvium was deposited in these tributary valleys.

The Illinoian ice advance brought further changes to the drainage systems (Figure 6). Drainage to the west of the Flushing Escarpment was toward the headwaters of the Massillon River, which flowed to the north (Stout et al., 1943). To the east, drainage followed the New Martinsville River. The New Martinsville River roughly followed the course of the Pomeroy River.

The most recent ice age, the Wisconsinan, brought further drainage changes to eastern Ohio (Stout et al. 1943). The silty alluvial (floodplain) and finer lacustrine (lake) sediments continued to be deposited over this time on both sides of the Flushing Escarpment.

Bedrock Geology

Bedrock exposed at the surface in Harrison County belongs to the Pennsylvanian and Permian Systems. Table 9 summarizes the bedrock stratigraphy found in Harrison County. The ODNR, Division of Geological Survey, has Open-File Reconnaissance Bedrock Geological Maps done on a 1:24,000 USGS topographic map base available for the entire county. Rocks of the Conemaugh Group, that covers approximately two thirds of the county, include interbedded dirty, micaceous sandstones, shales, siltstones, thin, fine-grained limestones, and minor coals. Higher in the section, the rocks tend to include more fine-grained mudstones and claystones (Collins, 1979).

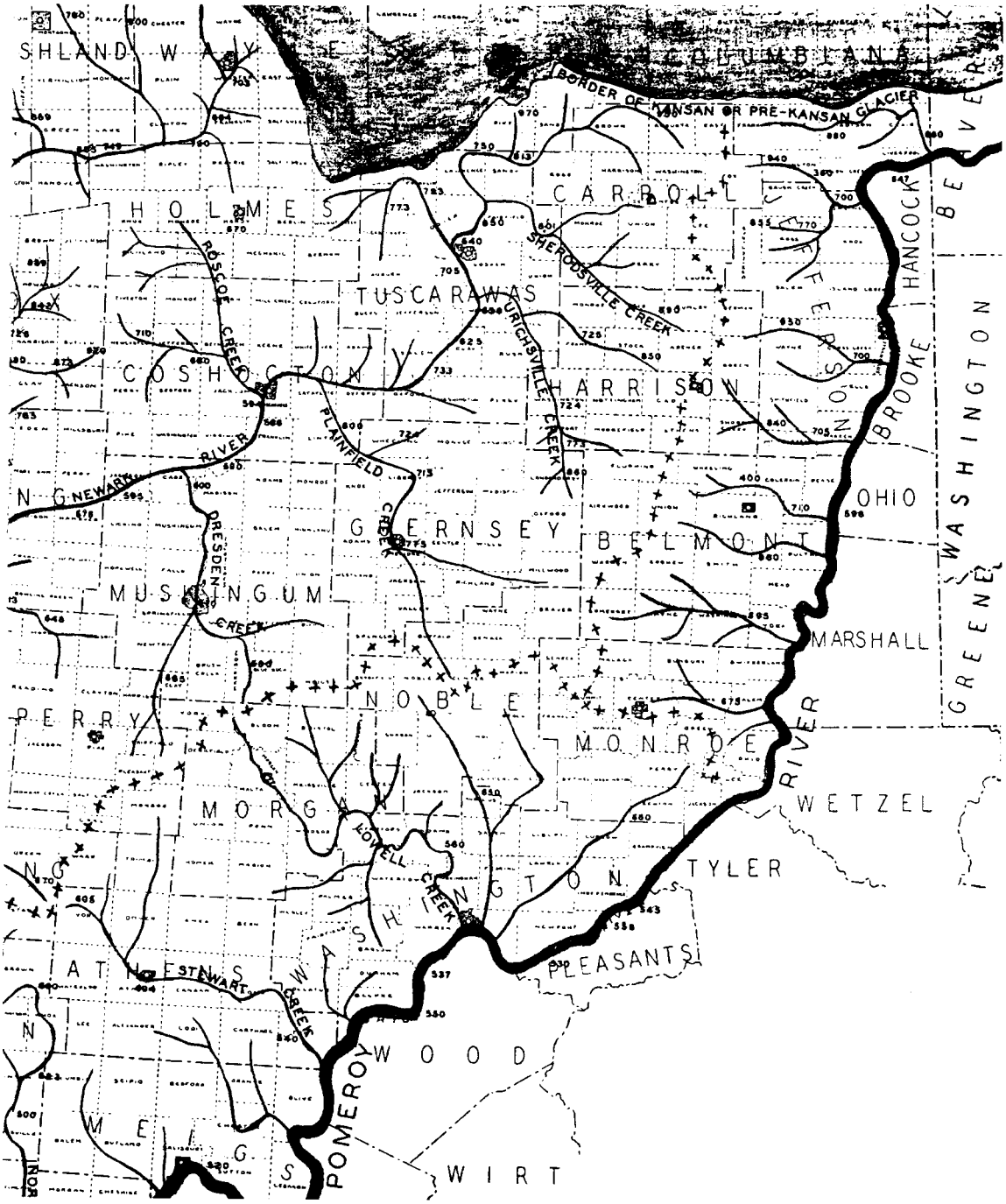


Figure 5. Pre-Illinoian (Deep Stage) drainage in eastern Ohio.

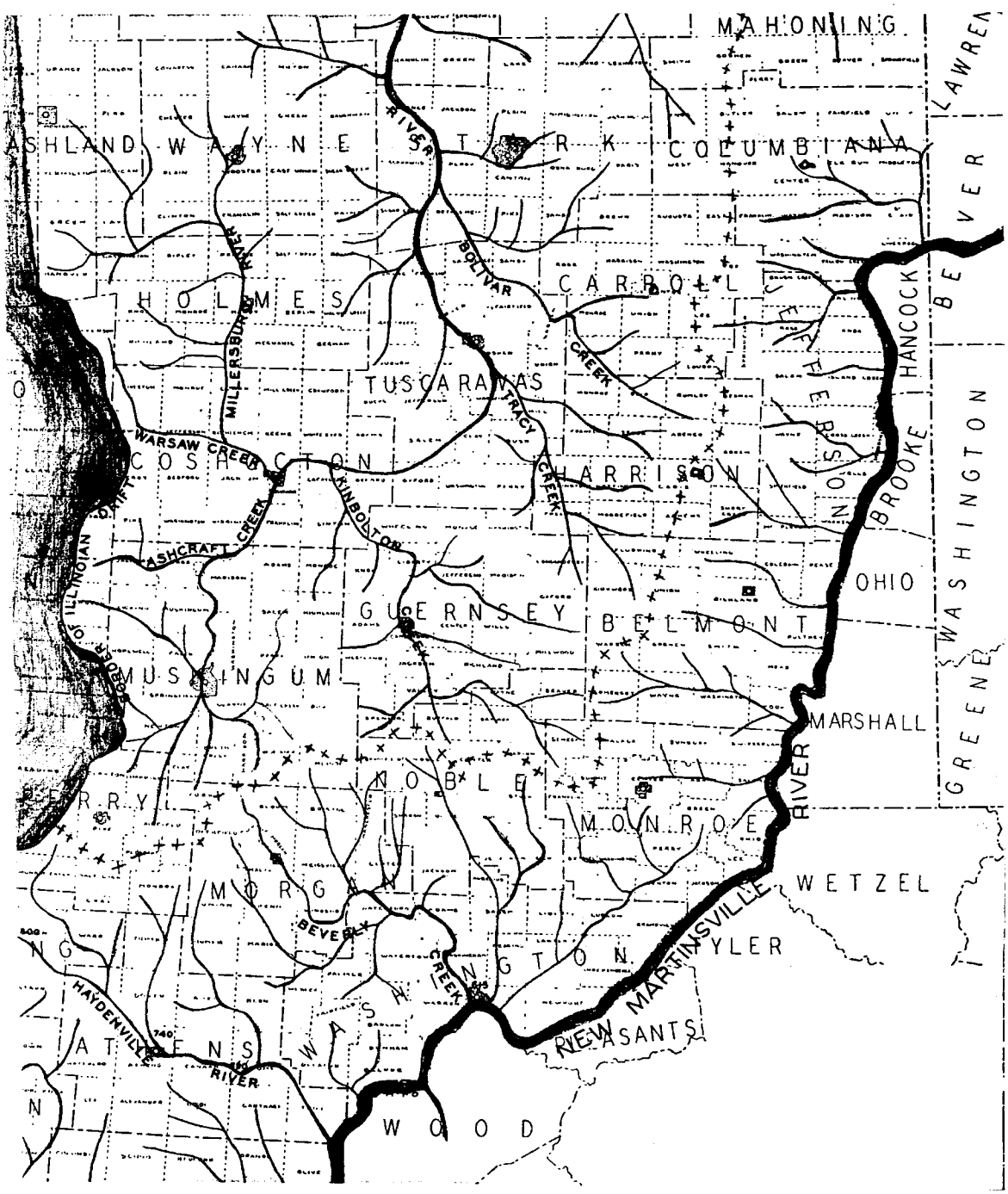


Figure 6. Post-Illinoian drainage in eastern Ohio.

Table 9. Bedrock stratigraphy of Harrison County, Ohio

System	Group/Formation (Symbol)	Lithologic Description
Permian	Dunkard (Pd)	Thin bedded to massive variable colored shales, siltstones, mudstones, dirty sandstones with minor amounts of coal and limestone. Found in southeastern corner of Harrison County. Poor aquifer with yields less than 5 gpm.
Pennsylvanian	Pennsylvanian Undifferentiated (Pu) Monongahela Conemaugh	Darkish brown shales, siltstones and dirty sandstones with minor amounts of clay, coal, limestone and flint. Widespread across the county. Poor aquifer with yields commonly less than 5 gpm.
	Allegheny and Pottsville Groups (Pap)	Gray to black thin shales, siltstone and sandstones, with minor amounts of coal, clay, limestone, and flint. Limited to valleys in western Harrison County. Poor aquifer with yields commonly less than 5 gpm.

Rocks of the Monongahela Group are found in southeastern Harrison County. These rocks include interbedded dirty sandstones, shales, minor limestones, and some important coal beds. Coal beds associated with the Monongahela Group are mined underground further south and east in the county where these units are limited to the subsurface.

The youngest rocks exposed in Harrison County are part of the Permian System. Rocks belonging to the Permian System are exposed in the southeastern portion Harrison County. These rocks include dirty sandstones, fine shales, and soft mudstones. The mudstones and shales tend to be calcareous and soft. Limestones are commonly freshwater and are dense and fine-grained. Sandstones are micaceous and have a high iron content. Typically, the rocks have a reddish to grayish look and may have been deposited under somewhat arid conditions (Collins, 1979). These rocks tend to be somewhat less resistant to erosion and tend to form broader, less steep ridge tops.

Weedman (1990) provides an excellent account of the complex depositional environments, which created the rocks of the Pennsylvanian System. These highly transitional environments included both terrestrial ("land-based") and marine derived sediments. The terrestrial environment was dominated by large river systems featuring broad

alluvial plains upland from coastal areas. Stream channels and point bar deposits were the source of sandstones and conglomerates. Shales and siltstones were derived from fine-grained floodplain deposits. Freshwater limestones were deposited in shallow, rapidly evaporating lakes and ponds found on the alluvial plain. The terrestrial environment was highly transitional with a marine environment over time. The position of the shoreline and the depth of water varied with the rate of sediment input into the basin, sea level, and the rate of subsidence. Subsidence refers to an uneven "settling" during the relatively rapid accumulation of sediments. In the Conemaugh Group, sandstones and shales represent deltaic/shoreline environments. Marine limestones formed in slightly deeper waters, which lacked clastic input from rivers and deltas. Coal and clay were deposited in two different environments. Coal was deposited in either a "back-barrier" environment along the shoreline or in "deltaic-plain" environment in swamps formed in abandoned river channels (Horne et al., 1978). Similarly, clay was deposited in either quiet lagoonal areas directly behind the shoreline or in abandoned "oxbow" river channels (Ferm, 1974).

Ground Water Resources

Ground water in Harrison County is obtained from both unconsolidated (alluvial) and consolidated (bedrock) aquifers. Stillwater Creek and Conotton Creek contain thin sand and gravel interbedded with thicker sequences of finer-grained lacustrine and alluvial deposits. Yields up to 25 gallons per minute are obtained from these sandy lenses (ODNR, Div. of Water, Open File, Glacial State Aquifer Map and Crowell, 1980). Other tributaries in the county contain deposits that are either too thin or fine-grained to constitute sustainable aquifers. These fine-grained deposits more likely help provide extra recharge to the underlying bedrock.

Yields from the consolidated, bedrock aquifers throughout the county tend to be low. Yields typically tend to be especially poor along ridge tops. Crowell (1980) and the ODNR, Div. Of Water, Open File, Bedrock State Aquifer Map shows the bedrock yielding less than 5 gpm for aquifers developed in the Permian, Conemaugh, and Monongahela. Aquifers developed in the Allegheny group potentially yield approximately 10 gpm. Yields were found to be approximately 10 gpm around Cadiz Township.

The yield in any particular area is dependent upon the number and type of formations drilled. Wells drilled in bedrock often intersect several aquifers or water producing zones. Sandstones and coals tend to be water-bearing units whereas underclays, mudstones, siltstones and shales tend to be aquitards that impede the flow of water. Limestones are typically thin, hard, and fine-grained and are generally poor aquifers. Thicker, fractured limestones, however, are capable of producing suitable yields. Water tends to "perch" or collect on top of lower permeability units (e.g. shale) and move laterally along the base of an overlying unit with higher permeability (e.g. sandstone). Springs and seeps mark where these contacts meet the slope or land surface. Peffer (1991) demonstrated that shales could provide sufficient water to serve domestic needs and still behave as an aquitard.

The number of fractures and bedding planes intersected by the well also influences yields. The amount of fracturing tends to increase along hill bottoms and valleys. This increase may be related to stress relief as shown by Wyrick and Borchers (1981) and Kipp et al. (1983). The net result is that there is usually a decrease in the depth to water (i.e. – a shallower static water level) and slightly higher yields. Fracturing is also an influence on the direction of ground water flow (Schubert, 1980) and affects the amount of recharge.

Strip and Underground Mined Areas

The pollution potential of strip-mined and abandoned underground mined areas were not evaluated in Harrison County. Although *DRASTIC: A Standardized System for Evaluating Ground Water Pollution Using Hydrogeologic Settings* (Aller et al., 1987) does identify mining as a possible source of ground water contamination, it does not discuss a methodology to evaluate the vulnerability of aquifers to contamination in these areas.

Many geologic and hydrogeologic changes occur in areas that have undergone or are undergoing mining and reclamation activities (Bonta et al., 1992 and Razem, 1983). The extent of these changes may not be known or may have a high degree of variability from one location to another.

Mining and reclamation activities have the ability to affect all DRASTIC parameters. Tables 10 and 11 list the DRASTIC parameters and the possible impacts that mining may have on rating the parameters in strip-mined and underground mined areas, respectively. These tables are not meant to be a comprehensive listing of the impacts of mining on ground water systems. They are provided to illustrate the uncertainty of evaluating the pollution potential of mined areas.

Although the pollution potential of strip and abandoned underground mined areas were not evaluated, they were delineated. Only the most prominent and conspicuous mined areas were delineated on the Pollution Potential Map of Harrison County. Delineations of mined areas were made using information from the *Soil Survey of Harrison County* (Rubel et al., 1981), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the Harrison County portion of U.S.G.S. 7-1/2 minute quadrangle maps. Site-specific information for mined areas can be obtained from the ODNR, Division of Geological Survey and Division of Mineral Resources Management.

Table 10. Potential factors influencing DRASTIC ratings for strip mined areas

Parameter	Impact of Activity/Effects on DRASTIC Ratings
Depth to water	Removal of material overlying the aquifer will decrease the depth to water (i.e. increase DRASTIC rating); removal of uppermost aquifer will increase the depth to water (i.e. decrease DRASTIC rating)
Net Recharge	Mineral extraction and reclamation could increase the degree of fracturing, increase the permeability of the vadose zone and soils and therefore increase the amount of recharge (i.e. increase DRASTIC rating); compaction of fine grained spoils could decrease the amount of recharge to the aquifer (i.e. decrease DRASTIC rating)
Aquifer media	Mineral extraction could remove the uppermost aquifer
Soil media	Removal of soils will provide less of a barrier for contaminant transport (i.e. increase soil rating); reclaimed soils may have a lower permeability than the original cover (i.e. decrease soil rating)
Topography	Strip mining can change the contour of the land surface making delineation of this parameter virtually impossible
Impact of the vadose zone	Fracturing of vadose zone media could increase the permeability (i.e. increase rating); compaction of spoils during reclamation could decrease the permeability (i.e. decrease rating)
Hydraulic Conductivity	Fracturing of aquifer media could increase the conductivity (i.e. increase DRASTIC rating)

Table 11. Potential factors influencing DRASTIC ratings for underground mined areas

Parameter	Impact of Activity/Effects on DRASTIC Ratings
Depth to water	Collapse of underground mines has the potential to fracture overlying confining units, therefore causing a dewatering of overlying aquifers (i.e. decrease rating)
Net Recharge	Fracturing of overlying strata can increase amount of recharge to the aquifer (i.e. increase rating)
Aquifer media	Upper aquifers could be dewatered and underground mine could become the aquifer
Soil media	Fractures may extend to the land surface
Topography	This factor will not be affected unless severe subsidence occurs
Impact of the vadose zone	Fracturing and air shafts in the vadose zone could increase the permeability and provide a direct conduit for contamination (i.e. increase rating)
Hydraulic Conductivity	Upper aquifers not dewatered as a result of fracturing or subsidence would have higher conductivity values; underground mines serving as the aquifer media will have high conductivity values (i.e. higher rating)

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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 2,584 water well log records are on file for Harrison County. Data from roughly 1,060 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 Harrison County* (Crowell, 1980) provided generalized depth to water information throughout the county. Topographic and geomorphic trends were utilized in areas where other sources of data were lacking.

Depths to water of 5 to 15 feet (DRASTIC rating = 9) were typical of the areas overlying floodplains immediately adjacent to the Ohio River and major tributaries. Depths of 15 to 30 feet (7) were used for stream terraces adjacent to major streams and along smaller tributaries. Depths of 30 to 50 feet (5) were utilized for the headwaters of upland tributaries and for less steep slopes. Depths to water of 50 to 75 feet were utilized for steeper slopes and lower ridge tops common throughout much of the county. Depths to water of 75 to 100 feet (2) were applied to very high, isolated ridge tops. These ridge tops are usually capped by thick sequences of fine-grained Pennsylvanian or Permian rocks.

Net Recharge

Net recharge is the precipitation that reaches the aquifer after evapotranspiration and run-off. 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) proved to be helpful. Mapping in adjoining Belmont County (Angle, Jonak and Walker, 2001), and Tuscarawas County (Baker and Angle, 2001) proved useful as a guideline for evaluating recharge.

Values of 4 to 7 inches per year (6) were used for areas with moderate recharge. These areas include most of the tributary and upland streams. These areas tend to have moderately shallow depths to water, surficial streams, and moderately permeable soils. Bedrock in these areas of stream valleys tends to be fractured. Values of 2 to 4 inches per year (3) were utilized for almost all upland slopes and ridge tops. The low permeability of the fine-grained soils and bedrock, the greater depths to water, and the high amount of run-off due to the steep slopes were the major factors for assigning the low recharge values.

Aquifer Media

Information on aquifer media was obtained from the reports of Stout et al. (1943), and Crowell (1980). Mapping in adjoining Belmont County (Angle, Jonak, and Walker, 2001) and Tuscarawas County (Baker and Angle, 2001) proved useful as a guideline for evaluating aquifers. Open File Bedrock Reconnaissance Maps based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of aquifer data. Water well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

Aquifer ratings of (5) or (6) were used for some thinner sand and gravel deposits associated with terraces along Stillwater Creek and Conotton Creek. An aquifer rating of (4) or (5) was used for aquifers comprised of predominantly fine-grained sediments in the upper headwaters and tributaries of Stillwater Creek and Conotton Creek. Well logs in these areas recorded silt and clay and sand layers were absent or very thin in these areas.

An aquifer rating of (4) or (5) was used for interbedded sandstone, shale, and siltstone bedrock occupying stream valleys and steep slopes in much of Harrison County. An aquifer rating of (3) was assigned to the Pennsylvanian and Permian bedrock occupying ridge tops in Harrison County. Typically the ridge tops are comprised predominantly of fine-grained shales, mudstones, and dense limestones that comprise very poor aquifers.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Harrison County* (Rubel et al., 1981). Each soil type was evaluated and given a rating for soil media. Evaluations were based upon the texture, permeability, and shrink-swell potential for each soil material. The soils of Harrison County showed a high degree of variability. This is a reflection of the parent material. Table 12 is a list of the soils, parent materials, setting, and corresponding DRASTIC values for Harrison County.

Soils were considered to be thin or absent (10) along many steep ridge tops and slopes where bedrock was exposed. Soils were rated as being sandy loams (6) in outwash-rich terraces. Loam soils (5) were also selected for coarser residual bedrock ridges. Shrink-swell clays (7) were rated for upland areas having very clayey shale and mudstone bedrock residuum. Shrink-swell clays (7) were rated for fine-grained lacustrine slackwater sediments in tributaries. Silt loam (4) soils were evaluated for silty shale and siltstone residuum on slopes and ridge tops and also for silty alluvial and lacustrine deposits on floodplains. Clay loam (3) soils were evaluated for fine-grained bedrock residuum.

Table 12. Soils of Harrison County, Ohio

Soil Name	Parent Material Or Setting	DRASTIC Rating	Soil Media
Aaron	Clayey shale	7	Shrink-swell
Berks	Interbedded sandstone, shale, and siltstone	10	Thin or absent
Bethesda	Strip mine	NA	Non-rated
Canadice	Dense lacustrine clay	3	Clay loam
Caneadea	Dense lacustrine clay	3	Clay loam
Coshocton	Interbedded sandstone, shale, and siltstone	3	Clay loam
Dekalb	Sandstone outcrops	10	Thin or absent
Fairport	Strip mine	NA	Non-rated
Fitchville	Alluvium, floodplains	4	Silt loam
Germano	Sandstone ridge tops	10	Thin or absent
Gilpin	Interbedded sandstone, shale and siltstone	10	Thin or absent
Gilpin-Coshocton	Interbedded sandstone, shale and siltstone	10	Thin or absent
Gilpin-Lowell	Interbedded sandstone, shale and siltstone	10	Thin or absent
Glenford	Alluvium, lacustrine	4	Silt loam
Guernsey	Clayey shale	7	Shrink-swell clay
Hazelton	Sandstone	10	Thin or absent
Keene	Shale and siltstone bedrock	3	Clay loam
Lowell	Shale and siltstone bedrock	3	Clay loam
Melvin	Alluvium, floodplain	4	Silt loam
Morristown	Strip mine	NA	Not rated
Nolin	Alluvium, floodplain	4	Silt loam
Omulga	Loess, alluvium, colluvium over lacustrine	4	Silt loam
Orrville	Coarse alluvium	6	Sandy loam
Oshtemo	Coarse alluvium	6	Sandy loam
Peoga	Lacustrine, slackwater	4	Silt loam
Richland	Colluvium from interbedded rocks	5	Loam
Rigley	Sandstone slopes	6	Sandy loam
Tioga	Course alluvium	6	Sandy loam
Upshur	Clayey shale	7	Shrink-swell
Westmoreland	Interbedded sandstone, shale, and siltstone	3	Clay loam
Westmoreland-Coshocton	Interbedded sandstone, shale, and siltstone	3	Clay loam
Westmoreland-Dekalb	Interbedded sandstone, shale, and siltstone	10	Thin or absent

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Harrison County* (Rubel et al., 1981). Slopes of 0 to 2 percent (10) and 2 to 6 percent (9) were selected for flat-lying floodplains, valley floors, and terraces. Slopes of 2 to 6 percent (9) and 6 to 12 percent (5) used for gentler, more rounded ridge tops. Slopes of 6 to 12 percent (5) were also used for less steep ridges, typically those flanking broader valleys and in areas with less resistant bedrock types. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were selected for steeper slopes in high relief, upland areas.

Impact of the Vadose Zone Media

Information on vadose zone media was obtained from the reports of Stout et al. (1943) and Crowell (1980). Mapping in adjoining Belmont County (Angle, Jonak, and Walker, 2001) and Tuscarawas County (Angle and Baker, 2001) proved useful as a guideline for evaluating vadose zone materials. Open File Bedrock Reconnaissance Maps based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of vadose zone media data. Information on parent materials derived from the *Soil Survey of Harrison County* (Rubel et al., 1981), also proved useful in evaluating vadose zone materials. Water well log records on file at the ODNR, Division of Water, were the primary source of information on vadose zone media for the county.

Vadose zone media was given ratings of (6) for sand and gravel interbedded with silt and clay layers for the terraces and floodplains. These ratings depend upon the proportion of coarse, well-sorted outwash to the finer-grained alluvial and lacustrine deposits. Silt and clay with a rating of (5) were selected for vadose zone media for floodplains in many tributary valleys.

Vadose zone media was given a rating of (4) for the interbedded sandstone, shales, limestones, and coals of the Pennsylvanian System and Permian System rocks that underlie the broader, upland stream valleys. It was determined that these rocks may contain more fracturing that is reflected by slightly higher yields in these areas. A vadose zone rating of (3) was utilized for the interbedded bedrock near ridge tops and higher slopes.

Hydraulic Conductivity

Published data for hydraulic conductivity for Harrison County was found lacking. Information from Crowell (1980), the ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map, and water well log records on file at the ODNR, Division of Water, were the primary sources of information. Hydraulic conductivity values utilized in

adjoining Belmont County (Angle, Jonak, and Walker, 2001) and Tuscarawas County (Baker and Angle, 2001) proved to be a useful guideline. Textbook tables (Freeze and Cherry, 1979; Fetter, 1980; and Driscoll, 1986) were useful in obtaining estimated values for hydraulic conductivity in a variety of sediments.

A hydraulic conductivity rating of 300-700 gpd/ft^2 (4) was utilized for deposits of thin sand and gravel lenses interbedded with finer-grained materials.

All of the bedrock aquifers were assigned hydraulic conductivity values of 1-100 gpd/ft^2 (1) due to the overall low permeability of these interbedded sedimentary rocks.

APPENDIX B

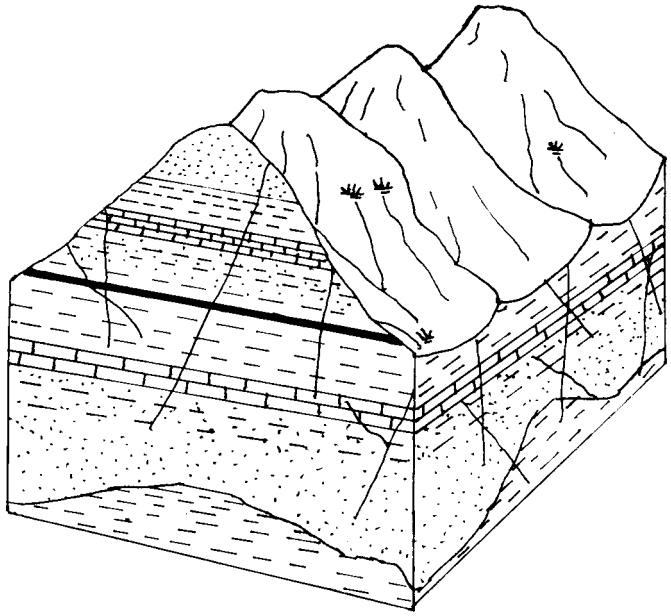
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Harrison County resulted in the identification of 5 hydrogeologic settings within the Unglaciated Allegheny Plateau Region. The list of these settings, the range of pollution potential indexes, and the number of index calculations for each setting are provided in Table 13. Computed pollution potential indexes for Harrison County range from 53 to 145.

Table 13. Hydrogeologic settings mapped in Harrison County, Ohio.

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da - Alternating Sandstone, Limestone, and Shale – Thin Regolith	53-93	42
6Fa – River Alluvium with Overbank Deposits	88-114	4
6Fb - River Alluvium Without Overbank Deposits	104-125	2
7D - Buried Valley	124-145	8
7Fa - Glacial Lakes and Slackwater Terraces	102-130	7

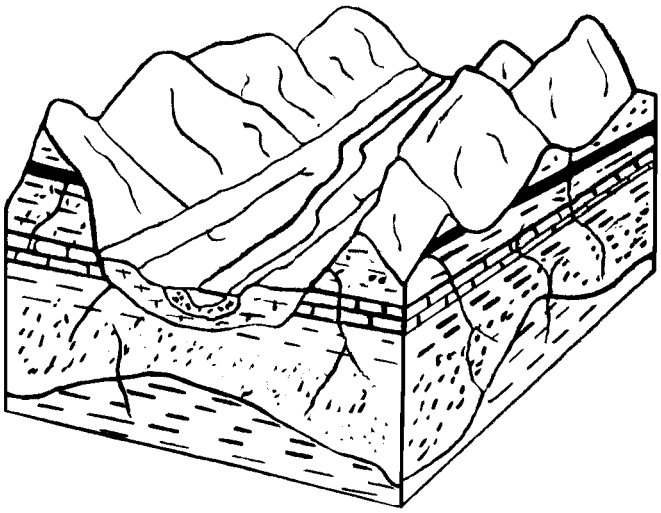
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide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



6Da Alternating Sandstone, Limestone, and Shale – Thin Regolith

This hydrogeologic setting is widespread, encompassing the upland areas in Harrison County. The area is characterized by high relief with broad, steep slopes and narrow, somewhat flatter ridge tops. The vadose zone and aquifers consist of slightly dipping, fractured, alternating sequences of dirty sandstones, shales, thin limestones, clays, and coals of the Pennsylvanian and Permian Systems. Multiple aquifers are typically present. Depth to water is generally deep; shallower perched zones may overlie low permeability shales, limestones, and clays. Soils are generally thin to absent on steeper slopes. On gentler slopes, soils vary with the bedrock lithology. Small supplies of ground water are obtained from intersecting bedding planes or vertical fractures. Ground water yields average less than 5 gpm. Recharge is limited due to the steep slopes, deep aquifers, and layers of impermeable bedrock.

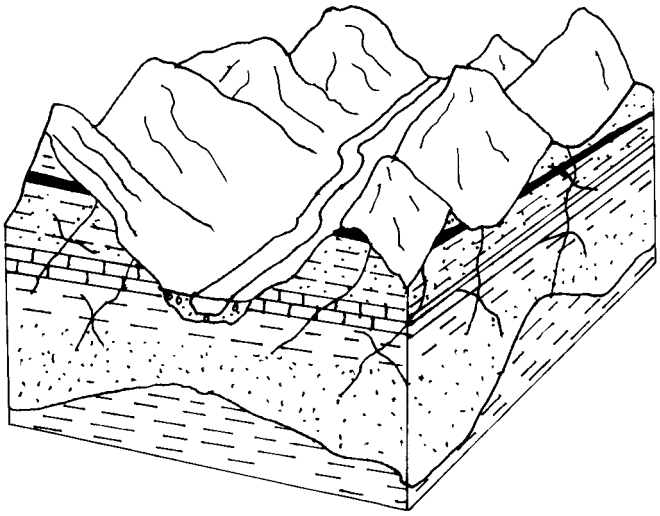
GWPP index values for the hydrogeologic setting of Alternating Sandstone, Limestone, and Shale – Thin Regolith range from 53 to 93, with the total number of GWPP index calculations equaling 42.



6Fa River Alluvium with Overbank Deposits

This hydrogeologic setting is limited to small tributary valleys in the uplands of Harrison County. This setting is somewhat similar to the 7Fa Glacial Lakes and Slackwater Terraces setting; however, the valleys and floodplains are narrower and the alluvial deposits are much thinner. Areas in this setting are similar to the adjacent uplands, which belong to the 6Da Alternating Sandstone, Limestone, and Shale - Thin Regolith setting. Narrow, relatively flat-bottomed stream valleys flanked by steep bedrock ridges characterize the setting. Depth to water is usually shallow, averaging less than 30 feet. Soils are generally silt loams. The alluvium is composed primarily of fine-grained floodplain ("overbank") sediments. The alluvial deposits are typically saturated; however, the alluvium is too thin to be utilized as an aquifer. The aquifer is the underlying dirty sandstones, shales, thin limestones, claystones, clays and coals of the Pennsylvanian and Permian Systems. In most areas, the alluvium is in direct connection with the underlying bedrock aquifers. Ground water yields average less than 5 gpm. Recharge is moderate due to the relatively shallow depth to water, flatter topography, and the relatively low permeability of the bedrock. Recharge is higher than the surrounding uplands.

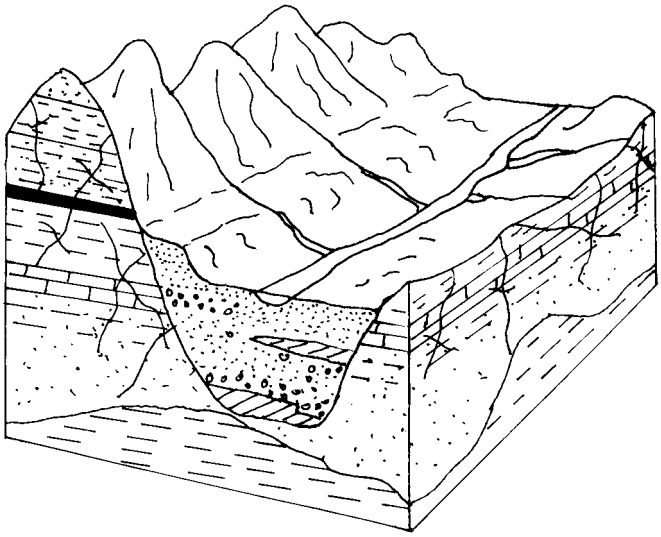
GWPP index values for the hydrogeologic setting of River Alluvium with Overbank Deposits range from 88 to 114 with the total number of GWPP index calculations equaling 4.



6Fb River Alluvium without Overbank Deposits

This hydrogeologic setting is limited to small tributary valleys in the uplands of southwestern Harrison County. This setting is somewhat similar to the 6Fa River Alluvium with Overbank Deposits setting; however, the valleys and floodplains are narrower and the alluvial deposits are thinner and coarser. Areas in this setting are similar to the adjacent uplands, which belong to the 6Da Alternating Sandstone, Limestone, Shale - Thin Regolith setting. Narrow, relatively flat-bottomed stream valleys flanked by steep bedrock ridges characterize the setting. Depth to water is usually shallow, averaging less than 30 feet. Soils are loams. The alluvial deposits are typically saturated; however, the alluvium is too thin to be utilized as an aquifer. The aquifer is the underlying dirty sandstones, shales, thin limestones, claystones, clays and coals of the Pennsylvanian System. In most areas, the alluvium is in direct connection with the underlying bedrock aquifers. Groundwater yields average less than 5 gpm. Recharge is moderate due to the relatively shallow depth to water, flatter topography, and the relatively low permeability of the bedrock. Recharge is higher than the surrounding uplands.

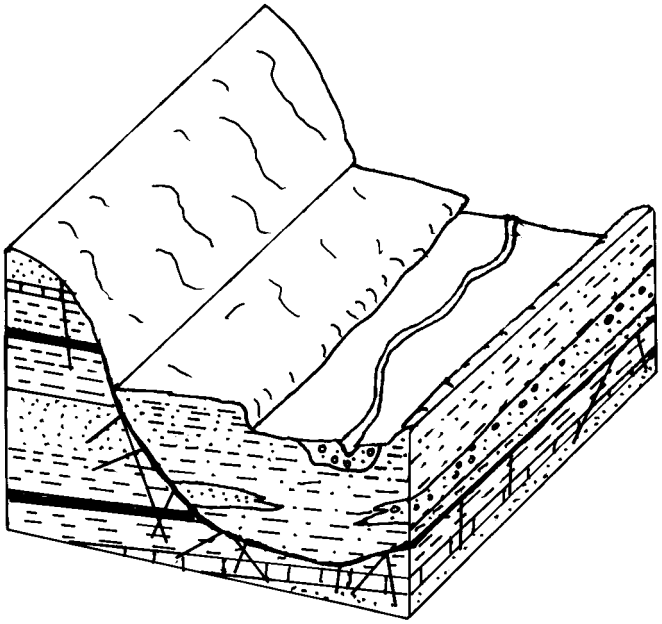
GWPP index values for the hydrogeologic setting of River Alluvium without Overbank Deposits range from 104 to 125 with the total number of GWPP index calculations equaling 2.



7D Buried Valleys

This hydrogeologic setting is easy to distinguish from the surrounding uplands. The broad, flat-lying floodplains and gently sloping terraces characterize the setting. Depth to water is typically less than 30 feet. Aquifers are composed of variable thicknesses of sand and gravel interbedded with finer-grained alluvium and lacustrine deposits. Soils are typically sandy loams derived from outwash. Recharge is typically relatively high due to the flat-lying topography, shallow depth to water, and the high permeability of the soils, vadose zone materials, and aquifer.

GWPP index values for the hydrogeologic setting of Buried Valley range from 124 to 145 with the total number of GWPP index calculations equaling 8.



7Fa Glacial Lakes and Slackwater Terraces

Flat-lying areas that were formed in low velocity water of glacial and slackwater lakes that filled pre-existing drainage systems characterize this setting. These areas are typically dissected by modern streams and contain remnant low-lying terraces. The valleys are typically broader and contain thicker drift than the somewhat similar 6Fa River Alluvium with Overbank Deposits. The setting is bordered by steep bedrock uplands. The drift is not as thick or as coarse as in adjacent 7D Buried Valley settings. The aquifer consists of thin sand and gravel lenses interbedded with finer lacustrine and alluvial deposits. If sand and gravel is not encountered, wells are completed in the underlying interbedded sedimentary rock. Depth to water is commonly shallow due to the presence of streams found within this setting. Soils are silt loams. Recharge in this setting is moderate due to the relatively shallow depth to water, flat-lying topography, and the moderate to low permeability soils, vadose, and underlying bedrock.

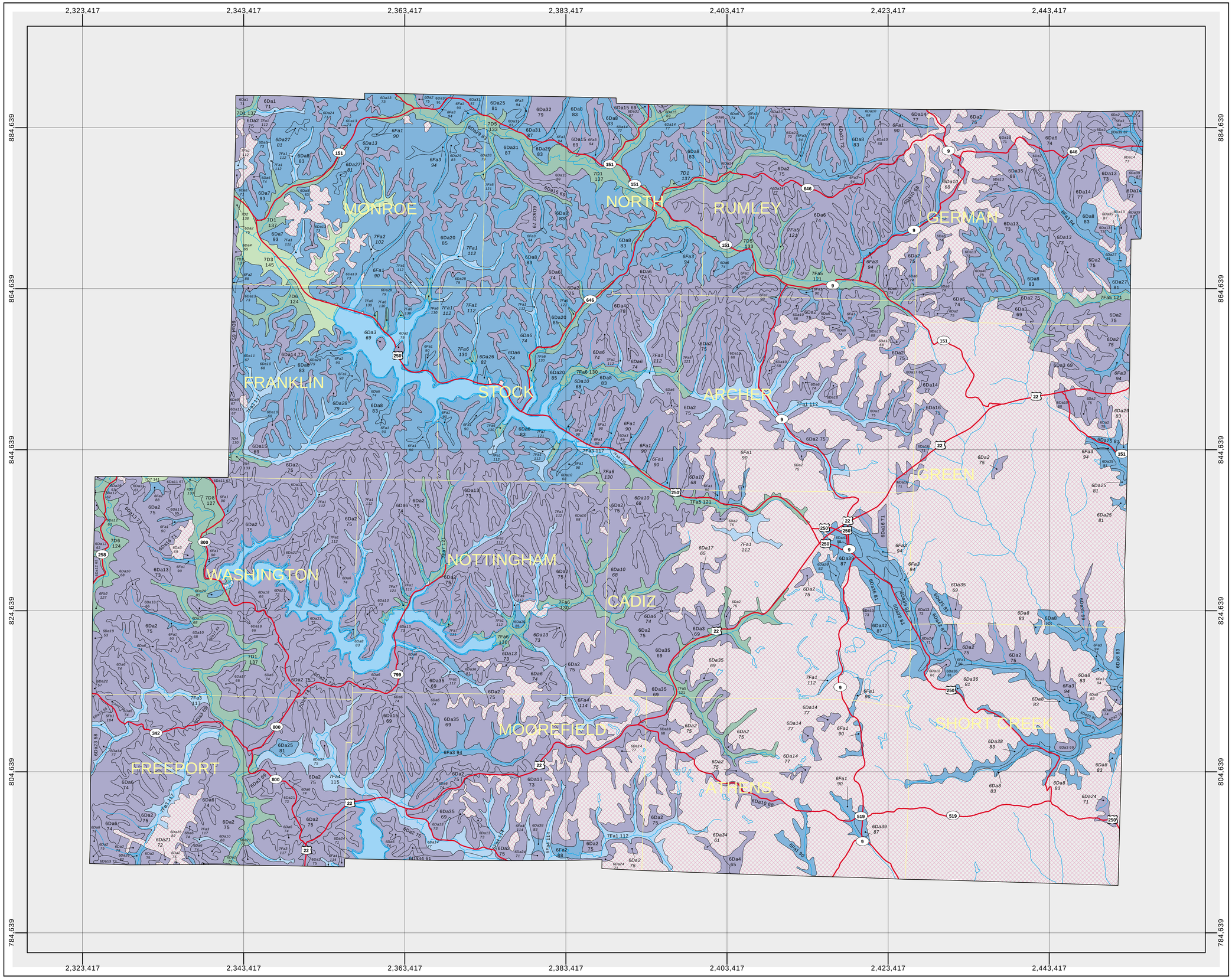
GWPP index values for the hydrogeologic setting of Glacial Lakes and Slackwater Terraces range from 102 to 130 with the total number of GWPP index calculations equaling 7.

Table 14. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
6Da01	50-75	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	18+	interbedded ss/sh/ls/cl/co	1-100	71
6Da02	50-75	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	75
6Da04	100+	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	65
6Da05	50-75	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	73
6Da06	75-100	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/cl/co	1-100	74
6Da07	30-50	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	93
6Da08	50-75	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	83
6Da09	50-75	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	67
6Da10	75-100	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/cl/co	1-100	68
6Da11	50-75	0-2	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	67
6Da12	75-100	0-2	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	62
6Da13	50-75	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/cl/co	1-100	73
6Da14	50-75	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/cl/co	1-100	77
6Da15	50-75	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	18+	interbedded ss/sh/ls/cl/co	1-100	69
6Da16	50-75	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	12-18	interbedded ss/sh/ls/cl/co	1-100	71
6Da17	50-75	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	65
6Da18	75-100	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	12-18	interbedded ss/sh/ls/cl/co	1-100	66
6Da19	100+	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	18+	interbedded ss/sh/ls/cl/co	1-100	53
6Da20	30-50	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	85
6Da21	75-100	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/cl/co	1-100	72
6Da22	100+	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	57
6Da23	75-100	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	18+	interbedded ss/sh/ls/cl/co	1-100	58
6Da24	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	18+	interbedded ss/sh/ls/cl/co	1-100	71
6Da25	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	12-18	interbedded ss/sh/ls/cl/co	1-100	81
6Da26	30-50	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	0-2	interbedded ss/sh/ls/cl/co	1-100	82

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
6Da27	50-75	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/cl/co	1-100	81
6Da28	50-75	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/cl/co	1-100	79
6Da29	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	83
6Da3	50-75	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	2-6	interbedded ss/sh/ls/cl/co	1-100	69
6Da30	30-50	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/cl/co	1-100	91
6Da31	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	2-6	interbedded ss/sh/ls/cl/co	1-100	87
6Da32	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	18+	interbedded ss/sh/ls/cl/co	1-100	79
6Da33	75-100	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	18+	interbedded ss/sh/ls/cl/co	1-100	70
6Da34	50-75	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	18+	interbedded ss/sh/ls/cl/co	1-100	61
6Da35	50-75	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	18+	interbedded ss/sh/ls/cl/co	1-100	69
6Da36	30-50	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	12-18	interbedded ss/sh/ls/cl/co	1-100	81
6Da37	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	6-12	interbedded ss/sh/ls/cl/co	1-100	75
6Da38	30-50	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	6-12	interbedded ss/sh/ls/cl/co	1-100	83
6Da39	30-50	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	12-18	interbedded ss/sh/ls/cl/co	1-100	87
6Da40	75-100	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	2-6	interbedded ss/sh/ls/cl/co	1-100	78
6Da41	30-50	2-4	interbedded ss/sh/ls/cl/co	Thin/Absent Gravel	6-12	interbedded ss/sh/ls/cl/co	1-100	89
6Da42	30-50	2-4	interbedded ss/sh/ls/cl/co	Shrink/Swell Clay	2-6	interbedded ss/sh/ls/cl/co	1-100	87
6Fa1	30-50	2-4	interbedded ss/sh/ls/cl/co	Silty Loam	0-2	silt/clay	1-100	90
6Fa2	30-50	2-4	interbedded ss/sh/ls/cl/co	Clay Loam	0-2	silt/clay	1-100	88
6Fa3	30-50	2-4	interbedded ss/sh/ls/cl/co	Sandy Loam	0-2	silt/clay	1-100	94
6Fa4	15-30	4-7	interbedded ss/sh/ls/cl/co	Silty Loam	0-2	silt/clay	1-100	114
6Fb1	30-50	4-7	silt/clay	Loam	0-2	silt/clay	1-100	104
6Fb2	15-30	4-7	interbedded ss/sh/ls/cl/co	Loam	0-2	sd+grvl/silt+clay	100-300	127
7D1	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+grvl/silt+clay	300-700	137
7D2	15-30	4-7	sand/gravel	Shrink/Swell Clay	0-2	sd+grvl/silt+clay	300-700	138
7D3	5-15	4-7	sand/gravel	Clay Loam	0-2	sd+grvl/silt+clay	300-700	145

Setting	Depth To Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating
7D4	15-30	4-7	sand/gravel	Shrink/Swell Clay	0-2	sd+grvl/silt+clay	300-700	130
7D5	15-30	4-7	sand/gravel	Sandy Loam	0-2	sd+grvl/silt+clay	300-700	133
7D6	15-30	4-7	sand/gravel	Silty Loam	0-2	sd+grvl/silt+clay	300-700	124
7D7	15-30	4-7	sand/gravel	Sandy Loam	0-2	sd+grvl/silt+clay	300-700	141
7D8	15-30	4-7	sand/gravel	Clay Loam	0-2	sd+grvl/silt+clay	300-700	127
7Fa1	15-30	4-7	interbedded ss/sh/ls/cl/co	Silty Loam	0-2	silt/clay	1-100	112
7Fa2	30-50	4-7	interbedded ss/sh/ls/cl/co	Silty Loam	0-2	silt/clay	1-100	102
7Fa3	15-30	4-7	silt/clay	Silty Loam	0-2	silt/clay	1-100	117
7Fa4	15-30	4-7	silt/clay	Clay Loam	0-2	silt/clay	1-100	115
7Fa5	15-30	4-7	interbedded ss/sh/ls/cl/co	Sandy Loam	0-2	silt/clay	1-100	121
7Fa6	5-15	4-7	silt/clay	Silty Loam	0-2	silt/clay	1-100	130
7Fa7	5-15	4-7	silt/clay	Clay Loam	12-18	silt/clay	1-100	121



Ground Water Pollution Potential of Harrison County

by

Michael P. Angle and Dave Walker

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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