GROUND WATER POLLUTION POTENTIAL OF COLUMBIANA COUNTY, OHIO

BY

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GROUND WATER POLLUTION POTENTIAL REPORT NO. 35

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ABSTRACT

A ground water pollution potential map of Columbiana County has been prepared using the DRASTIC mapping process. The DRASTIC system consists of two elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system for pollution potential.

Hydrogeologic settings incorporate the major hydrogeologic factors that control ground water movement and occurrence including the depth to water, net recharge, aquifer media, soil media, topography, impact of the vadose zone media, and hydraulic conductivity of the aquifer. The relative ranking scheme uses a combination of weights and ratings to produce a numerical value called the pollution potential index that helps prioritize areas with respect to ground water contamination vulnerability. Hydrogeologic settings and the corresponding pollution potential indexes are displayed graphically on maps.

Columbiana County lies primarily within the Glaciated Central hydrogeologic setting. The southern portion of the county lies within the Unglaciated Central hydrogeologic setting. The glaciated portion of Columbiana County is overlain by varying thicknesses of glacial till. The northern portion of Columbiana County is crossed by numerous buried valleys. The buried valleys are variable; some contain appreciable thicknesses of outwash sand and gravel, others are predominantly filled with fine-grained glacial till. The unconsolidated deposits are moderate to good aquifers with yields over 100 gallons per minute possible within some areas. Interbedded sandstones, shales, limestones, coals, and mudstones of the Pennsylvanian system comprise the aquifer in the majority of the county. Consolidated units are moderate to poor aquifers with typical yields ranging from 3 to 25 gallons per minute. Nine hydrogeologic settings were identified in Columbiana County. Ground water pollution potential indices ranged from 65 to 173.

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

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 percent of Ohio citizens rely on ground water for drinking and household use from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 700,000 rural households depend on private wells; approximately 4,000 of these wells exist in Columbiana County.

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

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

The purpose of this report and map is to aid in the protection of our ground water resources. This protection can be enhanced by understanding and implementing the results of this study which utilizes the DRASTIC system of evaluating an area's potential for ground water pollution. The mapping program identifies areas that are more or less vulnerable to contamination and displays this information graphically on maps. The system was not designed or intended to replace site-specific investigations, but rather to be used as a planning and management tool. The results of the map and report can be combined with other information to assist in prioritizing local resources and in making land use decisions.

APPLICATIONS OF POLLUTION POTENTIAL MAPS

The pollution potential mapping program offers a wide variety of applications in many counties. The ground water pollution potential map of Columbiana 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 expenditure allocation related to solid waste disposal. A county may use the map to help identify areas that are more or less 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 also be applied successfully where non-point source contamination is a concern. Non-point source contamination occurs where land use activities over large areas impact water quality. Maps providing information on relative vulnerability can be used to guide the selection and implementation of appropriate best management practices in different areas. Best management practices should be chosen based upon consideration of the chemical and physical processes that occur as a result of the practices, 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 also assist in developing ground water protection strategies. By identifying areas more vulnerable to contamination, officials can direct resources to areas where special attention or protection efforts might be warranted. This information can be utilized effectively at the local level for integration into land use decisions and as an educational tool to promote public awareness of ground water resources. Pollution potential maps may also be used to prioritize ground water monitoring and/or contamination clean-up efforts. Areas that are identified as being vulnerable to contamination may benefit from increased ground water monitoring for pollutants or from additional efforts to clean up an aquifer.

Other beneficial uses of the pollution potential maps will be recognized by individuals in the county who are familiar with specific land use and management problems. Planning commissions and zoning boards can use these maps to help make informed decisions about the development of areas within their jurisdiction. Developments proposed to occur within ground-water sensitive areas may be required to show how ground water will be protected.

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

The system chosen for implementation of a ground water pollution potential mapping program in Ohio, DRASTIC, was developed by the National Water Well Association for the United States Environmental Protection Agency. A detailed discussion of this system can be found in Aller et al. (1987).

The DRASTIC mapping system allows the pollution potential of any area to be evaluated systematically using existing information. The vulnerability to contamination is a combination of hydrogeologic factors, anthropogenic influences, and sources of contamination in any given area. The DRASTIC system focuses only on those hydrogeologic factors which influence ground water pollution potential. The system consists of two major elements: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system to determine pollution potential.

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area, assuming a contaminant with the mobility of water introduced at the surface and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than 100 acres in size and is not intended or designed to replace site-specific investigations.

Hydrogeologic Settings and Factors

To facilitate the designation of mappable units, the DRASTIC system used the framework of an existing classification system developed by Heath (1984), which divides the United States into 15 ground water regions based on the factors in a ground water system that affect occurrence and availability.

Within each major hydrogeologic region, smaller units representing specific hydrogeologic settings are identified. Hydrogeologic settings form the basis of the system and represent a composite description of the major geologic and hydrogeologic factors that control ground water movement into, through, and out of an area. A hydrogeologic setting represents a mappable unit with common hydrogeologic characteristics and, as a consequence, common vulnerability to contamination (Aller et al., 1987).

Figure 1 illustrates the format and description of a typical hydrogeologic setting found within Columbiana County. Inherent within each hydrogeologic setting are the physical characteristics which affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

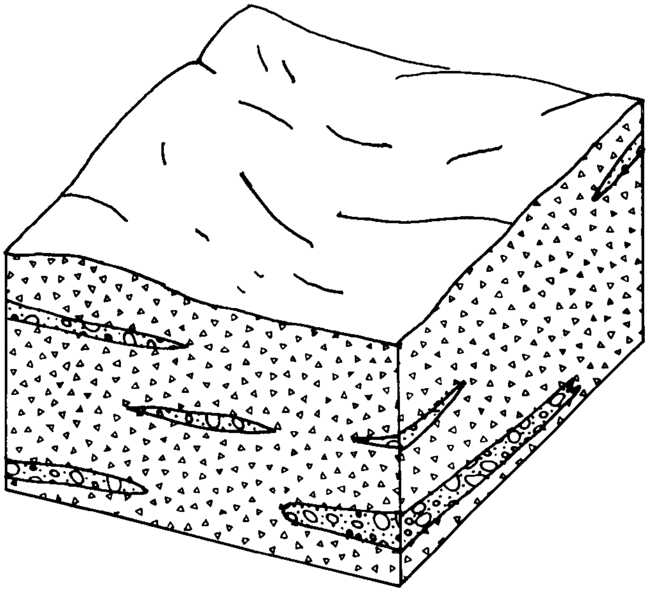
D - Depth to Water
R - Net Recharge
A - Aquifer Media
S - Soil Media
T - Topography
I - Impact of the Vadose Zone Media
C - Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is limited to a small area in far western Columbiana County, bordering Stark County. The setting encompasses areas where sand and gravel lenses within the till are the aquifer. The total thickness of drift in these areas is substantially less than that found in the 7D - Buried Valley hydrogeologic setting. This hydrogeologic setting is typically associated with end moraines and is characterized by rolling hills and low to moderate relief. Soils are typically clay loams. The sand and gravel aquifers are generally thin, discontinuous and isolated from each other. Till is the vadose zone media. Yields average from 10 to 20 gpm and are adequate for domestic supplies. Depth to water is moderate, averaging from 30 to 50 feet. Recharge is moderate due to the moderate relief, moderate depth of the water table, and the relatively low permeability of soils and till.

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

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

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

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

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

Weighting and Rating System

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

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

Pesticide DRASTIC

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

TABLE 1. ASSIGNED WEIGHTS FOR DRASTIC FEATURES

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

TABLE 2. RANGES AND RATINGS FOR DEPTH TO WATER

DEPTH TO WATER (FEET)	
Range	Rating
0-5	10
5-15	9
15-30	7
30-50	5
50-75	3
75-100	2
100+	1
Weight: 5	Pesticide Weight: 5

TABLE 3. RANGES AND RATINGS FOR NET RECHARGE

NET RECHARGE (INCHES)	
Range	Rating
0-2	1
2-4	3
4-7	6
7-10	8
10+	9
Weight: 4	Pesticide Weight: 4

TABLE 4. RANGES AND RATINGS FOR AQUIFER MEDIA

AQUIFER MEDIA		
Range	Rating	Typical Rating
Massive Shale	1-3	2
Metamorphic / Igneous	2-5	3
Weathered Metamorphic / Igneous	3-5	4
Glacial Till	4-6	5
Bedded Sandstone, Limestone and Shale Sequences	5-9	6
Massive Sandstone	4-9	6
Massive Limestone	4-9	6
Sand and Gravel	4-9	8
Basalt	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

TABLE 5. RANGES AND RATINGS FOR SOIL MEDIA

SOIL MEDIA	
Range	Rating
Thin or Absent	10
Gravel	10
Sand	9
Peat	8
Shrinking and / or Aggregated Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Muck	2
Nonshrinking and Nonaggregated Clay	1
Weight: 2	Pesticide Weight: 5

TABLE 6. RANGES AND RATINGS FOR TOPOGRAPHY

TOPOGRAPHY (PERCENT SLOPE)	
Range	Rating
0-2	10
2-6	9
6-12	5
12-18	3
18+	1
Weight: 1	Pesticide Weight: 3

TABLE 7. RANGES AND RATINGS FOR IMPACT OF THE VADOSE ZONE MEDIA

IMPACT OF THE VADOSE ZONE MEDIA		
Range	Rating	Typical Rating
Confining Layer	1	1
Silt/Clay	2-6	3
Shale	2-5	3
LImestone	2-7	6
Sandstone	4-8	6
Bedded Limestone, Sandstone, Shale	4-8	6
Sand and Gravel with significant Silt and Clay	4-8	6
Metamorphic/Igneous	2-8	4
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	8-10	10
Weight: 5	Pesticide Weight: 4	

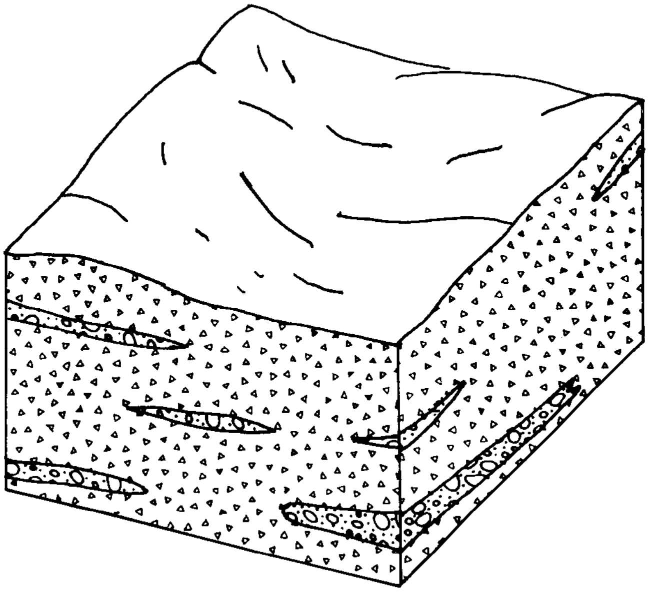
TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7Af1, Sand and Gravel Interbedded in Glacial Till, identified in mapping Columbiana 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 110. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 65 to 223. The diversity of hydrogeologic conditions in Columbiana County produces settings indicating a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the nine settings identified in the county range from 65 to 173.

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 Columbiana 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 Columbiana County is included with this report.



SETTING 7Af1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand & Gravel	3	5	15
Soil Media	Clay Loam	2	3	6
Topography	2-6%	1	9	9
Impact Vadose Zone	Sandy Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		DRASTIC	INDEX	110

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

INTERPRETATION AND USE OF A GROUND WATER POLLUTION POTENTIAL MAP

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

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

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

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (Af) refer to a specific hydrogeologic setting. The following number (1) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (110) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived in an area.

The maps are color-coded using ranges depicted on the map legend. The color codes used are part of a national color-coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow) representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet) representing areas of lower vulnerability to contamination. Large man-made features such as landfills, quarries, or strip mines have also been marked on the map for reference.

GENERAL INFORMATION ABOUT COLUMBIANA COUNTY

Demographics

Columbiana County occupies approximately 535 square miles in northeastern Ohio (Figure 3). Columbiana County is bounded to the north by Mahoning County, to the west by Stark County, to the southwest by Carroll County, to the south by Jefferson County, to the east by Pennsylvania, and to the southeast, across the Ohio River, by West Virginia. Elevation ranges from 1,447 feet at Round Knob in Madison Township to 652 feet along the Ohio River in Yellow Creek Township. Total relief within the county is 795 feet.

The approximate population of Columbiana County according to 1992 figures is 110,451 (Ohio Department of Development, personal communication). East Liverpool is the largest city and Lisbon is the county seat. Population growth reflects outward movement from major metropolitan areas such as Youngstown in the north and Canton in the west. About half of the county's land area is used for farming, including pasturing. Approximately 30% of the land area is used for woodlands, including reforestation projects associated with strip mining. The remaining land areas are used for residential, urban, recreational, and industrial uses, including strip mining and quarrying. Agricultural uses are dominant in the northern and far western portions of the county; woodlands and other land uses are more prominent to the south and east. More specific information on land usage can be obtained from the ODNR, Division of Soil and Water Conservation, Resource Analysis Program.

Climate

The weather station at Millport (approximately one mile north of Summitville) reports a mean annual temperature of 48.8 degrees Fahrenheit for a thirty-year (1961-1990) average (Owenby and Ezell, U.S. Department of Commerce, 1992). According to Harstine (1991), the average temperature is relatively constant across the county with a slight temperature increase towards the south and east along the Ohio River Valley. The mean annual precipitation recorded at Millport is 37.98 inches based on the same thirty-year (1961-1990) average (Owenby and Ezell, 1992). Harstine (1991) shows precipitation levels as relatively constant across the county with a slight decrease toward the northwest corner.

Figure 3. Location of Columbiana County

Physiography and Topography

Columbiana County lies within the Appalachian Plateau physiographic province (Fenneman, 1938). Fenneman (1938) depicts the northern strip of Columbiana County as occupying the Southern New York Section of the Appalachian Plateau and the remainder of the county as occupying the Kanawha Section of the Appalachian Plateau. Frost (1931) and Thornbury (1965) describe the northern portion of the county as lying within the Glaciated Allegheny Plateau and the southern portion of the county as occupying the Unglaciated Allegheny Plateau. The glacial boundary lies just to the north of Sandy Creek, West Fork Little Beaver Creek, and Little Beaver Creek (Goldthwait et. al., 1961 and White and Totten, 1985.

Northern Columbiana County is characterized by hummocky to rolling uplands associated with numerous end moraines. Valleys tend to be broad and relatively flat-lying. Central and southern Columbiana County is typified by much higher relief and steep bedrock-controlled uplands. Valleys tend to be narrower and have steep flanks. The topography becomes much more "rugged" and the relief much higher in the unglaciated portion of the county.

Modern Drainage

All of Columbiana County eventually drains into the Ohio River watershed. The southwestern corner of the county is drained by Sandy Creek. Sandy Creek flows westward where it joins the Tuscarawas River in Tuscarawas County. The northwestern corner of the county is drained by the Mahoning River. The Mahoning River flows to the northwest into Mahoning and Portage Counties and then turns eastward into Trumbull County. The Mahoning continues eastward, emptying in Little Beaver River in Pennsylvania. The far southern end of the county is drained by Little Yellow Creek and the North Fork Yellow Creek. The majority of the county is drained by West Fork Little Beaver Creek, North Fork Little Beaver Creek, Middle Fork Little Beaver Creek, and Little Beaver Creek.

Pre- and Inter-Glacial Drainage and Topography

Stout and Lamborn (1924) provide an extensive, somewhat dated account of pre-glacial and inter-glacial drainage and drainage changes in Columbiana County. Stout and Lamborn (1924) refer to an ancient, northerly-flowing precursor of the Ohio River as the Old Monongahela System. Stout et. al., (1943) refer to this system as the Pittsburgh River. The Negley River, a major tributary, ran from east to west draining all of Columbiana County (Stout et. al., 1943). Stout et. al., (1943) show the Pittsburgh-Negley drainage system as being a rough time equivalent of the Teays.

The advancing ice front blocked many of the pre-existing drainages, causing ponding which eventually led to new outlets being cut and the creation of new, southerly-flowing drainage systems. In northern and central Columbiana County, many of the pre-existing valleys were filled or "buried" by thick sequences of glacial drift. Examples of these buried valleys include a northwest-southwest valley underlying the present Mahoning River, north-south valleys underlying both Homeworth and North Georgetown, a northwest-southeast valley near Salem, a north-south valley near the town of Columbiana, a northeast-southwest valley by Leetonia, and a number of west-east trending valleys within the vicinity of East Palestine. South of the glacial boundary, the drainage reversals helped to create entrenched, steep-sided gorges. Minor drainage changes persisted throughout the later Illinoian and Wisconsinan ice advances. The complex nature of all of these changes is not yet fully understood.

Lessig (1963,1964) identified lacustrine deposits referred to as the Calcutta Silts south of the glacial boundary, primarily along West Fork Little Beaver Creek and Beaver Creek. The Calcutta Silts were believed to be the result of the ponding of the Pittsburgh River during the initial ice advance. The Calcutta Silts were comprised of 2 to 10 feet of silts, clays, and fine sands deposited between elevations of 1080 feet and 1180 feet. Recent field mapping activities by the ODNR, Division of Soil and Water for preparation of an updated Soil Survey of Columbiana County suggest that the extent of the Calcutta Silts may have been exaggerated. Many areas may actually contain weathered shale or loess deposits which had been mis-identified as fine lacustrine deposits. The nature and extent of the Calcutta Silts is being re-evaluated.

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years before present (Y.B.P.)) several episodes of ice advance occurred in northeastern Ohio. Table 9 summarizes the Pleistocene deposits found in Columbiana County. Older ice advances which predate the most recent (Brunhes) magnetic reversal (about 730,000 Y.B.P.) are now commonly referred to as pre-Illinoian (formerly Kansan). Lessig and Rice (1962) reported encountering some weathered "Kansan-age" tills in the Elkton area. The age of many of the glacial deposits in Columbiana County is poorly understood.

A three to four mile wide-band of relatively thin, highly weathered glacial till extends from west to east across Columbiana County. This band of thin till separates the unglaciated portion of the county to the south from the thicker end moraine and buried valley deposits to the north. This area is typified by a silty to sandy, stony till which thinly mantles the underlying bedrock. Goldthwait et. al., (1961) mapped this as an area of Illinoian till. Deposition of Illinoian deposits is believed to have occurred prior to 100,000 Y.B.P. White, (1982) and White and Totten (1985), based upon research in northwestern Pennsylvania,

Table 9. Generalized Glacial Statigraphy of Columbiana County, Ohio (after White and Totten, 1985, and Totten, 1987).

AGE (years ago)	**EPOCH**	**STAGE**		**SUBSTAGE**	**UNIT OR INTERVAL**
25, 000	PLEISTOCENE	WISCONSINAN	LATE	Wood-fordian	Lavery Till Kent Till Titusville Till (2)
40,000			MIDDLE	Farmdalian (1)	Paleosol ?
70,000			EARLY	Altonian (1)	Titusville Till (2)
120,000		SANGAMONIAN			Paleosol ?, Unknown
730,000		ILLINOIAN			Titusville Till (2)
2,000,000		PRE-ILLINOIAN			"Kansan" deposits at Elkton (Lessing and Rice, 1962) Calcutta Silts (Lessing, 1963)

(1) Usage of these terms is being reveiwed.
(2) Age duration of Titusville Till is currently unknown.

believed that these deposits were early Wisconsinan in age and referred to them as the Titusville Till. According to earlier literature, the Early Wisconsinan occurred between 40,000 to 80,000 Y.B.P. Current thinking (Totten, 1987) suggests that there was probably insufficient ice thickness in northern North America for a major ice advance into the Great Lakes region. Therefore, the age of deposits previously determined to be Early Wisconsinan needs to be re-evaluated. Volpi and Szabo (1988) infer that the Titusville deposits are probably Illinoian in age.

The surficial deposits which cap the end moraines across northern Columbiana County are Late Wisconsinan Woodfordian sub-stage in age and range from approximately 15,000 to 25,000 Y.B.P. in age. These deposits reflect two distinctive ice advances. The older Kent Till is sandy, stony, loose, and contains abundant stringers of sand and gravel (White and Totten, 1985). The younger Lavery Till lies to the north of the Kent Till and is silty to clay-rich, less stony, relatively compact, and commonly lacking sand and gravel stringers (White and Totten, 1985). Ravenna, Wooster, and Canfield soils tend to form upon Kent Till, whereas the Lavery Till weathers into finer Rittman, Wadsworth, Ellsworth, and Mahoning soils.

The age and nature of deposits within the deeper buried valleys are poorly understood. The majority of these valleys probably contain Illinoian drift at depth and Wisconsinan drift near the surface. Similarly, the moraines may contain a "core" comprised of older till covered by a mantle of later, Woodfordian till (Totten, 1969).

The majority of the glacial deposits fall into four main types: (glacial) till, lacustrine, outwash, and ice-contact sand and gravel (kames). Buried valleys may contain a mix of all of these types of deposits. Drift is an older term that collectively refers to the entire sequence of glacial deposits. Modern post-glacial alluvium or floodplain deposits also account for valley fill. In very steep-sided valleys, colluvium, or material which has collapsed down hillslopes, accumulates.

Till is an unsorted, non-stratified (non-bedded), mixture of sand, silt, clay, and gravel deposited directly by the ice sheet. There are two main types or facies of till. Lodgement till is "plastered-down" or "bulldozed" at the base of an actively moving ice sheet. Lodgement till tends to be relatively dense and compacted, and pebbles tend to be angular, broken, and have a preferred direction or orientation. 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 bands melts. Ablation till tends to be less dense, less compact, and slightly coarser as meltwater tends to wash away some of the fine silt and clay.

At the land surface, till accounts for two primary landforms: ground moraine and end moraine. Ground moraine is typically gently rolling. End moraines are more ridge-like, with terrain that is steeper and more hummocky. End moraines tend to be dissected by surrounding streams and commonly function as local drainage divides. End moraines ideally should also represent a net thickening of till. Moraines in Columbiana County have been mapped by White and Totten (1985). It is difficult to differentiate between ground and end moraine in the central and southern portions of the county as a result of the light relief and bedrock control of the topography.

Lacustrine deposits were created as a result of lakes formed by the damming of streams by either ice sheets or deposits resulting from ice sheets. The buried valleys may contain appreciable thicknesses of lacustrine deposits (Lessig, 1964 and White and Totten, 1985). Thin lacustrine or "slackwater" deposits are created by the ponding or "backing-up" of water in tributaries in upland areas. Lacustrine deposits tend to be composed of fairly dense, uniform silt and clay with minor fine sand. The deposits may display very thin bedding referred to as laminations. These sediments infer deposition into quiet, low-energy environments with little or no current. The older Calcutta Silts have been previously discussed above.

Outwash deposits are created by active deposition of sediments by meltwater streams. These deposits are generally bedded or stratified and are sorted. Outwash deposits in Columbiana County are predominantly located in stream valleys. Such outwash deposits were referred to in earlier literature as valley trains. Sorting and the degree of coarseness depend upon the nature and proximity of the melting ice sheet. Outwash is typically deposited by braided streams. Such streams have multiple channels which migrate across the width of the valley floor, leaving behind a complex record of deposition and erosion. As modern streams downcut, the older, now higher elevation, remnants of the valley floor are referred to as terraces. Lessig (1961) and White and Totten (1985) have mapped major terraces in the county. The majority of the surficial terraces are reported as being Wisconsinan in age (White and Totten, 1985). White and Totten (1985) noted a difference in the coarseness and lithologies of the gravel between the Woodfordian and older Titusville equivalent outwash. The age of the earlier Wisconsinan outwash deposits may therefore need to be re-evaluated. White and Totten (1985) inferred that the outwash gravels along West Fork Little Beaver Creek and Little Beaver Creek were Illinoian in age. Lessig et. al., (1968) and White and Totten (1985) suggest that the surficial deposits bordering the Ohio River are Wisconsinan outwash and more recent alluvium.

Kames and eskers are ice contact features. They are composed of masses of generally poorly-sorted sand and gravel with minor till, deposited in depressions, holes, tunnels, or other cavities in the ice. As the surrounding ice melts, a mound of sediment remains behind. Typically, these deposits may collapse or flow as the surrounding ice melts. These deposits may display high angle, distorted or tilted beds, faults, and folds. In Columbiana County the majority of the kames are deposited along the margins or flanks of valleys, particularly within the headwaters of the drainage systems. The kames tend to coalesce together along the valley margins. These features are referred to as kame terraces. They represent deposition of materials between the melting ice sheet and the bedrock slopes flanking the ice-filled valley. A few isolated kames can be found in the uplands of central and eastern Columbiana County. White and Totten (1985) suggest that the majority of the kames and kame terrace depositions may be associated with the deposition of the Kent Moraine during the Woodfordian Sub-stage. White and Totten (1985) give a thorough discussion on the deposition of kames and outwash features in the county.

Peat and muck are organic-rich deposits associated with low-lying depressional areas, kettles, bogs, and swamps. Muck is a dense, fine silt with a high content of organics and a dark black color. Peat is typically brownish and contains pieces of decaying plant material. The two deposits commonly occur together. They commonly overlie lacustrine, slackwater, or fine-grained floodplain deposits. The majority of these deposits are found occupying stream valleys in the northern portion of the county.

Another glacially derived deposit found in Columbiana County is loess. Loess is formed by wind-blown silt and is important in the soil development process. Deposits of loess are derived from the wind picking up fine silt-sized particles covering the floodplains of the wide, outwash-covered valley floors. These deposits are commonly found capping kames and bedrock and till uplands to the east (downwind) of major river valleys. Loess may also have been deposited in the shallow slackwater ponds of upland areas. Such deposits' origins are difficult to identify. Average thickness is typically less than five feet thick.

Alluvium is associated with the floodplains of most of the major drainage ways in Columbiana County. Alluvium varies from a clayey-silt to sandy-silt. Alluvium tends to coarsen within the actual channel area of streams where finer sediments are washed away and the coarser "bed-load" sediments are reworked. Finer silts and clays are associated with overbank deposits which occur during flood events.

Bedrock Geology

Bedrock exposed at the surface in Columbiana County belongs to the Pennsylvanian System. Table 10 summarizes the bedrock stratigraphy found in Columbiana County. The upper portion of the Pottsville Group, the Allegheny Group, and the majority of the Conemaugh Group are represented in the county (Stout and Lamborn, 1924). Strata are generally flat-lying and dip towards the south and east. Small, localized structural features are present in the southern portion of the county (Stout and Lamborn, 1924 and Slucher and Rice, in progress).

Table 10. Generalized Bedrock Stratigraphy for Columbiana County, Ohio. (after Stout and Lamborn, 1924; Collens, 1979; and Larsen, 1991.)

AGE	SYSTEM	GROUP	SIGNIFICANT FORMATIONS	DESCRIPTIONS
325 TO 280 MILLION YEARS AGO	PENNSYLVANIAN	CONEMAUGH	Ames Brush Creek Mahoning	Interbedded dirty, fine grained sandstones, shales, mudstones. Red mudstones dominate upper section. Some thin limestones, minor coals. Lower section sandier to the east. Poor aquifer.
		ALLEGHENY	Upper Freeport Lower Kittaning Vanport Putnam Hill Brooksville	Interbedded dirty sandstones and shales. Contains many important coals, clay, minor thin limestones. Overall, the section fines upwards. Poor to moderate aquifer.
		POTTSVILLE	Homewood Upper Mercer	Interbedded shales and sandstones. Minor coal and clay. Moderate aquifer.

Historically, bedrock mapping in the county has focused on the identification of key economic beds, particularly coals, but also shales and clays used in theceramic industry and limestones (Larsen, 1991 and Slucher and Rice, in progress). Little emphasis has been placed upon characterizing the entire sediment package between these key units (Collins, 1979, Larsen, 1991 and Slucher and Rice, in progress) since the initial work of Stout and Lamborn (1924). Recent stratigraphic work (Larsen, 1991 and Slucher and Rice, in progress) is placing increased emphasis upon marine marker beds and identifying key fossil assemblages.

The Pottsville Group is primarily represented by interbedded shales, sandstone, and siltstones along with thin but important coals, underclays, and limestones. The lowermost unit identified at the surface is the Upper Mercer Limestone. The easily identifiable, coarse sandstone and conglomerates of the lower Pottsville, particularly the Sharon and Massillon, are not found above drainage in the county and are rarely encountered in subsurface drilling and cores (Slucher and Rice, in progress). The uppermost units of the Pottsville Group are the Tionesta Clay and Brookville Clay, which are both rarely found within the county. The contact between the Pottsville Group and the overlying Allegheny Group is very gradational and almost arbitrary in many places (Stout and Lamborn, 1924). Pottsville units are most commonly exposed in the northern portion of the county and at the base of steeply entrenched streams farther south.

Rocks of the Allegheny Group are widespread across the central portion of the county. Rocks of the Allegheny Group are predominantly comprised of shales and dirty sandstones. The strata are interbedded with several thin but important coals as well as clay and limestone beds. In the northern part of the county, Allegheny units are exposed at the tops of ridges, overlying the Pottsville rocks. In the southern portion of the county, the Allegheny rocks are exposed at the base of stream cuts and are overlain by units of the Conemaugh Group. The rocks of the Allegheny Group have historically had the greatest economic importance. Of particular importance are the Lower Kittaning and Upper Freeport Coals. The Brookville Coal marks the base of the section, but is very poorly represented in the county. The Upper Freeport marks the top of the section and is a more identifiable marker bed.

Rocks of the Conemaugh Group are widespread throughout southern Columbiana County. Rocks in the Conemaugh Group are predominantly comprised of dirty, fine-grained sandstones, shales, and mudstones. In the lower Conemaugh, below the Brush Creek Limestone, the proportion of sandstone is higher in the eastern part of the county and shales are more abundant to the west. Reddish mudstones dominate the upper portion of the section. The top of the Upper Freeport Coal marks the base of the Conemaugh Group. The Mahoning Coal, which is near the base of the Conemaugh, is the only important coal. Thin limestones serve as important marker beds, but are generally too thin to be of major economic importance.

Rocks of the Pottsville and Allegheny Groups present in Columbiana County were primarily deposited in a shallow marine environment (Stout and Lamborn, 1924, Ferm, 1974, Horne et. al., 1978, Collins, 1979; and Weedman, 1990). The shallow marine environment was transitional with a terrigenous ("landward") environment over time. Environments varied with the 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. Sandstones and shales represent deltaic/shoreline environments. Limestones formed in slightly deeper marine waters which lacked clastic input from rivers and deltas. Coal and clay were deposited in two different environments. Coal was deposited in "back-barrier" environments along the shoreline or in "deltaic- plain" environments in swamps formed in abandoned river channels

(Horne et. al., 1978). Similarly, clay was deposited in quiet lagoonal areas directly behind the shoreline or in abandoned "oxbow" river channels (Ferm, 1974).

Rocks of the Conemaugh Group were deposited in more of a terrigenous environment (Stout and Lamborn, 1924 and Collins, 1979). The shales and mudstones have a distinctive reddish color which indicates that they were deposited in a more aerated (oxidizing) environment (Collins, 1979). These sediments were deposited in alluvial plains, landward portions of deltas, and coastal plains (Ferm, 1974). Climatic conditions were believed to be arid to semi-arid (Collins, 1979 and Weedman, 1990).

Hydrogeology

Ground water in Columbiana County is obtained from both glacial (unconsolidated) and bedrock (consolidated) aquifers. Glacial deposits are utilized as the aquifer in the buried valleys. Sand and gravel lenses within till are also utilized in upland areas in the northwestern corner of the county adjacent to Stark County. The alluvial fill and underlying outwash flanking the Ohio River also constitute an inportant aquifer. Elsewhere in the county, the glacial deposits are either too thin or too fine-grained to serve as aquifers.

Glacial aquifers in Columbiana County are highly variable, particularly within the buried valleys. The aquifers range from thin, isolated, discontinuous lenses of sand and gravel interbedded in thick sequences of glacial till or lacustrine deposits to relatively thick, extensive outwash deposits. Yields from the non-buried valley glacial deposits in northwestern Columbiana County range from 5 to 20 gallons per minute (gpm) (Crowell, 1978). These aquifers are comprised of thin lenses of sand and gravel interbedded in till. Yields in buried valleys are quite variable. Generally yields are higher in the main axis or trunk of the buried valley. Margins, the "headlands" or "up-valley" portions of the valleys, and smaller tributary valleys typically have yields averaging less than 25 gpm (Crowell, 1978). These marginal areas of the buried valleys include many areas mapped as kame terraces by White and Totten (1985). The sand and gravel lenses within the margins and tributaries of the major buried valleys tend to be thinner, finer-grained, and less well sorted. Buried valley deposits with potential yields of up to 100 gpm include aquifers underlying the Mahoning River adjacent to Mahoning County, aquifers underlying Sandy Creek in southwestern Columbiana County, portions of North Fork Little Beaver Creek northeast of Salem, the vicinity underlying Leetonia, and a portion of Middle Fork Little Beaver Creek at Lisbon (Crowell, 1978). Small segments of Sandy Creek and the valley underlying East Palestine have deposits capable of yielding between 100 and 500 gpm (Crowell, 1978) The most productive aquifers in the county are the alluvial and outwash deposits paralleling the Ohio River. These have yields up to or exceeding 500 gpm for properly constructed wells (Crowell, 1978). Test drilling may be necessary to locate water supplies from the higher-yielding aquifers.

Yields obtained from the bedrock (consolidated) aquifers range from moderate to poor. The higher-yielding aquifers of the lower Pottsville Group, such as the Sharon Sandstone and Massillon Sandstone, are largely absent in Columbiana County (Sedam, 1973). Yields ranging from 10 to 25 gpm are obtainable from wells completed primarily in the upper Pottsville and lower Allegheny Groups (Crowell, 1978). Yields ranging from 3 to 10 gpm are obtainable from wells completed primarily in the upper portions of the Allegheny Group and wells completed in the sandier, lower Conemaugh Group rocks (Crowell, 1978). Yields averaging less than 3 gpm are typical of areas where the Conemaugh Group is predominantly composed of shales, mudstones, and clay. The latter aquifer is extremely poor. Many of the wells show nearly total drawdown with pumping; "dry holes" have been reported by many drillers, and use of cisterns has historically not been uncommon.

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, limestone, and shale tend to be aquitards which impede the flow of water. Water tends to "perch" or collect on top of low permeability units (eg. shale) and move laterally through the base of an overlying unit with higher permeability (eg. sandstone). Springs and seeps mark where these contacts meet the slope or land surface. Peffer (1991) demonstrated that shales can provide sufficient water to serve domestic needs and still behave as an aquitard.

Yields are also influenced by the number of fractures and bedding planes intersected by the well. The amount of fracturing tends to increase along hillslopes 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 due to strip mining or underground mining may produce similar results. 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 underground mined areas was not evaluated in Columbiana County. Although "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Using Hydrogeologic Settings (Aller et. al., 1987)" does identify mining as a source of 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 activities have the ability to affect all DRASTIC parameters. Table 11 and 12 list the DRASTIC parameters and the possible impacts that mining may have on rating the parameters for 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 mined and underground mined areas was not evaluated, they were delineated. Only the most areal extensive mined areas were delineated on the Pollution Potential Map of Columbiana County. Delineations of mined areas were made from the Soil Survey of Columbiana County (Lessig et. al., 1968), the on-going update for the Soil Survey of Columbiana County (Roth and Buzard in progress), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the U.S.G.S. 7 1/2 minute topographic maps. Site specific information for mined areas can be obtained from the Ohio Department of Natural Resources, Division of Reclamation, and Division of Geological Survey and the U.S. Department of Interior, Division of Surface Mining.

Dr. Ann Harris at the Department of Geology, Youngstown State University, is also an authority on the historical perspective of underground mining in the Columbiana County area. It is highly recommended that a site-specific study of the mined area and surrounding areas be conducted before further use of these areas.

Table 11. Potential Factors Influencing DRASTIC Ratings for Strip Mined Areas

Parameter	Impacts and effects of activity 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 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 12. Potential Factors Influencing DRASTIC Ratings for Underground Mined Areas

Parameter	Impact of Activity and 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 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, Division of Water, Water Resources Section (WRS). Approximately 10,000 water well log records are on file for Columbiana County. Almost 3,000 of the well logs were located. Roughly 1,000 additional well logs were located by the Columbiana County SCS and by interns from the WRS. Data from approximately 4,000 well logs were plotted on U.S.G.S. 7 1/2 minute topographic maps during the course of the project. Static water levels and information on the depth to saturated zones were taken from the well log records. The Ground Water Resources of Columbiana County (Crowell, 1978) and the reports of Rau (1969) and Sedam (1973) helped to provide generalized depth to water information throughout Columbiana County. Topographic and geomorphic trends were utilized in areas where other data sources were lacking.

Depths of 5 to 15 feet (DRASTIC value = (9)) and 15 to 30 feet (7) were typical of areas in both smaller stream valleys and areas parallelling the floodplains in larger valleys in both the glaciated and unglaciated portions of the county. Depths of 15 to 30 feet (7) were common in outwash terraces along streams and in the terraces flanking the Ohio River. Depths of 5 to 15 feet (9) and 15 to 30 feet (7) were common in areas of slackwater lacustrine terraces (7Fa). Depth of 30 to 50 feet (5) were common along hill slopes and along the margins of valleys. Many of the areas mapped by White and Totten (1985) as kames and kame terraces were evaluated as having depths of water of 30 to 50 feet (5). Margins of buried valleys furthest away from modern streams also had ratings of 30 to 50 feet (5). Depths of 30 to 50 feet (5) were utilized in areas of ground moraine in northern Columbiana County. Areas with depths ranging from 30 to 50 feet (5) are typically transitional between the upland divides and ridges, and stream valleys and floodplains.

Depths of 50 to 75 feet (3) were selected for the majority of the upland areas, particularly in central and southern Columbiana County where the glacial drift is thin to absent. Ridges and crests of higher end moraines in northern Columbiana County were rated as having depths of 50 to 75 feet (3). Depths of 75 to 100 feet (2) were selected for a limited number of isolated ridge tops in southeastern Columbiana County. These ridgetops were capped by appreciable thicknesses of non-water-bearing Conemaugh rocks.

Net Recharge

This factor was evaluated using many criteria, including depth to water, topography, soil type, surface drainage, vadose zone material, and annual precipitation. General estimates of recharge provided by Pettyjohn and Henning (1979) proved to be helpful. Recharge is the precipitation that reaches or recharges the aquifer after evapotranspiration and recharge.

Values of 7 to 10 inches per year (8) of recharge were assigned to areas with highly permeable soils (e.g. sandy loams) and vadose materials (e.g. outwash), shallow depths to water, and gentle slopes. These areas typically occur on terraces or floodplains flanking modern streams. They are generally limited to the higher-rated buried valley areas within the county, as well as along the Ohio River. Values of 4 to 7 inches per year (6) were assigned to multiple settings in Columbiana County. In the glaciated portions of Columbiana County, 4 to 7 inches (6) per year of recharge was utilized for the margins, headwater areas , and tributaries of buried valleys. Kames and kame terraces were also given recharge values of 4 to 7 inches (6) per year. This rating was also utilized for end moraines which have a depth to water of less than 50 feet and slopes less than 12 percent. In the unglaciated portion of the county, recharge values of 4 to 7 inches (6) per year were selected for areas having a depth of water less than 50 feet and slopes less than 12 percent.

Recharge values of 2 to 4 inches (3) per year were selected for glaciated areas where the depth to water was greater than 50 feet. Values of 2 to 4 (3) inches per year were utilized for areas having slopes greater than 18 percent for a depth of water between 30 to 50 feet. For areas having a depth of water of 30 to 50 feet and a slope of 6 to 12 percent, the recharge value varied with soil type. In the glaciated areas, till-covered bedrock uplands and crests of end moraines typically have recharge values of 2 to 4 inches (3) per year.

In the unglaciated portion of Columbiana County, recharge values of 2 to 4 inches per year were selected for most upland areas, due to the steep topography, the absence of soils to soak up precipitation, and the generally low-permeability rocks.

Aquifer Media

Information on aquifer media was obtained from the reports of Stout and Lamborn (1924), Sedam (1973), Crowell (1978), White and Totten (1985), and Slucher and Rice (in progress). Open file bedrock topography maps from the ODNR, Division of Geological Survey proved invaluable in delineating buried valleys and mapping aquifer media. These maps include the Alliance Quarangle (Larsen, 1990a), New Middleton Quadrangle (Larsen, 1990b), Elkton Quadrangle (Larsen, 1990c), Salem Quadrangle (Larsen, in progress(a)), Damascus Quadrangle (Larsen, in progress(b)), Columbiana Quadrangle (Larsen, in progress(c), Homeworth Quadrangle (Larsen and Slucher, 1990), Lisbon Quadrangle (Larsen and Slucher in progress(a)), Hanoverton Quadrangle (Larsen and Slucher, in progress(b)), Minerva Quadrangle (Slucher, 1990), and the East Palestine Quadrangle (Slucher and Larsen 1990). Generalized bedrock topography contours also appear on the Glacial Map of Columbiana County (White and Totten, 1985). The bedrock geology maps from the ODNR, Division of Geological Survey, were used to differentiate the various bedrock units. These maps include the Alliance Quadrangle (Larsen and Rea 1990a), New Middleton Quadrangle (Larsen and Rea, 1990b), Columbiana Quadrangle (Larsen and Rea, in progress), Wellsville Quadrangle (Caudill, 1991), Salineville Quadrangle (Caudill and Slucher, 1990), Kensington Quadrangle (Slucher, 1992), Homeworth Quadrangle (Larsen and Slucher, 1991), Minerva Quadrangle (Slucher, 1990b), West Point Quadrangle (Slucher, in progress(a)), East Liverpool North and East Liverpool South Quadrangles (Slucher, in progress (b)), Gavers Quadrangle (Slucher, in progress(c)), and East Palestine Quadrangle (Slucher and Larsen, 1989). The water well records on file at the water resources section were also an important source of data. Field observations at outcrops, excavations, strip mine highwalls, and quarries helped to verify ratings in complex areas. Where more than one aquifer was present, the uppermost aquifer was rated.

The aquifer media rating for bedrock varied across the county. Where wells were completed in rocks of the Pottsville Group, an aquifer rating of (5) was selected. These aquifers are found throughout the northern part of the county and in valley areas in central Columbiana County. An aquifer rating of (4) was utilized for wells completed within the rocks of the Allegheny Group. These aquifers are best represented in the uplands of central Columbiana County and in valleys in the southern part of the county. For wells completed in the rocks of the Conemaugh Group, an aquifer rating of (3) was used. These aquifers are best represented in the uplands of southern Columbiana County.

Ratings for the aquifers in the glacial deposits varied across Columbiana County. The sand and gravel aquifers in the till uplands bordering Stark County were given an aquifer rating of (5). Sand and gravel aquifers within the buried valleys were given aquifer ratings of (6) or (7). The sand and gravel outwash and alluvial deposits flanking the Ohio River were given an aquifer rating of (8).

Soil Media

This factor was primarily evaluated using data obtained from the Soil Survey of Columbiana County (Lessig et. al., 1968). Field mapping is nearly complete for an updated Soil Survey of Columbiana County (Roth and Buzard, in progress). The new data and discussions with the mappers proved invaluable in finalizing ratings for many of the soils. Table 13 lists the soil types encountered in Columbiana County and gives information on the soils' parent material or setting and the corresponding DRASTIC rating.

Glaciation and bedrock type were two of the main factors influencing soil types in Columbiana County. Major differences can be noted between the glaciated and unglaciated portions of the county. Soil ratings were based upon the most restrictive layer or horizon within the soil profile.

Silt loam (4) was the most common soil type found in the glaciated uplands of northern and central Columbiana County. Clay loam (3) was also encountered in these uplands along the Mahoning County border. Clay loam (3) and silt loam (4) were also found occupying the slackwater terraces and lacustrine deposits of the 7Fa-Glacial Slackwater Lakes Hydrogeologic setting. Silt loam (4) was very common in alluvium and floodplain deposits. Silt loam (4) caps the terraces flanking the Ohio River. Loam (5) and sandy loam (6) were encountered on kames and kame terraces, outwash terraces, and underlying faster-flowing streams in outwash-filled valleys. In these stretches, the streams have the ability to consistently rework their channels and wash away fines. Silt loam (4), loam (5), and sandy loam (6) were also encountered in upland areas where the bedrock was covered by a very thin mantle of till.

In the unglaciated portions of Columbiana County and along the steep bedrock slopes and ridges having a very thin till cover, the bedrock lithology (type) was the major factor controlling soil type. Clay loam (3) and silt loam (4) soils were the weathering products of shales, mudstones, and siltstones. Loam (5) and sandy loam (6) were the weathering products of sandstones. Shrink-swell (aggregated) clays were the weathering products of the underclays associated with coal-bearing strata. Where the bedrock was less than 36 inches from the surface, particularly in areas of steep slopes and high erosion, soils were considered to be thin or absent and given a rating of (10).

The Canfield, Gresham, Hanover, Ravenna, Rittman, Titusville, Wadsworth, and Wooster soils, all of which are derived from weathering till, contain fragipans. A fragipan is a dense, mineralized, impermeable zone found within a few feet of the ground surface. Fragipans may noticeably restrict the downward movement of water. The net effect of the fragipan is to reduce the overall permeability of a soil within a given textural range (Aller et. al., 1987). Hence, a soil with a loam texture (5) would be rated equivalent to a silt loam (4) and a soil with a slit loam (4) texture would be rated as a clay loam (3) due to the presence of a fragipan (Table 13).

TABLE 13. Columbiana County Soils (after Lessing et. al., 1968).

Soil Name	Parent Material or Setting	DRASTIC Rating	Soil Media
Alleghney	alluvium, colluvium	4	silt loam
Bogart	outwash terraces, kames	6	sandy loam
Canfield	sandy till	4*	silt loam
Carlisle	kettles, bogs	8	peat
Cavode	weathered shale	7	shrink/swell clay
Chagrin	alluvium	4	silt loam
Chili	outwash terrraces, kames	6	sandy loam
Chilo	alluvium, fill depressions	3	clay loam
Damascus	outwash over till/lacustrine	5	loam
Dekalb	weathered sandstone	6	sandy loam
Ernest	colluvium, hillslopes	3	clay loam
Fitchville	lacustrine, slackwater	3	clay loam
Glenford	lacustrine, slackwater	4	silt loam
Gresham	till	4*	silt loam
Guernsey	weathered bedrock	7	shrink/swell clay
Hanover	till	4*	silt loam
Jimtown	outwash terraces, kames	6	sandy loam
Kerston	bogs in floodplains	8	peat
Laidig	colluvium, hillslopes	6	sandy loam
Lobdell	alluvium	4	silt loam
Lorain	lacustrine, slackwater	7	shrink/swell clay
Loudonville	till over bedrock	5	loam
Londonville/Muskingum	till over weathered bedrock	6	sandy loam
Luray	lacustrine, slackwater	4	silt loam
Marengo	slackwater, fill depressions	4	silt loam
Monongala	alluvium, colluvium	3	clay loam
Negley	outwash terraces, kames	6	sandy loam
Olmsted	outwash, coarse alluvium	5	loam
Orrville	alluvium	4	silt loam
Papakating	depressions on floodplains	5	loam
Parke	outwash terraces, kames	6	sandy loam
Purdy	colluvium, alluvium	3	clayloam
Rainsboro	lacustrine over outwash	4	silt loam
Ravenna	sandy till	4*	silt loam
Rittman	till	3*	clay loam
Sebring	lacustrine, slackwater	4	silt loam
Summitville	colluvium	7	shrink/swell clay
Titusville	till	4*	silt loam
Tyler	alluvium, colluvium	3	clay loam
Upshur	red shales, mudstones	7	shrink/swell clay
Wadsworth	till	3*	clay loam
Wayland	alluvium	5	loam
Weikert	bedrock ridges, cliff	10	thin to absent
Wellston	colluvium, hillslope	4	silt loam
Wharton	weathered shale	3	clay loam
Wilette	kettles, bogs	8	peat
Wooster	sandy till	4*	silt loam

* Soil contains a fragipan

Topography

Topography was evaluated by determining the percentage of slope obtained from the U.S.G.S. 7 1/2 minute quadrangle maps and from the Soil Survey of Columbiana County (Lessig et. al., 1968). Slopes of 0 to 2 percent (10) were selected for floodplains, flat-lying outwash or lacustrine terraces, some stream valleys, and limited areas of ground moraine. Slopes of 2 to 6 percent (9) were common in the ground moraine areas and along the crests of end moraines in the northern portion of the county. Slopes of 6 to 12 percent (5) were common along the sides of valleys in the glaciated northern part of the county and for ridgetops in the unglaciated or thinly glaciated portions of the county. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were extensively used in central and southern portions of the county.

Impact of the Vadose Zone Media

This factor was evaluated using the reports of Stout and Lamborn (1924), Crowell (1978), White and Totten (1985), and Slucher and Rice (in progress). Open file bedrock topography maps from the ODNR, Division of Geological Survey proved invaluable in delineating buried valleys and mapping the vadose media. These maps include the Alliance Quarangle (Larsen, 1990a), New Middleton Quadrangle (Larsen, 1990b), Elkton Quadrangle (Larsen, 1990c), Salem Quadrangle (Larsen, in progress(a)), Damascus Quadrangle (Larsen, in progress(b)), Columbiana Quadrangle (Larsen, in progress(c), Homeworth Quadrangle (Larsen and Slucher, 1990), Lisbon Quadrangle (Larsen and Slucher in progress(a)), Hanoverton Quadrangle (Larsen and Slucher, in progress(b)), Minerva Quadrangle (Slucher, 1990), and the East Palestine Quadrangle (Slucher and Larsen 1990). Generalized bedrock topography contours also appear on the Glacial Map of Columbiana County (White and Totten, 1985). The bedrock geology maps from the ODNR, Division of Geological Survey, were used to differentiate the various bedrock units. These maps include the Alliance Quadrangle (Larsen and Rea 1990a), New Middleton Quadrangle (Larsen and Rea, 1990b), Columbiana Quadrangle (Larsen and Rea, in progress), Wellsville Quadrangle (Caudill, 1991), Salineville Quadrangle (Caudill and Slucher, 1990), Kensington Quadrangle (Slucher, 1992), Homeworth Quadrangle (Larsen and Slucher,1991), Minerva Quadrangle (Slucher, 1990b), West Point Quadrangle (Slucher, in progress(a)), East Liverpool North and East Liverpool South Quadrangles (Slucher, in progress (b)), Gavers Quadrangle (Slucher, in progress(c)), and East Palestine Quadrangle (Slucher and Larsen, 1989).

Till was chosen as the vadose zone material in much of the glaciated, northern portion of the county. Typically a rating of (4) was selected for till. White and Totten (1985) delineated areas of "gravelly till". These areas generally corresponded with kames and kame terraces and were associated with the Kent Moraine and Kent Till in general. The Kent Till has a more sandy texture than other till units (White and Totten, 1985). Till in these areas was given a vadose rating of (5) and is referred to in the DRASTIC index charts as "sandy till". In many of the buried valleys, sand and gravel with significant silt and clay were selected as the vadose zone material and ratings of (5), (6), and (7) were utilized. The ratings varied based upon the relative proportion of sand and gravel and the coarseness and degree of sorting of the deposits. Outwash terraces in both buried valleys and in streams extending into the unglaciated portions of the county were also given ratings of (5) and (6). Sand and gravel with significant silt and clay were also selected for the terraces flanking the Ohio River. Ratings of

(6) and (7) were selected for this setting. Silt and clay were selected as the vadose zone media for alluvium and for lacustrine terraces. Ratings of (4) or (5) were selected in these areas.

Bedrock was chosen as the vadose zone media in the majority of central and in all of the southern, unglaciated portions of the county. A rating of (4) was applied to the vadose zone for rocks of the Pottsville Group and Allegheny Group. Areas with a substantial thickness of rocks of the Conemaugh Group were given a rating of (3).

Hydraulic Conductivity

Very little published hydraulic conductivity data exists for Columbiana County. The regional studies of Rau (1969) and Sedam (1973) proved to be useful. Textbook tables (Freeze and Cherry, 1979; Fetter, 1980; and Driscoll, 1986) were useful in obtaining estimated values for a variety of aquifer materials.

Values for hydraulic conductivity roughly followed the aquifer ratings; i.e. the more highly-rated aquifers have higher hydraulic conductivities. For the sand and gravel aquifers, the hydraulic conductivity is a function of coarseness, stratification, sorting, and cleanliness (absence of fines). For sand and gravel with an aquifer media rating of (5), a hydraulic conductivity of 100-300 gallons per day per square foot (gpd/ft^2) (2) was used. For sand and gravel with an aquifer media rating of (6), hydraulic conductivity values of 100-300 gpd/ft^2 (2) or 300-700 gpd/ft^2 were used. For sand and gravel with an aquifer media rating of (7), a hydraulic conductivity of 700-1,000 gpd/ft^2 (6) was selected. For sand and gravel along the Ohio River with an aquifer media rating of (8), a hydraulic conductivity of 1,000-2,000 gpd/ft^2 (8) was used.

A hydraulic conductivity rating of 1-100 gpd/ft^2 (1) was selected for all of the bedrock aquifers. The hydraulic conductivity of the bedrock is more dependent upon the amount of joints, fractures, and bedding planes and the degree of weathering than on the primary porosity of the rock.

APPENDIX B

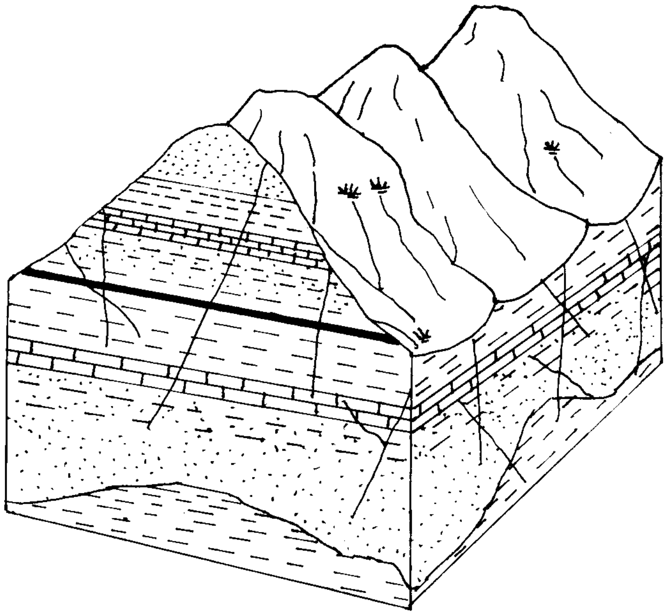
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Columbiana 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 14. Computed pollution potential indexes for Columbiana County range from 65 to 173.

TABLE 14. Hydrogeologic Settings Mapped in Columbiana County, Ohio.

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
6Da - Thin Regolith Over Bedded Sedimentary Rocks	65 - 112	58
6Fa - Alluvium With Overbank Deposits	110 - 130	11
7Aa - Glacial Till Over Bedded Sedimentary Rock	72 -123	79
7Af - Sand & Gravel Interbedded in Glacial Till	106 - 110	2
7Bb - Outwash Over Bedded Sedimentary Rocks	115 - 142	15
7D - Buried Valley	104 - 173	49
7Ea - Alluvium With Overbank Deposits	162 - 171	4
7Ec - Alluvium Over Sedimentary Rock	114 - 147	13
7Fa - Glacial Lakes and Slackwater Terrices	83 - 132	12

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. 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.



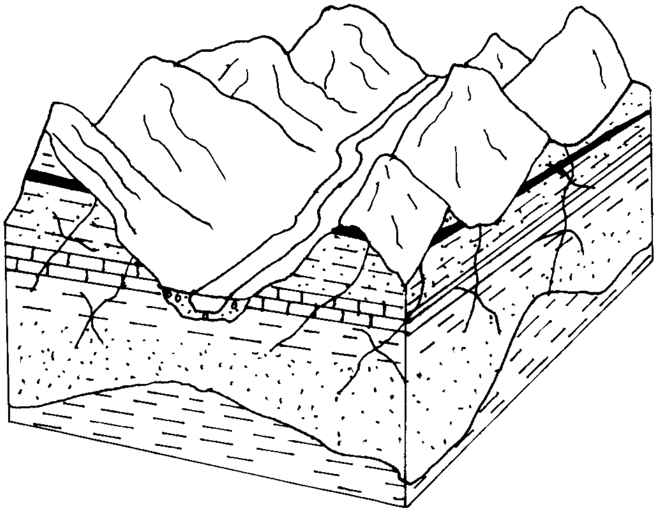
6Da Alternating Sandstone, Limestone, Shale - Thin Regolith

This hydrogeologic setting is limited to upland areas in Columbiana County outside the glacial boundary. The glacial boundary closely follows the boundary mapped by White and Totten (1985). The Soil Survey of Columbiana County (Lessig et. al., 1968) and the updated Soil Survey of Columbiana County (Roth and Buzard, in progress) were very helpful in delineating the glacial boundary. The area is characterized by high relief with broad, steep slopes and narrow, somewhat flatter ridgetops. The vadose zone and aquifers consist of slightly-dipping, fractured, alternating sequences of sandstone, shale, limestone, and coal in the Pottsville Group and Allegheny Group and sandstone, shale, and clay (mudstone) in the Conemaugh Group. Multiple aquifers are typically present. Depth to water is generally deep; shallower perched zones overlie low permeability shales, limestones, and mudstones. 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 under 10 gpm. Recharge is limited due to the steep slopes, deep aquifers, and layers of impermeable bedrock.

GWPP index values for alternating sandstone, limestone, shale - thin regolith range from 65 to 112 with the total number of GWPP index calculations equaling 58.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
6Da1	30-50	2-4	nt ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	85	100
6Da2	50-75	2-4	nt ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	77	96
6Da3	50-75	2-4	nt ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	73	86
6Da4	50-75	2-4	nt ss/sh/ls/coal	Thin or Absent	18+	int ss/sh/ls/coal	1-100	83	110
6Da5	30-50	2-4	nt ss/sh/ls/coal	Thin or Absent	12-18	int ss/sh/ls/coal	1-100	95	126
6Da6	30-50	2-4	nt ss/sh/ls/coal	Shrink-Swell (Aggregated) Clay	12-18	int ss/sh/ls/coal	1-100	89	111
6Da7	30-50	2-4	nt ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	87	106
6Da8	15-30	4-7	nt ss/sh/ls/coal	Clay Loam	2-6	int ss/sh/ls/coal	1-100	109	131
6Da9	30-50	2-4	nt ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	83	96

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
6Da10	30-50	2-4	int ss/sh/clay	Clay Loam	12-18	int ss/sh/clay	1-100	73	84
6Da11	30-50	2-4	int ss/sh/clay	Thin or Absent	18+	int ss/sh/clay	1-100	85	113
6Da12	30-50	2-4	int ss/sh/clay	Clay Loam	18+	int ss/sh/clay	1-100	71	78
6Da13	30-50	2-4	int ss/sh/clay	Thin or Absent	12-18	int ss/sh/clay	1-100	87	119
6Da14	50-75	2-4	int ss/sh/clay	Thin or Absent	6-12	int ss/sh/clay	1-100	79	115
6Da15	50-75	2-4	int ss/sh/clay	Shrink-Swell (Aggregated) Clay	6-12	int ss/sh/clay	1-100	73	100
6Da16	50-75	2-4	int ss/sh/clay	Thin or Absent	12-18	int ss/sh/clay	1-100	77	109
6Da17	30-50	2-4	int ss/sh/clay	Thin or Absent	6-12	int ss/sh/clay	1-100	89	125
6Da18	30-50	2-4	int ss/sh/clay	Sandy Loam	18+	int ss/sh/clay	1-100	77	93
6Da19	50-75	2-4	int ss/sh/clay	Silty Loam	6-12	int ss/sh/clay	1-100	67	85
6Da20	50-75	2-4	int ss/sh/clay	Thin or Absent	6-12	int ss/sh/clay	1-100	79	115
6Da21	30-50	2-4	int ss/sh/clay	Silty Loam	18+	int ss/sh/clay	1-100	73	83
6Da22	30-50	2-4	int ss/sh/clay	Clay Loam	6-12	int ss/sh/clay	1-100	75	90
6Da23	30-50	2-4	int ss/sh/clay	Silty Loam	6-12	int ss/sh/clay	1-100	77	95
6Da24	30-50	2-4	int ss/sh/clay	Shrink-Swell (Aggregated) Clay	18+	int ss/sh/clay	1-100	79	98
6Da25	50-75	2-4	int ss/sh/clay	Shrink-Swell (Aggregated) Clay	12-18	int ss/sh/clay	1-100	71	94
6Da26	30-50	2-4	int ss/sh/clay	Loam	18+	int ss/sh/clay	1-100	75	88
6Da27	50-75	2-4	int ss/sh/clay	Sandy Loam	12-18	int ss/sh/clay	1-100	69	89
6Da28	50-75	2-4	int ss/sh/clay	Sandy Loam	18+	int ss/sh/clay	1-100	67	83
6Da29	50-75	2-4	int ss/sh/clay	Thin or Absent	18+	int ss/sh/clay	1-100	75	103
6Da30	30-50	4-7	int ss/sh/ls/coal	Loam	0-2	int ss/sh/ls/coal	1-100	104	134
6Da31	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	2-6	int ss/sh/ls/coal	1-100	91	134
6Da32	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	18+	int ss/sh/ls/coal	1-100	96	123
6Da33	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	112	131
6Da34	50-75	2-4	int ss/sh/ls/coal	Shrink-Swell (Aggregated) Clay	12-18	int ss/sh/ls/coal	1-100	79	101
6Da35	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	12-18	int ss/sh/ls/coal	1-100	98	129
6Da36	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	6-12	int ss/sh/ls/coal	1-100	87	122
6Da37	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	18+	int ss/sh/ls/coal	1-100	93	120
6Da38	30-50	2-4	int ss/sh/ls/coal	Silty Loam	6-12	int ss/sh/ls/coal	1-100	85	102
6Da39	50-75	2-4	int ss/sh/clay	Silty Loam	6-12	int ss/sh/clay	1-100	67	85
6Da40	50-75	2-4	int ss/sh/clay	Silty Loam	12-18	int ss/sh/clay	1-100	65	79
6Da41	30-50	2-4	int ss/sh/clay	Sandy Loam	12-18	s + g w/sl + cl	1-100	95	113
6Da42	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	88	103
6Da43	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	6-12	int ss/sh/ls/coal	1-100	90	125
6Da44	75-100	2-4	int ss/sh/clay	Thin or Absent	18+	int ss/sh/clay	1-100	70	98
6Da45	50-75	2-4	int ss/sh/clay	Shrink-Swell (Aggregated) Clay	18+	int ss/sh/clay	1-100	69	88
6Da46	50-75	2-4	int ss/sh/clay	Silty Loam	18+	int ss/sh/clay	1-100	63	73
6Da47	50-75	2-4	int ss/sh/ls/coal	Silty Loam	6-12	int ss/sh/ls/coal	1-100	75	92
6Da48	30-50	2-4	int ss/sh/ls/coal	Clay Loam	18+	int ss/sh/ls/coal	1-100	82	88
6Da49	75-100	2-4	int ss/sh/clay	Thin or Absent	12-18	int ss/sh/clay	1-100	72	104
6Da50	75-100	2-4	int ss/sh/clay	Silty Loam	2-6	int ss/sh/clay	1-100	66	92
6Da51	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	75	90
6Da52	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	6-12	int ss/sh/ls/coal	1-100	79	102
6Da53	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	12-18	int ss/sh/ls/coal	1-100	88	119
6Da54	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	12-18	int ss/sh/ls/coal	1-100	85	116
6Da55	50-75	2-4	int ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	76	89
6Da56	75-100	2-4	int ss/sh/ls/coal	Silty Loam	6-12	int ss/sh/ls/coal	1-100	70	87
6Da57	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	78	93
6Da58	50-75	2-4	int ss/sh/ls/coal	Thin or Absent	18+	int ss/sh/ls/coal	1-100	86	113

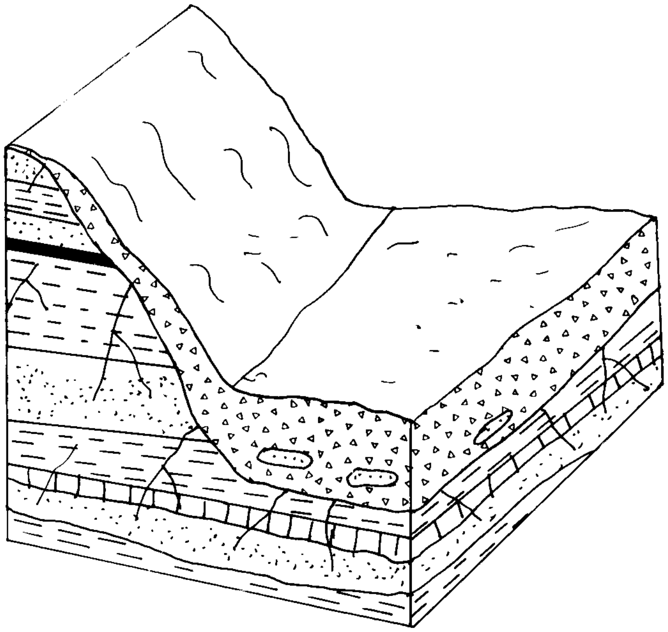


6Fa River Alluvium with Overbank Deposits

This hydrogeologic setting is limited to small tributary stream valleys within the uplands of southern Columbiana County. These streams begin and end within the unglaciated portion of Columbiana County. The setting is characterized by narrow, relatively flat-bottomed stream valleys flanked by steep bedrock ridges. Depth to water is typically shallow. Soils are predominantly silt loams or loams. The alluvium is composed primarily of fine-grained floodplain (overbank) sediments and contains minor lenses of sand and gravel. The alluvial deposits are commonly saturated, however, the alluvium is too thin to be utilized as an aquifer. The aquifer is the underlying fractured interbedded sandstones, shales, mudstones, and limestones of the Pennsylvanian System. In most areas, the alluvium is in direct connection with the underlying bedrock aquifer. Ground water yields average under 10 gpm. Recharge is moderate and is higher than along the surrounding steep bedrock slopes.

GWPP index values for the hydrogeologic setting of river alluvium with overbank depostis range from 110 to 130 with the total number of GWPP index calculations equaling 11.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
6Fa1	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	int ss/sh/ls/coal	1-100	114	144
6Fa2	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	int ss/sh/ls/coal	1-100	116	149
6Fa3	15-30	4-7	int ss/sh/ls/coal	Silty Loam	0-2	int ss/sh/ls/coal	1-100	112	139
6Fa4	15-30	4-7	int ss/sh/ls/coal	Clay Loam	0-2	int ss/sh/ls/coal	1-100	110	134
6Fa5	5-15	4-7	int ss/sh/clay	Loam	0-2	silt/clay	1-100	126	155
6Fa6	15-30	4-7	int ss/sh/ls/coal	Silty Loam	0-2	int ss/sh/ls/coal	1-100	115	142
6Fa7	5-15	4-7	int ss/sh/ls/coal	Silty Loam	0-2	silt/clay	1-100	130	156
6Fa8	15-30	4-7	int ss/sh/ls/coal	Silty Loam	0-2	silt/clay	1-100	120	146
6Fa9	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	silt/clay	1-100	122	151
6Fa10	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	int ss/sh/ls/coal	1-100	111	136
6Fa11	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	silt/clay	1-100	124	156



7Aa Glacial Till Over Bedded Sedimentary Rocks

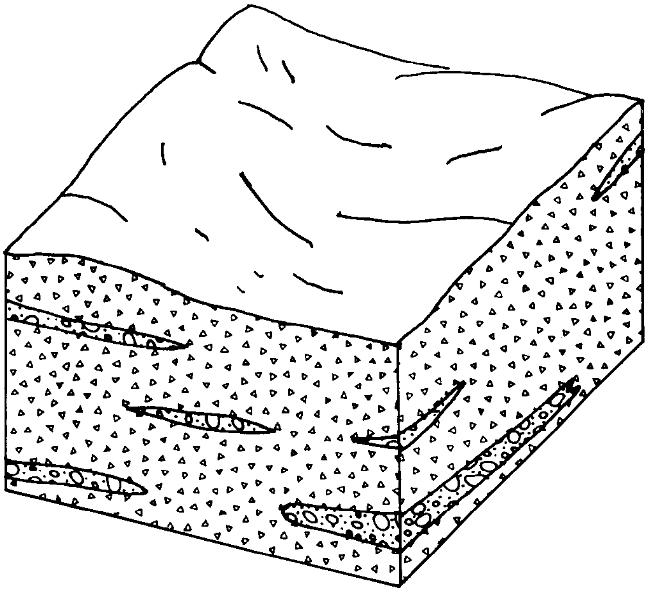
This hydrogeologic setting is variable and widespread across Columbiana County. Topography varies from rolling, low relief areas in northern portions of the county to steep, high relief areas in the central portion of the county. The aquifer consists of interbedded sandstones, shales, limestone, and coal of the Pennsylvanian, Pottsville, and Allegheny Groups. Yields range from 10 to 25 gpm for wells developed in the rocks of the Pottsville Group and lower Allegheny Group, and from 3 to 10 gpm for rocks of the upper Allegheny Group. The aquifer is typically overlain by varying thicknesses of glacial till. The till cover has an average thickness of 20 to 30 feet in the northern part of the county and thins southward to 5 to 10 feet. Soils may be thin to absent along a limited number of particularly steep slopes. Typically the till weathers to a silt loam. Depth to water is variable, averaging from 30 to 50 feet in northern Columbiana County to 50 to 75 feet in central Columbiana County. Recharge is moderate to low, depending upon the slope, thickness of the till cover, and depth to water.

GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rocks range from 72 to 123 with the total number of GWPP index calculations equaling 79.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa1	30-50	4-7	int ss/sh/ls/coal	Clay Loam	6-12	till	1-100	98	112
7Aa2	30-50	4-7	int ss/sh/ls/coal	Clay Loam	2-6	till	1-100	102	124
7Aa3	30-50	4-7	int ss/sh/ls/coal	Silty Loam	2-6	till	1-100	104	129
7Aa4	30-50	4-7	int ss/sh/ls/coal	Loam	2-6	till	1-100	106	134
7Aa5	50-75	2-4	int ss/sh/ls/coal	Clay Loam	6-12	till	1-100	76	90

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa6	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	sandy till	1-100	113	143
7Aa7	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	sandy till	1-100	109	131
7Aa8	50-75	2-4	int ss/sh/ls/coal	Clay Loam	2-6	till	1-100	80	102
7Aa9	50-75	2-4	int ss/sh/ls/coal	Loam	12-18	int ss/sh/ls/coal	1-100	78	94
7Aa10	75-100	2-4	int ss/sh/ls/coal	Clay Loam	2-6	int ss/sh/ls/coal	1-100	72	94
7Aa11	30-50	2-4	int ss/sh/ls/coal	Clay Loam	12-18	int ss/sh/ls/coal	1-100	84	94
7Aa12	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	sandy till	1-100	95	113
7Aa13	30-50	4-7	int ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	98	111
7Aa14	30-50	2-4	int ss/sh/ls/coal	Loam	12-18	int ss/sh/ls/coal	1-100	88	104
7Aa15	30-50	4-7	int ss/sh/ls/coal	Loam	6-12	sandy till	1-100	107	126
7Aa16	50-75	2-4	int ss/sh/ls/coal	Clay Loam	2-6	till	1-100	77	99
7Aa17	50-75	2-4	int ss/sh/ls/coal	Silty Loam	2-6	int ss/sh/ls/coal	1-100	79	104
7Aa18	50-75	2-4	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	75	92
7Aa19	30-50	4-7	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	100	117
7Aa20	30-50	2-4	int ss/sh/ls/coal	Silty Loam	18+	int ss/sh/ls/coal	1-100	84	93
7Aa21	50-75	2-4	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	78	95
7Aa22	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	85	100
7Aa23	30-50	2-4	int ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	83	96
7Aa24	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	77	96
7Aa25	50-75	2-4	int ss/sh/ls/coal	Loam	12-18	int ss/sh/ls/coal	1-100	75	91
7Aa26	30-50	2-4	int ss/sh/ls/coal	Loam	12-18	int ss/sh/ls/coal	1-100	85	101
7Aa27	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	87	106
7Aa28	50-75	2-4	int ss/sh/ls/coal	Silty Loam	12-18	int ss/sh/ls/coal	1-100	73	86
7Aa29	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	18+	int ss/sh/ls/coal	1-100	88	103
7Aa30	30-50	2-4	int ss/sh/ls/coal	Loam	18+	int ss/sh/ls/coal	1-100	83	95
7Aa31	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	int ss/sh/ls/coal	1-100	90	109
7Aa32	30-50	2-4	int ss/sh/ls/coal	Loam	18+	int ss/sh/ls/coal	1-100	86	98
7Aa33	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	12-18	sandy till	1-100	107	125
7Aa34	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	till	1-100	108	139
7Aa35	30-50	4-7	int ss/sh/ls/coal	Silty Loam	2-6	sandy till	1-100	109	133
7Aa36	30-50	4-7	int ss/sh/ls/coal	Silty Loam	6-12	sandy till	1-100	105	121
7Aa37	50-75	2-4	int ss/sh/ls/coal	Silty Loam	2-6	till	1-100	82	107
7Aa38	15-30	4-7	int ss/sh/ls/coal	Thin or Absent	6-12	int ss/sh/ls/coal	1-100	127	161
7Aa39	15-30	4-7	int ss/sh/ls/coal	Silty Loam	6-12	sandy till	1-100	115	131
7Aa40	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	sandy till	1-100	123	153
7Aa41	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	sandy till	1-100	106	128
7Aa42	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	sandy till	1-100	110	140
7Aa43	30-50	4-7	int ss/sh/ls/coal	Silty Loam	2-6	till	1-100	101	126
7Aa44	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	till	1-100	104	127
7Aa45	30-50	4-7	int ss/sh/ls/coal	Silty Loam	2-6	sandy till	1-100	106	130
7Aa46	30-50	4-7	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	97	114
7Aa47	30-50	4-7	int ss/sh/ls/coal	Silty Loam	6-12	sandy till	1-100	102	118
7Aa48	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	6-12	till	1-100	79	102
7Aa49	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	sandy till	1-100	119	143
7Aa50	30-50	4-7	int ss/sh/ls/coal	Loam	6-12	till	1-100	102	122
7Aa51	30-50	4-7	int ss/sh/ls/coal	Loam	6-12	till	1-100	99	119
7Aa52	50-75	2-4	int ss/sh/ls/coal	Loam	6-12	till	1-100	77	97
7Aa53	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	sandy till	1-100	119	141
7Aa54	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	sandy till	1-100	92	110
7Aa55	15-30	4-7	int ss/sh/ls/coal	Loam	2-6	sandy till	1-100	121	148
7Aa56	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	till	1-100	111	134
7Aa57	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	12-18	int ss/sh/ls/coal	1-100	95	126
7Aa58	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	6-12	int ss/sh/ls/coal	1-100	97	132

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Aa59	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	122	151
7Aa60	30-50	2-4	int ss/sh/ls/coal	Silty Loam	12-18	till	1-100	86	99
7Aa61	30-50	4-7	int ss/sh/ls/coal	Silty Loam	12-18	till	1-100	95	108
7Aa62	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	18+	till	1-100	100	115
7Aa63	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	till	1-100	114	139
7Aa64	30-50	4-7	int ss/sh/ls/coal	Silty Loam	12-18	sandy till	1-100	103	115
7Aa65	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	12-18	till	1-100	102	121
7Aa66	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	12-18	sandy till	1-100	117	135
7Aa67	15-30	4-7	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	110	127
7Aa68	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	12-18	till	1-100	112	131
7Aa69	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	18+	till	1-100	75	90
7Aa70	30-50	2-4	int ss/sh/ls/coal	Sandy Loam	18+	sandy till	1-100	93	107
7Aa71	30-50	4-7	int ss/sh/ls/coal	Loam	12-18	till	1-100	100	116
7Aa72	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	till	1-100	118	149
7Aa73	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	6-12	till	1-100	82	105
7Aa74	30-50	2-4	int ss/sh/ls/coal	Thin or Absent	18+	int ss/sh/ls/coal	1-100	96	123
7Aa75	30-50	2-4	int ss/sh/ls/coal	Silty Loam	12-18	sandy till	1-100	91	103
7Aa76	50-75	2-4	int ss/sh/ls/coal	Loam	6-12	till	1-100	77	97
7Aa77	50-75	2-4	int ss/sh/ls/coal	Sandy Loam	12-18	till	1-100	80	99
7Aa78	30-50	2-4	int ss/sh/ls/coal	Silty Loam	6-12	till	1-100	88	105
7Aa79	30-50	4-7	int ss/sh/ls/coal	Sandy Loam	18+	sandy till	1-100	105	119

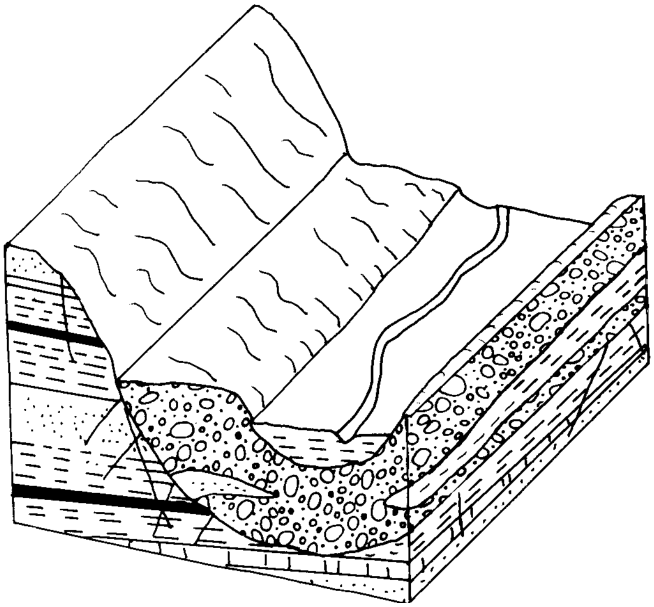


7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting is limited to a small area in far western Columbiana County, bordering Stark County. The setting encompasses areas where sand and gravel lenses within the till are the aquifer. The total thickness of drift in these areas is substantially less than that found in the 7D - Buried Valley hydrogeologic setting. This hydrogeologic setting is typically associated with end moraines and is characterized by rolling hills and low to moderate relief. Soils are typically clay loams. The sand and gravel aquifers are generally thin, discontinuous and isolated from each other. Till is the vadose zone media. Yields average from 10 to 20 gpm and are adequate for domestic supplies. Depth to water is moderate, averaging from 30 to 50 feet. Recharge is moderate due to the moderate relief, moderate depth of the water table, and the relatively low permeability of soils and till.

GWPP index values for the hydrogeologic setting of sand and gravel interbedded in glacial till range from 106 to 110 with the total number of GWPP index calculations equaling 2.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Af1	30-50	4-7	sand & gravel	Clay Loam	2-6	sandy till	100-300	110	130
7Af2	30-50	4-7	sand & gravel	Clay Loam	6-12	sandy till	100-300	106	118



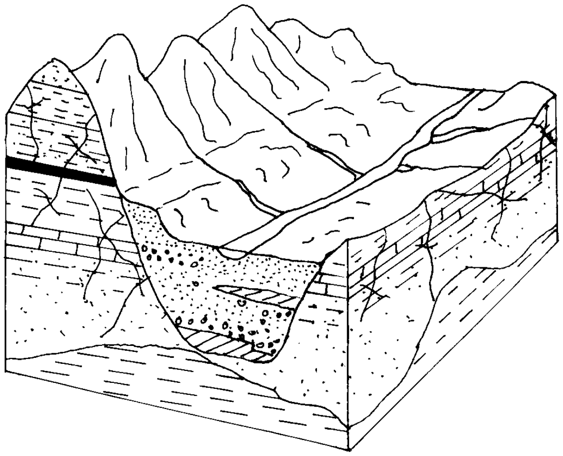
7Bb Outwash Over Bedded Sedimentary Rocks

This hydrogeologic setting consists of relatively small areas limited to outwash terraces along the valleys of West Fork Little Beaver Creek, North Fork Little Beaver Creek, and Little Beaver Creek. These outwash terraces overlie segments of stream valleys that do not contain an adequate amount of drift to be considered buried valleys. These terraces are typically outside of the glacial boundary and represented meltwater moving away from the melting ice sheet. Relief is low and the flat to rolling terraces occur at higher elevations than the modern floodplains. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with finer alluvial and lacustrine deposits. The outwash terraces are generally not thick enough to comprise the aquifer. Underlying fractured, interbedded sandstones, shales, limestone, and coals of the Pennsylvanian System serve as the aquifer. Yields average 15 to 25 gpm. The overlying terraces may be in direct contact with the aquifer or there may be finer alluvial sediments between them. Depth to water is typically shallow to moderate and is usually less than 50 feet. Soils vary from silt loam to sandy loam, depending upon whether fine alluvial material is capping the coarser outwash. Recharge is moderately high due to the relatively flat topography, relatively permeable soils and vadose, and the moderate to shallow depth to water.

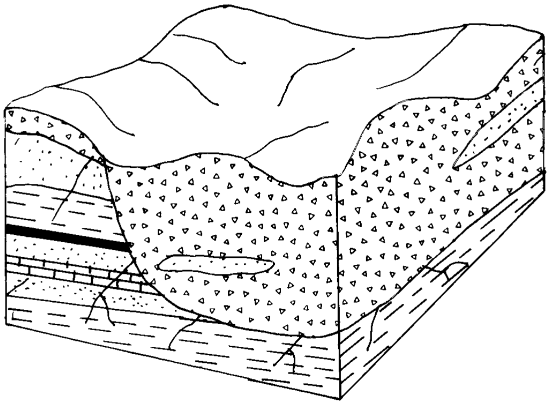
GWPP index values for the hydrogeologic setting of outwash over bedded sedimentary rocks range from 115 to 142 with the total number of GWPP index calculations equaling 15.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Bb1	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	s + g w/sl + cl	1-100	124	156
7Bb2	5-15	4-7	int ss/sh/ls/coal	Silty Loam	0-2	s + g w/sl + cl	1-100	130	156
7Bb3	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	127	155
7Bb4	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	s + g w/sl + cl	1-100	123	153
7Bb5	5-15	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	s + g w/sl + cl	1-100	134	166

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Bb6	15-30	4-7	int ss/sh/ls/coal	Silty Loam	0-2	s + g w/sl + cl	1-100	120	146
7Bb7	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	122	151
7Bb8	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	s + g w/sl + cl	1-100	119	141
7Bb9	5-15	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	137	165
7Bb10	5-15	4-7	int ss/sh/ls/coal	Peat	2-6	s + g w/sl + cl	1-100	142	177
7Bb11	5-15	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	s + g w/sl + cl	1-100	133	163
7Bb12	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	s + g w/sl + cl	1-100	128	157
7Bb13	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	s + g w/sl + cl	1-100	124	147
7Bb14	15-30	4-7	int ss/sh/ls/coal	Silty Loam	6-12	s + g w/sl + cl	1-100	115	131
7Bb15	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	s + g w/sl + cl	1-100	124	145



(A)



(B)

7D Buried Valleys

This hydrogeologic setting varied across Columbiana County. There were two common types or varieties of buried valleys within the county.

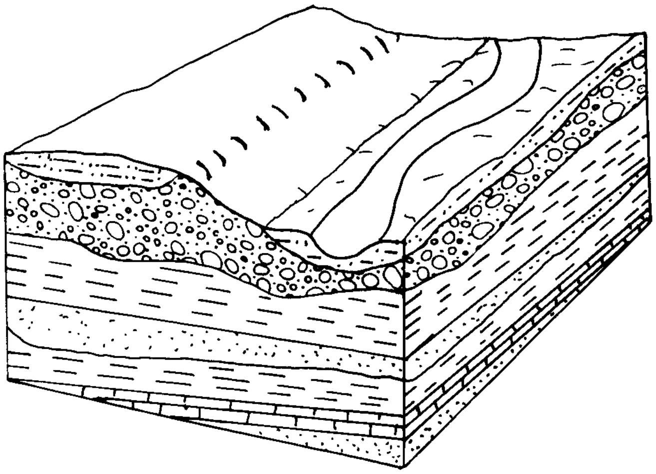
The first type of buried valley (Block diagram A) is occupied by a modern stream valley, contains abundant outwash or kame deposits, and is easy to distinguish from the surrounding steep bedrock and till uplands. Valley floors are relatively flat and margins may be rolling. These valleys contain variable thicknesses of sand and gravel and finer-grained till and lacustrine sediments. The upper 20 to 30 feet is typically composed of sand and gravel outwash or kame deposits. Depth to water is usually less than 30 feet for the trunk of the valley and 30 to 50 feet for the margins. Yields up to 500 gpm have been reported; typical yields are in the 25 to 100 gpm range. Soils are typically sandy loams or loams. The streams are commonly in direct hydraulic connection with the aquifer. Recharge is high due to the permeable soils and vadose, the shallow to moderate depth to water, and the relatively flat topography.

The second type of buried valley (Block diagram B) extends across upland areas. They are typically not easily distinguished from the surrounding topography. The relief varies from moderate to high rolling to relatively steep topography where moraines overlie the valleys. They typically are overlain by only an intermittent stream or no stream at all. The aquifer consists of thin lenses of sand and gravel interbedded in thick sequences of glacial till and lacustrine deposits. Yields commonly range from 10 to 25 gpm. Soils are typically clay loams or silt loams derived from weathering till. Depth of water is typically 30 to 50 feet and may be as deep as 50 to 75 feet. Recharge is typically moderate to low because of the greater depth to water, lower permeability soils and vadose, and steeper topography.

GWPP index values for the hydrogeologic setting of buried valley range from 104 to 173 with the total number of GWPP index calculations equaling 49.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D1	30-50	4-7	sand & gravel	Clay Loam	2-6	till	100-300	108	129
7D2	30-50	4-7	sand & gravel	Clay Loam	0-2	till	100-300	109	132
7D3	15-30	4-7	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	100-300	126	151

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7D4	30-50	4-7	sand & gravel	Clay Loam	6-12	till	100-300	104	117
7D5	30-50	7-10	sand & gravel	Loam	2-6	till	100-300	112	139
7D6	30-50	4-7	sand & gravel	Silty Loam	2-6	till	100-300	110	134
7D7	30-50	4-7	sand & gravel	Silty Loam	0-2	till	100-300	111	137
7D8	30-50	4-7	sand & gravel	Clay Loam	2-6	till	300-700	114	133
7D9	15-30	4-7	sand & gravel	Loam	0-2	s + g w/sl + cl	100-300	128	156
7D10	15-30	4-7	sand & gravel	Sandy Loam	2-6	s + g w/sl + cl	100-300	129	158
7D11	15-30	4-7	sand & gravel	Silty Loam	2-6	s + g w/sl + cl	100-300	125	148
7D12	5-15	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	100-300	153	183
7D13	5-15	7-10	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	100-300	149	173
7D14	30-50	4-7	sand & gravel	Loam	6-12	till	100-300	108	127
7D15	30-50	4-7	sand & gravel	Loam	2-6	s + g w/sl + cl	300-700	123	147
7D16	30-50	4-7	sand & gravel	Silty Loam	6-12	s + g w/sl + cl	300-700	117	130
7D17	5-15	7-10	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	100-300	144	169
7D18	15-30	4-7	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	300-700	136	165
7D19	30-50	4-7	sand & gravel	Silty Loam	6-12	till	100-300	106	122
7D20	5-15	7-10	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	300-700	155	177
7D21	30-50	4-7	sand & gravel	Sandy Loam	6-12	sandy till	100-300	115	136
7D22	15-30	4-7	sand & gravel	Loam	2-6	sandy till	100-300	127	153
7D23	15-30	4-7	sand & gravel	Loam	0-2	s + g w/sl + cl	300-700	134	160
7D24	5-15	7-10	sand & gravel	Loam	0-2	s + g w/sl + cl	300-700	157	182
7D25	5-15	7-10	sand & gravel	Loam	0-2	s + g w/sl + cl	300-700	162	186
7D26	5-15	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	300-700	159	187
7D27	15-30	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	300-700	149	177
7D28	5-15	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	700-1000	173	198
7D29	5-15	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	300-700	164	191
7D30	30-50	4-7	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	300-700	122	145
7D31	15-30	4-7	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	300-700	141	169
7D32	15-30	4-7	sand & gravel	Sandy Loam	12-18	sandy till	100-300	123	140
7D33	5-15	7-10	sand & gravel	Peat	0-2	s + g w/sl + cl	100-300	157	193
7D34	15-30	4-7	sand & gravel	Silty Loam	6-12	s + g w/sl + cl	100-300	121	136
7D35	30-50	4-7	sand & gravel	Sandy Loam	2-6	s + g w/sl + cl	100-300	119	148
7D36	30-50	4-7	sand & gravel	Silty Loam	6-12	s + g w/sl + cl	100-300	111	126
7D37	15-30	4-7	sand & gravel	Sandy Loam	2-6	s + g w/sl + cl	300-700	135	162
7D38	30-50	4-7	sand & gravel	Silty Loam	2-6	s + g w/sl + cl	100-300	115	138
7D39	5-15	7-10	sand & gravel	Loam	0-2	s + g w/sl + cl	700-1000	166	189
7D40	15-30	4-7	sand & gravel	Sandy Loam	6-12	s + g w/sl + cl	300-700	131	150
7D41	15-30	4-7	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	100-300	130	161
7D42	15-30	4-7	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	300-700	145	167
7D43	15-30	4-7	sand & gravel	Sandy Loam	2-6	s + g w/sl + cl	700-1000	149	173
7D44	5-15	4-7	sand & gravel	Peat	0-2	s + g w/sl + cl	300-700	163	197
7D45	5-15	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	700-1000	168	194
7D46	15-30	4-7	sand & gravel	Silty Loam	2-6	s + g w/sl + cl	300-700	131	152
7D47	5-15	4-7	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	300-700	142	165
7D48	5-15	4-7	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	100-300	148	179
7D49	15-30	7-10	sand & gravel	Sandy Loam	0-2	s + g w/sl + cl	700-1000	158	184

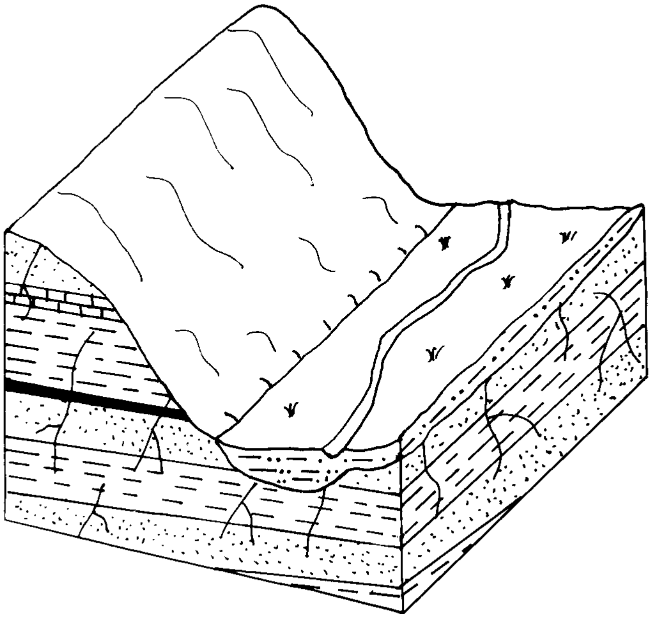


7Ea River Alluvium with Overbank Deposits

This hydrogeologic setting is limited to the alluvial/outwash deposits flanking the Ohio River. These terraces sit from 15 to 75 feet above the Ohio River. The terraces are relatively flat to rolling. The aquifer is comprised of interbedded layers of sand and gravel outwash. The vadose media consists of sand and gravel interbedded with siltier alluvial deposits. Depth to water ranges from 15 to 30 feet. Soils vary from silt loams on lower terraces to sandy loams on higher terraces. Maximum yields range from 100 to 500 gpm. Yields over 600 gpm are found in Jefferson County. There may be some degree of interconnection between the Ohio River and its tributaries and the underlying aquifers. Recharge is high due to the permeable soils and vadose, the shallow depth to water, and the relatively flat topography.

GWPP index values for the hydrogeologic setting of river alluvium with overbank deposits range from 162 to 171 with the total number of GWPP index calculations equaling 4.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ea1	15-30	4-7	sand & gravel	Silty Loam	0-2	s + g w/sl + cl	1000-2000	168	185
7Ea2	15-30	7-10	sand & gravel	Silty Loam	2-6	s + g w/sl + cl	1000-2000	167	182
7Ea3	15-30	7-10	sand & gravel	Sandy Loam	6-12	s + g w/sl + cl	1000-2000	162	176
7Ea4	15-30	7-10	sand & gravel	Sandy Loam	2-6	s + g w/sl + cl	1000-2000	171	192



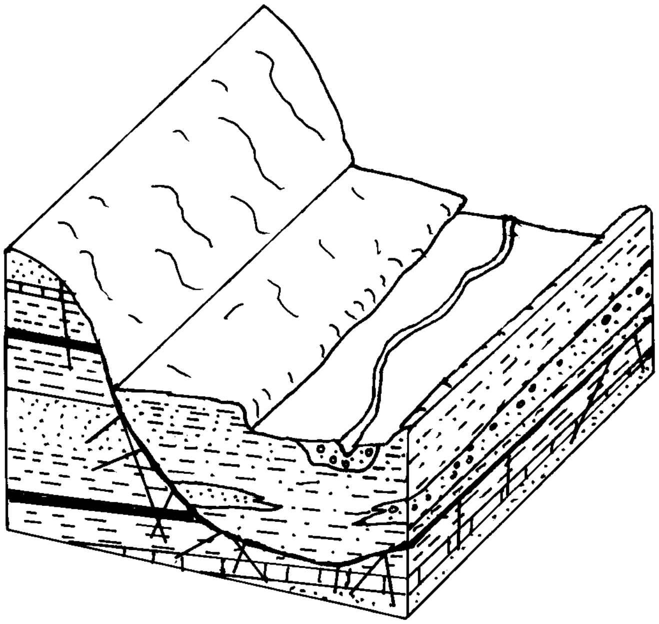
7Ec Alluvium Over Bedded Sedimentary Rock

This hydrogeologic setting is predominantly located in upland areas of northern and central Columbiana County. The setting consists of small tributary streams in upland areas with thin glacial cover. The setting is characterized by narrow, flat-bottomed stream valleys flanked by steeper bedrock uplands. Depth to water is typically shallow, averaging from 10 to 30 feet. The aquifer consists of fractured, interbedded sandstones, shales, limestones, and coals of the Pennsylvanian System. Soils range from silt loams to sandy loams, but are usually silt loams developed in the alluvium. The alluvium is typically in direct connection with the aquifer. Yields developed from the fractures and bedding planes in the bedrock average from 10 to 20 gpm. The vadose zone media may be the silty alluvium or the bedrock, depending upon the thickness of the alluvium and the depth to water. Recharge is moderate to high due to the shallow depth to water, flat-lying topography, presence of modern streams, and the moderately low permeability of the bedrock and fine alluvium.

GWPP index values for the hydrogeologic setting of alluvium over bedded sedimentary rocks range from 114 to 147 with the total number of GWPP index calculations equaling 13.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ec1	15-30	4-7	int ss/sh/ls	Silty Loam	0-2	s + g w/sl + cl	1-100	120	146
7Ec2	5-15	4-7	int ss/sh/ls/coal	Silty Loam	0-2	s + g w/sl + cl	1-100	130	156
7Ec3	5-15	4-7	int ss/sh/ls/coal	Loam	0-2	silt/clay	1-100	132	161
7Ec4	15-30	4-7	int ss/sh/ls/coal	Silty Loam	0-2	silt/clay	1-100	117	143
7Ec5	15-30	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	122	151
7Ec6	15-30	4-7	int ss/sh/ls/coal	Loam	2-6	s + g w/sl + cl	1-100	121	148
7Ec7	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	2-6	s + g w/sl + cl	1-100	123	153
7Ec8	5-15	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	silt/clay	1-100	134	166

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Ec9	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	silt/clay	1-100	114	139
7Ec10	5-15	4-7	int ss/sh/ls/coal	Loam	0-2	s + g w/sl + cl	1-100	145	173
7Ec11	5-15	7-10	int ss/sh/ls/coal	Sandy Loam	0-2	s + g w/sl + cl	1-100	147	178
7Ec12	5-15	7-10	int ss/sh/ls/coal	Silty Loam	0-2	s + g w/sl + cl	1-100	143	168
7Ec13	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	0-2	s + g w/sl + cl	1-100	124	156



7Fa Glacial Lakes and Slackwater Terraces

This setting is characterized by flat-lying areas that were formed in low velocity water of glacial and slackwater lakes that filled pre-existing drainage systems. These areas are often dissected by modern streams and contain remnant terraces. The terraces are generally flat-lying to rolling. The terraces are comprised primarily of clay and silt, but may also contain some sand and gravel outwash. The setting is bordered by steep, unglaciated bedrock uplands. The sand and gravel lenses are not thick enough or persistent enough to constitute the aquifer. Underlying fractured, interbedded sandstones, shales, limestones, and coals of the Pennsylvanian System serve as the aquifer. Depth to water is typically shallow due to the presence of streams found within the setting. Soils are variable and include clay loams, silt loams, sandy loams, and shrink-swell (aggregated) clays. Recharge in this setting is moderate due to the relatively shallow depth to water, flat-lying topography, and the moderate to low permeability soils and vadose.

GWPP index values for the hydrogeologic setting of glacial lakes and slackwater terraces range from 83 to 132 with the total number of GWPP index calculations equaling 12.

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Fa1	15-30	4-7	int ss/sh/ls/coal	Clay Loam	0-2	silt/clay	1-100	110	134
7Fa2	15-30	4-7	int ss/sh/ls/coal	Sandy Loam	6-12	silt/clay	1-100	111	134
7Fa3	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	silt/clay	1-100	111	136
7Fa4	30-50	2-4	int ss/sh/ls/coal	Silty Loam	12-18	silt/clay	1-100	83	96
7Fa5	15-30	4-7	int ss/sh/ls/coal	Clay Loam	2-6	silt/clay	1-100	109	131
7Fa6	5-15	4-7	int ss/sh/ls/coal	Loam	0-2	silt/clay	1-100	127	157
7Fa7	5-15	4-7	int ss/sh/ls/coal	Loam	0-2	silt/clay	1-100	132	161

Setting	Depth to Water (ft)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography	Vadose Zone Media	Hydraulic Conductivity	Rating	Pest Rating
7Fa8	15-30	4-7	int ss/sh/ls/coal	Shrink-Swell (Aggregated) Clay	0-2	silt/clay	1-100	115	151
7Fa9	15-30	4-7	int ss/sh/ls/coal	Silty Loam	2-6	silt/clay	1-100	114	139
7Fa10	15-30	4-7	int ss/sh/ls/coal	Shrink-Swell (Aggregated) Clay	2-6	silt/clay	1-100	120	154
7Fa11	15-30	4-7	int ss/sh/ls/coal	Clay Loam	2-6	silt/clay	1-100	112	134
7Fa12	30-50	2-4	int ss/sh/ls/coal	Silty Loam	6-12	silt/clay	1-100	85	102