GROUND WATER POLLUTION POTENTIAL
OF SUMMIT COUNTY, OHIO

BY

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ABSTRACT

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

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

Ground water pollution potential analysis in Summit County resulted in a map with symbols and colors, which illustrate areas of varying ground water pollution potential indexes ranging from 52 to 193.

Summit County lies entirely within the Glaciated Central hydrogeologic setting. A complex network of buried valley systems cross the county. Valleys that were flowing south prior to the advance of ice typically contain fairly coarse, thick sand and gravel outwash deposits that can have maximum yields exceeding 500 gallons per minute (gpm). Valleys that were flowing northward prior to the advance of ice typically were blocked and filled with fine-grained till and lacustrine deposits. Maximum yields from these valleys rarely exceed 50 gpm. Yields of 5-25 gpm to less than 5 gpm are obtained from thin lenses of sand and gravel interbedded with glacial till and lacustrine sediments along the margins of the buried valleys and in upland areas containing moderately thick drift.

Interbedded sandstones, shales, and siltstones of the Pennsylvanian System and interbedded sandstones, siltstones, and shales of the Mississippian System comprise the aquifer for the many of the upland areas in Summit County. Wells developed from highly fractured sandstones of the Pennsylvanian Sharon and Massillon Formations yield up to 100 gpm in parts of eastern and southern Summit County. Yields in the Pennsylvanian Pottsville range from 25-100 gpm to 5-25 gpm depending upon the proportion of sandstones to finer-grained rocks and presence of fractures. In the southeastern corner of the county, thin limestones, coals, and clays are encountered. These rocks commonly have yields around 5-25 gpm. Rocks from the Sharon and Massillon Formations and the Pottsville Group typically occupy higher uplands and ridge tops. Wells developed in the interbedded shales, fine-grained sandstones, and siltstones of the Mississippian Cuyahoga Group typically yield from 5 to 25 gpm. These units are widespread throughout the county. Yields of 5 to 25 gpm are developed in wells completed in thin sandstones of the Mississippian Logan and Black Hand

Formations in southwestern Summit County. Yields of 5 to 25 gpm are obtained from the Mississippian Berea Sandstone in the northern part of the county. Fine-grained shales from the Mississippian Bedford Shale, lower Cuyahoga Group, and the Devonian Ohio Shale are found in the northwestern and north central part of the county and yield less than 5 gpm.

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

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 percent of Ohio citizens rely on ground water for drinking and household use from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 750,000 rural households depend on private wells; 43,500 of these wells exist in Summit County.

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

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

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

APPLICATIONS OF POLLUTION POTENTIAL MAPS

The pollution potential mapping program offers a wide variety of applications in many counties. The ground water pollution potential map of Summit County has been prepared to assist planners, managers, and state and local officials in evaluating the relative vulnerability of areas to ground water contamination from various sources of pollution. This information can be used to help direct resources and land use activities to appropriate areas, or to assist in protection, monitoring, and clean-up efforts.

An important application of the pollution potential maps for many areas will be assisting in county land use planning and resource expenditures related to solid waste disposal. A county may use the map to help identify areas that are suitable for disposal activities. Once these areas have been identified, a county can collect more site-specific information and combine this with other local factors to determine site suitability.

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

A pollution potential map can assist in developing ground water protection strategies. By identifying areas more vulnerable to contamination, officials can direct resources to areas where special attention or protection efforts might be warranted. This information can be utilized effectively at the local level for integration into land use decisions and as an educational tool to promote public awareness of ground water resources. Pollution potential maps may be used to prioritize ground water monitoring and/or contamination clean-up efforts. Areas that are identified as being vulnerable to contamination may benefit from increased ground water monitoring for pollutants or from additional efforts to clean up an aquifer.

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

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

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

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

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

Hydrogeologic Settings and Factors

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

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

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

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

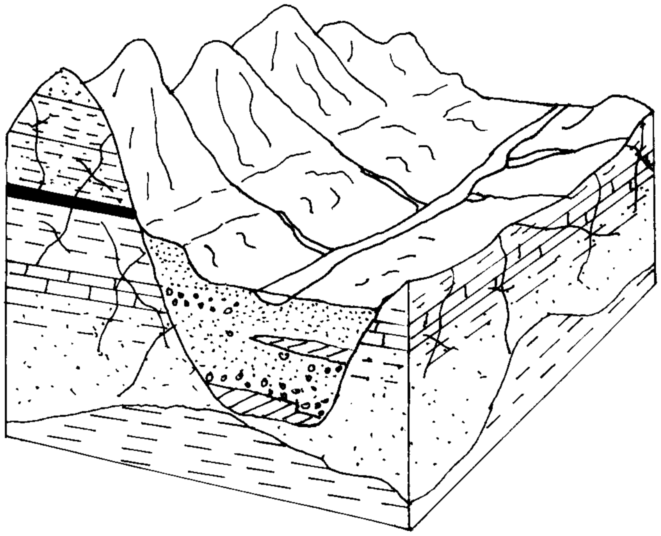
These factors incorporate concepts and mechanisms such as attenuation, retardation, and time or distance of travel of a contaminant with respect to the physical characteristics of the hydrogeologic setting. Broad consideration of these factors and mechanisms coupled with existing conditions in a setting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

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

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

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

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



7D Buried Valley

This hydrogeologic setting is widespread and varies considerably through Summit County. An extensive network of pre-glacial and interglacial rivers created the buried valleys that downcut into the bedrock. Summit County lies on a major drainage divide that was breached and modified extensively by the multiple glacial advances.

The block diagram above shows one common form of buried valley deposit, which is exemplified by the Tuscarawas River in Springfield Township and the Little Cuyahoga River north of the airport. These valleys are occupied by a modern river and floodplain and contain abundant outwash and kame deposits. The upper portion of these valleys contains 50 to 100 feet of sand and gravel interbedded with alluvium. Depth to water is typically less than 30 feet. Yields over 100 gpm are obtainable from large diameter wells. Soils are typically sandy loams or silt loams. The streams are in direct connection with the aquifer and recharge is typically high. GWPP index values for these settings are usually over 140.

GWPP index values for the hydrogeologic setting of Buried Valley range from 80 to 193, with the total number of GWPP index calculations equaling 225.

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

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

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

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

Weighting and Rating System

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

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

Pesticide DRASTIC

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

Table 1. Assigned weights for DRASTIC features

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

Table 2. Ranges and ratings for depth to water

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

Table 3. Ranges and ratings for net recharge

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

Table 4. Ranges and ratings for aquifer media

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

Table 5. Ranges and ratings for soil media

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

Table 6. Ranges and ratings for topography

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

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

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

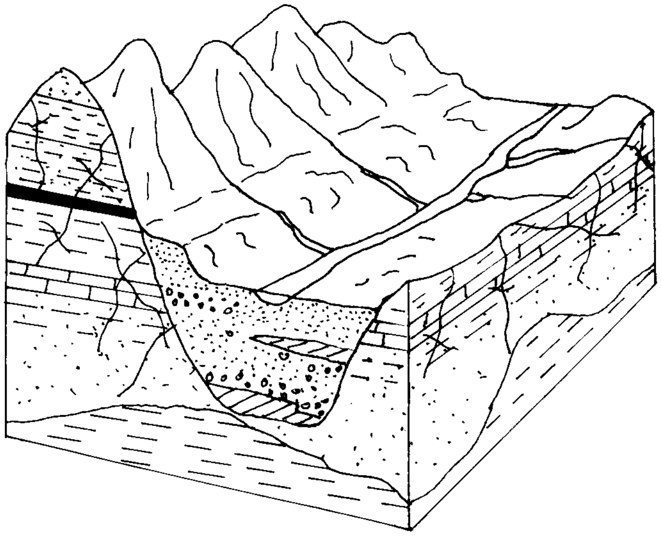
Table 8. Ranges and ratings for hydraulic conductivity

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

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1, Buried Valley, identified in mapping Summit 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 148. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 45 to 223. The diversity of hydrogeologic conditions in Summit County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the 10 settings identified in the county range from 52 to 193.

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 Summit 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 Summit County is included with this report.



SETTING 7D1		GENERAL		
FEATURE	**RANGE**	**WEIGHT**	**RATING**	**NUMBER**
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand & Gravel	3	7	21
Soil Media	Sandy Loam	2	6	12
Topography	6-12%	1	5	5
Impact of Vadose Zone	Sand & Gravel w/Silt & Clay	5	7	35
Hydraulic Conductivity	700-1000	3	6	18
		DRASTIC	INDEX	148

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

INTERPRETATION AND USE OF GROUND WATER POLLUTION POTENTIAL MAPS

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

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

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

Here the first number (**7**) refers to the major hydrogeologic region and the upper case letter (**D**) refers to a specific hydrogeologic setting. The following number (**1**) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (**148**) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived.

The maps are color-coded using ranges depicted on the map legend. The color codes used are part of a national color-coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow) representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet) representing areas of lower vulnerability to contamination. The maps also delineate large man-made and natural features such as lakes, landfills, quarries, and strip mines, but these areas are not rated and therefore are not color-coded.

GENERAL INFORMATION ABOUT SUMMIT COUNTY

Demographics

Summit County occupies approximately 413 square miles in northeastern Ohio (Figure 3). It is bounded to the west by Medina County, to the north by Cuyahoga County, to the east by Portage County, to the south by Stark County, and to the southwest by Wayne County.

The approximate population of Summit County, based upon year 2000 census estimates, is 542,899 (Department of Development, Ohio County Profiles, 2002). Akron is the largest community and the county seat. Agriculture accounts for roughly 15 percent of the land usage in Summit County. Woodlands, primarily in the northern part of the county, account for approximately 15 percent of the land usage. Urban, industrial, and residential are the other major land uses in the county. Residential growth is increasing primarily along the margins of the county, particularly in Hudson Township, Green Township, and Bath Township (Montrose). Mining, including sand and gravel pits, is a land use in various sections of the county. There are numerous lakes and reservoirs, especially in the southern part of the county. More specific information on land usage can be obtained from the Ohio Department of Natural Resources, Division of Real Estate and Land Management (REALM), Resource Analysis Program (formerly OCAP).

Climate

The *Hydrologic Atlas for Ohio* (Harstine, 1991) reports an average annual temperature of approximately 50 degrees Fahrenheit for Summit County. The average temperatures decrease slightly towards the northeastern corner. Harstine (1991) shows that the average precipitation ranges from approximately 36 inches per year in the southern edge of the county up to 40 inches near the northeast corner. The normal annual precipitation at the Akron-Canton Airport is 36.82 inches per year based upon a twenty-year (1961-1980) period (Owenby and Ezell, 1992). The mean annual temperature at the Akron-Canton Airport for the same twenty-year period is 49.7 degrees Fahrenheit (Owenby and Ezell, 1992).

Physiography and Topography

Summit County lies within the Glaciated Allegheny Plateau section of the Appalachian Plateau Province (Frost, 1931; Fenneman, 1938, and Bier, 1956). Brockman (1987) and Schiefer (2002) indicate that the northern and southwestern portions of the county are part of the Killbuck-Glaciated Pittsburgh Plateau and the southeastern and central portions of the county are part of the Akron-Canton Interlobate Plateau. Highly variable topography and relief are found in Summit County. Broad, flat-lying buried valleys are found in the south

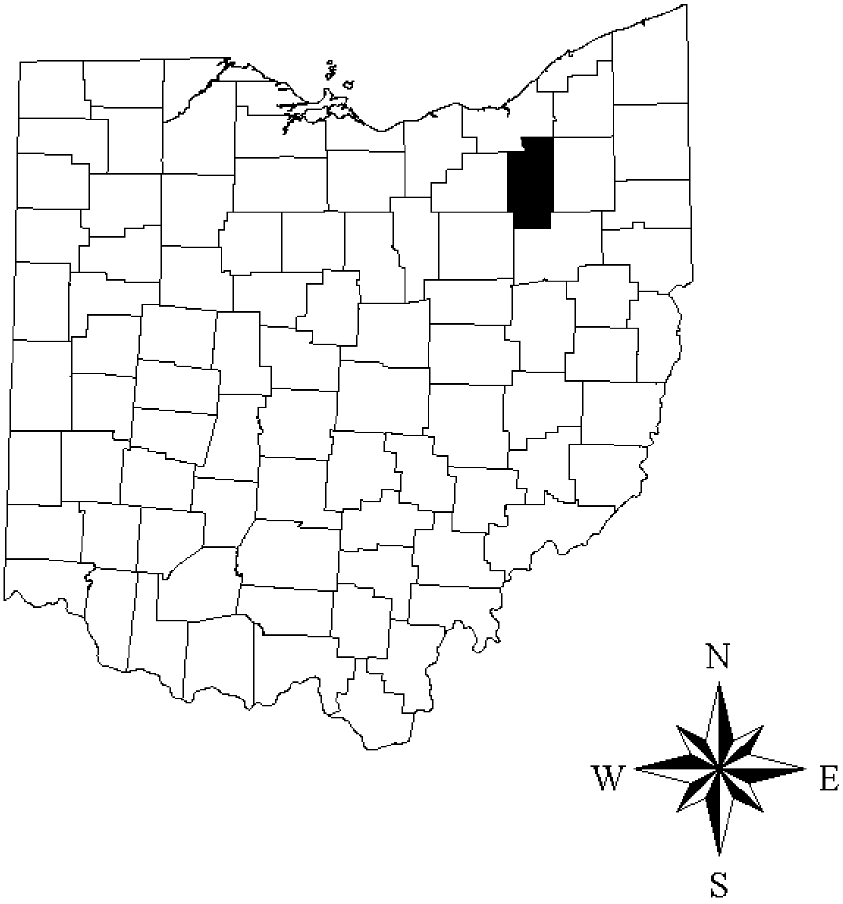


Figure 3. Location map of Summit County, Ohio.

central and western portions of the county. Hummocky end moraine complexes and resistant sandstone ridges increase the relief of upland areas. Steeply dissected ravines and valley walls flank the Cuyahoga River Valley north of Akron.

Modern Drainage

The drainage divide between the Ohio River Basin and the Lake Erie Basin extends across southern Summit County. The Cuyahoga River and its tributaries drain much of northern, central, and eastern Summit County. Important local tributaries include the Little Cuyahoga River, Tinkers Creek, Mud Brook, Furnace Run, and Yellow Creek. The western fringe of Richfield Township serves as part of the headwaters of the East Branch of the Rocky River. The Tuscarawas River and its tributaries drain the southern and southwestern part of Summit County. Important tributaries include Wolf Creek, Pigeon Creek, and Hudson Run.

Pre- and Inter-Glacial Drainage Changes

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

Prior to glaciation, the drainage in Ohio is referred to as the Teays Stage. The Teays River drained the southern and western two thirds of the state and was the master stream for what is now the upper Ohio River Valley. Other drainages of that age are referred to as Teays Stage even if they did not drain into the Teays or its tributaries. Summit County lies to the north of the drainage divide; drainage was to the north towards the Lake Erie Basin.

Stout et al. (1943) referred to the master stream draining Summit County during Teays Stage as the Dover River. The Dover River had its headwaters in Harrison County. In Summit County, the Dover River’s course was similar to that of the modern Cuyahoga River north of Akron. The Ravenna River, a northerly flowing stream, drained northeastern Twinsburg Township (Fig. 4). Smith and White (1953) suggested that the Dover River instead cut through just the very southwest corner of Summit County near Clinton. The Dover River then followed a course similar to that of Chippewa Creek and extended through Medina County. Smith and White (1953) referred to the deep ancestral river underlying the present Cuyahoga River north of Akron as the Akron River. The headwaters of the Akron River were local, perhaps near Summit Lake or perhaps further west nearby present Yellow Pond.

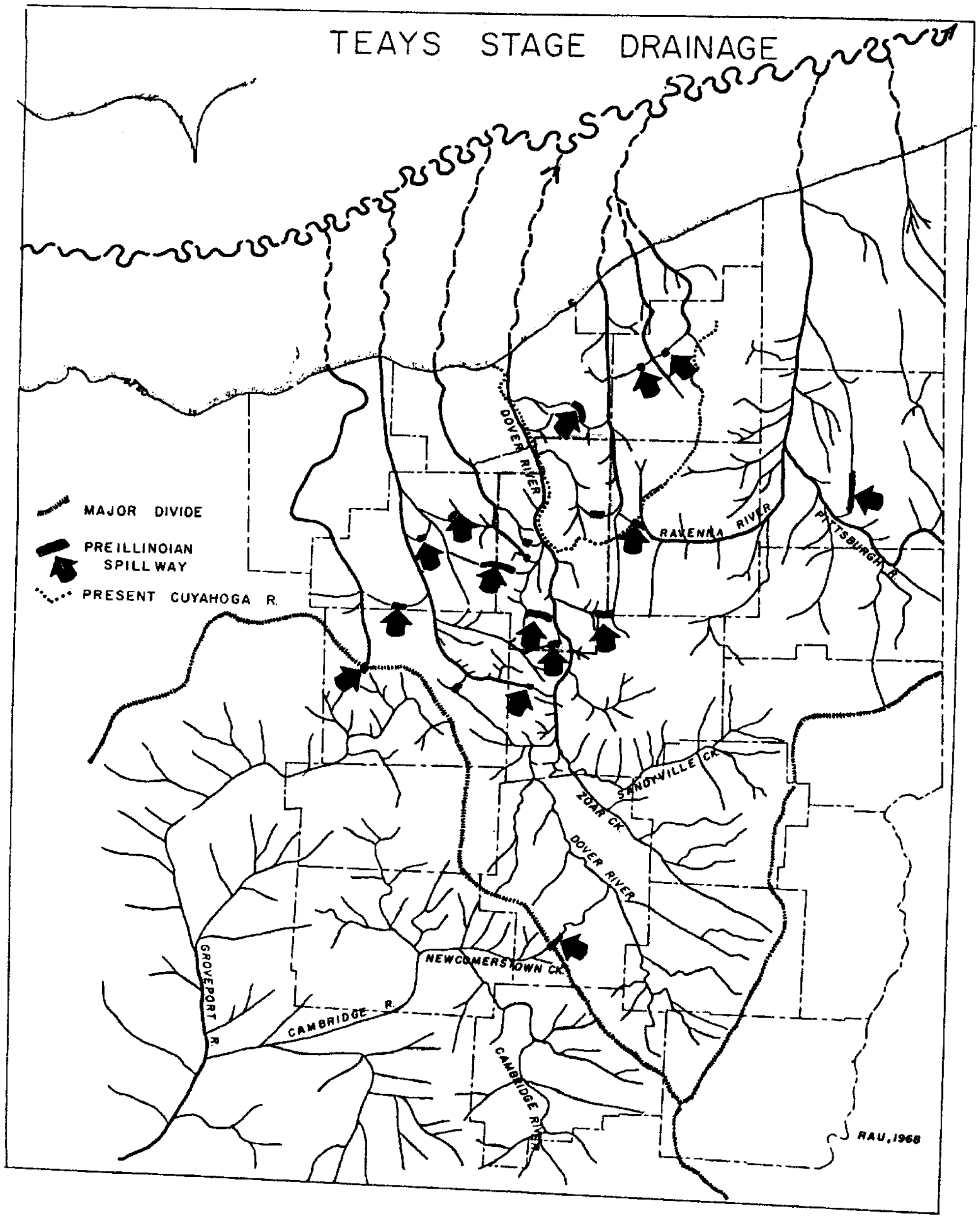


Figure 4. Teays Stage drainage-paleodrainage (after Rau, 1969).

Smith and White (1953) tied a number of the buried valleys found in Summit County into this paleodrainage system. One tributary entered the county in southern Green Township and trended northwest under the Portage Lakes, then due north, under Summit Lake. Another tributary followed a course similar to the modern Tuscarawas River through southwestern Springfield Township. A shorter tributary followed a course similar to that of modern Little Cuyahoga River to nearby the Akron Municipal Airport. A larger tributary flowed from Barberton northeastward through Norton Township and Copley Township following a course similar to that of present Pigeon Creek. A southeasterly flowing tributary in Bath Township followed a course similar to the lower portion of Yellow Creek. A deep valley originating in southwestern Hudson Township flowed southwestward through parts of Stow and Northampton Townships. Modern Mud Brook closely follows this course.

With the advance of the earliest, pre-Illinoian ice sheet, the northerly flowing ancestral stream was blocked. Ponding resulted from the ice damming. As the lake grew, it eventually spilled over, creating a new outlet. Drainage reversed to the south following a course similar to that of the modern Tuscarawas River. Southerly drainage and deepening of the valley underlying the Portage Lakes probably also occurred at this time.

The advance of Illinoian ice probably caused a continuation of the ice blockage to northerly flowing streams. Stout et al. (1943) initially proposed that during the Illinoian ice advance that northeastern Ohio was ice-free and that a northerly flowing river, referred to as the Massillon River, followed a course similar to the earlier Dover River. Smith and White (1953), Rau (1969a), Wittine (1970), White (1982, 1984) and Szabo (1987) all discuss the advance of Illinoian ice into Summit County. Perhaps during the ice-free interval before or following the Illinoian advance, the drainage reverted temporarily back to the north, towards the Lake Erie Basin. Such drainage may more accurately reflect the concept of the Massillon River.

Further drainage changes that occurred during the Illinoian and Wisconsinan ice advances will be discussed in the following section on glacial geology, as these changes are concurrent with the overall glaciation of Summit County.

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 Summit County. Older ice advances, which predate the most recent (Brunhes) magnetic reversal (about 730,000 Y.B.P.), are now commonly referred to as pre-Illinoian (formerly Kansan).

The majority of the glacial deposits fall into four main types: (glacial) till, lacustrine, outwash, and ice-contact sand and gravel (kames). Drift is an older term that collectively refers to the entire sequence glacial deposits. Buried valleys may contain a mix of all of these types of deposits. Ancestral stream channels filled with glacial/alluvial sediments are referred to as buried valleys. The buried valleys are filled with differing sequences of coarse sand and gravel outwash, glacial till, ice-contact deposits, finer-grained lacustrine (lake) and modern, silty alluvial or floodplain deposits. These deposits vary with the energy level of the

Table 9. Generalized Pleistocene stratigraphy of Summit County, Ohio

Age (years ago)	**Epoch**	**Stage**	**Killbuck Lobe** SW Summit Co. Medina Co.	**Cuyahoga Lobe** Cuyahoga Co. Central/northern Summit Co.	**Grand River Lobe** Portage Co. SE Summit Co.
25,000 to 70,000	Pleistocene	Wisconsinan	Hiram Till Hayesville Till Navarre Till	Hiram Till Lavery Till Kent Till	Hiram Till Lavery Till Kent Till
			?	Lacustrine?	?
70,000 to 120,000		Sangamonian	Lake and alluvial deposits		
120,000 to 730,000		Illinoian	Millbrook Till	Northhampton Till Mogadore Till	Titusville Till
			Kame deposits		
730,000 to 2,000,000		Pre-Illinoian	Sediments in deep buried valleys		

streams at that time. Streams leading away from melting glaciers are high energy and deposit coarser outwash. Streams that are blocked by ice or by thick channel deposits tend to be ponded and filled with finer-grained sediments. Such valleys are also typically filled with till from the advancing ice sheets. As the ice sheets melt within the valleys, both outwash and ice-contact features may be deposited. Modern tributaries, which lead into streams overlying the buried valleys, tend to contain variable thicknesses of sand, gravel, and silty alluvium. Till is an unsorted, non-stratified (non-bedded) mixture of sand, gravel, silt, and clay deposited directly by the ice sheet. There are two main types or facies of glacial till.

Lodgement till is "plastered-down" or "bulldozed" at the base of an actively moving ice sheet. Lodgement till tends to be relatively dense and compacted and pebbles typically are angular, broken, and have a preferred direction or orientation. "Hardpan" and "boulder-clay" are two common terms used for lodgement till. Ablation or "melt-out" till occurs as the ice sheet melts or stagnates away. Debris bands are laid down or stacked as the ice between the bands melts. Ablation till tends to be less dense, less compacted, and slightly coarser as meltwater commonly washes away some of the fine silt and clay.

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

At the land surface, till accounts for two primary landforms: ground moraine and end moraine. Ground moraine (till plain) is relatively flat to gently rolling. End moraines are ridge-like, with terrain that is steeper and more rolling or hummocky. Goldthwait et al. (1961 and Pavey et al., 1999) mapped end moraines regionally across the state. In northern Summit County, the northernmost end moraine, the Defiance Moraine, maintains a fairly recognizable trend, wrapping around the Cuyahoga River Valley in Northfield, Boston, and Northfield

Townships. The remaining end moraines all coalesce together, becoming largely indistinguishable from each other. Further complicating the moraine patterns are a number of factors including resistant sandstone ridges that create a bedrock-controlled topography. Intensive stream dissection and gully erosion along the flanks of the Cuyahoga River complicate moraine patterns. Underlying kame deposits beneath the surficial till create hummocky terrain similar to end moraines. White (1982 and 1984) referred to these coalesced moraines as the Summit Morainic Complex. Other studies (Rau, 1969a and Wittine, 1970) refer to the coalesced moraines collectively as the Wabash Moraine. The Kent Moraine lies immediately east of Summit County in Portage County (Winslow and White, 1966 and White, 1982). End moraines commonly serve as local drainage divides.

During the Wisconsinan (most recent) ice advance, ice advanced into northeastern Ohio in 3 distinct lobes. These lobes extended from the main ice sheet crossing the Lake Erie basin much like fingers extending from a hand. The Grand River Lobe extended from the very eastern margin of Summit County into Pennsylvania. The relatively narrow Cuyahoga Lobe came down the Cuyahoga River Valley. The Killbuck Lobe entered the western margin and southwestern corner of Summit County. It has been suggested (Rau, 1969, Szabo and Totten, 1995, and Szabo, 1987) that the Illinoian ice may have been deposited in much the same matter.

Pre-Illinoian deposits have not been identified in Summit County (White, 1984). It is possible they may exist in one of the deeper buried valleys. Illinoian age deposits in Summit County include subsurface till and kame deposits and some of the surficial till in southeastern Summit County. Initially, it was believed that the Cuyahoga Lobe deposited the Mogadore Till during an early Wisconsinan ice advance. The Mogadore Till is dense, sandy and stony. This till is associated with the Millbrook Till found to the west in the Killbuck Lobe and the Titusville Tills found in the Grand River Lobe east of Akron (White, 1982). The Titusville Till was proposed as being older than 40,000 Y.B.P. based upon radiocarbon (C^{14}) dates from exposures in northwestern Pennsylvania (White et al.., 1969). Current thinking (Totten, 1987 and Eyles and Westgate, 1987) suggests that there was probably insufficient ice available in North America for a major ice advance into the Great Lakes area until the Late Wisconsinan Woodfordian sub-stage (approximately 25,000 Y.B.P.). The age of deposits previously determined to be early to mid-Wisconsinan in age is therefore being re-evaluated. The Mogadore Till is now believed to be Illinoian in age. Some of the subsurface kame deposits identified by White (1984) underlie the Mogadore Till and are now considered to be Illinoian in age. Another till, which seems to be correlative to the Millbrook Till, is the Northampton Till (Szabo 1987, Szabo and Totten, 1995 and Szabo and Ryan, 1981). The Northampton Till is also now believed to be Illinoian in age.

The Navarre Till of the Killbuck Lobe and the Kent Till of the Cuyahoga and Grand River Lobes are the oldest of the Late Wisconsinan Woodfordian tills (White, 1982 and 1984, and Szabo and Totten, 1995). These advances occurred about 23,000 YBP. The Navarre Till extends across the southwest corner of the county (White, 1984). The Navarre Till is friable (loose), non-compact, sandy, and stony. Sand and gravel lenses are common in this till. Some of the outwash and kame deposits in the southwestern corner of the county may be associated with the Navarre Till advance. Many of the surficial kame and outwash deposits found in the county are associated with this till unit (White, 1982 and 1984). The Kent Till is very similar to the Navarre Till in compositions and character. It is found at the surface along the eastern margin of Summit County. It also underlies younger tills across much of northern Summit County.

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

The Hayesville Till of the Killbuck Lobe is the surficial till found in the western uplands of Bath, Copley, Norton, and Franklin Townships (White, 1982 and 1984). The Hayesville Till is moderately compact, dense, sparingly to moderately pebbly, and has a clayey-silty texture. The till is commonly thin, patchy, and discontinuous in this area. It is typically highly weathered. The equivalent Lavery Till, deposited by either the Cuyahoga Lobe or Grand River Lobe, is the surficial till found in northern Stow Township (White, 1984). The Lavery Till is quite similar to the Haysville Till in texture and pebble content. The Lavery Till is also, thin, patchy, and discontinuous.

The Hiram Till is the youngest till encountered in Summit County (White, 1982 and 1984). It is the surficial till found across northern Summit County. The Hiram Till is not differentiated between the three lobes. The Hiram Till is relatively soft, non-compact, and sparingly pebbly and has a silty-clay to clayey texture. The fine texture is probably due to the till eroding and incorporating lacustrine deposits or shale bedrock. The Hiram Till may have been deposited in a fairly wet environment transitional between lacustrine and an ablational environment. The Hiram Till is commonly thin; however, it is thicker in areas of lower relief.

Lacustrine deposits were created as a result of the formation of lakes, particularly within the Cuyahoga River Valley and in other buried valleys (Rau, 1969a, Szabo and Miller, 1986, and Szabo, (1987). The damming of northerly-flowing streams by the advancing ice sheets typically created the lakes. Smaller, localized lakes could be created along tributaries as they were cut-off from the main trunk streams. Typically, lacustrine deposits are composed of fairly dense, cohesive, uniform silt and clay with minor fine sand. Thin bedding, referred to as laminations, is common in these deposits. Such sediments were deposited in quiet, low-energy environments with little or no current.

Outside of the Cuyahoga River Valley, lacustrine deposits probably occur at depth in many of the deeper buried valleys (Smith and White, 1953). Surficial lacustrine deposits are found in the vicinity of Pigeon Creek in eastern Copley Township (White, 1984). These deposits may have been created by local damming of streams due to blockage by recently deposited kames. Lacustrine deposits are found in eastern Twinsburg Township, just west of Aurora Pond. These deposits are associated with drainage blockage in Portage County (Winslow and White, 1966 and Angle, 1991).

Rau (1969a), Wittine (1970), and Szabo (1987) discuss the evolution of a series of lakes in the Cuyahoga River Valley in great detail. Evidence supplied by these authors show that these sequences of lake deposition date back into the Illinoian Advance and pre-date the Mogadore Till. Figure 5 (Szabo, 1987) shows the rough sequence of the ancestral lakes occupying the Cuyahoga River Valley. The lakes were formed between the advancing (or retreating) ice sheet and the Summit Morainic Complex (or Wabash Moraine of older literature). Lakes occupying this position have been referred to as Lake Cuyahoga. It is believed that these lakes were formed during the ice advance that deposited the Mogadore Till, the Northampton Till, perhaps the Kent Till, and the Lavery Till. Drainage outlets and spillways were cut through the Summit Morainic Complex and flow was to the south towards the Tuscarawas River. Thick sequences of lacustrine silts and clay interbedded with fine-grained tills are exposed in ravines throughout the Cuyahoga River Valley in northern Summit County. These lacustrine units are saturated and subject to erosion and slope failure, which has created numerous engineering problems in the area (Miller, 1970) and Gardner et al. (1974).

Tributary valleys such as ancestral Yellow Creek and Mud Brook that emptied into Lake Cuyahoga deposited sandy deltas. Bain (1975) and Wittine (1970) discuss the deltaic deposits at length. Similarly, water was trapped between the ice sheets and the Defiance Moraine. This more northerly lake in the Lower Cuyahoga Valley was referred to as Lake Independence. This lake eventually drained to the north as the ice sheet receded further into the Lake Erie Basin. White (1984) speculated that gravelly terraces along the Cuyahoga River Valley in Northfield Township/Sagamore Hills area are related to Lake Maumee, the highest ancestral level of Lake Erie. Eventually, headward erosion of newly formed streams breached both the Defiance Moraine and the Summit Morainic Complex.

The Cuyahoga River eventually broke through the Kent Moraine near the Summit County-Portage County Line and reached the zone of headward erosion working upstream (south) from the ancestral modern Cuyahoga River. Drainage along the Little Cuyahoga River was also captured at this time. Rau (1969a) and Smith and White (1953) discuss the evolution of the Cuyahoga River. The deposition of kames in the vicinity of Summit Lake diverted the flow of the headwaters of the Tuscarawas River westward and southward across Coventry Township. Eventually this portion of the river was captured by the headwaters of the main trunk of the Tuscarawas River eroding northward through Barberton (Smith and White, 1953 and White, 1984).

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 Summit County may be located in upland areas or in valleys adjacent to modern streams. Outwash deposits associated with stream valleys were referred to in earlier literature as valley trains. Sorting and degree of coarseness depend upon the nature and proximity of the melting ice sheet. Braided streams usually deposited the outwash. Such streams have multiple channels, which migrate across the width of the valley floor, leaving behind a complex record of deposition and erosion. As modern streams downcut, the older, now higher elevation,

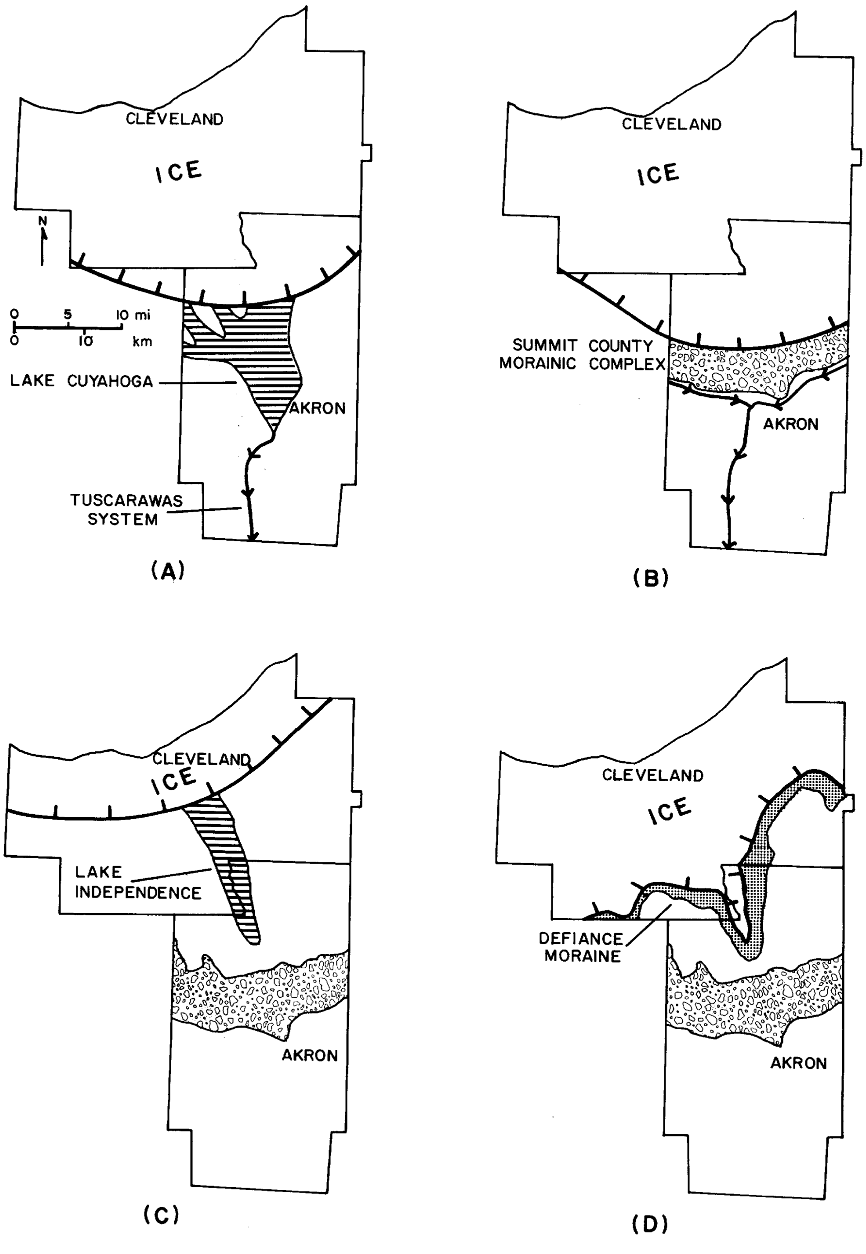


Figure 5. Relation of ice, lakes, and moraines during the deposition of Northampton till (Szabo, 1987).

remnants of the original valley floor are called terraces. White (1984) has delineated some of the major terraces in the county. All of the surficial terraces were reported as being Wisconsinan in age (White, 1984). Areas of outwash deposits include those adjacent to Tinkers Creek in Twinsburg Township, a large upland area north of Northfield Center and west of Hudson, extensive deposits adjacent to Pigeon Creek, terraces along the Tuscarawas River, the Little Cuyahoga River, and the Cuyahoga River in Northampton Township, an area east of Tallmadge, an area west of Springfield Lake, and the Portage Lakes area.

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 Summit County, the majority of the kames are deposited along the margins or flanks of valleys, particularly within the headwaters of the drainage systems. These kames tend to coalesce together along the valley margins. Such features are referred to as kame terraces. They represent deposition of materials between the melting ice sheet and the bedrock and till slopes flanking the ice-filled valleys. Eskers are elongate, sinuous deposits that marked deposition by drainage channels beneath the iced sheet. Crevasse fills are similar except that they occurred at the top of the ice sheet or within the ice sheet.

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

The most notable kames are found extending from southwestern Copley Township and northeastern Norton Township southeastward into the Portage Lakes area of Coventry, Franklin, and Green Townships and into Springfield Township. These fairly continuous kame fields extend into Stark County (Delong and White, (1963) and Williams (1991) and Portage County (Winslow and White, 1966 and Angle, 1991) forming the largest area of kame deposition and topography in Ohio (White, 1982). It is believed that these kame deposits are related to the deposition of both the Mogadore Till and the later Kent Till and Navarre Till. The Kent Till and Kent Moraine in Portage County especially appear to be related to the deposition of this kame field (Winslow and White, 1966). Other areas with abundant kame deposits include Van Huyning Run, Hudson Run, and Wolf Creek in southwestern Summit Count, along Yellow Creek in Bath Township, along the Little Cuyahoga River and the Cuyahoga River in Tallmadge Township, southern Northampton Township, and in southern Hudson Township.

Peat and muck are organic-rich deposits associated with low-lying depression areas, bogs, kettles, and swamps. Muck is a dense, fine silt with a high content of organics and a dark black color. Peat is typically brownish and contains pieces of plant fibers, decaying wood, and mosses. The two deposits commonly occur together, along with lacustrine or slack water clays and silts. The majority of these deposits are found along lower-lying portions of valley floors including margins of floodplains and terraces. Extensive peat deposits are found in the vicinity of Pigeon Creek and Schocalog Run in Copley Township. Smaller, isolated peat deposits are found in bogs and kettles in the Portage Lakes area and Springfield Township.

Bedrock Geology

Most of the bedrock exposed at the surface in Summit County belongs to the Mississippian and Pennsylvanian Systems. Some Devonian shales crop out at the stream base of some of the ravine walls in extreme northern Summit County. Table 10 summarizes the bedrock stratigraphy found in Summit County. The ODNR, Division of Geological Survey, has Open-File Reconnaissance Bedrock Geological Maps done on a 1:24,000 USGS topographic map base available for the entire county. The ODNR, Division of Water, has Open File Bedrock State Aquifer mapping available for the county also.

The Devonian Ohio Shale is the oldest bedrock unit exposed in Summit County. It crops out near the stream base along the Cuyahoga River in northern Northfield Township (Smith and White, 1953 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). This unit is also believed to underlie most of the prominent buried valleys, including the main trunk of the Cuyahoga River, Furnace Run, and Yellow Creek. The Ohio Shale is a brownish black to greenish gray thin-bedded carbonaceous shale. It is commonly found with carbonate/siderite concretions in the lowermost 50 feet of the formation. The Ohio Shale is typically fractured and contains a high degree of organic matter, pyrite, petroleum, and is also very mildly radioactive. The Ohio Shale was deposited in deep oceans that had limited circulation of fresher waters and sediments. Organic material was slow to decompose in the oxygen-starved, stagnant water. The Olentangy Shale is greenish gray to medium gray, thin-bedded, and contains limestone nodules in the lower third of the formation.

The Mississippian Bedford Shale crops out along the edges of the lower valley walls of the Cuyahoga River Valley and its major western tributary valleys (Smith and White, 1953 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). The Bedford Shale is a gray to brown or reddish-brown shale with interbedded sandstone and siltstone. It is comprised of very fine-grained silt and clay particles deposited in the outer (distal) margins of a delta.

The Mississippian Berea Sandstone is relatively widespread through the northern part of Summit County (Smith and White, 1953 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). It is a fine- to medium-grained, light greenish-gray to brown sandstone that may contain minor shale interbeds. This aquifer is present in most of the northern half of the county. Thickness does not exceed 100 feet. The Berea Sandstone consisted of river channel and bank sediments deposited along the proximal or near-shore edge of a broad delta. Near the top of the unit, encroaching marine waters submerged the sediments. The sediments were then re-deposited along adjacent shorelines (Rau, 1969b). Further south in Summit County, the Berea and Bedford are mapped together because the units are so highly interbedded (ODNR, Division of Water, Bedrock State Aquifer Map, 2000).

Table 10. Bedrock stratigraphy of Summit County, Ohio

System	Group/Formation (Symbol)	Lithologic Description
Pennsylvanian	Allegheny-Upper Pottsville (Pa-up)	Thin brown to gray sandstones, siltstones, shale, and coal. Local thickness <100 feet. Poor to moderate aquifer yielding 5-25 gpm. Limited to southeast corner of county.
	Massillon through Sharon Formations (Pm-s)	The Massillon Formation is a coarse to medium-grained gray-white cross-bedded sandstone. The Sharon is a loosely cemented, cross-bedded, coarse-grained gray to tan sandstone with conglomerate zones. This aquifer exceeds 100 feet in thickness. The best bedrock aquifer in the area, yields range from 5 to 100 gpm. Found in upland areas throughout Summit County.
Mississippian	Logan and Black Hand Formations (Mlb)	The Logan consists of reddish-brown fine-grained sandstones interbedded with siltstones and shales. The Black Hand is a massive, coarse-grained sandstone, yellow to brown in color. Limited to southwest corner of county. Thickness exceeds 100 feet. Yields range from 5 to 100 gallons per minute.
	Cuyahoga Formation (Mcg)	Gray to brown shale with thin sandstone and siltstone interbeds. Thickness commonly greater than 100 feet. Yields range from 5 to 25 gpm. Widespread aquifer in Summit County.

Mississippian	Berea Sandstone (Mb)	Fine- to medium-grained, light greenish-gray to brown sandstone. Thickness is typically <100 feet. Yields average 5-25 gpm. Found in northern Summit County.
	Bedford Shale (Mbd)	Gray to reddish brown shale with minor siltstone. Thickness less than 100 feet. Poor aquifer, yields less than 5 gpm. Limited to valleys in northern Summit County.
	Berea Sandstone and Bedford Shale (Mb-bd)	Interbedded, transitional mix of the two units. Usually less than 100 feet thick, yields less than 5 gpm. Limited to valleys in central Summit County.
Devonian	Ohio and Olentangy Shales (Dohol)	The Ohio Shale is a brownish-black to greenish-gray thin-bedded fissile shale. Concretions, high organics, and pyrite are common. The Olentangy Shale is greenish-gray, softer, and may have limestone nodules. Thickness is greater than 100 feet. Poor aquifer with poor water quality, yields <5 gpm. Limited to areas immediately adjacent to the Cuyahoga River and Furnace Run in northwestern Summit County.

The Mississippian Cuyahoga Formation is widespread throughout Summit County. It crops out along numerous valley walls and underlies Pennsylvanian rocks in most upland areas. The Cuyahoga Formation consists of interbedded sandstones, siltstones, and shales that represent deltaic to fluvial sediments deposited in a rapidly fluctuating, shoreline environment. Older literature (Smith and White, 1953, Szmuc, 1957, Winslow et al., 1953, and Winslow and White, 1966, Szmuc, 1970) identifies three members of the Cuyahoga Formation. The oldest unit is the Orangeville Shale and is overlain by the Sharpsville Sandstone and the Meadville Shale. The Gorge Metro Park in Cuyahoga Falls is perhaps the best place to see these units exposed.

The Mississippian Black Hand and Logan Formation are found along the southern margin of Franklin Township. These units are found in the subsurface and cropping out along the valley walls of the Tuscarawas River. The Logan formation consists of brown to reddish-brown sandstones interbedded with siltstones and shales; in some areas, siltstones and shales may predominate. The Black Hand formation is massive, coarse-grained sandstone, yellow to brown in color. The transition between shales and sandstones reflects the transition between coarser and finer stream deposition. The gradation also reflects the relative position of the shoreline over time, with coarser deposition closer to land and finer-grained sediments more distal from the shore. Drillers commonly refer to these sandstones as the “Big Injun”. These units reflect deposition in a high-energy, near-shore, deltaic environment.

Pennsylvanian System rocks are present in the upland areas of much of Summit County (Smith and White, 1953 and ODNR, Division of Water, Bedrock State Aquifer Map, 2000). The basal units are the Sharon and Massillon Formations of the Pottsville Group. The Massillon Formation is coarse- to medium-grained gray-white sandstone that is commonly cross-bedded, but can be massive with prominent shale breaks. The Sharon Formation is a loosely cemented, cross-bedded, coarse- to medium-grained gray-white to light reddish-tan sandstone with interbedded zones of pebbly conglomerate. Various shales, coals, and minor sandstones occur between the two major formations in this aquifer. The coal seams were mined locally for a number of years in Green and Coventry Townships. Thickness of these coarse-grained units is highly variable and can locally exceed 200 feet. Outcrop area may include remnants of the Mercer Formation (Allegheny and Upper Pottsville undivided) up to 50 feet thick. The Sharon and Massillon Formations are very resistant to erosion and tend to form steep, narrow ridges and ledges, particularly where the glacial drift is thin. Recent research (Coogan, 1974 and Ninke and Evans, 2002) indicates that the Sharon and Massillon Formations were deposited by high-energy, braided stream, fluvial deposits. These deposits dominated a relatively high-energy alluvial plain, perhaps transitional between an upland and the coastline. Earlier studies had suggested a variety of marine, deltaic, or meandering stream environments (Ninke and Evans, 2002). Locally, the Sharon Formation has downcut channels into the earlier Mississippian sediments.

The Allegheny and undivided Pottsville Groups occupy uplands in the southeastern corner of Green Township. These units include all formations above the Massillon Formation, particularly the Homewood Sandstone, where present. The Allegheny and Pottsville Groups include gray to black shales, siltstones, and sandstones with minor amounts of clay, flint, limestone, and coal. Weedman (1990) provides an excellent account of the complex depositional environments, which created the rocks of the Pennsylvanian System, particularly of the Allegheny Group. These highly transitional environments included both terrestrial ("land-based") and marine-derived sediments.

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

Ground Water Resources

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

Yields exceeding 500 gpm are obtainable from the coarse, well-sorted sand and gravel outwash deposits in the Cuyahoga River Valley nearby Silver Lake and the east-west trending portion of the Tuscarawas River (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000). These aquifers have modern, overlying streams that provide recharge to sustain these high yields. Test drilling or geophysical methods are recommended to help locate the higher yielding zones. Proper well construction and development is also needed to insure the high sustainable yields capable from these larger diameter wells. Smaller diameter wells should be suitable for serving domestic/farm needs within this aquifer. Yields of 100 to 500 gpm are obtained from wells completed in coarse, well-sorted outwash deposits. These deposits are found along Wolf Creek and Pigeon Creek in Copley and Norton Townships and Barberton, the north-south buried valley in the central Akron area near Summit Lake, the Little Cuyahoga River north of Akron Municipal Airport, the upper portion of the Mud Brook buried valley just west of Hudson and Stow, a portion of lower Mud Brook Valley just east of the Cuyahoga River, and by the confluence of Chippewa Creek and the Tuscarawas River near Clinton (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Smith and White, 1953 and Schmidt, 1979). These high yielding deposits commonly are nearby modern overlying streams or are overlain by permeable kame fields.

Yields of 25 to 100 gpm are obtained from wells drilled in outwash, lacustrine, alluvial, or kame deposits. Typically, these deposits are thinner, less coarse, and are not as clean or well-sorted as the above, higher-yielding aquifers. They also may not have nearby overlying streams. The sand and gravel units may be interbedded with finer-grained silty to clayey lacustrine or alluvial deposits or till. Aquifers yielding 25 to 100 gpm include portions of the Cuyahoga River north of Akron, Yellow Creek Valley, the southern and eastern Portage Lakes area, northeastern Green Township and southeastern Springfield Township, along east-west trending buried valley between Stow and Hudson, a similar buried valley lying between Stow and Twinsburg, and parts of a buried valley underlying Tinkers Creek (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Smith and White, 1953, Schmidt, 1979, Williams, 1982, and Heaton, 1983).

Yields of 5 to 25 gpm are obtained from thin lenses of sand and gravel interbedded with glacial till where the drift is of adequate thickness. Such upland areas include many portions of southern and eastern Summit County (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979). Other areas yielding 5 to 25 gpm include buried valley sequences that predominantly contain thick sequences of clayey to silty lacustrine and alluvial deposits or till. Examples include portions of the Cuyahoga River Valley just north of Akron and in southern Northampton Township, portions of valleys underlying Furnace Run, Van Huyning Creek, Hudson Run, and areas of thick drift between the Portage Lakes and Barberton (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979). In some areas, yields average less than 5 gpm. These areas contain thick fine-grained tills and lacustrine deposits with very limited sand and gravel lenses. Alternatively, the sand to silty-sand lenses may be thick; however the material is so fine-grained that it makes it difficult to develop and pump a well. Low-yielding areas of thick drift include the main trunk of the buried valley just east of the Cuyahoga River Valley in parts of northern Northampton, Boston, and Northfield Townships, and portions of the buried valley in northeastern Twinsburg Township (ODNR, Division of Water Open File, Glacial State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979)

Yields from the consolidated, bedrock aquifers throughout the county are variable. The highest-yielding bedrock aquifers are the coarse, highly fractured zones of the Sharon Sandstone and Massillon Sandstone (ODNR, Division of Water, Bedrock State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979). These units, which cap the higher elevation upland areas and ridges, typically yield 25 to 100 gpm (ODNR, Division of Water Open File, Bedrock State Aquifer Map, 2000, Smith and White, 1953, Sedam, 1973, and Schmidt, 1979). These zones are in the vicinity of Smithville and Orrville. In some areas near Stow, Cuyahoga Falls, and Portage Lakes, these highly productive sandstone aquifers are overlain by sand and gravel outwash deposits, which provide additional recharge and increased yields to the bedrock. Lower elevation areas covered by thicker drift and areas where the Sharon and Massillon Formations are less fractured yield 5 to 25 gpm (ODNR, Division of Water Open File, Bedrock State Aquifer Map, 2000).

Wells developed in the Mississippian Black Hand Sandstone and coarser units of the Logan Formation in southern Franklin Township have yields ranging from 25 to 100 gpm (ODNR, Division of Water, Bedrock State Aquifer Map, 2000). Yields ranging from 5 to 25 gpm are associated with the interbedded shales, fine-grained sandstones, and siltstones of the Cuyahoga Formation (ODNR, Division of Water, Bedrock State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979). These aquifers are widespread through almost all of the uplands in Summit County. Yields from wells developed in the dirty sandstones, shales, siltstones, coals, and thin limestones of the Allegheny-Pottsville undivided Groups in the southeastern part of Green Township range from 5 to 25 gpm (ODNR, Division of Water, Open File, Bedrock State Aquifer Map, 2000).

Yields of 5 to 25 gpm are obtained from the Berea Sandstone in much of the northwestern and north central portion of the county (ODNR, Division of Water, Bedrock State Aquifer Map, 2000 and Rau, 1969). The Berea Sandstone is encountered along the valley sides of the Cuyahoga River and its tributaries. It is also found at depth underlying shaley portions of the Cuyahoga Formation. Yields less than 5 gpm are obtained from shaley portions of the Cuyahoga Formation, the Bedford Shale, and the Devonian Ohio Shale in northwestern Summit County (ODNR, Division of Water, Bedrock State Aquifer Map, 2000, Smith and White, 1953, and Schmidt, 1979). These units are encountered along the margins of the Cuyahoga River Valley and its tributaries. Wells that could not be completed in the thick, fine-grained sequences of drift may be completed in these shaley units. Typically, yields from these units are marginal for even domestic needs and may require extra storage. Water quality from these deep aquifers also tends to be quite poor.

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

Strip and Underground Mined Areas

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

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

Mining and reclamation activities have the ability to affect all DRASTIC parameters. Tables 11 and 12 list the DRASTIC parameters and the possible impacts that mining may have on rating the parameters in strip-mined and underground mined areas. These tables are not meant to be a comprehensive listing of the impacts of mining on ground water systems. They are provided to illustrate the uncertainty of evaluating the pollution potential of mined areas.

Although the pollution potential of strip and abandoned underground mined areas were not evaluated, they were delineated. Only the most prominent and conspicuous mined areas were delineated on the Pollution Potential Map of Summit County. Delineations of mined areas were made using information from the *Soil Survey of Summit County* (Ritchie et al., 1974), abandoned underground mine maps (ODNR, Division of Geological Survey, open file maps), and the Summit County portion of U.S.G.S. 7-1/2 minute quadrangle maps. Site-specific information for mined area can be obtained from the ODNR, Division of Geological Survey and Division of Mineral Resources Management.

Table 11. Potential factors influencing DRASTIC ratings for strip-mined areas

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

Table 12. Potential factors influencing DRASTIC ratings for underground mined areas

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

REFERENCES

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

Angle, M.P., 1982. Quaternary stratigraphy of part of Richfield Township, Summit County, Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio, 155 pp.

Angle, M.P., 1991. Ground water pollution potential of Portage County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 22, 292 pp.

Angle, M.P., 1994. Ground water pollution potential of Medina County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 13, 87 pp.

Angle, M.P. and Akins, M., 2002. Ground water pollution potential of Wayne County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 22, 292 pp.

Barber, D.J., 1994. Ground water pollution potential of Cuyahoga County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 4, 65 pp.

Bier, J.A., 1956. Landforms of Ohio. Ohio Department of Natural Resources, Division of Geological Survey, map.

Bonta, J.V., C.R. Amerman, W.A. Dick, G.F. Hall, T.J. Harlukowicz, A.C. Razem, and N.E. Smeck, 1992. Impact of surface coal mining on three Ohio watersheds – physical conditions and groundwater hydrology. Water Resources Bulletin, Volume 28, No. 3, PP. 577-596.

Bain, L.G., 1975. The nature, distribution, and origin of terraces in the Cuyahoga Valley between Akron and Peninsula. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio.

Coogan, A.H., R.M. Feldman, E.J. Szmuc, and J.R. Mrakovich, 1974. Sedimentary environments of the Lower Pennsylvanian Sharon Conglomerate near Akron, Ohio. In Heimlich, R.A. and Feldmann, R.M. (eds.), Selected Field Trips in Northeastern Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Guidebook No. 2, Field Trip No. 2, pp. 21-41. Also found as Contribution No. 97, Department of Geology, Kent State University, Kent, Ohio.

DeLong, R.M. and G.W. White, 1963. Geology of Stark County. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 61, 209 pp.

Donovan, K., 1983. Quaternary stratigraphy of the east side of the Cuyahoga Valley between State Route 303 and State Route 82. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio.

Driscoll, F.G., 1986. Groundwater and wells. Johnson Filtration Systems , St. Paul, Mn, 1089 pp.

Dumouchelle, D.H. and M.C. Schiefer, 2002. Use of streamflow records and basin characteristics to estimate ground-water recharge rates in Ohio. Ohio Department of Natural Resources, Division of Water, Bulletin 46, 45 pp.

Eyles, N. and J.A. Westgate, 1987. Restricted regional extent of the Laurentide Ice Sheet in the Great Lakes Basin during early Wisconsinan glaciation. Geology, v. 15, p. 537-540.

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

Ferm, J.C., 1974. Carboniferous environmental models in eastern United States and their significance. In G. Briggs, ed. Carboniferous of the southern United States. Geological Society of America Special Paper 148.

Fernandez, R.L., 1983. Stratigraphy and clay mineralogy of Wisconsinan tills in the Cuyahoga Valley National Recreation Area, northeastern Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio 94 pp.

Fetter, C.W., 1980. Applied hydrogeology. Charles E. Merrill Publishing Co., Columbus, Ohio, 488 pp.

Freeze, R.A. and J.A. Cherry, 1979. Ground water. Prentice-Hall, Englewood Cliffs, N.J., 604 pp.

Frost, R.B., 1931. Physiographic map of Ohio. Oberlin College, The Geographical Press, Columbia Univ., N.Y., N.Y., map with text.

Gardner, G., A.H. Wittine, M.R. McComas, B.B. Miller, and R.W. Manus, 1974. Engineering and Pleistocene geology of the Lower Cuyahoga Valley. In Heimlich, R.A. and Feldmann, R.M. (eds.), Selected Field Trips in Northeastern Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Guidebook No. 2, Field Trip No. 3, pp. 45-59. Also found as Contribution No. 98, Department of Geology, Kent State University, Kent, Ohio.

Gardner, S.B., 1981. Seismic investigation of a buried valley near Cuyahoga Falls, Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio.

Garvey, J.T., 1988. The hydrogeology of eastern Franklin Township and western Green Townships, Summit County, Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio, 97 pp.

Goldthwait, R.P., G.W. White, and J.L. Forsyth, 1961. Glacial map of Ohio. U. S. Department of Interior, Geological Survey, Miscellaneous Map, I-316, map with text.

Harstine, L.J., 1991. Hydrologic atlas for Ohio. Ohio Department of Natural Resources, Division of Water, Water Inventory Report, No. 28, 13 pp.

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

Heaton, K.P., 1982. The hydrogeology of the city of Stow and Hudson Township, Summit County, Ohio. Unpublished M.S. Thesis, Kent State University, Kent, Ohio, 251 pp.

Horne, J.C., J.C. Ferm, F.T. Carrucio, and B.P. Baganz, 1978. Depositional models in coal exploration and mine planning in Appalachian region. American Association of Petroleum Geologists Bulletin, Vol. 62, No. 12, pp.2379-2411.

Katzmark, R.R., 1985. Elemental composition of tills in the Cuyahoga Valley National Recreation Area, northeastern Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio, 97 pp.

Miller, B.B., 1970. The Quaternary Period: in P.O. Banks and R.M. Feldmann eds: Guide to the geology of northeastern Ohio. Northeast Ohio Geological Society Field Guidebook, pp. 149-163. Also found as Contribution No. 42, Department of Geology, Kent State University, Kent, Ohio.

Ninke, D.J. and J.E. Evans, 2002. Alluvial architecture of the Early Pennsylvanian Sharon Formation in northeastern Ohio. Ohio Journal of Science, Vol. 102, No.4, pp. 70-81.

Ospanik, L.F., 1983. Quaternary stratigraphy of the west side of the Cuyahoga Valley between Peninsula, Ohio and State Route 82. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio.

Ohio Department of Natural Resources, Division of Geological Survey, Open File, Reconnaissance Bedrock Geology Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Geological Survey, Open File, Bedrock Topography Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Water, Open File Bedrock State Aquifer Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

Ohio Department of Natural Resources, Division of Water, Open File Glacial State Aquifer Maps. Available on a U.S.G.S. 7-1/2 minute quadrangle basis.

The Ohio Drilling Company, 1971. Ground Water Potential of Northeast Ohio. Consultant's report prepared for the Ohio Department of Natural Resources, Division of Water, 361 pp.

Owenby, J.R. and D.S. Ezell, 1992. Monthly station normals of temperature, precipitation, and heating and cooling degree days, 1961-1990. Climatography of the United States No. 81, OHIO. U.S. Department of the Interior, Project A-051-OHIO, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 30 pp.

Pavey, R.R., R.P. Goldthwait, C. S. Brockman, D.N. Hull, E.M. Swinford, and R.G. Van Horn, 1999. Quaternary geology of Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Map No. 2, map with text.

Pavey, R.R., G.A. Schumacher, G.E. Larsen, E.M. Swinford, and K.E. Vorbau, 2000. Surficial geology of the Canton 30 x 60 minute quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Map SG-1.

Pavey, R.R., G.A. Schumacher, G.E. Larsen, E.M. Swinford, and K.E. Vorbau, 2002. Surficial geology of the Cleveland South 30 x 60 minute quadrangle. Ohio Department of Natural Resources, Division of Geological Survey, Map SG-2.

Pettyjohn, W.A. and R. Henning, 1979. Preliminary estimate of ground-water recharge rates, related streamflow and water quality in Ohio. U.S. Department of the Interior, Project A-051-OHIO, Project Completion Report No. 552, Water Resources Center, The Ohio State University, Columbus, Ohio, 323 pp.

Raab, J.M. and Piskura, J., 1990. Investigation and analysis of ground water levels along Sheppard Road, Twinsburg, Ohio, Summit County. Ohio Department of Natural Resources, Division of Water, Report of Investigations, 5 pp.

Raab, J.M. and W.C. Haiker, 1995. Potentiometric surface map of the bedrock aquifer in the vicinity of Bey Road, Springfield Township, Summit County. Ohio Department of Natural Resources, Division of Water, Report of Investigations, 5 pp.

Rau, J.L., 1969a. The evolution of the Cuyahoga River: it's geomorphology and environmental geology. In J.P. Cooke (eds.), The Cuyahoga River Watershed. Institute of Limnology and Department of Biological Sciences, Kent State University, Kent, Ohio. Also found as Contribution No. 43, Department of Geology, Kent State University, Kent, Ohio.

Rau, J.L., 1969b. Hydrogeology of the Berea and Cussewago Sandstones in northeastern Ohio. U.S. Geological Survey, Hydrologic Investigations, Atlas Ha-341, 2 maps with text.

Rau, J.L., 1970. Pennsylvanian System of northeast Ohio: in Banks, P.O. and Feldmann, R.M., eds: Guide to the geology of northeast Ohio: Northern Ohio Geological Society, p. 69-89.

Razem, A.C., 1983. Ground-water hydrology before, during, and after coal strip mining of a small watershed in Jefferson County, Ohio. U.S. Geological Survey, Water Resources Investigations Report 83-4215, 36 pp.

Ritchie, A., J.R. Steiger, R.L. Christman, J.R. Bauder, D.D. Waters, 1974. Soil survey of Summit County, Ohio. U.S. Department of Agriculture, Natural Resources Conservation Service, 117 pp.

Ryan, D.E., 1980. Quaternary stratigraphy of the Lower Mud Brook Basin, Northampton Township, Summit County, Ohio. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio, 140 pp.

Schiefer, M. C., 2002. Basin descriptions and flow characteristics of Ohio Streams. Ohio Department of Natural Resources, Div. of Water, Bulletin 47, 161 pp.

Schmidt, J.J., 1979. The ground water resources of Summit County. Ohio Department of Natural Resources, Division of Water, Ground Water Resources Map, map with text.

Simmers, R.J., 1985. Hydrogeologic analysis of Granger and western Bath Townships. Unpublished M.S. Thesis, The University of Akron, Akron, Ohio, 153 pp.

Schubert, J.P., 1980. Fracture flow of groundwater in coal-bearing strata. Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, Kentucky, pp. 61-73.

Sedam, A.C., 1973. Hydrogeology of the Pottsville Formation in northeastern Ohio. U.S. Geological Survey Hydrologic Investigations, Atlas Ha-494, 2 maps with text.

Smith, R.C. and G.W.White, 1953. The ground-water resources of Summit County, Ohio. Ohio Department of Natural Resources, Division of Water, Bulletin 27, 130 pp.

Stout W., K. Ver Steeg, and G.F. Lamb, 1943. Geology of water in Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 44, 694 pp.

Szabo, J.P., 1987. Wisconsinan stratigraphy of the Cuyahoga Valley in the Erie Basin, northeastern Ohio. Canadian Journal of Earth Science, Vol. 24, pp. 279-290.

Szabo, J.P. and M.P. Angle, 1983. Influence of local bedrock: an important consideration in the interpretation of textural and mineralogic analyses of till. Journal of Sedimentary Petrology, Society of Economic Paleontologists and Mineralogists, Vol. 53, No.3, pp. 981-990.

Szabo, J.P. and R.L. Fernandez, 1984. Clay mineralogy of Wisconsinan tills of the Cuyahoga Valley National Recreation Area, northeastern Ohio. Ohio Journal of Science, Vol. 84, No.4, pp. 205-214.

Szabo, J.P. and R.R. Katzmark, 1987. Elemental composition of Wisconsinan tills of the Lower Cuyahoga Valley, northeastern Ohio. Ohio Journal of Science, Vol. 87, No. 1, pp. 10-15.

Szabo, J.P. and B.B. Miller, 1986. Pleistocene stratigraphy of the Lower Cuyahoga River Valley and adjacent Garfield Heights, Ohio. Geological Society of America, Northcentral Section Meeting, GSA Field Trip Guidebook No. 2, 100 pp.

Szabo, J.P. and D.E. Ryan, 1981. Quaternary stratigraphy of the Lower Mud Brook Basin, Northampton Township, Summit County, Ohio. Ohio Journal of Science, Vol. 81, No. 4, p. 239-246.

Szabo, J.P. and S.M. Totten, 1995. Multiple pre-Wisconsinan glaciations along the northwestern edge of the Allegheny Plateau in Ohio and Pennsylvania. Canadian Journal of Earth Science, Vol. 32, pp. 2081-2089.

Szmuc, E.J., 1957. Stratigraphy and paleontology of the Cuyahoga Formation of northern Ohio. Unpublished Ph.D. dissertation, The Ohio State University, Columbus, Ohio, 607 pp.

Szmuc, E.J., 1970. The Mississippian System in: Banks, P.O. and R.M. Feldman, eds: Guide to the geology of Northeastern Ohio: Northern Ohio Geological Society, p. 23-68.

Totten, S.M., 1987. Stratigraphy of tills in northern Ohio: in Totten S.M. and J.P. Szabo, eds. Pre-Woodfordian stratigraphy of north-central Ohio. Guidebook, 34th Annual Field Conference, Mid-West Friends of the Pleistocene, Ohio Department of Natural Resources, Division of Geological Survey, 25 pp.

Van Horn, R.G., 1976. Land areas in Summit County, Ohio-Geologic Suitability for Solid-Waste Disposal. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 98, map sheet with text.

Van Horn, R.G., 1979. Surficial materials of Summit County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 109, map sheet with text.

Weedman, S.D., 1990. Freshwater limestones of the Allegheny Group. Pennsylvania Geology, Vol. 21, NO. 1, pp. 9-16.

White, G.W., 1984. Glacial geology of Summit County, Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Report of Investigations No. 123, 25 pp.

White, G.W., 1982. Glacial geology of northeastern Ohio. Ohio Department of Natural Resources, Division of Geological Survey, Bulletin 68, 75 pp.

Williams, F.W., 1983. Hydrogeologic investigation of Boston and Northampton Townships, Summit County, Ohio. Unpublished M.S. Thesis, Kent State University, Kent, Ohio, 349 pp.

Williams, S., 1991. Ground water pollution potential of Stark County, Ohio. Ohio Department of Natural Resources, Division of Water, GWPP Report No. 6, 75 pp.

Winslow, J.D. and G.W. White, 1966. Geology and ground-water resources of Portage County, Ohio. U. S. Geological Survey, Professional Paper 511, 80 pp.

Winslow, J.D., G.W. White, and E.E. Weber, 1953. The water resources of Cuyahoga County, Ohio. Ohio Department of Natural Resources, Division of Water, Bulletin 26, 123 pp.

Wittine, A.H., 1970. A study of a Late Pleistocene lake in the Cuyahoga River Valley, Summit County, Ohio. Unpublished M.S. Thesis, Kent State University, Kent, Ohio, 64 pp.

UNPUBLISHED DATA

Ohio Department of Development. Office of Strategic Research, County wide profiles, 2002.

Ohio Department of Natural Resources, Division of Water. Well log and drilling reports for Summit County.

Szabo, J.P. Unpublished maps of the surficial materials of northern Summit County. Department of Geology, The University of Akron.

APPENDIX A
DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

This factor was primarily evaluated using information from water well log records on file at the Ohio Department of Natural Resources (ODNR), Division of Water, Water Resources Section (WRS). Approximately 43,500 water well log records are on file for Summit County. Data from roughly 14,840 located water well log records were analyzed and plotted on U.S.G.S. 7-1/2 minute topographic maps during the course of the project. Static water levels and information as to the depths water was encountered at were taken from these records. The *Ground Water Resources of Summit County* (Smith and White, 1953 and Schmidt, 1979) provided generalized depth to water information throughout the county. Depth to water trends mapped in adjoining Stark County (Williams, 1991) Portage County (Angle, 1991), Cuyahoga County (Barber, 1994), Wayne County (Angle and Akins, 2002) and Medina County (Angle, 1994) were used as a guideline. Localized studies on the potentiometric surface provided depth to water information for Springfield Township (Raab and Haiker, 1995), Stow and Hudson Townships (Heaton, 1982), and Twinsburg Township (Raab and Piskura, 1990).

Depths to water of 0 to 5 feet (10) were assigned to limited areas of the Cuyahoga River Valley and to marshy areas in eastern Twinsburg Township. Depths to water of 5 to 15 feet (9) were typical of areas associated with floodplains of major streams. Depths of 15 to 30 feet (7) were used for stream terraces adjacent to major streams and along smaller tributaries. Depths to water of 15 to 30 feet were also common in areas of predominantly shale bedrock. Depths of 30 to 50 feet (5) were utilized for upland areas with lower relief and for buried valleys that are not overlain by modern streams. Depths to water of 50 to 75 feet (3) were utilized for higher ridges in the uplands and in deeper buried valleys, which lack modern surficial streams. Depths to water of 75 to 100 feet (2) were selected for some steep, isolated bedrock ridges. Depths to water greater than 100 feet (1) were applied to isolated areas where deep, confined sandstone aquifers were present. Typically, these were areas where the Berea Sandstone was overlain by thick sequences of glacial till and shale. These areas were limited to the margins of Cuyahoga County and Medina County.

Net Recharge

Net recharge is the precipitation that reaches the aquifer after evapotranspiration and run-off. This factor was evaluated using many criteria, including depth to water, topography, soil type, surface drainage, vadose zone material, aquifer type, and annual precipitation. General estimates of recharge provided by Pettyjohn and Henning (1979) and Dumouchelle and Schiefer (2002) proved to be helpful. Recharge ratings from adjoining Stark County (Williams, 1991) Portage County (Angle, 1991), Cuyahoga County (Barber, 1994), Wayne County (Angle and Akins, 2002) and Medina County (Angle, 1994) were used as a guideline. Information from the following theses was useful in obtaining recharge rates for Franklin Township (Garvey, 1988), Bath Township (Simmers, 1985), Boston and Northampton Townships (Williams, 1983), and Stow and Twinsburg Townships (Heaton, 1982).

Recharge values of 7 to 10 inches per year (8) were assigned to floodplains adjacent to modern streams overlying outwash buried valley deposits. These areas contain highly permeable soils, vadose, and aquifer materials, have shallow depths to water, gentle slopes, and surficial streams. These areas are limited to terraces and floodplains underlain by coarse-grained outwash deposits. Values of 4 to 7 inches per year (6) were used for areas with moderate recharge. These areas include margins of buried valleys and uplands. These areas tend to have moderately shallow depths to water and lower permeability soils, or areas with moderate depths to water and moderately permeable soils, vadose, and aquifers. Values of 2 to 4 inches per year (3) were utilized for some upland areas and some buried valley areas lacking modern overlying streams. Greater depths to water, lower permeability soils, lower permeability glacial till, finer-grained bedrock, and greater depths to water characterize these areas of lower recharge. Values of 2 to 4 inches per year (3) or less than 2 inches per year (1) were used for deep sandstone aquifers subjected to confining or nearly confining conditions. These areas are found along the boundary of both Medina County and Cuyahoga County.

Aquifer Media

Information on evaluating aquifer media was obtained from the reports and maps of Smith and White (1953), Winslow et al., (1953), Winslow and White (1966), White (1982 and 1984), Rau (1969), The Ohio Drilling Co. (1971), Sedam (1973), Heaton (1982), Garvey (1988), Williams (1983), and Simmers (1985). Maps of the surficial geology of the Canton 30 x 60 minute quadrangle (Pavey et al., 2002) and the surficial geology of the Cleveland South 30 x 60 minute quadrangle (Pavey et al., 2000) were useful in delineating glacial aquifers. Mapping in adjoining counties proved useful as a guideline for evaluating aquifers. Open File Bedrock Reconnaissance Maps and Open File Bedrock Topography Maps, based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) were an important source of aquifer data. Aquifer media data from adjoining Stark County (Williams, 1991) Portage County (Angle, 1991), Cuyahoga County (Barber, 1994), Wayne County (Angle and Akins, 2002) and Medina County (Angle, 1994). Water well log records on file at the ODNR, Division of Water, were the primary source of aquifer information.

An aquifer rating of (8) was designated for the high-yielding sand and gravel outwash deposits underlying portions of Wolf Creek and Pigeon Creek, the Tuscarawas River, the Little Cuyahoga River, and Mud Brook. An aquifer rating of (7) was assigned to thinner, less continuous sand and gravel outwash deposits associated with portions of the Cuyahoga River Valley, Mud Brook, Yellow Creek, and the Portage Lakes area. These outwash deposits also tend to be somewhat finer-grained and less well sorted. An aquifer rating of (7) was also utilized for ice-contact deposits such as kames and eskers. An aquifer rating of (6) was used for some thinner sand and gravel deposits associated with tributaries and margins of the major buried valleys. An aquifer rating of (5) was used for the thin sand and gravel lenses interbedded with thick sequences of fined-grained glacial till in uplands. An aquifer rating of (5) was used for thin sand and gravel lenses interbedded with fine-grained till or lacustrine materials in the Cuyahoga River Valley and Tinker’s Creek Valley in northern Summit County.

Sandstone was designated for the aquifer primarily in wells in which just sandstone was encountered or in which overlying shale functions as an aquiclude or aquitard and not part of the aquifer. These areas primarily are found bordering Medina County, Portage County, and Cuyahoga County. It also includes some high, isolated sandstone ridges through northern Summit County. Wells that encounter both sandstone and shale were in the majority for most areas of Summit County. The aquifer in these areas was evaluated as being interbedded sandstone and shale even if the majority of the yield was probably derived from the sandstone. Shale was evaluated as the aquifer for wells completed in shale in which sandstone was absent. Shale aquifers were limited to areas adjacent to the Cuyahoga River Valley in northern Summit County.

An aquifer rating of (6) was assigned to limited areas of highly fractured Sharon Sandstone and Massillon Sandstone adjacent to Stark County and Portage County. An aquifer rating of (5) was utilized for sandstones and interbedded sandstones and shales of the Pennsylvanian Pottsville and Allegheny Group, portions of the Sharon Sandstone and Massillon Sandstone, the Mississippian Black Hand Sandstone and Logan Formation, and some units of the Cuyahoga Formation. This rating was widespread throughout Summit County. An aquifer rating of (4) was designated for some deep units of the Cuyahoga Formation containing abundant shales and fine-grained sandstones in northern Summit County. These aquifers are found along deeper sections of the Cuyahoga River Valley, Furnace Run, and Tinker’s Creek. The Berea Sandstone was given a rating of (4) where this deep unit was evaluated as the aquifer along the border of Medina County and Cuyahoga County. Aquifer ratings of (3) or (2) were assigned to shaley portions of the Cuyahoga Formation, Sunbury Shale, and Bedford Shale.

Soils

Soils were mapped using the data obtained from the *Soil Survey of Summit County* (Ritchie et al., 1974). Each soil type was evaluated and given a rating for soil media. Evaluations were based upon the texture, permeability, and shrink-swell potential for each soil material. The soils of Summit County showed a high degree of variability. This is a reflection of the parent material. Table 13 is a list of the soils, parent materials, setting, and corresponding DRASTIC values for Summit County.

Soils were considered to be thin or absent (10) along many steep, prominent ridge tops and slopes where bedrock was exposed. Gravel (10) was evaluated as the soil media in limited portions of southeastern Summit County adjacent to Stark County. Sand (9) was evaluated as the soil media for limited outwash deposits in southern Summit County. Soils were rated as being a peat (8) for limited organic soils in depressions or kettles on floodplains. These areas overlie buried valleys and the largest occurrence of these soils is found along Schocalog Run and Pigeon Creek in Copley Township. Shrink-swell (aggregated) clays (7) were evaluated for some clay-rich lacustrine soils in northern Summit County. A rating of (7) was also used for some clayey soils caused by the weathering of fine-grained shales that are close to the surface. Sandy loams (6) were selected for soils overlying outwash terraces, plains, and kames overlying buried valleys. Sandy loam soils (6) were also selected for steep, residual sandstone ridges throughout the county. Loam soils (5) were designated for soils derived from coarser, ablational glacial till along the Portage County

Table 13. Summit County soils

Soil Name	Parent Material or Setting	DRASTIC Rating	Soil Media
Berks	Shale-siltstone bedrock	10	Thin or absent
Bogart	Outwash, kames	6	Sandy loam
Canadice	Pond, lacustrine	7	Shrink-swell clay
Caneadea	Pond, lacustrine	7	Shrink-swell clay
Canfield*	Loamy till	4	Silt loam
Carlisle	Bogs, depressions	8	Peat
Chagrin	Coarse alluvium	6	Sandy loam
Chili	Outwash, kames	6	Sandy loam
Conotton	Coarse outwash	10	Gravel
Damascus	Outwash terrace	6	Sandy loam
DeKalb	Sandstone outcrops	10	Thin or absent
Ellsworth	Clayey till	3	Clay loam
Fitchville	Silty lacustrine terrace	4	Silt loam
Frenchtown*	Loamy till	4	Silt loam
Geeburg	Lacustrine, depressions	7	Shrink-swell clay
Glenford	Silty lacustrine	4	Silt loam
Haskins	Kames, ablational deposits	6	Sandy loam
Holly	Coarse alluvium	6	Sandy loam
Jimtown	Outwash, kames	6	Sandy loam
Linwood	Bogs, depressions	2	Muck
Lobdell	Alluvium, floodplain	4	Silt loam
Lorain	Clayey lacustrine	7	Shrink-swell clay
Loudonville	Sandstone bedrock	10	Thin or absent
Luray	Silty lacustrine	4	Silt loam
Mahoning	Clayey till	3	Clay loam
Mitiwanga	Sandstone outcrop	10	Thin or absent
Olmsted	Outwash terraces	6	Sandy loam
Orrville	Alluvium, floodplain	4	Silt loam
Oshtemo	Outwash	9	Sand
Ravenna*	Loamy till	4	Silt loam
Rittman*	Silty till	3	Clay loam
Rough, broken land-silt, clay	Steep slopes along the Cuyahoga River	3	Clay loam
Rough, broken land-silt, sand	Steep slopes along the Cuyahoga River	4	Silt loam
Sebring	High lacustrine terraces	3	Clay till
Shale rock	Shale outcrop	10	Thin or absent
Sloan	Alluvium, floodplain	4	Silt loam
Tioga	Coarse alluvium	6	Sandy loam
Trumbull	Clayey till	3	Clay loam
Wadsworth*	Silty till	3	Clay loam
Walkill	Lacustrine, depression	2	Muck
Wheeling	Coarse alluvium	6	Sandy loam
Wilette	Bog, depression	8	Peat
Wooster*	Loamy till	4	Silt loam

* denotes soils containing a fragipan

border. Silt loam (4) soils were evaluated for loamy glacial till found in much of southern Summit County. Silt loam (4) was also selected for silty alluvial and lacustrine deposits on floodplains. Clay loam (3) soils were evaluated for areas with clay-rich glacial till, primarily in central and northern Summit County. Muck (2) was evaluated for a depressional area in Franklin Township bordering Stark County. Non-shrinking, non-aggregated clay (1) was evaluated for clayey lacustrine deposits in eastern Twinsburg Township bordering Stark County.

The Rittman-Wadsworth Soils, which are associated with the Lavery till in much of north central Summit County, and the Ravenna-Canfield-Frenchtown-Wooster soils, which are associated with the Mogadore, Kent, and Navarre Tills in southern and eastern Summit County, contain fragipans. A fragipan is a dense, impermeable zone found within certain loamy, till-derived soils. Fragipans may notably restrict the downward movement of water (Ritchie et al., 1974 and Williams, 1990). The net effect of the fragipan is to reduce the overall permeability of a soil within a given textural range (Aller et al., 1987). Hence, a soil with a loam (5) texture would be evaluated as a silt loam (4), and a soil with a silt loam (4) texture would be evaluated as a clay loam (3) due to the presence of a fragipan (see Table 13).

Topography

Topography, or percent slope, was evaluated using U.S.G.S. 7-1/2 minute quadrangle maps and the *Soil Survey of Summit County* (Ritchie et al., 1974). Slopes of 0 to 2 percent (10) and 2 to 6 percent (9) were selected for flat-lying floodplains, valley floors, and terraces. Slopes of 0 to 2 (10) and 2 to 6 percent (9) were also used for flat lying ground moraine or till plain areas on the uplands. Slopes of 6 to 12 percent (5) were used for less steep bedrock-controlled topography, for steeper kame features, and for areas of end moraines. Slopes of 12 to 18 percent (3) and greater than 18 percent (1) were selected for steeper slopes in higher relief, upland areas. These areas have bedrock-controlled topography and drift is thin or absent. These steep areas are primarily found flanking the Cuyahoga River Valley and portions of the Tuscarawas River.

Impact of the Vadose Zone Media

Information on evaluating vadose zone media was obtained from the reports and maps of Smith and White (1953), Winslow et al., (1953), Winslow and White (1966), White (1982 and 1984), Rau (1969b), The Ohio Drilling Co. (1971), Sedam (1973), Heaton (1982), Garvey (1988), Williams (1983), Simmers (1985), and Van Horn (1976 and 1979). A wealth of information on the finer-grained tills and lacustrine deposits in the Cuyahoga River Valley and tributaries was gathered from studies conducted by Kent State University and The University of Akron including Rau (1969), Wittine (1970), Bain (1975), Szabo (1987), Szabo and Ryan (1981), Szabo and Fernandez (1984), Szabo and Katzmark (1987), Szabo and Angle (1983), Angle (1982), Donovan (1983), Fernandez (1983), Gardner (1981), Ospanik (1983), Ryan (1980), Katzmark (1985), Szabo and Miller (1986) and Miller (1970).

Maps of the surficial geology of the Canton 30 x 60 minute quadrangle (Pavey et al., 2002) and the surficial geology of the Cleveland South 30 x 60 minute quadrangle (Pavey et al., 2000) were useful in delineating glacial vadose media. Vadose zone media data from adjoining Stark County (Williams, 1991) Portage County (Angle, 1991), Cuyahoga County (Barber, 1994), Wayne County (Angle and Akins, 2002) and Medina County (Angle, 1994) proved useful as a guideline for evaluating vadose zone materials. Unpublished maps of surficial materials provided by Szabo proved to be helpful. Open File Bedrock Reconnaissance Maps based upon U.S.G.S. 7-1/2 minute topographic maps from the ODNR, Division of Geological Survey proved helpful. The ODNR, Division of Water, Glacial State Aquifer Map and Bedrock State Aquifer Map were an important source of vadose zone media data. Information on parent materials derived from the *Soil Survey of Summit County* (Ritchie et al., 1974), also proved useful in evaluating vadose zone materials. Water well log records on file at the ODNR, Division of Water, were the primary source of information on vadose zone media for the county.

Vadose zone media was given ratings of (7), (8), and (9) for sand and gravel interbedded with silt and clay layers for outwash terraces, kames, and coarse alluvium overlying buried valleys, primarily in the southern and central portions of the county. Vadose zone media ratings of (5) and (6) were selected for sand and gravel interbedded with silt and clay layers for deposits overlying buried valleys and alluvium. These ratings depend upon the proportion of coarse, well-sorted outwash to the finer-grained alluvial and lacustrine deposits. Sand and gravel with silt and clay with ratings of (4) and (5) were also evaluated for some upland areas containing ablational materials or materials that the well logs were not detailed enough to allow for more positive identification. Such ratings were commonly used along the boundary of Medina County and Cuyahoga County. Silt and clay with ratings of (3), (4), and (5) were selected for vadose zone media for floodplains in many of the buried valleys containing predominantly finer-grained alluvial and lacustrine deposits in northern Summit County. Silt and clay as a vadose zone media was common in buried valleys associated with the Cuyahoga River, upper Mud Brook, and Tinker’s Creek.

Till with a rating of (6) was utilized for loamy glacial tills associated with the Kent Till and Kent End Moraine along the eastern margin of Summit County. Till with a rating of (6) was also used for till occupying sandstone ridge tops in northeastern Summit County. These thin tills had incorporated a high percentage of sand while overriding the sandstone outcrops. Till with a rating of (5) was utilized for loamy glacial tills associated with the Mogadore Till and Kent Till in the southern and eastern part of the county and the Navarre Till found in the southwestern corner of the county. Till was also given a rating of (5) where the till was relatively thin, weathered, and presumably fractured through much of its extent. Till with a rating of (5) was also used in some areas where till had incorporated large amounts of sand from sandstone outcrops. Till with a rating of (4) was used for more clayey-textured tills and for tills of significant thickness in which the majority of the till would be unweathered and fractured to a lower degree. Till with a rating of (4) was used for silty to clayey tills associated with the Lavery Till and Hiram Till in northern Summit County. Till with a rating of (4) was also used for till which had incorporated large amounts of fine-grained shale in the northwestern part of the county. A vadose zone media rating of (3) was selected for till interbedded with fine lacustrine sediments in a deep buried valley in central Northampton Township.

A vadose zone media rating of (5) was selected for sandstone associated with the Sharon Sandstone, Massillon Sandstone, the Mississippian Black Hand Sandstone and Logan Formation. A vadose zone media rating of (4) was selected for sandstone associated with the Berea Sandstone along the border of Cuyahoga County and Medina County. Interbedded sandstone and shale was selected as the vadose zone media for much of the Cuyahoga Formation and the Pottsville-Allegheny Group. Vadose zone media for these units were given a rating of (4) or (5) depending upon the relative proportion of sandstone and shale in these sequences. A vadose zone rating of (3) was selected for shale bedrock where thick sequences of this bedrock are found along the margins of the Cuyahoga River Valley and Furnace Run. Ratings of (3) and (4) were selected for the interbedded, fine-grained predominantly shale bedrock of the Cuyahoga Group in ridge tops and higher slopes. A confining unit with a rating of (1) was selected as the vadose zone media for thick sequences of fine-grained glacial till and shale overlying the Berea Sandstone along the border of Cuyahoga County.

Hydraulic Conductivity

Published data for hydraulic conductivity for Summit County included the reports of Smith and White (1953), The Ohio Drilling Company (1971), Sedam (1973), Heaton (1982), Williams (1983), Simmers (1985), and Garvey (1988). Mapping in adjoining Stark County (Williams, 1991) Portage County (Angle, 1991), Cuyahoga County (Barber, 1994), Wayne County (Angle and Akins, 2002) and Medina County (Angle, 1994) were used as a guideline for determining the range of hydraulic conductivity values. The ODNR, Division of Water, Glacial State Aquifer Map (2000) and Bedrock State Aquifer Map (2000) proved valuable. Water well log records on file at the ODNR, Division of Water, were the primary sources of information. Textbook tables (Freeze and Cherry, 1979, Fetter, 1980, and Driscoll, 1986) were useful in obtaining estimated values for hydraulic conductivity in a variety of sediments.

Values for hydraulic conductivity correspond to aquifer ratings; i.e., the more highly rated aquifers have higher values for hydraulic conductivity. For sand and gravel aquifers with an aquifer rating of (8), hydraulic conductivity values greater than 2,000 gallons per day per square foot (gpd/ft^2) (10), 1,000-2,000 gpd/ft^2 (8), or 700-1,000 gpd/ft^2 (6) were selected. These high values were limited to the clean outwash and kame deposits associated with buried valleys in central and southern Summit County. For sand and gravel deposits associated with buried valleys with an aquifer media rating of (7), hydraulic conductivities of 700-1000 gpd/ft^2 (6) and 300-700 gpd/ft^2 (4) were chosen. These ratings vary upon how coarse, clean (free of fines), and well-sorted the permeable deposits are. For sand and gravel deposits with an aquifer rating of (6) or (5), hydraulic conductivity values ranged from 300-700 gpd/ft^2 (4) to or 100-300 gpd/ft^2 (2). In these deposits, thin sand and gravel lenses are interbedded with thicker sequences of finer-grained materials.

Bedrock aquifers with an aquifer rating of (6) have been assigned a hydraulic conductivity rating of 300-700 gpd/ft^2 (4) or 100-300 gpd/ft^2 (2). These rocks tend to be coarser-grained, more porous, and more highly fractured. Bedrock aquifers with an aquifer rating of (5) were given hydraulic conductivity ratings of 100-300 gpd/ft^2 (2) or 1-100 gpd/ft^2 (1). All of the shale aquifers with an aquifer rating of (3) were given a hydraulic conductivity rating of 1-100 gpd/ft^2 (1) due to the low permeability of these rocks.

APPENDIX B

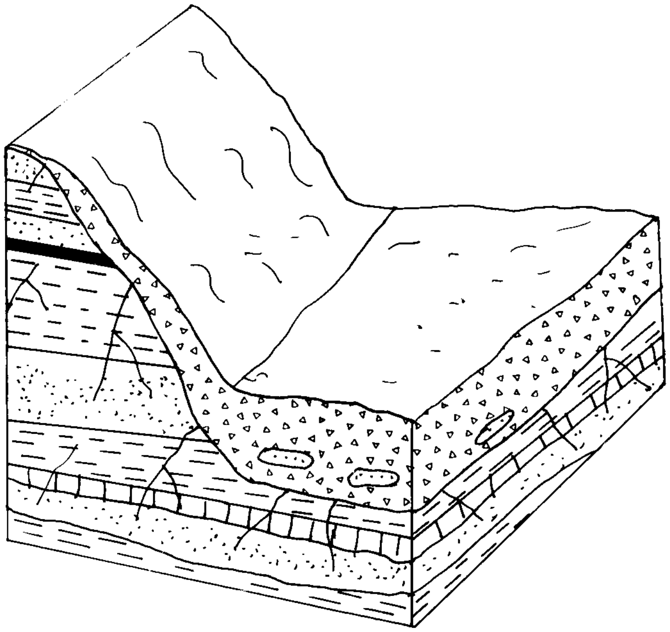
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Summit County resulted in the identification of 10 hydrogeologic settings within the Glaciated Central Region. The list of these settings, the range of pollution potential index calculations, and the number of index calculations for each setting are provided in Table 14. Computed pollution potential indexes for Summit County range from 52 to 193.

Table 14. Hydrogeologic settings mapped in Summit County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa-Glacial till over bedded sedimentary rocks	66-143	123
7Ad-Glacial till over sandstone	52-158	51
7Ae-Glacial till over shale	69-114	36
7Af-Sand and gravel interbedded in glacial till	90-121	5
7Ba-Outwash	124-176	31
7Bb-Outwash over bedded sedimentary rock	104-158	27
7D-Buried valley	80-193	225
7Ec-Alluvium over bedded sedimentary rock	112-149	14
7Ed-Alluvium over glacial till	113-141	3
7G-Thin glacial till over bedded sedimentary rock	79-140	26

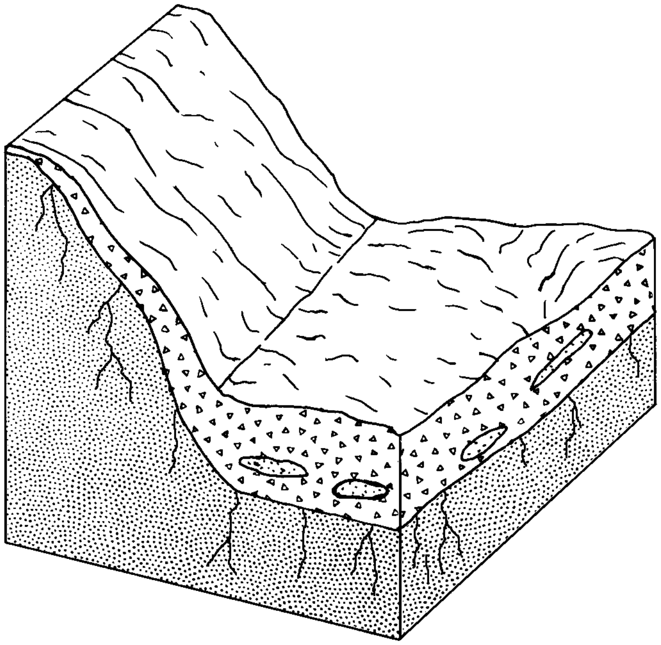
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide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



7Aa Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is variable and widespread across Summit County. This setting is associated with upland areas and commonly features bedrock-controlled topography. Topography varies from rolling, moderate relief areas to steeper, higher relief areas associated with bedrock ridges. Well log data indicates that wells in this setting encounter both sandstone and shale sequences. The aquifer consists of thin interbedded shales, sandstones, and siltstones of the Pottsville Group and Allegheny Group, sandstones and conglomerates (with minor shales) of the Sharon Formation and Massillon Formation of the Pennsylvanian System, interbedded shale, siltstones, and fine-grained sandstones of the Mississippian Cuyahoga Formation, Logan Formation, Berea Sandstone, and Black Hand Sandstone. Yields range from 5 to 25 gpm for wells completed in rocks of the Allegheny Group and Cuyahoga Formation to yields locally over 100 gpm for massive, fractured sandstones in the Pottsville Group. Varying thicknesses of glacial till typically overlies the aquifer. The various till units commonly weather into either silt loams or clay loams. Where the till was thin and depths to water greater, the interbedded sandstone and shale were inferred as being the vadose zone media. The depth to water is variable, averaging from 15 to 30 feet in areas adjacent to streams to 50 to 75 feet for steeper, isolated ridges. Recharge is typically low to moderated due to low permeability soils, moderate to steep slopes, thickness of the till cover, and depth to water.

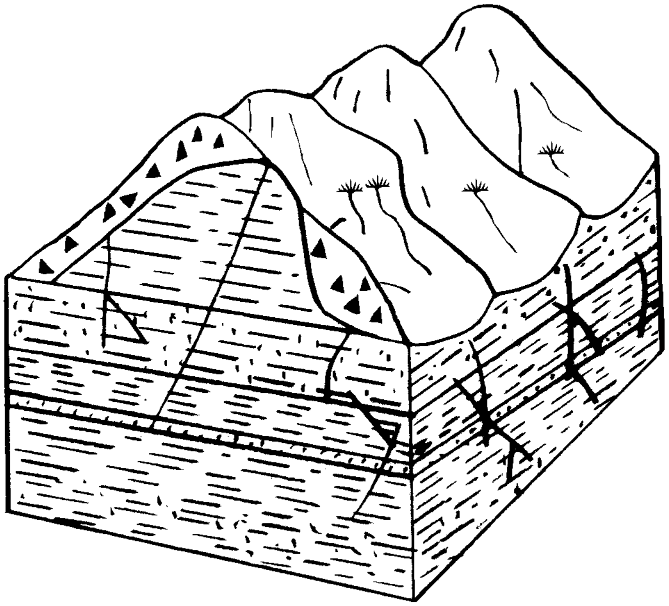
GWPP index values for the hydrogeologic setting of glacial till over bedded sedimentary rocks range from 66 to 143, with the total number of GWPP index calculations equaling 123.



7Ad Glacial Till over Sandstone

This hydrogeologic setting is found in northern Summit County and along the far eastern and western edges of the county. It is commonly associated with resistant, steep-sided ridges with moderately broad, flat ridge tops. The topography varies from gently rolling to relatively steep. Well logs in these areas show that wells are not open to shales or siltstones interbedded with the sandstone aquifer. The aquifer is considered confined in some areas due to great thicknesses of lower permeability till and sometimes shales overlying the sandstone aquifer. Depths to water vary considerably depending whether the areas are adjacent to stream valleys or on isolated ridge tops. Soils are clay loams or silt loams derived from tills. The vadose zone varies from glacial till to sandstone depending upon the drift thickness. Yields range from 5 to 25 gpm up to 25 to 100 gpm depending upon the various sandstone units present. Recharge is commonly moderate to low due to low permeability soils and vadose, variable depths to water, and moderately steep slopes.

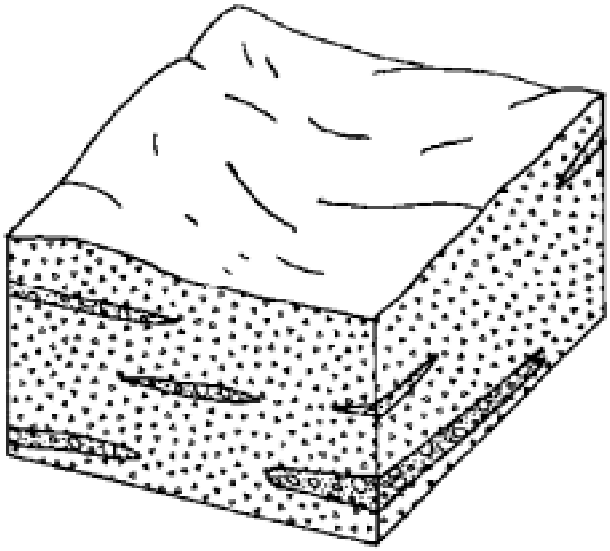
GWPP index values for the hydrogeologic setting of glacial till over sandstone ranges from 52 to 158, with the total number of GWPP index calculations equaling 51.



7Ae Glacial Till over Shale

This hydrogeologic setting is limited to the north central part of the county roughly paralleling the Cuyahoga River. This setting is characterized by clayey glacial till overlying shaley bedrock of the lower Cuyahoga Formation, Sunbury Shale, and Bedford Shale. Wells are completed in the shale and siltstone bedrock. Yields are commonly less than 5 gpm. Topography varies from flat lying on broad uplands to relatively steep along slopes of the Cuyahoga River Valley. Soils are clay loams and the vadose zone media is clayey glacial till. Depths to water vary from shallow to moderate depending upon the thickness of the drift overlying the shale and how steep the relief is locally. Recharge is low due to the low permeability of the soils, vadose, and aquifer media itself.

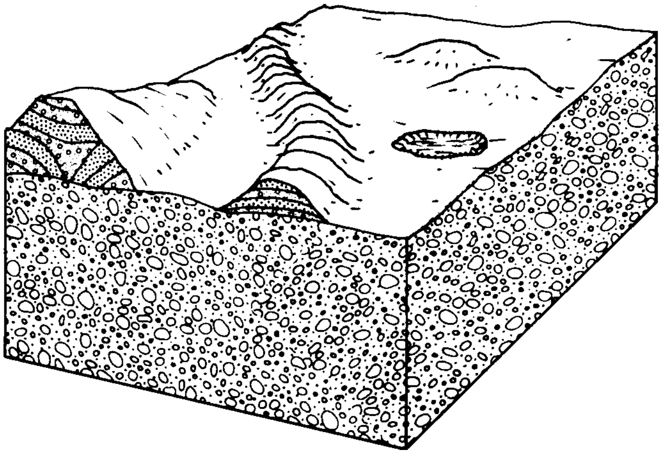
GWPP index values for the hydrogeologic setting of glacial till over shale ranges from 69 to 114, with the total number of GWPP index calculations equaling 36.



7Af Sand and Gravel Interbedded in Glacial Till

This hydrogeologic setting occurs sporadically in southern and western Summit County. The setting encompasses areas where sand and gravel lenses interbedded within till are the aquifer. It is associated with relatively thick sequences of glacial till occupying upland areas between major buried valleys. The setting is characterized by relatively flat-lying to rolling topography. The total thickness of drift in these areas is substantially less than that found in the 7D - Buried Valley hydrogeologic setting. Drift is commonly thicker than in adjacent settings with bedrock aquifers. Soils are usually clay loams or silt loams derived from the weathering of glacial tills. The sand and gravel aquifers are typically thin, discontinuous, lenses. Yields average 10 to 25 gpm and are adequate for domestic purposes. Till is the vadose zone media. Depth to water is highly variable depending upon how much total relief there is in the particular upland. Recharge is moderate to low due to the low relief, moderate to great depths to the water table, moderate thickness of the till, and low permeability soils.

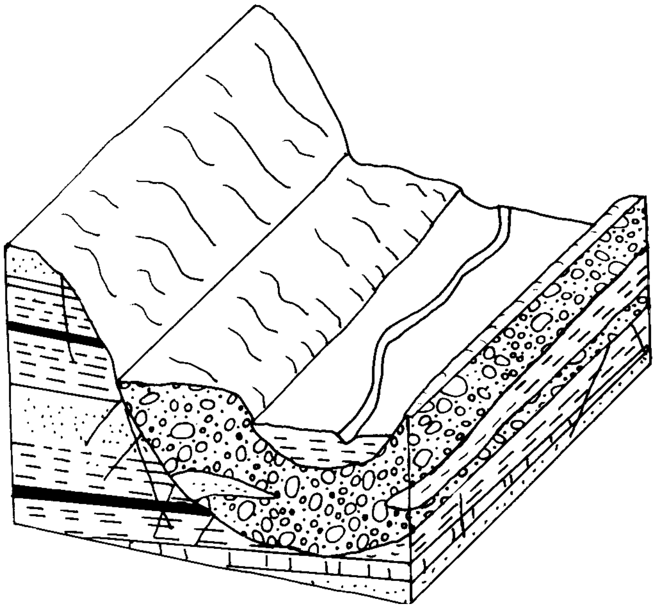
GWPP index values for the hydrogeologic setting of sand and gravel interbedded in glacial till range from 90 to 121, with the total number of GWPP index calculations equaling 5.



7Ba Outwash

This hydrogeologic setting consists of areas of outwash and kames that are adjacent to the major buried valley systems. The overall drift thickness is substantially less than in the neighboring 7D - Buried Valleys setting and is thicker than in the 7Bb – Outwash over Bedded Sedimentary Rocks setting. This setting is most common in southern Summit County, especially in Springfield Township and Green Township. This setting is characterized by rolling topography and low to moderate relief. The aquifer consists of sand and gravel outwash deposits. Yields average 25 to 100 gpm with maximum local yields over 100 gpm. Test drilling may be necessary to locate higher-yielding areas. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with varying thicknesses of glacial till. Depth to water is moderate and the aquifer may be in direct hydraulic connection with overlying streams. Soils are sandy loams. Recharge is moderately high due to the relatively flat topography, relatively permeable soils and vadose media, and the shallow depth to water.

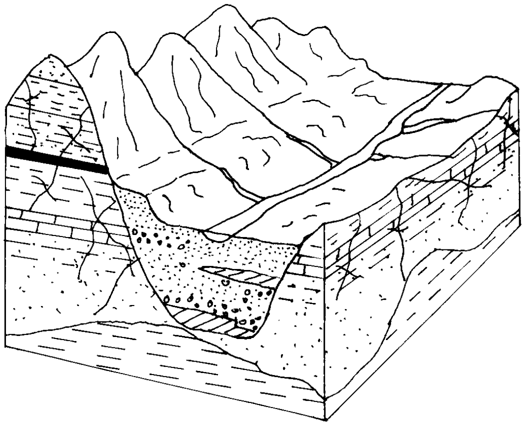
GWPP index values for the hydrogeologic setting of outwash range from 124 to 176, with the total number of GWPP index calculations equaling 31.



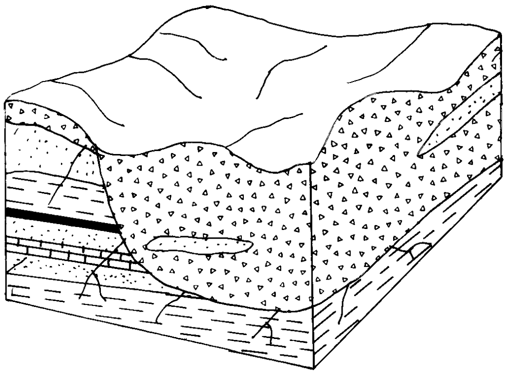
7Bb Outwash over Bedded Sedimentary Rock

This hydrogeologic setting consists of relatively small, high-level outwash terraces that set on top of bedrock benches. These terraces are limited to the margins or tributaries to the buried valleys. The total thickness of drift is not adequate to be considered buried valleys. Drift is also thinner than in the similar 7Ba – Outwash setting. Relief is rolling to moderately steep depending upon the amount of local stream dissection. Vadose zone media consists of bedded sandy to gravelly outwash interbedded with finer alluvial deposits. Soils are usually sandy loams. The outwash terraces are not thick enough to comprise the aquifer; underlying fractured, interbedded sandstones and shale of the Mississippian and Pennsylvanian Systems serve as the aquifer. In a few limited areas wells are completed in the very top of the sandstone; the aquifer is realistically the sand and gravel and the bedrock was drilled for use as a “screen” by the driller. Yields average 10 to 25 gpm. The overlying terraces are typically in direct contact with the underlying bedrock aquifer. Depth to water is typically shallow to moderate and is usually less than 50 feet. Recharge is moderately high due to the relatively permeable soils and vadose, moderate to shallow depth to water, and the moderately steep topography.

GWPP index values for the hydrogeologic setting of Outwash over Bedded Sedimentary Rocks range from 104 to 158, with the total number of GWPP index calculations equaling 27.



(A)



(B)

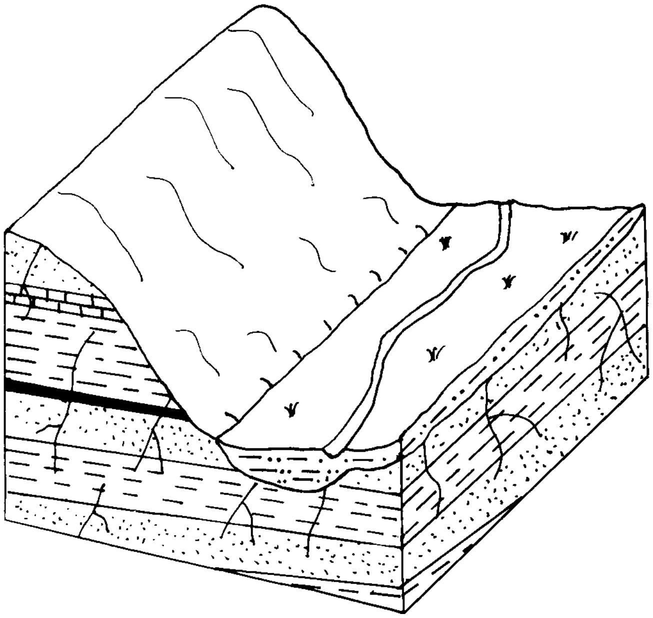
7D Buried Valleys

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

The block diagram (A) above shows one common form of buried valley deposit, which is exemplified by the Tuscarawas River in Springfield Township and the Little Cuyahoga River north of the Airport. These valleys are occupied by a modern river and floodplain and contain abundant outwash and kame deposits. The upper portion of these valleys contains 50 to 100 feet of sand and gravel interbedded with alluvium. Depth to water is typically less than 30 feet. Yields over 100 gpm are obtainable from large diameter wells. Soils are typically sandy loams or silt loams. The streams are in direct connection with the aquifer and recharge is typically high. GWPP index values for these settings are usually over 140.

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

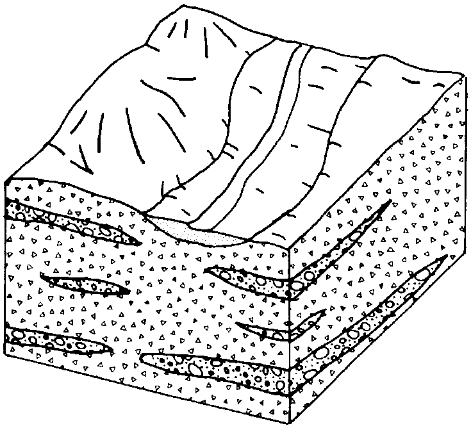
GWPP index values for the hydrogeologic setting of Buried Valley range from 80 to 193, with the total number of GWPP index calculations equaling 225.



7Ec Alluvium Over Bedded Sedimentary Rock

This hydrogeologic setting is found in upland areas throughout Summit County. This setting consists of the headwaters of small tributary streams in upland areas with thin glacial cover. The setting is characterized by narrow, flat-bottomed stream valleys, which are flanked by rolling to steep bedrock-controlled uplands. The aquifer consists of fractured, interbedded sandstones, shales, limestones and coals of the Pennsylvanian System and interbedded shales, siltstones, and fine-grained sandstones of the Mississippian System. Yields developed from the fractures and bedding planes of the bedrock range from 10 to 25 gpm. Soils vary but are usually silt loams or sandy loams. Vadose zone media is typically either silty to sandy alluvium or fractured bedrock depending upon the thickness of the drift locally. The depth to water is commonly shallow, averaging from 10 to 35 feet. The alluvium is commonly in direct hydraulic connection with the underlying aquifer. Recharge is moderately high due to the shallow depth to water, flat-lying topography, proximity of modern streams, and the moderately low permeability of the soils, alluvium, and bedrock.

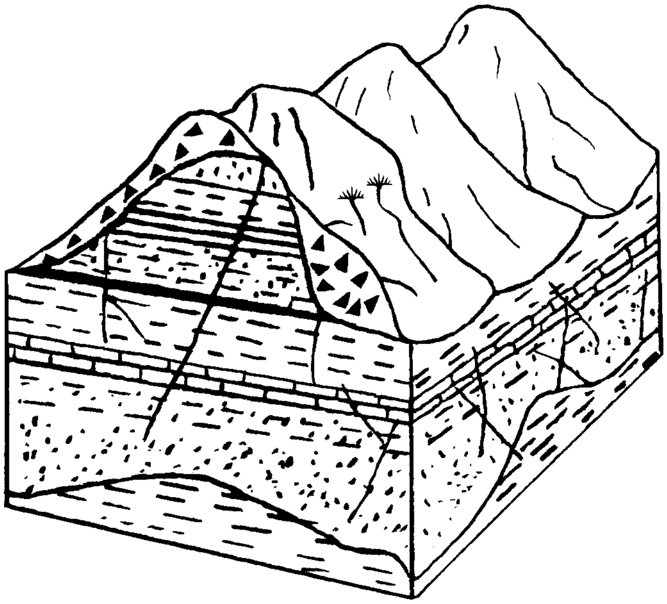
GWPP index values for the hydrogeologic setting of alluvium over bedded sedimentary rocks ranges from 112 to 149, with the total number of GWPP index calculations equaling 14.



7Ed Alluvium Over Glacial Till

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

GWPP index values for the hydrogeologic setting Alluvium Over Glacial Till range from 113 to 141, with the total number of GWPP index calculations equaling 3.



7G Thin Glacial Till Over Bedded Sedimentary Rock

This hydrogeologic setting is found in upland areas throughout Summit County. The setting is characterized by rolling to steep bedrock-controlled topography and deposits of thin, patchy glacial till overlying alternating layers of fractured sedimentary rock. The rock is typically resistant sandstone, but also includes shale. The till is less than 25 feet thick and consists of varying amounts of unsorted clay, silt, and sand with minor pebbles and cobbles. Due to its thin nature, the till is probably weathered and fractured. The till may be absent in some areas along steep slopes. All of Summit County is within the glacial margin. Ground water is obtained from the underlying, fractured Mississippian or Pennsylvanian bedrock. Depth to water varies greatly depending whether the setting is close to a stream valley or consists of an isolated ridge top. Soils are evaluated as thin or absent, especially along steeper slopes and rock outcrops. Recharge is low due to depth to water, relatively steep slopes, and the high runoff due to the lack of a thick, permeable soil layer.

GWPP index values for the hydrogeologic setting of Thin Glacial Till Over Bedded Sedimentary Rock range from 79 to 140, with the total number of GWPP index calculations equaling 26.

Table 15. Hydrogeologic Settings, DRASTIC Factors, and Ratings

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa001	30-50	4-7	interbedded ss+sh	Silty Loam	0-2	till	1-100	110	136
7Aa002	30-50	4-7	interbedded ss+sh	Silty Loam	2-6	till	1-100	109	133
7Aa003	50-75	4-7	interbedded ss+sh	Silty Loam	2-6	till	1-100	99	123
7Aa004	30-50	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	119	148
7Aa005	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	till	1-100	119	143
7Aa006	5-15	4-7	interbedded ss+sh	Silty Loam	2-6	till	1-100	129	153
7Aa007	15-30	4-7	interbedded ss+sh	Silty Loam	6-12	till	100-300	118	133
7Aa008	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	till	100-300	108	123
7Aa009	15-30	4-7	interbedded ss+sh	Silty Loam	0-2	till	100-300	123	148
7Aa010	30-50	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	112	135
7Aa011	15-30	4-7	interbedded ss+sh	Silty Loam	0-2	till	1-100	120	146
7Aa012	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	till	1-100	105	121
7Aa013	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	122	145
7Aa014	30-50	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	115	136
7Aa015	30-50	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	112	135
7Aa016	30-50	4-7	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	100-300	106	117
7Aa017	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	100-300	108	123
7Aa018	50-75	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	102	125
7Aa019	30-50	4-7	interbedded ss+sh	Silty Loam	12-18	till	100-300	106	117
7Aa020	75-100	2-4	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	85	108
7Aa021	50-75	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	97	121
7Aa022	75-100	2-4	interbedded ss+sh	Silty Loam	2-6	till	100-300	80	104
7Aa023	50-75	4-7	interbedded ss+sh	Silty Loam	6-12	till	100-300	93	109
7Aa024	50-75	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	100-300	98	113
7Aa025	50-75	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	102	125
7Aa026	50-75	4-7	interbedded ss+sh	Silty Loam	6-12	till	100-300	98	113

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa027	15-30	2-4	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	1-100	107	131
7Aa028	15-30	2-4	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	1-100	108	134
7Aa029	50-75	2-4	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	1-100	82	107
7Aa030	30-50	2-4	interbedded ss+sh	Silty Loam	2-6	till	1-100	92	117
7Aa031	30-50	4-7	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	100-300	113	138
7Aa032	30-50	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	1-100	109	133
7Aa033	50-75	2-4	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	1-100	88	114
7Aa034	30-50	4-7	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	1-100	103	115
7Aa035	50-75	2-4	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	1-100	81	93
7Aa036	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	1-100	105	121
7Aa037	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	1-100	119	143
7Aa038	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	122	145
7Aa039	50-75	2-4	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	1-100	87	111
7Aa040	50-75	2-4	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	90	113
7Aa041	50-75	2-4	interbedded ss+sh	Silty Loam	2-6	till	100-300	90	113
7Aa042	5-15	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	132	155
7Aa043	30-50	4-7	interbedded ss+sh	Clay Loam	2-6	till	100-300	110	130
7Aa044	15-30	4-7	interbedded ss+sh	Sandy Loam	2-6	interbedded ss+sh	100-300	126	155
7Aa045	30-50	4-7	sand + gravel	Sandy Loam	6-12	till	100-300	112	133
7Aa046	30-50	4-7	interbedded ss+sh	Sandy Loam	6-12	interbedded ss+sh	100-300	112	133
7Aa047	15-30	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	100-300	118	133
7Aa048	30-50	4-7	interbedded ss+sh	Sandy Loam	2-6	till	100-300	116	145
7Aa049	15-30	4-7	interbedded ss+sh	Silty Loam	0-2	till	100-300	131	155
7Aa050	5-15	4-7	interbedded ss+sh	Silty Loam	0-2	till	100-300	141	165
7Aa051	15-30	4-7	interbedded ss+sh	Loam	0-2	till	100-300	133	160
7Aa052	15-30	4-7	interbedded ss+sh	Loam	2-6	till	100-300	132	157
7Aa053	15-30	4-7	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	100-300	123	148

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa054	30-50	4-7	interbedded ss+sh	Sandy Loam	12-18	interbedded ss+sh	100-300	110	127
7Aa055	15-30	4-7	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	100-300	116	127
7Aa056	5-15	4-7	interbedded ss+sh	Loam	2-6	till	100-300	142	167
7Aa057	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	130	152
7Aa058	5-15	4-7	interbedded ss+sh	Loam	0-2	till	100-300	143	170
7Aa059	30-50	4-7	interbedded ss+sh	Loam	0-2	till	100-300	123	150
7Aa060	15-30	4-7	interbedded ss+sh	Sandy Loam	0-2	interbedded ss+sh	100-300	127	158
7Aa061	5-15	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	100-300	128	143
7Aa062	15-30	4-7	interbedded ss+sh	Sandy Loam	6-12	interbedded ss+sh	100-300	122	143
7Aa063	15-30	4-7	interbedded ss+sh	Sandy Loam	2-6	till	100-300	126	155
7Aa064	5-15	4-7	interbedded ss+sh	Silty Loam	0-2	till	100-300	133	158
7Aa065	15-30	4-7	interbedded ss+sh	Sandy Loam	6-12	till	100-300	122	143
7Aa066	30-50	4-7	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	100-300	106	118
7Aa067	30-50	4-7	interbedded ss+sh	Clay Loam	6-12	till	100-300	106	118
7Aa068	15-30	4-7	interbedded ss+sh	Clay Loam	6-12	till	1-100	110	123
7Aa069	15-30	4-7	interbedded ss+sh	Clay Loam	2-6	till	1-100	114	135
7Aa070	30-50	4-7	interbedded ss+sh	Clay Loam	2-6	till	1-100	99	121
7Aa071	15-30	4-7	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	1-100	109	131
7Aa072	15-30	4-7	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	1-100	105	119
7Aa073	15-30	4-7	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	100-300	108	121
7Aa074	15-30	4-7	interbedded ss+sh	Clay Loam	0-2	till	1-100	115	138
7Aa075	30-50	4-7	interbedded ss+sh	Clay Loam	6-12	till	1-100	95	109
7Aa076	50-75	2-4	interbedded ss+sh	Clay Loam	2-6	till	1-100	77	99
7Aa077	15-30	4-7	interbedded ss+sh	Clay Loam	12-18	till	1-100	108	117
7Aa078	30-50	4-7	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	1-100	95	109
7Aa079	15-30	4-7	interbedded ss+sh	Clay Loam	12-18	interbedded ss+sh	1-100	103	113
7Aa080	30-50	4-7	interbedded ss+sh	Sandy Loam	2-6	interbedded ss+sh	100-300	116	145

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa081	30-50	4-7	interbedded ss+sh	Clay Loam	2-6	till	100-300	105	126
7Aa082	15-30	4-7	interbedded ss+sh	Clay Loam	6-12	till	100-300	116	128
7Aa083	50-75	2-4	interbedded ss+sh	Clay Loam	6-12	till	1-100	68	83
7Aa084	30-50	2-4	interbedded ss+sh	Clay Loam	18+	till	1-100	79	85
7Aa085	50-75	2-4	interbedded ss+sh	Clay Loam	2-6	till	1-100	72	95
7Aa086	50-75	2-4	interbedded ss+sh	Clay Loam	12-18	till	1-100	66	77
7Aa087	30-50	2-4	interbedded ss+sh	Silty Loam	18+	till	1-100	81	90
7Aa088	50-75	2-4	interbedded ss+sh	Clay Loam	12-18	interbedded ss+sh	1-100	71	81
7Aa089	50-75	2-4	interbedded ss+sh	Clay Loam	0-2	till	1-100	73	98
7Aa090	75-100	2-4	interbedded ss+sh	Clay Loam	2-6	till	1-100	67	90
7Aa091	50-75	2-4	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	1-100	77	99
7Aa092	30-50	2-4	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	1-100	83	97
7Aa093	15-30	4-7	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	1-100	105	118
7Aa094	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	1-100	97	114
7Aa095	30-50	4-7	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	1-100	99	121
7Aa096	15-30	4-7	interbedded ss+sh	Clay Loam	18+	interbedded ss+sh	1-100	101	107
7Aa097	50-75	2-4	interbedded ss+sh	Clay Loam	6-12	interbedded ss+sh	1-100	73	87
7Aa098	15-30	4-7	interbedded ss+sh	Clay Loam	2-6	till	1-100	109	131
7Aa099	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	silt + clay	1-100	111	136
7Aa100	15-30	4-7	interbedded ss+sh	Sandy Loam	2-6	till	1-100	120	150
7Aa101	50-75	2-4	interbedded ss+sh	Clay Loam	6-12	till	1-100	73	87
7Aa102	5-15	4-7	interbedded ss+sh	Clay Loam	2-6	till	1-100	124	145
7Aa103	15-30	4-7	interbedded ss+sh	Clay Loam	18+	till	1-100	101	107
7Aa104	50-75	2-4	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	1-100	80	107
7Aa105	30-50	4-7	interbedded ss+sh	Silty Loam	0-2	interbedded ss+sh	1-100	102	129
7Aa106	15-30	4-7	interbedded ss+sh	Clay Loam	0-2	interbedded ss+sh	1-100	110	134
7Aa107	30-50	4-7	interbedded ss+sh	Silty Loam	0-2	till	1-100	102	129

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Aa108	50-75	2-4	interbedded ss+sh	Silty Loam	0-2	till	1-100	80	107
7Aa109	50-75	2-4	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	100-300	78	100
7Aa110	30-50	4-7	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	100-300	110	130
7Aa111	30-50	4-7	interbedded ss+sh	Loam	6-12	till	100-300	118	135
7Aa112	30-50	4-7	interbedded ss+sh	Clay Loam	0-2	interbedded ss+sh	100-300	111	133
7Aa113	30-50	4-7	interbedded ss+sh	Sandy Loam	0-2	interbedded ss+sh	100-300	117	148
7Aa114	15-30	4-7	interbedded ss+sh	Sandy Loam	12-18	interbedded ss+sh	100-300	120	137
7Aa115	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	117	141
7Aa116	30-50	4-7	interbedded ss+sh	Silty Loam	2-6	till	100-300	107	131
7Aa117	50-75	2-4	interbedded ss+sh	Clay Loam	2-6	till	100-300	83	104
7Aa118	30-50	4-7	interbedded ss+sh	Clay Loam	6-12	till	100-300	101	114
7Aa119	15-30	4-7	interbedded ss+sh	Clay Loam	2-6	till	100-300	120	140
7Aa120	30-50	4-7	interbedded ss+sh	Clay Loam	0-2	till	100-300	111	133
7Aa121	5-15	4-7	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	1-100	119	141
7Aa122	50-75	4-7	interbedded ss+sh	Clay Loam	2-6	till	1-100	89	111
7Aa123	15-30	4-7	interbedded ss+sh	Shrink/Swell Clay	0-2	silt + clay	1-100	118	154
7Ad01	50-75	0-2	sandstone	Silty Loam	6-12	sandstone	1-100	67	84
7Ad02	100+	0-2	sandstone	Silty Loam	2-6	interbedded ss+sh	1-100	56	82
7Ad03	75-100	0-2	sandstone	Silty Loam	2-6	interbedded ss+sh	1-100	61	87
7Ad04	50-75	0-2	sandstone	Silty Loam	2-6	interbedded ss+sh	1-100	66	92
7Ad05	30-50	2-4	sandstone	Silty Loam	2-6	sand + gvl w/ silt + clay	1-100	97	121
7Ad06	30-50	2-4	sandstone	Silty Loam	6-12	sand + gvl w/ silt + clay	1-100	93	109
7Ad07	15-30	2-4	sandstone	Silty Loam	2-6	sand + gvl w/ silt + clay	1-100	107	131
7Ad08	15-30	2-4	sandstone	Silty Loam	6-12	sand + gvl w/ silt + clay	1-100	103	119
7Ad09	5-15	4-7	sandstone	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	119	141
7Ad10	50-75	0-2	sandstone	Silty Loam	2-6	sand + gvl w/ silt + clay	1-100	71	96
7Ad11	30-50	2-4	sandstone	Silty Loam	0-2	sand + gvl w/ silt + clay	1-100	98	124

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ad12	15-30	2-4	sandstone	Sandy Loam	2-6	sand + gvl w/ silt + clay	1-100	106	137
7Ad13	30-50	2-4	sandstone	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	90	112
7Ad14	15-30	2-4	sandstone	Silty Loam	18+	sand + gvl w/ silt + clay	1-100	94	103
7Ad15	30-50	2-4	sandstone	Clay Loam	6-12	sand + gvl w/ silt + clay	1-100	86	100
7Ad16	15-30	2-4	sandstone	Shrink/Swell Clay	12-18	sand + gvl w/ silt + clay	1-100	102	124
7Ad17	15-30	4-7	sandstone	Clay Loam	6-12	sand + gvl w/ silt + clay	1-100	108	122
7Ad18	15-30	4-7	sandstone	Clay Loam	2-6	sandstone	100-300	120	140
7Ad19	50-75	2-4	sandstone	Clay Loam	6-12	sandstone	100-300	84	96
7Ad20	50-75	2-4	sandstone	Clay Loam	2-6	sandstone	100-300	88	108
7Ad21	30-50	4-7	sandstone	Clay Loam	2-6	sandstone	100-300	110	130
7Ad22	15-30	4-7	sandstone	Clay Loam	6-12	sandstone	100-300	116	128
7Ad23	15-30	4-7	sandstone	Clay Loam	6-12	sand + gvl w/ silt + clay	1-100	105	119
7Ad24	15-30	4-7	sandstone	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	109	131
7Ad25	50-75	2-4	sandstone	Clay Loam	2-6	till	1-100	77	99
7Ad26	50-75	2-4	sandstone	Clay Loam	0-2	till	1-100	78	102
7Ad27	50-75	2-4	sandstone	Clay Loam	6-12	till	1-100	73	87
7Ad28	30-50	4-7	sandstone	Silty Loam	2-6	till	1-100	101	126
7Ad29	75-100	2-4	sandstone	Clay Loam	0-2	confining unit	1-100	58	85
7Ad30	100+	2-4	sandstone	Clay Loam	0-2	confining unit	1-100	53	80
7Ad31	75-100	2-4	sandstone	Clay Loam	6-12	sandstone	1-100	68	82
7Ad32	75-100	2-4	sandstone	Clay Loam	2-6	sandstone	1-100	72	94
7Ad33	30-50	4-7	sandstone	Clay Loam	2-6	sandstone	1-100	99	121
7Ad34	15-30	4-7	sandstone	Loam	2-6	till	100-300	132	157
7Ad35	5-15	7-10	sandstone	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	158	187
7Ad36	15-30	4-7	sandstone	Clay Loam	6-12	till	100-300	124	135
7Ad37	15-30	4-7	sandstone	Clay Loam	2-6	till	100-300	118	139
7Ad38	30-50	4-7	sandstone	Clay Loam	2-6	till	100-300	108	129
7Ad39	30-50	4-7	sandstone	Clay Loam	0-2	till	100-300	109	132
7Ad40	50-75	2-4	sandstone	Clay Loam	0-2	till	100-300	87	110
7Ad41	50-75	2-4	sandstone	Clay Loam	6-12	till	100-300	82	95
7Ad42	30-50	4-7	sandstone	Clay Loam	6-12	till	100-300	104	117
7Ad43	5-15	4-7	sandstone	Clay Loam	0-2	till	300-700	135	156
7Ad44	5-15	4-7	sandstone	Clay Loam	2-6	sandstone	100-300	130	150
7Ad45	15-30	4-7	sandstone	Clay Loam	0-2	till	100-300	121	143
7Ad46	100+	2-4	sandstone	Clay Loam	2-6	confining unit	1-100	52	77
7Ad47	30-50	4-7	sandstone	Clay Loam	0-2	till	100-300	106	129
7Ad48	30-50	4-7	sandstone	Clay Loam	2-6	till	100-300	105	126

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ad49	15-30	4-7	sandstone	Clay Loam	0-2	sandstone	100-300	121	143
7Ad50	30-50	4-7	sandstone	Clay Loam	0-2	sandstone	100-300	111	133
7Ad51	30-50	4-7	sandstone	Clay Loam	6-12	sandstone	100-300	106	118
7Ae01	30-50	4-7	shale	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	93	115
7Ae02	15-30	4-7	shale	Clay Loam	2-6	till	1-100	111	132
7Ae03	15-30	4-7	shale	Clay Loam	2-6	shale	1-100	101	124
7Ae04	5-15	4-7	shale	Clay Loam	2-6	shale	1-100	111	134
7Ae05	30-50	4-7	shale	Sandy Loam	6-12	shale	1-100	93	117
7Ae06	15-30	4-7	shale	Sandy Loam	18+	shale	1-100	99	115
7Ae07	15-30	4-7	shale	Silty Loam	18+	shale	1-100	95	105
7Ae08	15-30	4-7	shale	Clay Loam	12-18	shale	1-100	95	106
7Ae09	30-50	2-4	shale	Clay Loam	2-6	shale	1-100	79	102
7Ae10	50-75	2-4	shale	Clay Loam	2-6	shale	1-100	69	92
7Ae11	15-30	4-7	shale	Clay Loam	6-12	shale	1-100	97	112
7Ae12	30-50	2-4	shale	Clay Loam	18+	till	1-100	76	82
7Ae13	50-75	4-7	shale	Clay Loam	6-12	till	1-100	82	96
7Ae14	15-30	4-7	shale	Clay Loam	6-12	till	1-100	107	120
7Ae15	30-50	2-4	shale	Clay Loam	6-12	till	1-100	80	94
7Ae16	30-50	2-4	shale	Clay Loam	0-2	till	1-100	85	109
7Ae17	15-30	4-7	shale	Clay Loam	18+	till	1-100	103	108
7Ae18	30-50	2-4	shale	Clay Loam	2-6	till	1-100	84	106
7Ae20	30-50	2-4	shale	Silty Loam	6-12	till	1-100	82	99
7Ae21	30-50	2-4	shale	Clay Loam	6-12	shale	1-100	75	90
7Ae22	30-50	2-4	shale	Clay Loam	12-18	shale	1-100	73	84
7Ae23	15-30	4-7	shale	Clay Loam	18+	shale	1-100	93	100
7Ae24	30-50	2-4	shale	Silty Loam	2-6	shale	1-100	81	107
7Ae25	15-30	4-7	shale	Clay Loam	0-2	shale	1-100	102	127
7Ae26	15-30	4-7	shale	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	103	125
7Ae27	15-30	4-7	shale	Clay Loam	6-12	sand + gvl w/ silt + clay	1-100	99	113
7Ae28	15-30	2-4	shale	Shrink/Swell Clay	18+	sand + gvl w/ silt + clay	1-100	91	109
7Ae29	30-50	4-7	shale	Sandy Loam	18+	shale	1-100	89	105
7Ae30	15-30	4-7	shale	Clay Loam	18+	till	1-100	103	108
7Ae31	15-30	4-7	shale	Shrink/Swell Clay	18+	till	1-100	106	124
7Ae32	15-30	4-7	shale	Silty Loam	2-6	shale	1-100	103	129
7Ae33	15-30	4-7	shale	Sandy Loam	2-6	shale	1-100	107	139
7Ae34	15-30	4-7	shale	Shrink/Swell Clay	0-2	shale	1-100	110	147
7Ae35	5-15	4-7	shale	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	113	135

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ae36	5-15	4-7	shale	Clay Loam	0-2	sand + gvl w/ silt + clay	1-100	114	138
7Af01	30-50	4-7	sand + gravel	Silty Loam	2-6	till	300-700	121	142
7Af02	50-75	4-7	sand + gravel	Silty Loam	2-6	till	300-700	114	135
7Af03	15-30	2-4	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	1-100	110	134
7Af04	30-50	2-4	sand + gravel	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	90	112
7Af05	15-30	2-4	sand + gravel	Clay Loam	2-6	sand + gvl w/ silt + clay	1-100	100	122
7Ba01	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	163	188
7Ba02	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	162	185
7Ba03	15-30	7-10	sand + gravel	Gravel	6-12	sand + gvl w/ silt + clay	700-1000	166	193
7Ba04	15-30	7-10	sand + gravel	Peat	0-2	silt + clay	700-1000	157	190
7Ba05	15-30	7-10	sand + gravel	Sand	2-6	sand + gvl w/ silt + clay	700-1000	168	200
7Ba06	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	1000-2000	167	180
7Ba07	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	171	192
7Ba08	15-30	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	700-1000	151	170
7Ba09	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	151	177
7Ba10	30-50	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	141	167
7Ba11	30-50	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	124	143
7Ba12	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	148	163
7Ba13	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	141	169
7Ba14	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	158	184
7Ba15	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	152	180
7Ba16	30-50	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	142	170
7Ba17	15-30	4-7	sand + gravel	Silty Loam	0-2	till	100-300	131	155
7Ba18	30-50	4-7	sand + gravel	Loam	6-12	till	700-1000	133	146
7Ba19	15-30	4-7	sand + gravel	Loam	0-2	till	700-1000	148	171
7Ba20	30-50	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	143	161

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ba21	30-50	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	148	174
7Ba22	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	148	174
7Ba23	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	159	187
7Ba24	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	137	155
7Ba25	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	144	162
7Ba26	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	147	165
7Ba27	15-30	7-10	sand + gravel	Sandy Loam	12-18	sand + gvl w/ silt + clay	300-700	145	159
7Ba28	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	149	177
7Ba30	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	176	201
7Ba31	15-30	4-7	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	300-700	148	182
7Bb01	50-75	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	1-100	104	125
7Bb02	15-30	7-10	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	158	185
7Bb03	30-50	7-10	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	133	152
7Bb04	30-50	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	1-100	114	135
7Bb05	15-30	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	100-300	144	167
7Bb06	30-50	7-10	interbedded ss+sh	Thin or Absent	12-18	sand + gvl w/ silt + clay	100-300	131	159
7Bb07	30-50	7-10	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	1-100	122	143
7Bb08	15-30	7-10	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	1-100	136	165
7Bb09	15-30	7-10	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	135	155
7Bb10	30-50	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	121	149
7Bb11	50-75	4-7	sand + gravel	Gravel	12-18	sand + gvl w/ silt + clay	100-300	113	141
7Bb12	15-30	7-10	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	139	167
7Bb13	30-50	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	117	137
7Bb14	30-50	4-7	interbedded ss+sh	Sand	6-12	sand + gvl w/ silt + clay	100-300	123	152
7Bb15	50-75	4-7	interbedded ss+sh	Sand	6-12	sand + gvl w/ silt + clay	100-300	113	142
7Bb16	15-30	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	131	159

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Bb17	30-50	7-10	interbedded ss+sh	Sand	6-12	sand + gvl w/ silt + clay	100-300	131	160
7Bb18	50-75	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	107	127
7Bb19	50-75	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	111	139
7Bb20	15-30	4-7	interbedded ss+sh	Sandy Loam	6-12	sand + gvl w/ silt + clay	100-300	127	147
7Bb21	5-15	7-10	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	150	180
7Bb22	5-15	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	142	172
7Bb23	15-30	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	126	155
7Bb24	15-30	4-7	interbedded ss+sh	Sandy Loam	12-18	sand + gvl w/ silt + clay	100-300	120	137
7Bb25	5-15	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	137	168
7Bb26	30-50	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	117	148
7Bb27	15-30	7-10	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	140	170
7D001	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	148	163
7D002	30-50	7-10	sand + gravel	Sand	2-6	sand + gvl w/ silt + clay	700-1000	158	190
7D003	30-50	7-10	sand + gravel	Sand	12-18	sand + gvl w/ silt + clay	700-1000	152	172
7D004	30-50	7-10	sand + gravel	Sandy Loam	12-18	sand + gvl w/ silt + clay	700-1000	146	157
7D005	30-50	7-10	sand + gravel	Sand	6-12	sand + gvl w/ silt + clay	700-1000	154	178
7D006	15-30	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	700-1000	162	194
7D007	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	158	173
7D008	30-50	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	152	175
7D009	30-50	7-10	sand + gravel	Gravel	18+	sand + gvl w/ silt + clay	700-1000	149	168
7D010	50-75	4-7	sand + gravel	Sand	2-6	sand + gvl w/ silt + clay	700-1000	140	172
7D011	30-50	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	153	178
7D012	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	175	198
7D013	5-15	7-10	sand + gravel	Peat	0-2	silt + clay	700-1000	167	200
7D014	30-50	7-10	sand + gravel	Gravel	12-18	sand + gvl w/ silt + clay	700-1000	154	177
7D015	30-50	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	135	153

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D016	30-50	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	126	146
7D017	30-50	4-7	sand + gravel	Silty Loam	6-12	sand + gvl w/ silt + clay	300-700	117	130
7D018	30-50	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	121	140
7D019	15-30	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	137	159
7D020	30-50	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	131	159
7D021	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	162	185
7D022	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	171	192
7D023	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	181	202
7D024	5-15	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	1000-2000	178	195
7D025	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	1000-2000	182	205
7D026	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	1000-2000	167	180
7D027	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	157	181
7D028	30-50	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	147	171
7D029	5-15	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	1000-2000	177	190
7D030	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	168	194
7D031	15-30	7-10	sand + gravel	Muck	0-2	sand + gvl w/ silt + clay	1000-2000	164	175
7D032	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	1000-2000	157	170
7D033	5-15	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	1000-2000	181	211
7D034	15-30	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	1000-2000	171	201
7D035	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	148	174
7D036	50-75	4-7	sand + gravel	Sandy Loam	12-18	sand + gvl w/ silt + clay	700-1000	128	139
7D037	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	158	184
7D038	30-50	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	126	144
7D039	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	173	198
7D040	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	172	195
7D041	15-30	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	300-700	148	183
7D042	15-30	7-10	sand + gravel	Sand	2-6	sand + gvl w/ silt + clay	300-700	162	196

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D043	30-50	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	141	167
7D044	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	151	177
7D045	5-15	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	157	177
7D046	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	161	187
7D047	15-30	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	153	171
7D048	50-75	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	130	145
7D049	30-50	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	144	167
7D050	15-30	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	158	175
7D051	5-15	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	168	185
7D052	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	186	206
7D053	50-75	2-4	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	104	124
7D054	75-100	2-4	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	94	115
7D055	15-30	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	136	156
7D056	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	1000-2000	172	195
7D057	5-15	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	100-300	151	173
7D058	5-15	7-10	sand + gravel	Loam	0-2	sand + gvl w/ silt + clay	300-700	165	189
7D059	15-30	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	139	159
7D060	30-50	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	138	164
7D061	15-30	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	131	152
7D062	15-30	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	129	152
7D063	5-15	7-10	sand + gravel	Shrink/Swell Clay	0-2	sand + gvl w/ silt + clay	1000-2000	179	206
7D064	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	162	190
7D065	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	152	180
7D066	5-15	4-7	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	300-700	140	160
7D067	5-15	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	139	162
7D068	50-75	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	119	137
7D069	30-50	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	133	159

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D070	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	149	177
7D071	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	176	196
7D072	5-15	7-10	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	1000-2000	171	186
7D073	5-15	7-10	sand + gravel	Peat	0-2	silt + clay	1000-2000	176	207
7D074	15-30	4-7	sand + gravel	Silty Loam	6-12	sand + gvl w/ silt + clay	300-700	132	144
7D075	15-30	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	161	178
7D076	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	151	166
7D077	30-50	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	137	155
7D078	15-30	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	1000-2000	162	178
7D079	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	159	187
7D080	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	176	201
7D081	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	165	188
7D082	5-15	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	700-1000	172	204
7D083	30-50	7-10	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	1000-2000	157	172
7D084	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	1000-2000	187	209
7D085	30-50	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	118	139
7D086	30-50	7-10	sand + gravel	Silty Loam	6-12	sand + gvl w/ silt + clay	1000-2000	153	160
7D087	30-50	4-7	sand + gravel	Silty Loam	6-12	till	700-1000	126	137
7D088	15-30	4-7	sand + gravel	Silty Loam	12-18	sand + gvl w/ silt + clay	700-1000	134	141
7D089	15-30	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	145	161
7D090	15-30	7-10	sand + gravel	Sand	2-6	sand + gvl w/ silt + clay	700-1000	163	196
7D091	30-50	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	300-700	124	145
7D092	15-30	4-7	sand + gravel	Silty Loam	18+	sand + gvl w/ silt + clay	300-700	126	131
7D093	30-50	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	134	159
7D094	30-50	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	135	162
7D095	30-50	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	129	158
7D096	30-50	4-7	sand + gravel	Silty Loam	6-12	sand + gvl w/ silt + clay	300-700	122	134

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D097	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	144	172
7D098	5-15	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	148	178
7D099	15-30	4-7	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	100-300	121	143
7D100	5-15	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	100-300	136	161
7D101	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	155	180
7D102	30-50	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	700-1000	140	157
7D103	15-30	4-7	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	700-1000	144	150
7D104	50-75	2-4	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	700-1000	107	114
7D105	30-50	4-7	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	300-700	123	132
7D106	15-30	4-7	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	300-700	133	142
7D107	30-50	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	129	147
7D108	50-75	2-4	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	300-700	101	110
7D109	30-50	4-7	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	300-700	128	147
7D110	30-50	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	130	152
7D111	30-50	4-7	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	300-700	133	168
7D112	30-50	4-7	sand + gravel	Clay Loam	12-18	sand + gvl w/ silt + clay	300-700	121	126
7D113	50-75	2-4	sand + gravel	Clay Loam	2-6	sand + gvl w/ silt + clay	300-700	105	122
7D114	30-50	4-7	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	300-700	112	122
7D115	15-30	4-7	sand + gravel	Clay Loam	6-12	sand + gvl w/ silt + clay	300-700	130	139
7D116	30-50	4-7	sand + gravel	Clay Loam	6-12	till	300-700	110	121
7D117	15-30	4-7	sand + gravel	Silty Loam	0-2	till	300-700	127	151
7D118	15-30	4-7	sand + gravel	Clay Loam	2-6	sand + gvl w/ silt + clay	100-300	115	136
7D119	15-30	4-7	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	100-300	116	139
7D120	15-30	4-7	sand + gravel	Silty Loam	18+	till	300-700	121	127
7D121	30-50	4-7	sand + gravel	Silty Loam	2-6	till	300-700	119	141
7D122	15-30	4-7	sand + gravel	Silty Loam	18+	till	300-700	118	124
7D123	30-50	4-7	sand + gravel	Sandy Loam	2-6	till	300-700	120	148

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D124	30-50	4-7	sand + gravel	Clay Loam	12-18	till	300-700	108	115
7D125	30-50	4-7	sand + gravel	Clay Loam	2-6	till	300-700	114	133
7D126	30-50	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	130	156
7D127	30-50	4-7	sand + gravel	Sandy Loam	12-18	sand + gvl w/ silt + clay	300-700	124	138
7D128	50-75	4-7	sand + gravel	Sandy Loam	12-18	sand + gvl w/ silt + clay	300-700	114	128
7D129	15-30	4-7	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	300-700	136	154
7D130	5-15	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	160	186
7D131	15-30	4-7	sand + gravel	Silty Loam	18+	sand + gvl w/ silt + clay	700-1000	137	139
7D132	15-30	4-7	sand + gravel	Clay Loam	18+	till	700-1000	135	134
7D133	5-15	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	154	182
7D134	30-50	2-4	sand + gravel	Clay Loam	18+	till	300-700	99	101
7D135	15-30	4-7	sand + gravel	Clay Loam	18+	till	300-700	121	123
7D136	50-75	2-4	sand + gravel	Clay Loam	6-12	till	300-700	88	99
7D137	15-30	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	300-700	143	169
7D138	15-30	4-7	sand + gravel	Clay Loam	2-6	till	300-700	127	146
7D139	15-30	4-7	sand + gravel	Sandy Loam	18+	sand + gvl w/ silt + clay	300-700	130	141
7D140	15-30	4-7	sand + gravel	Clay Loam	6-12	till	300-700	128	138
7D141	15-30	4-7	sand + gravel	Clay Loam	6-12	till	300-700	125	135
7D142	0-5	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	167	195
7D143	15-30	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	145	167
7D144	30-50	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	135	157
7D145	0-5	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	163	185
7D146	15-30	4-7	sand + gravel	Silty Loam	18+	sand + gvl w/ silt + clay	300-700	123	128
7D147	30-50	4-7	sand + gravel	Shrink/Swell Clay	6-12	silt + clay	300-700	118	141
7D148	30-50	4-7	sand + gravel	Silty Loam	18+	silt + clay	300-700	105	111
7D149	50-75	2-4	sand + gravel	Clay Loam	6-12	silt + clay	300-700	80	92
7D150	15-30	4-7	sand + gravel	Clay Loam	18+	silt + clay	300-700	113	116

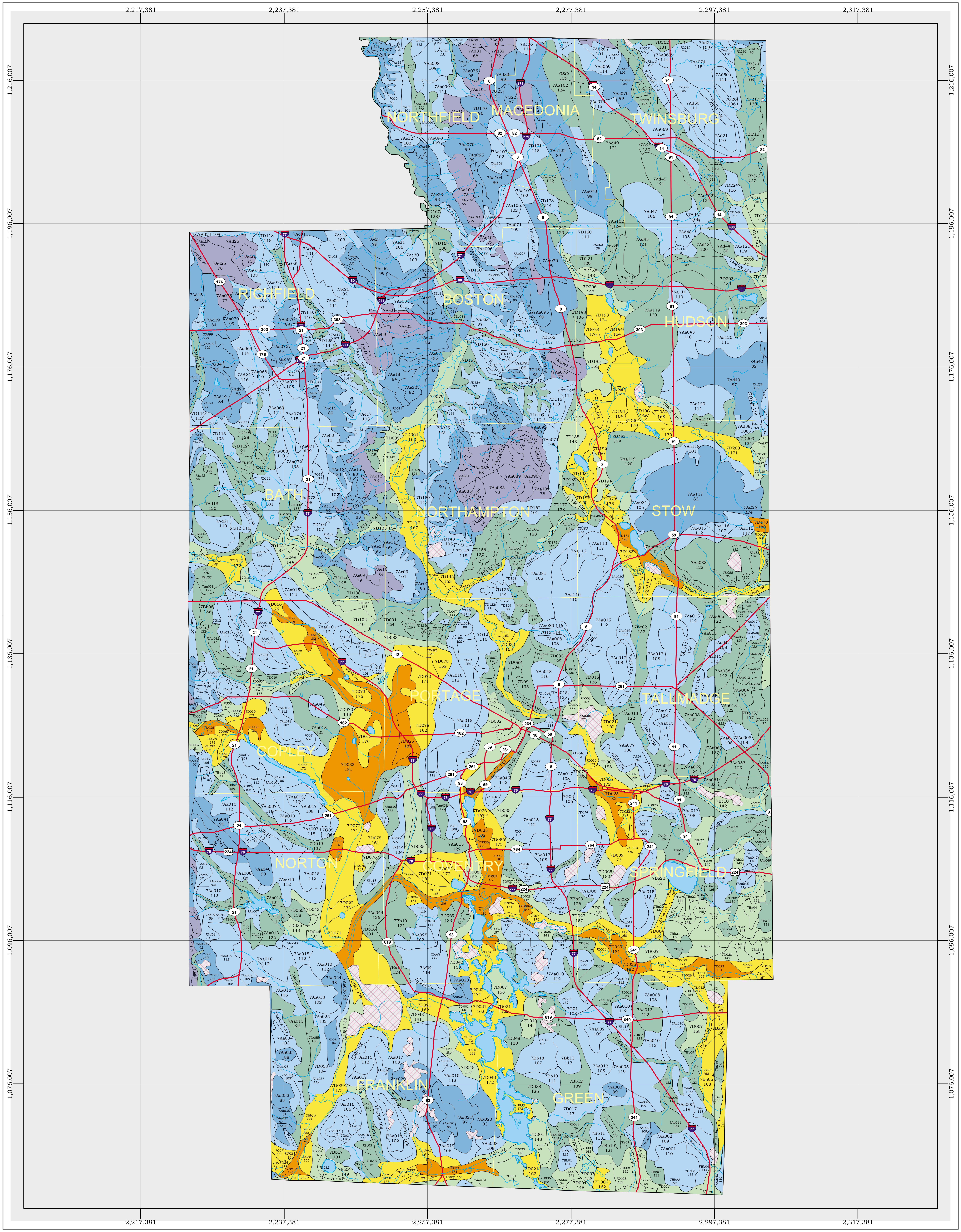
Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D151	30-50	2-4	sand + gravel	Clay Loam	18+	silt + clay	300-700	91	94
7D152	15-30	4-7	sand + gravel	Clay Loam	18+	sand + gvl w/ silt + clay	300-700	124	126
7D153	15-30	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	132	155
7D155	30-50	2-4	sand + gravel	Clay Loam	6-12	silt + clay	300-700	90	102
7D156	30-50	4-7	sand + gravel	Shrink/Swell Clay	6-12	silt + clay	700-1000	127	148
7D157	30-50	4-7	sand + gravel	Shrink/Swell Clay	2-6	silt + clay	300-700	119	150
7D158	15-30	4-7	sand + gravel	Shrink/Swell Clay	2-6	silt + clay	300-700	129	160
7D159	50-75	2-4	sand + gravel	Clay Loam	0-2	till	300-700	90	111
7D160	30-50	4-7	sand + gravel	Clay Loam	2-6	till	300-700	111	130
7D161	30-50	4-7	sand + gravel	Clay Loam	2-6	till	700-1000	128	144
7D162	50-75	2-4	sand + gravel	Clay Loam	2-6	till	700-1000	101	118
7D163	15-30	4-7	sand + gravel	Clay Loam	6-12	till	700-1000	134	142
7D164	15-30	4-7	sand + gravel	Silty Loam	18+	till	700-1000	132	135
7D166	30-50	4-7	sand + gravel	Clay Loam	6-12	till	300-700	107	118
7D167	5-15	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	100-300	128	154
7D168	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	136	165
7D169	5-15	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	143	172
7D170	50-75	2-4	sand + gravel	Sandy Loam	0-2	till	300-700	96	126
7D171	30-50	4-7	sand + gravel	Sandy Loam	0-2	till	300-700	118	148
7D172	15-30	4-7	sand + gravel	Clay Loam	0-2	till	300-700	122	143
7D173	30-50	4-7	sand + gravel	Silty Loam	0-2	till	300-700	114	138
7D174	50-75	2-4	sand + gravel	Clay Loam	2-6	till	100-300	83	104
7D175	5-15	4-7	sand + gravel	Silty Loam	0-2	till	300-700	147	169
7D176	30-50	4-7	sand + gravel	Clay Loam	2-6	till	300-700	124	141
7D177	15-30	4-7	sand + gravel	Clay Loam	2-6	till	700-1000	138	154
7D178	5-15	7-10	sand + gravel	Loam	0-2	sand + gvl w/ silt + clay	1000-2000	180	200
7D179	15-30	4-7	sand + gravel	Loam	0-2	sand + gvl w/ silt + clay	700-1000	156	178

Setting	**Depth to Water**	**Recharge (In/Yr)**	**Aquifer Media**	**Soil Media**	**Topography (% Slope)**	**Vadose Zone Media**	**Hydraulic Conductivity**	**Rating**	**Pesticide Rating**
7D180	5-15	4-7	sand + gravel	Loam	0-2	sand + gvl w/ silt + clay	300-700	152	177
7D181	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	2000+	193	213
7D182	15-30	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	1000-2000	177	199
7D183	30-50	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	1000-2000	167	189
7D184	15-30	7-10	sand + gravel	Sandy Loam	6-12	sand + gvl w/ silt + clay	700-1000	153	169
7D185	5-15	7-10	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	700-1000	164	184
7D186	15-30	4-7	sand + gravel	Clay Loam	2-6	till	700-1000	146	161
7D187	5-15	4-7	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	700-1000	160	190
7D188	15-30	4-7	sand + gravel	Clay Loam	2-6	till	700-1000	143	158
7D189	30-50	4-7	sand + gravel	Clay Loam	2-6	till	700-1000	133	148
7D190	15-30	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	1000-2000	166	188
7D191	15-30	7-10	sand + gravel	Clay Loam	6-12	till	1000-2000	156	161
7D192	15-30	7-10	sand + gravel	Clay Loam	2-6	till	1000-2000	160	173
7D193	5-15	7-10	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	1000-2000	174	202
7D194	15-30	7-10	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	1000-2000	164	192
7D195	15-30	7-10	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	700-1000	155	185
7D196	15-30	7-10	sand + gravel	Peat	0-2	silt + clay	1000-2000	166	197
7D197	15-30	7-10	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	1000-2000	161	176
7D198	15-30	4-7	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	300-700	138	170
7D199	5-15	7-10	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	700-1000	170	194
7D200	5-15	7-10	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	700-1000	171	197
7D201	5-15	7-10	sand + gravel	Clay Loam	2-6	sand + gvl w/ silt + clay	1000-2000	170	183
7D202	5-15	4-7	sand + gravel	Sandy Loam	2-6	sand + gvl w/ silt + clay	100-300	131	161
7D203	15-30	4-7	sand + gravel	Clay Loam	2-6	till	300-700	134	151
7D204	30-50	4-7	sand + gravel	Clay Loam	2-6	till	300-700	119	137
7D205	5-15	4-7	sand + gravel	Peat	0-2	till	100-300	149	185
7D206	15-30	4-7	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	700-1000	147	177

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7D207	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	141	169
7D208	5-15	4-7	sand + gravel	Clay Loam	2-6	till	300-700	139	157
7D209	5-15	4-7	sand + gravel	Clay Loam	2-6	till	100-300	128	149
7D210	0-5	7-10	sand + gravel	Loam	0-2	sand + gvl w/ silt + clay	100-300	153	180
7D211	0-5	7-10	sand + gravel	Peat	0-2	sand + gvl w/ silt + clay	100-300	159	195
7D212	5-15	4-7	sand + gravel	Clay	0-2	till	100-300	122	139
7D213	0-5	4-7	sand + gravel	Clay	0-2	till	100-300	127	144
7D214	30-50	4-7	sand + gravel	Clay Loam	2-6	till	100-300	105	126
7D215	50-75	4-7	sand + gravel	Clay Loam	0-2	till	100-300	96	119
7D216	15-30	4-7	sand + gravel	Silty Loam	2-6	sand + gvl w/ silt + clay	100-300	117	141
7D217	15-30	4-7	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	300-700	130	163
7D218	30-50	4-7	sand + gravel	Clay Loam	6-12	till	300-700	120	129
7D219	5-15	4-7	sand + gravel	Clay Loam	0-2	sand + gvl w/ silt + clay	100-300	126	149
7D220	30-50	4-7	sand + gravel	Shrink/Swell Clay	0-2	silt + clay	300-700	120	153
7D221	15-30	4-7	sand + gravel	Clay Loam	2-6	till	300-700	129	147
7D222	5-15	4-7	sand + gravel	Clay Loam	2-6	till	300-700	136	154
7D223	15-30	4-7	sand + gravel	Clay Loam	2-6	till	300-700	126	144
7D224	30-50	4-7	sand + gravel	Clay Loam	2-6	till	300-700	116	134
7D225	15-30	2-4	sand + gravel	Shrink/Swell Clay	18+	sand + gvl w/ silt + clay	100-300	103	120
7Ec01	15-30	4-7	sand + gravel	Clay Loam	0-2	silt + clay	1-100	113	137
7Ec02	15-30	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	132	162
7Ec03	15-30	4-7	interbedded ss+sh	Silty Loam	0-2	sand + gvl w/ silt + clay	100-300	123	148
7Ec04	5-15	7-10	sand + gravel	Peat	0-2	silt + clay	100-300	149	186
7Ec05	5-15	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	1-100	134	166
7Ec06	5-15	4-7	interbedded ss+sh	Silty Loam	0-2	sand + gvl w/ silt + clay	1-100	130	156
7Ec07	15-30	4-7	interbedded ss+sh	Silty Loam	2-6	interbedded ss+sh	100-300	122	145

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7Ec08	5-15	4-7	shale	Sandy Loam	0-2	sand + gvl w/ silt + clay	1-100	128	160
7Ec09	5-15	4-7	shale	Sandy Loam	2-6	sand + gvl w/ silt + clay	1-100	127	157
7Ec10	5-15	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	100-300	142	172
7Ec11	15-30	4-7	shale	Sandy Loam	2-6	sand + gvl w/ silt + clay	1-100	112	143
7Ec12	5-15	4-7	interbedded ss+sh	Sandy Loam	2-6	sand + gvl w/ silt + clay	1-100	125	156
7Ec13	5-15	4-7	interbedded ss+sh	Silty Loam	0-2	sand + gvl w/ silt + clay	1-100	127	153
7Ec14	5-15	4-7	interbedded ss+sh	Sandy Loam	0-2	sand + gvl w/ silt + clay	1-100	131	163
7Ed01	15-30	4-7	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	300-700	137	159
7Ed02	15-30	4-7	sand + gravel	Sandy Loam	0-2	sand + gvl w/ silt + clay	300-700	141	169
7Ed03	5-15	2-4	sand + gravel	Silty Loam	0-2	sand + gvl w/ silt + clay	1-100	113	140
7G01	30-50	4-7	interbedded ss+sh	Silty Loam	6-12	interbedded ss+sh	100-300	108	123
7G02	30-50	4-7	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	100-300	106	117
7G03	50-75	4-7	interbedded ss+sh	Thin or Absent	6-12	interbedded ss+sh	100-300	110	143
7G04	50-75	2-4	interbedded ss+sh	Thin or Absent	12-18	interbedded ss+sh	100-300	96	125
7G05	30-50	2-4	interbedded ss+sh	Thin or Absent	12-18	interbedded ss+sh	100-300	106	135
7G06	50-75	2-4	interbedded ss+sh	Silty Loam	12-18	interbedded ss+sh	1-100	81	93
7G07	15-30	2-4	interbedded ss+sh	Thin or Absent	18+	interbedded ss+sh	1-100	111	137
7G08	50-75	2-4	interbedded ss+sh	Silty Loam	18+	interbedded ss+sh	1-100	79	87
7G09	30-50	2-4	interbedded ss+sh	Thin or Absent	18+	interbedded ss+sh	1-100	101	127
7G10	15-30	2-4	interbedded ss+sh	Thin or Absent	6-12	interbedded ss+sh	100-300	118	151
7G11	30-50	2-4	interbedded ss+sh	Thin or Absent	6-12	interbedded ss+sh	100-300	108	141
7G12	15-30	2-4	interbedded ss+sh	Thin or Absent	12-18	interbedded ss+sh	100-300	116	145
7G13	15-30	2-4	interbedded ss+sh	Thin or Absent	18+	interbedded ss+sh	100-300	114	139
7G14	30-50	2-4	interbedded ss+sh	Thin or Absent	18+	interbedded ss+sh	100-300	104	129
7G15	15-30	4-7	interbedded ss+sh	Sandy Loam	18+	interbedded ss+sh	100-300	118	131
7G16	15-30	2-4	sandstone	Thin or Absent	2-6	sandstone	100-300	122	163

Setting	Depth to Water	Recharge (In/Yr)	Aquifer Media	Soil Media	Topography (% Slope)	Vadose Zone Media	Hydraulic Conductivity	Rating	Pesticide Rating
7G17	15-30	4-7	interbedded ss+sh	Clay Loam	2-6	interbedded ss+sh	1-100	109	131
7G18	50-75	2-4	interbedded ss+sh	Thin or Absent	12-18	interbedded ss+sh	1-100	85	116
7G19	30-50	2-4	interbedded ss+sh	Thin or Absent	18+	interbedded ss+sh	1-100	93	120
7G20	15-30	2-4	shale	Thin or Absent	18+	shale	1-100	95	123
7G22	50-75	2-4	sandstone	Thin or Absent	6-12	sandstone	1-100	87	122
7G23	50-75	2-4	sandstone	Thin or Absent	2-6	sandstone	1-100	91	134
7G24	5-15	4-7	sandstone	Thin or Absent	6-12	sandstone	100-300	140	173
7G25	15-30	4-7	sandstone	Thin or Absent	6-12	sandstone	100-300	130	163
7G26	30-50	2-4	sandstone	Thin or Absent	12-18	sandstone	100-300	106	135

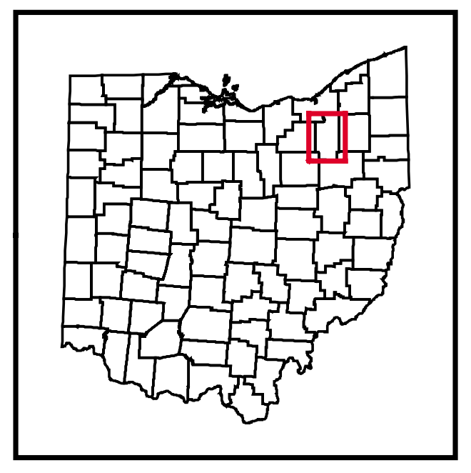


Ground Water Pollution Potential of Summit County

by

Michael P. Angle, Chris Russel, and Brad Ziss

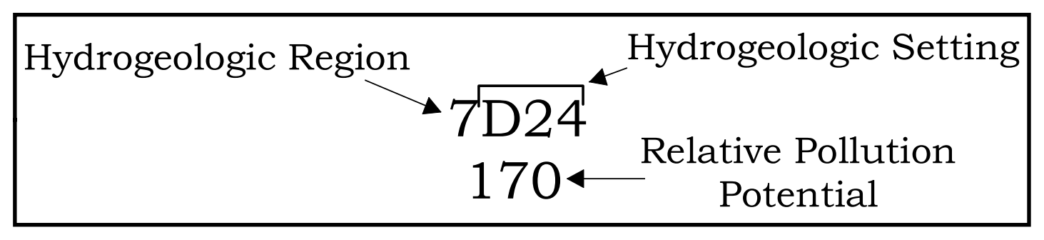
Ohio Department of Natural Resources, Division of Water



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

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

Description of Map Symbols



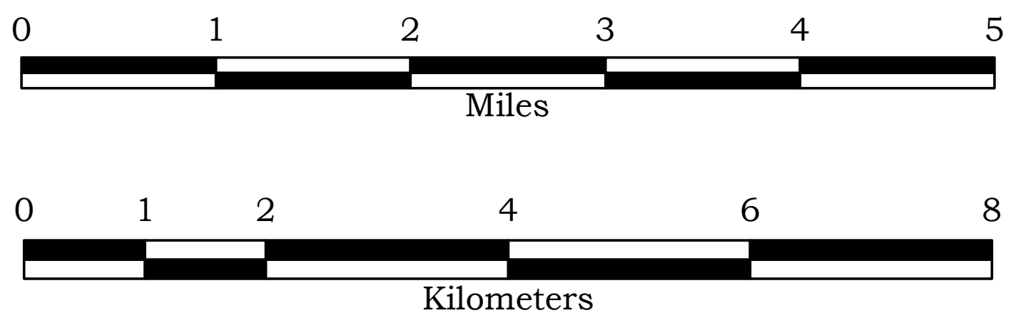
Legend

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

			Index Ranges
—	Roads	▨	Not Rated
~	Streams	🟪	Less Than 79
●	Lakes	🟦	80 - 99
☐	Townships	🟦	100 - 119
		🟩	120 - 139
		🟩	140 - 159
		🟨	160 - 179
		🟧	180 - 199
		🟥	Greater Than 200

N

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



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