GROUND WATER POLLUTION POTENTIAL OF BUTLER COUNTY, OHIO

GROUND WATER POLLUTION POTENTIAL REPORT NO. 11

BY

GROUND WATER RESOURCES SECTION

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ABSTRACT

A ground water pollution potential map of Butler 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 the major 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. The relative ranking scheme uses a combination of weights and ratings to produce a numerical value called the pollution potential index that helps prioritize areas with respect to ground water contamination vulnerability. Hydrogeologic settings and the corresponding pollution potential indexes are displayed graphically on maps.

Butler County lies within the Glaciated Central hydrogeologic region. The county is covered by variable thicknesses of glacial till, moraines, river alluvium, and outwash deposits in buried valleys. These unconsolidated deposits are underlain by shale and shaley limestone bedrock that is capable of supplying only small quantities of ground water. Pollution potential indexes are relatively low to moderate in areas of till cover over bedrock, and moderate in areas covered by glacial moraines. Areas of river alluvium with overbank deposits exhibit a moderate vulnerability to contamination. Buried valleys containing sand and gravel aquifers have moderate to high vulnerabilities to contamination. Four hydrogeologic settings were identified in Butler County with computed ground water pollution potential indexes ranging from 79 to 211.

The ground water pollution potential map of Butler County was prepared to assist planners, managers, and local officials in evaluating the potential for contamination from various sources of pollution. This information can be used to help direct resources and land-use activities to appropriate areas, or to assist in protection, monitoring, and cleanup efforts.

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ACKNOWLEDGEMENTS

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. About 42 per cent of Ohio citizens rely on ground water for their drinking and household uses from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 700,000 rural households depend on private wells; approximately 6,500 of these wells exist in Butler County.

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

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

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

APPLICATIONS OF POLLUTION POTENTIAL MAPS

The pollution potential mapping program offers a wide variety of applications in many counties. The ground water pollution potential map of Butler 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 to assist 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 more or less suitable for land 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.

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

Pollution potential maps may also be applied successfully where non-point source contamination is a concern. Non-point source contamination occurs where land use activities over large areas impact water quality. Maps providing information on relative vulnerability can be used to guide the selection and implementation of appropriate best management practices in different areas. Best management practices should be chosen based upon consideration of the chemical and physical processes that occur 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.

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

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

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

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

The application of DRASTIC to an area requires the recognition of a set of assumptions made in the development of the system. DRASTIC evaluates the pollution potential of an area assuming a contaminant with the mobility of water, introduced at the surface, and flushed into the ground water by precipitation. Most important, DRASTIC cannot be applied to areas smaller than one-hundred 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 fifteen 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 Butler County. Inherent within each hydrogeologic setting are the physical characteristics which affect the ground water pollution potential. These characteristics or factors identified during the development of the DRASTIC system include:

D - Depth to Water

R - Net Recharge

A - Aquifer Media

S - Soil Media

T - Topography

I - Impact of the Vadose Zone Media

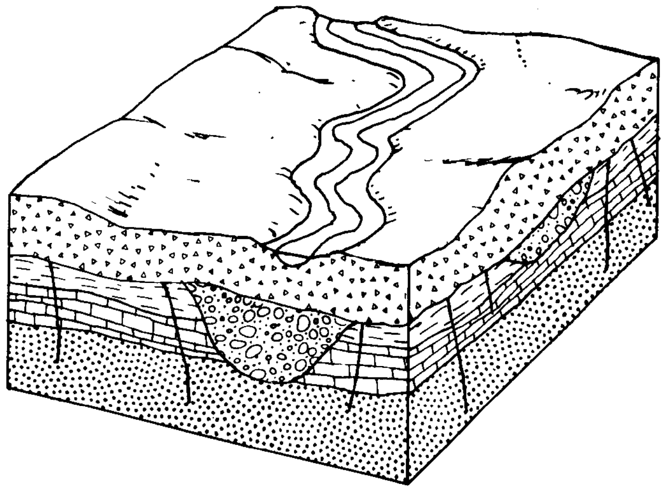
C - Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a pre-glacial river valley) by glacial meltwaters. These deposits are capable of yielding large quantities of ground water. The deposits may or may not underlie a present-day river and may or may not be in direct hydraulic connection with a stream. Glacial till or recent alluvium often overlies the buried valley. Usually the deposits are several times more permeable than the surrounding bedrock, with finer-grained alluvium covering the underlying sand and gravel. Soils are typically a sandy loam. Recharge to the sand and gravel is moderate to high and water levels are relatively shallow, although they may be quite variable.

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

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

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

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

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

Weighting and Rating System

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

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

Pesticide DRASTIC

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

TABLE 1. ASSIGNED WEIGHTS FOR DRASTIC FEATURES

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

TABLE 2. RANGES AND RATINGS FOR DEPTH TO WATER

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

TABLE 3. RANGES AND RATINGS FOR NET RECHARGE

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

TABLE 4. RANGES AND RATINGS FOR AQUIFER MEDIA

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

TABLE 5. RANGES AND RATINGS FOR SOIL MEDIA

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

TABLE 6. RANGES AND RATINGS FOR TOPOGRAPHY

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

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

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

TABLE 8. RANGES AND RATINGS FOR HYDRAULIC CONDUCTIVITY

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

Integration of Hydrogeologic Settings and DRASTIC Factors

Figure 2 illustrates the hydrogeologic setting 7D1 Buried Valley, identified in mapping Butler 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 205. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 65 to 223. The diversity of hydrogeologic conditions in Butler County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the four settings identified in the county range from 79 to 211.

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 mapping in Butler 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 Butler County is included with this report.

INTERPRETATION AND USE OF A GROUND WATER POLLUTION POTENTIAL MAP

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

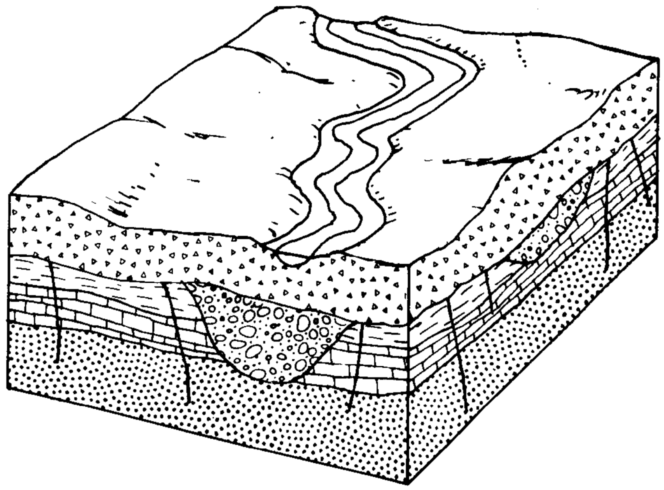
The map accompanying this report displays both the hydrogeologic settings identified in the county and the associated pollution potential indexes calculated in those hydrogeologic settings. The symbols on the map represent the following information:

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

Here the first number (7) refers to the major hydrogeologic region and the upper and lower case letters (D) refer to a specific hydrogeologic setting. The following number (1) references a certain set of DRASTIC parameters that are unique to this setting and are described in the corresponding setting chart. The second number (205) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived in an area.

The maps are color coded using ranges depicted on the map legend. The color codes used are part of a national color coding scheme developed to assist the user in gaining a general insight into the vulnerability of the ground water in the area. The color codes were chosen to represent the colors of the spectrum, with warm colors (red, orange, and yellow), representing areas of higher vulnerability (higher pollution potential indexes), and cool colors (greens, blues, and violet), representing areas of lower vulnerability to contamination.

The map also includes information on the locations of selected observation wells. Available information on these observation wells is referenced in Appendix A, Description of the Logic in Factor Selection. Large man-made features such as landfills, quarries or strip mines have also been marked on the map for reference.



SETTING 7D1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand & Gravel	3	9	27
Soil Media	Sandy Loam	2	6	12
Topography	0-2%	1	10	10
Impact Vadose Zone	Sand & Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		DRASTIC	INDEX	205

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

GENERAL INFORMATION ABOUT BUTLER COUNTY

Butler County occupies an area of approximately 469 square miles and is located in the southwestern corner of Ohio (Figure 3). It is bounded by Indiana to the west, Hamilton County to the south, Warren County to the east; and Montgomery County and Preble County to the north. Hamilton, the largest city, is the county seat. Approximately two-thirds of the county is farmland (including woods); the remaining third is mixed residential-commercial-industrial. Nonagricultural usage is on the increase with the expansion of the Cincinnati-Dayton population centers.

Physiography

Butler County lies within the Till Plains section of the Central Lowland physiographic province (Fenneman, 1938). The county is characterized by steeply rolling uplands dissected by broad, flat-bottomed valleys. The uplands are composed of late Ordovician shale and limestone bedrock covered by varying thicknesses of till deposits. Prior to glaciation the region was a gently rolling bedrock plain known as the Lexington Peneplain. This relatively even surface was interrupted by tributary stream valleys of the Teays drainage system.

The modern land surface is a result of glacial and post-glacial processes over time. Valleys reflect complex drainage changes spanning the Pleistocene Epoch. The glacial till covering the bedrock in upland areas primarily reflects the most recent (Wisconsinan) glaciation. In Butler County, end moraines are not nearly as prominent as they are in northern Ohio. End moraines are ridges which reflect a thickening of till. Locally, bedrock highs and the highly stream-dissected nature of the topography helps obscure moraines. The Camden Moraine, which extends across Preble County, does fringe northeastern Butler County. To the south, the Butler -Hamilton County boundary roughly follows the Hartwell Moraine. The Hartwell Moraine approximately marks the southernmost extent of the Wisconsinan ice sheet in Ohio.

Climate

Climatic data for the city of Hamilton is reasonably representative of Butler County. Annual precipitation at Hamilton, based on a thirty-year (1951-1980) average, was 38.2 inches (U.S. Department of Commerce, 1982). The majority of this precipitation is lost through run-off and evapotranspiration, with the remainder infiltrating into the subsurface to become recharge. Hamilton had an average annual temperature of 54.0 degrees Fahrenheit for the same thirty-year period (U.S. Department of Commerce, 1982).

Figure 3. Location of Butler County, Ohio

Modern Drainage

Butler County falls entirely within the Ohio River Drainage System. The Great Miami River is the predominant stream and drains much of northern, western, and central Butler County. Important tributaries include Elk Creek, Sevenmile Creek, Fourmile Creek, and Dry Fork Creek. The southeastern corner of the county is drained by Mill Creek. The eastern margin of the county, in the vicinity of Middletown and Monroe, drains eastward to the Little Miami River in Warren County. The modern drainages are typically underlain by ancestral buried valleys (Leow, 1985a; b).

Pre-Glacial and Pleistocene Drainage

The pre-glacial drainage of Butler County is complex and its interpretation has been disputed by geologists over time. The principal pre-glacial drainageway was the Teays River which flowed northwards from Portsmouth to Chillicothe before veering northwestwards and eventually entering Indiana west of Grand Lake St. Marys in Mercer County. Once in Indiana, the Teays followed a course similar to that of the modern Wabash River. Ver Steeg (1936) and Stout and others (1945) speculated that drainage in Butler County flowed southwestward along the Hamilton River which corresponds to the trend of the present Great Miami Valley. The Hamilton River joined the Norwood River and continued westwards, joining the Teays System in western Indiana. Wayne (1952) and Coffey (1958) shared a very different perspective and envisioned drainage flowing northeastward towards the Teays System. Specifically, the Licking River flowed northward up the Mill Creek Valley, then cut westward towards Hamilton before resuming a northerly course up the Great Miami Valley (Durrell, 1982). The Kentucky River followed the Lower Great Miami River Valley through Hamilton County and merged with the Licking River just south of the city of Hamilton. Current opinion supports the later, northerly- flowing direction for the Teays' tributaries in southwestern Ohio (Brockman, in progress).

During the Pleistocene Epoch (two million to 10,000 years ago) at least four major episodes of glaciation occurred in North America. Evidence for three of these episodes exists in southwestern Ohio (Table 9). Glaciation in the early part of the Pleistocene Epoch blocked the northerly flowing Teays System creating large lakes as the streams backed up. Eventually, the lakes breached their divide and cut a new channel, initiating a new drainage system. This system is referred to as the Deep Stage as it cut very broad, deep channels into the bedrock. The Deep Stage channel flowed northward up Mill Creek Valley, veered towards the city of Hamilton, and then followed the Great Miami Valley southwestward, nearly encircling present-day Cincinnati in the process.

TABLE 9. GENERALIZED PLEISTOCENE (GLACIAL) STRATIGRAPHY OF BUTLER COUNTY, OHIO (after Goldthwait et al., 1981)

EPOCH	STAGE		SUBSTAGE	UNIT or INTERVAL
PLEISTOCENE	WISCONSINAN	late	Woodfordian	Shelbyville Till Connersville Interstade? Fayette Till (1)
		middle	Farmdalian	Sidney Interstade (2) Fairhaven Till (3)
		early	Altonian	New Paris Interstade (2) Whitewater Till (3)
	Sangamonian			Paleosol Sidney (2) New Paris (2)
	Illinoian			Fairhaven Till (3) Whitewater Till (2) Richmond Till (4) Centerville Till (4)
	Pre–Illinoian			Not Exposed

(1) Fayette Till only exposed in subsurface

(2) Sidney and/or New Pairs Interstades may be Sangamonian in age

(3) Age of Fairhaven Till and Whitewater Till is in dispute

(4) Richmond and Centerville Tills are not differentiated in Butler County

The Great Miami Valley and Mill Creek Valley then underwent several episodes of cutting (erosion) and filling (deposition) throughout the Illinoian and Wisconsinan glaciations (Goldthwait et al., 1981). Lacustrine (lake) clay and silt was deposited as streams were blocked and lakes formed. Till was deposited in the valleys by advancing ice sheets. Till is an unsorted deposit comprised of varying amounts of clay, silt, sand, and gravel. Small lenses or pockets of sand, gravel or silt are commonly associated with till. Till was deposited at the base of both actively moving and stagnating (melting) ice sheets. Meltwater eroded the valleys and subsequently deposited outwash. Outwash consists of layered, well to moderately sorted, sand and gravel deposits. These outwash (valley train) deposits are represented by a complex sequence of outwash terraces (Spieker, 1968; Newdale, 1980; Durrell, 1982).

Bedrock Geology

The bedrock in Butler County consists of interbedded limestones and shales of Late Ordovician age (Table 10). Rocks from the Ordovician System were formed between 438 and nearly 505 million years ago, representing the oldest rocks exposed at the surface in Ohio. The Ordovician System is characterized by soft, calcareous shales, interbedded with thin, hard limestone layers. Bedrock classification of the Ordovician in this region has historically followed two main pathways. Early researchers relied on biostratigraphy which separated rock units on the basis of their fossil assemblages. Recent studies based their classifications upon lithostratigraphy which looks at the nature of the rock units themselves.

Sedimentation during the Late Ordovician was influenced by the presence of the Cincinnati Arch, a broad, gently sloping structural ridge. Deposition of sediment occurred in a shallow marine shelf (ramp) environment along the rise associated with the Cincinnati Arch. Limestones were deposited in these areas of clear water containing abundant marine life. The water deepened somewhat to the east where a relatively shallow sea formed between the Arch and the uplifting ancestral Appalachian chain. This uplift, or past mountain building event, provided a source for abundant fine sediments from the uplifting landmass. These sediments were then washed into the shallow sea where storm events suspended them and redeposited them along the shelf. Shaley units of rock reflect these terrigenous clastic (i.e. “land-derived”) deposits washed into the shelf area by major storm events.

TABLE 10. GENERALIZED BEDROCK STRATIGRAPHY OF BUTLER COUNTY, OHIO (after Tobin, 1986; Swinford, in progress)

SYSTEM	FORMATION AND MEMBER		ROCK TYPE
ORDOVICIAN	Drakes Formation		Limestone containing minor shale (shale averages 13%)
	Whitewater Formation		Limestone containing minor shale (shale averages 14%)
	Liberty Formation		Interbedded shale and limestone (shale averages 45% of unit)
	Waynesville Formation		Interbedded shale and limestone (shale 65% or more of unit)
	Arnheim Formation		Interbedded limestone and shale
	Grant Lake Limestone	Mt. Auburn Member	Limestone and shale (shale 60% or more of unit)
		Corryville Member	Interbedded limestone and shale (shale 60% or more of unit)
		Bellevue Member	Limestone
	Miamitown Formation		Interbedded shale and limestone (shale averages 60% of unit)
	Fairview Formation		Interbedded shale and limestone (shale averages 60% of unit)
	Kope Formation		Interbedded shale and limestone (shale 75% or more of unit)

Within each shaley unit, there were typically numerous fluctuations or cycles between two modes of sedimentation. Over time, more generalized long-term cycles occurred which affected multiple units of sediments. Tobin (1986) and Schumacher et al. (1987) have referred to these as shoaling (shallowing) upward cycles. As these cycles progress, the depositional environment tends to shift from a lower energy, somewhat deeper water setting where shale deposition is predominant, to a shallower, higher energy setting where limestone deposition occurs. Such cycles tend to repeat over time and reflect periods of transgression (a relative rise in sea level) or regression (a relative decline in sea level). These periods are ultimately controlled by the overall (eustatic) sea level, occurrence of tectonic (crustal) subsidence or uplift, and sedimentation rates, among other factors. More detailed descriptions and information on the depositional environments of the Ordovician System can be found in Tobin (1986), Schumacher et al. (1987), and Schumacher et al. (1991).

Glacial Geology

The glacial history of Butler County is complex and is not completely understood to date. In Hamilton County, evidence for Pre-Illinoian (Kansan) glaciation has been inferred from ancient, buried soil profiles (Norton et al., 1983). These deposits represent the oldest known glacial sediments in Ohio. The presence of Illinoian till at the base of deep stream cuts has been confirmed in northern Butler County (Goldstein, 1968; Goldthwait et al., 1981). The surficial till covering most upland areas in Butler County is Wisconsinan in age (Goldstein, 1968; Reddin, 1981).

The Pleistocene stratigraphic scheme (Table 9) utilized in Butler County is largely based upon the work of Gooding (1963; 1975) in southeastern Indiana. Two Illinoian-aged tills have been identified in the sub-surface of Butler County (Goldstein, 1968); however, the extent of these tills is unknown and they typically have not been differentiated. Illinoian till can be found at the surface in limited areas of southeastern Butler County (Lerch et al., 1980); however, exposures of these tills are lacking and they have not been extensively studied. The top of the Illinoian sequence is marked by the Sangamon weathering profile (Goldthwait and Forsyth, 1965). In the subsurface, two Wisconsinan-aged tills, the Fayette and the Whitewater, and potentially a third, the Fairhaven, are known to exist (Goldthwait et al., 1981). The age of the Whitewater and Fairhaven Tills, which have classically been interpreted as being early and middle Wisconsinan respectively, (Dreimanis and Goldthwait, 1973; Fullerton, 1986) is now in dispute (Miller et al., in progress). These two units are now inferred as being Illinoian in age (Miller et al., in progress). The Fayette Till is generally accepted as being Late Wisconsinan (Woodfordian) in age. Newdale (1980) reported that thin silts commonly overlie the Fayette Till.

Surficial till in most upland areas of Butler County is the Wisconsinan-aged Shelbyville Till (Goldstein, 1968; Goldthwait et al., 1981). This till essentially comprises the Hartwell Moraine in southern Butler County and northern Hamilton County. Goldstein (1968) and Reddin (1981) report the possibility that two distinct facies exist within the Shelbyville Till and that perhaps it should be mapped as two units.

In the northeastern corner of the county, the slightly younger Crawfordsville Till (Goldthwait et al., 1981) may overlap the Shelbyville Till in the vicinity of the Camden

Moraine. Appreciable amounts of gravel exist in portions of the Camden Moraine (Reddin, 1981; Schmidt, 1986).

Extensive sand and gravel deposits, in conjunction with locally-important lenses of till, silt, and clay, are found in the valleys of Butler County (Struble, 1986). Silty alluvium (layered deposits of silt, sand and gravel) represents deposition within the floodplains of modern rivers.

Upland areas in Butler County are blanketed by a thin (usually less than five foot) cover of windblown silt called loess. Loess is derived from the wind reworking dried silty deposits along major outwash valleys. Loess has an important influence on the development of soils of the region (Lerch et al., 1980).

Hydrogeology

The principal aquifers in Butler County are restricted to the buried valley networks, and are developed in the extensive sand and gravel outwash deposits. Yields well over 1000 gallons per minute have been developed in the central portions of the buried valley systems (Spieker, 1968; Schmidt, 1986). Wells located in marginal portions of larger valleys or in smaller valley systems usually are capable of developing 70 to 100 plus gallons per minute (Schmidt, 1986). These wells are developed in somewhat less areally extensive, thinner sands and gravels. Vertical hydraulic interconnection between sands and gravels will decrease in these areas as the likelihood of interlayered till or silt increases. In smaller tributary valleys, the finer-grained sediments predominate, and sands and gravels are limited to localized lenses. Yields in these areas average about 40 gallons per minute (Spieker, 1968; Schmidt, 1986). Wells intended for municipal or commercial usage should be confined to the main valleys and a site investigation is generally necessary. Wells developed in the tributaries are suitable for domestic or small allotment use.

In the upland areas along minor streams and bordering major valleys, the glacial deposits are generally a poor source of water. Wells are developed in small isolated sand and gravel zones or perhaps even zones of sand in till. These wells usually have yields of five gallons per minute or less and are marginally suitable for domestic use (Schmidt, 1986). Greater yields occur in northern Madison Township where appreciable sand and gravel lenses are found within the Camden Moraine; wells produce yields up to 15-20 gallons per minute (Schmidt, 1986).

Bedrock in Butler County is generally a very poor source of water (Spieker, 1968; Schmidt, 1986) due to the interbedded, shaley nature of the limestone. The bedrock, is, however, the primary source of ground water in the upland areas. Ground water in the upland areas typically occurs at the interface between the glacial till and the underlying upper few feet of weathered bedrock, and in shallow bedding planes and fractures. Wells are typically drilled deeper into the bedrock to provide additional storage in the borehole. There are no bedrock aquifers of any regional importance and domestic wells are developed in a "hit-or-miss" fashion. Yields are usually under two gallons per minute, and water quality is poor, with high hardness, iron, and sulfur being a problem. In higher uplands areas, where neither the till nor bedrock is productive, cisterns or municipal water systems become a necessity.

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Based on well log data, depth to water in the Till Over Bedded Sedimentary Rock hydrogeologic setting ranges from 5-15 feet (9) to 30-50 feet (5). Depth to water in the Moraine hydrogeologic setting ranges from 15-30 feet (7) to 30-50 feet (5) (ODNR, unpublished water well log data).

In areas of River Alluvium With Overbank Deposits, depth to water is relatively shallow, ranging from 5-15 feet (9). This determination was based on topographic relief and the area's proximity to streams.

Depth to water in the Buried Valley setting varies greatly depending on the thickness of the deposits, the proximity to major streams or rivers, and the topographic relief of the surficial material overlying the valley. In this setting, depths range from 5-15 feet (9) to 30-50 feet (5). Near large pumping centers, where the water table has declined from long periods of high ground water use, the pre-pumping depth to water was used to evaluate this parameter. This value was estimated based on historic data, such as water well logs, the piezometric (water table) surface maps contained in Spieker (1968), and hydrographs found in Klaer and Thompson (1948). Further verification of the pre-pumping water table levels was obtained by comparing the estimated values from pumping centers to values from unaffected areas in similar regions within the county and throughout southwestern Ohio.

Net Recharge

Limited data were available to determine the net recharge in the upland areas of Butler County. This parameter was estimated based upon precipitation values for the county, and the nature and thickness of the soil and till cover over the bedrock. Additional data on recharge to the bedrock aquifer is contained in Pettyjohn and Henning (1979). Based on the above cited data, net recharge for the uplands area was estimated at 2-4 inches per year (3).

Recharge to the buried valley aquifers is highly variable. Within most of the Great Miami Buried Valley Aquifer recharge was estimated at greater than 10 inches per year (9). This value was assigned based on low topographic relief, the permeable nature of the materials above the water table, and estimates of recharge to similar buried valley aquifers in southwest Ohio (Norris and Spieker, 1966; Walton and Scudder, 1960). In areas where there is extensive paving and storm water runoff control, recharge to the aquifer was reduced to 7-10 inches per year (8).

Estimates of recharge to other buried valley aquifers within the county range from over 10 inches per year (9) to 2-4 inches per year (4). These values are based on variations in the topographic relief, and the nature and thickness of the materials above the water table.

Aquifer Media

In the Glacial Till Over Bedded Sedimentary Rocks and River Alluvium With Overbank Deposits hydrogeologic settings, the limestone-shale deposits (bedrock) were determined to be the uppermost aquifer most commonly used for domestic purposes. The limestone-shale formations yield ground water primarily from the upper few feet of the weathered bedrock at the rock/till interface. Little or no water is available from the limestone-shale at greater depths. Domestic wells are commonly drilled deeper into the bedrock to provide additional storage in the borehole. Based upon water well log and geologic map data, the limestone-shale bedrock received an aquifer media rating of (3).

Within the major buried valleys the aquifers consist of thick outwash sand and gravel deposits. Interbedded layers of clay/till of varying lateral extent may be present in some areas (ODNR, unpublished well log data; Spieker, 1968). The major buried valley deposits were assigned aquifer media ratings of (8) or (9) based on the relatively coarse nature of the aquifers and the generally low silt/clay content within the sand and gravel units (ODNR, unpublished well log data; Schmidt, 1986; Spieker, 1968, Klaer and Thompson, 1948; Struble, 1986). Sand and gravel aquifers within the tributaries to the major buried valleys received ratings ranging from (4) to (8) based on clay content (Burgess & Niple, 1987; Dames & Moore, 1972; ODNR, unpublished water well log data; Schmidt 1986; Spieker, 1968; Struble 1986). Generally, the larger tributary valleys contain thicker, cleaner, and therefore, higher-rated deposits.

Aquifer media ratings (sand and gravel) in the Moraine hydrogeologic setting are relatively low, ranging from (4) to (5). These values were assigned based on data contained within Schmidt (1986), and unpublished water well logs on file at the Ohio Department of Natural Resources, Division of Water.

Soil Media

Soils ratings in Butler County are based on the "Soil Survey of Butler County, Ohio" (Lerch et al., 1980). As in most areas, the soil types within the county are highly dependent on the parent material. Soils developed on glacial tills are generally clays (1), clay loams (3) or loams (5); soils developed on outwash deposits are usually sands (9) or sandy loams (6), and soils developed on alluvium are often silt loams (4) or loams (5). Soils developed on loess are clay loams (3) or silt loams (4).

In the upland areas, where there are extensive deposits of glacial till, the predominant soil types are clay loam (3) and loam (5). Soils in the River Alluvium setting are sand (9) and silt loam (4).

Within the buried valleys, soils range from clay to sand depending on the nature of the parent material present at the surface. Sand (9) and sandy loams (6) are the predominant soil types in most major buried valleys. Soils in the tributary valleys are typically loam (5) or sandy loam (6).

Topography

Ratings for topography in Butler County were determined based upon U.S. Geological Survey 7 and 1/2 minute topographic maps. The greatest relief in the county is found in the Glacial Till Over Bedded Sedimentary Rock hydrogeologic setting, with slopes ranging from 0-2% (10) to 18+% (1). In the River Alluvium With Overbank Deposits setting, topography is moderately flat with slopes of 0-2% (10). Slopes within the Buried Valley setting generally range from 0-2% (10) to 2-6% (9); however, a few small areas have topography ranging from 6-12% (5). In the Moraine setting, the topography is relatively hummocky in nature, with slopes ranging from 2-6% (9).

Impact of the Vadose Zone Media

Vadose zone media in the Glacial Till Over Bedded Sedimentary Rock setting are typically glacial tills. Except along the south, east, and part of the north boundaries of the county, the till is relatively thin, highly weathered, and fractured (ODNR, unpublished water well log data; Leow, 1985; Angle, personal communication). Where the till is as described above, it was assigned a rating value of (5). In the south, east, and northern portions of the county where the till is somewhat thicker, the vadose zone was given a rating of (4). A few scattered areas with this setting have sand and gravel with significant silt and clay (6) as a vadose zone.

The vadose zone media within the Buried Valley setting are highly variable. Sand and gravel deposits within the main buried valley extending from Middletown to the Hamilton County line, are relatively clean (silt- and clay-free) (ODNR, unpublished water well log data; Spieker, 1968). These deposits were assigned a vadose zone media value of (8) or (9). The sand and gravel in the main valley northeast of Middletown to the Warren County line contains an appreciable amount of silt and clay; therefore, the vadose zone media in that area was given a rating of (7) (Norris and Spieker, 1966; Schmidt et al., in production; ODNR, unpublished water well log data; Spieker, 1968). Within the large buried valleys from Middletown east-southeast to the Warren County line, and from Fairfield southeast to the Hamilton County line, the vadose zone consists largely of sand and gravel with a high percentage of silt and clay or glacial till (unpublished water well logs; Spieker, 1968). The vadose zone media ratings for these areas range from (6) to (5). The small tributary valleys contain a wide spectrum of vadose zone media. Ratings in these areas range from till, and silt and clay (5), to clean sand and gravel (9) (ODNR, unpublished water well log data; Burgess & Niple, 1987; Dames & Moore, 1972; Struble, 1986)

Vadose zone media in the Moraine hydrogeologic setting was determined to be sand and gravel with significant silt and clay (6). The River Alluvium setting has a vadose zone rating of silt and clay (4) or sand and gravel with significant silt and clay (5).

Hydraulic Conductivity

Limited hydraulic conductivity data were available for the limestone-shale bedrock in the upland areas. Estimates for these formations were made based on there limited water bearing characteristics and values suggested in Freeze and Cherry (1985). A rating of 1-100 gallons per day/per foot squared (gpd/ft^2) (1) was assigned to the bedrock aquifer.

The sand and gravel aquifers contained within the buried valleys have a wide range of hydraulic conductivities. The larger valleys generally contain aquifers with high hydraulic conductivities, in the 1000-2000 (8) or 2000+ (9) gpd/ft^2 range (Norris and Spieker, 1966; Spieker, 1968; Dove, 1969; Miami Valley Regional Planning Commission, 1987). Aquifers in the small tributary valleys range from 1-100 (1) to 1000-2000 (8) gpd/ft^2 (ODNR, unpublished water well log data; Burgess and Niple, 1987; Dames & Moore, 1972). The sand and gravel aquifers in the Moraine hydrogeologic setting have hydraulic conductivities estimated at either 1-100 (1) or 100-300 (2) gpd/ft^2.

APPENDIX B

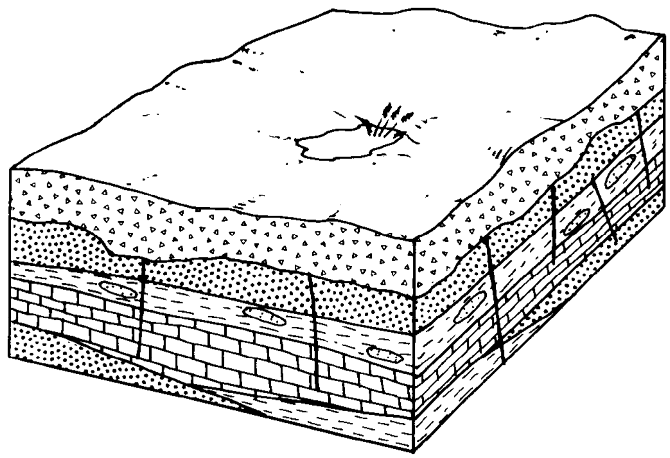
DESCRIPTION OF THE HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Butler County resulted in the identification of four 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 11. Computed pollution potential indexes for Butler County range from 79 to 211.

TABLE 11. HYDROGEOLOGIC SETTING MAPPED IN BUTLER COUNTY, OHIO

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Aa - Glacial Till Over Bedded Sedimentary Rocks	79-114	42
7C - Moraine	113-129	4
7D - Buried Valley	93-211	87
7Ea - River Alluvium With Overbank Deposits	113-128	2

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 characterized by low topography and relatively flat-lying, fractured sedimentary rocks consisting of limestone and shale, which are covered by varying thicknesses of glacial till. The till is principally unsorted deposits which may be interbedded with loess or localized deposits of sand and gravel. Although ground water occurs in both the glacial deposits and in the intersecting bedrock fractures, the bedrock is typically the principal aquifer. The glacial till serves as a source of recharge to the underlying bedrock.

Although precipitation is abundant in most of the region, recharge is moderate because of the glacial till and soils which are typically clay loams. Depth to water is extremely variable depending in part on the thickness of the glacial till.

Setting: 7Aa1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	109

Setting: 7Aa2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	110

Setting: 7Aa3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105

Setting: 7Aa4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	95

Setting: 7Aa5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	109

Setting: 7Aa6		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	101

Setting: 7Aa7		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	99

Setting: 7Aa8		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	113

Setting: 7Aa9		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	91

Setting: 7Aa10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	95

Setting: 7Aa11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	89

Setting: 7Aa12		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	97

Setting: 7Aa13		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	79

Setting: 7Aa14		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	99

Setting: 7Aa15		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Sand	2	9	18
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7A16		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105

Setting: 7Aa17		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	93

Setting: 7A18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	103

Setting: 7Aa19		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	104

Setting: 7Aa20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	6-12	1	5	5
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	96

Setting: 7Aa21		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	104

Setting: 7Aa22		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	100

Setting: 7Aa23		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	90

Setting: 7Aa24		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	108

Setting: 7Aa25		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Silty Loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	92

Setting: 7Aa26		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Shrink/Swell Clay	2	7	14
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	98

Setting: 7Aa27		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Shrink/Swell Clay	2	7	14
Topography	18+	1	1	1
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	94

Setting: 7Aa28		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	94

Setting: 7Aa29		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	109

Setting: 7Aa30		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	2	6
Soil Media	Clay Loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	Silt and Clay	5	3	15
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	82

Setting: 7Aa31		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Shrink/Swell Clay	2	7	14
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	86

Setting: 7Aa32		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Shrink/Swell Clay	2	7	14
Topography	6-12	1	5	5
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	88

Setting: 7Aa33		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	82

Setting: 7Aa34		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	12-18	1	3	3
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	98

Setting: 7Aa35		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	86

Setting: 7Aa36		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	95

Setting: 7Aa37		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	84

Setting: 7Aa38		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay	2	1	2
Topography	18+	1	1	1
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	87

Setting: 7Aa39		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	114

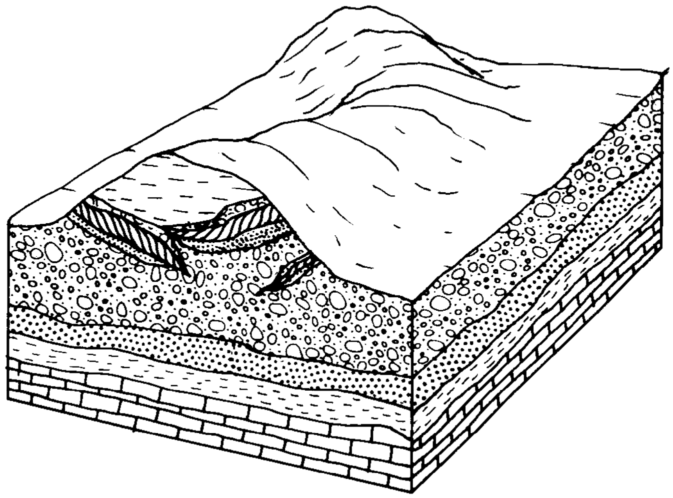
Setting: 7Aa40		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	98

Setting: 7Aa41		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	94

Setting: 7Aa42		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	105

Setting: 7Aa43		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Silt Loam	2	4	8
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7Aa44		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Shale and Limestone	3	3	9
Soil Media	Shrink/Swell Clay	2	7	14
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	103



7C Moraine

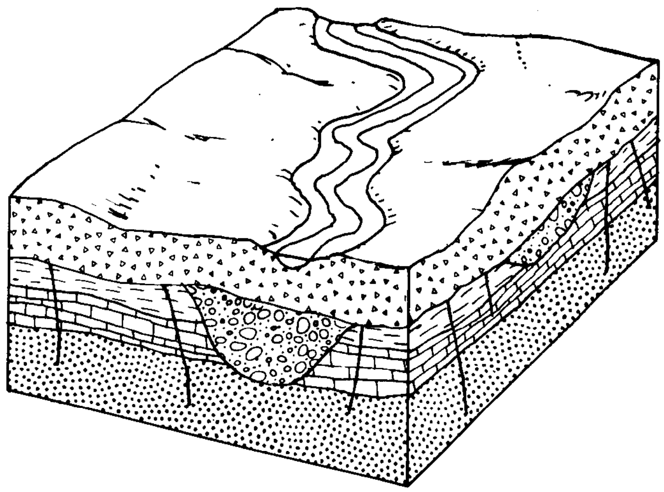
This hydrogeologic setting is characterized by moderate to moderately steep topography and varying thicknesses of mixed glacial deposits which overlie sequences of relatively flat-lying, fractured sedimentary rocks. This setting is similar to 7Ba Outwash in that the sand and gravel within the morainal deposits may be well-sorted and serve as the principal aquifer in the area. These deposits also serve as a source of recharge for the underlying bedrock. Moraines also contain sediments that are typically unsorted and unstratified; these deposits contain more fine materials than outwash deposits, are less permeable and characteristic of glacial till. Moraines are typically mounds or ridges of till which were deposited along the margin of a stagnant or retreating glacier. Surficial deposits often weather to sandy loam or clay loam. Precipitation is abundant throughout the region and ground water recharge is moderate. Water levels are relatively variable, based in part on the thickness of the glacial till, but are typically fairly shallow.

Setting: 7C1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	129

Setting: 7C2		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	119

Setting: 7C3		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	113

Setting: 7C4		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Clay Loam	2	3	6
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	125



7D Buried Valley

This hydrogeologic setting is characterized by thick deposits of sand and gravel that have been deposited in a former topographic low (usually a pre-glacial river valley) by glacial meltwaters. These deposits are capable of yielding large quantities of ground water. The deposits may or may not underlie a present-day river and may or may not be in direct hydraulic connection with a stream. Glacial till or recent alluvium often overlies the buried valley. Usually the deposits are several times more permeable than the surrounding bedrock, with finer-grained alluvium covering the underlying sand and gravel. Soils are typically a sandy loam. Recharge to the sand and gravel is moderate to high and water levels are relatively shallow, although they may be quite variable.

Setting: 7D1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	205

Setting: 7D2		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	197

Setting: 7D3		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	203

Setting: 7D4		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	211

Setting: 7D5		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	189

Setting: 7D6		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	187

Setting: 7D7		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	189

Setting: 7D8		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	197

Setting: 7D9		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	201

Setting: 7D10		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	185

Setting: 7D11		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	180

Setting: 7D12		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	196

Setting: 7D13		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	206

Setting: 7D14		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	191

Setting: 7D15		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	189

Setting: 7D16		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	197

Setting: 7D17		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/ Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	165

Setting: 7D18		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Silty Clay	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	130

Setting: 7D19		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	132

Setting: 7D20		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	187

Setting: 7D21		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	118

Setting: 7D22		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	117

Setting: 7D23		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	96

Setting: 7D24		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	114

Setting: 7D25		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	93

Setting: 7D26		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	193

Setting: 7D27		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	177

Setting: 7D28		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	150

Setting: 7D29		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	179

Setting: 7D30		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	107

Setting: 7D31		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	183

Setting: 7D32		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	9	27
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	9	45
Hydraulic Conductivity	2000+	3	10	30
		GWPP	INDEX	191

Setting: 7D33		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	161

Setting: 7D34		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	173

Setting: 7D35		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	141

Setting: 7D36		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	7	21
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	140

Setting: 7D37		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	138

Setting: 7D38		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	128

Setting: 7D39		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	138

Setting: 7D40		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Silty Loam	2	4	8
Topography	2-6	1	9	9
Impact of Vadose Zone	TIll	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	127

Setting: 7D41		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	103

Setting: 7D42		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	145

Setting: 7D43		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	143

Setting: 7D44		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	155

Setting: 7D45		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	143

Setting: 7D46		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	141

Setting: 7D47		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	125

Setting: 7D48		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	171

Setting: 7D49		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	187

Setting: 7D50		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	185

Setting: 7D51		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	193

Setting: 7D52		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	173

Setting: 7D53		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	161

Setting: 7D54		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	151

Setting: 7D55		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	149

Setting: 7D56		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	175

Setting: 7D57		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	148

Setting: 7D58		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	152

Setting: 7D59		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	154

Setting: 7D60		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	30-50	5	5	25
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	160

Setting: 7D61		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	121

Setting: 7D62		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	124

Setting: 7D63		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	131

Setting: 7D64		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	137

Setting: 7D65		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	122

Setting: 7D66		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	157

Setting: 7D67		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	149

Setting: 7D68		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	145

Setting: 7D69		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	7	21
Soil Media	Sandy Loam	2	6	12
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	174

Setting: 7D70		GENERAL		
FEATURE	Range	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	7	21
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	172

Setting: 7D71		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	129

Setting: 7D72		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Clay Loam	2	3	6
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	101

Setting: 7D73		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	132

Setting: 7D74		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	143

Setting: 7D75		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	5	15
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	135

Setting: 7D76		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	183

Setting: 7D77		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel	5	8	40
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	181

Setting: 7D78		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Sand and Gravel	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	105

Setting: 7D79		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	300-700	3	4	12
		GWPP	INDEX	147

Setting: 7D80		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	134

Setting: 7D81		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	182

Setting: 7D82		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	10+	4	9	36
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	7	35
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	192

Setting: 7D83		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	130

Setting: 7D84		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	118

Setting: 7D85		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	6	18
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	700-1000	3	6	18
		GWPP	INDEX	153

Setting: 7D86		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	123

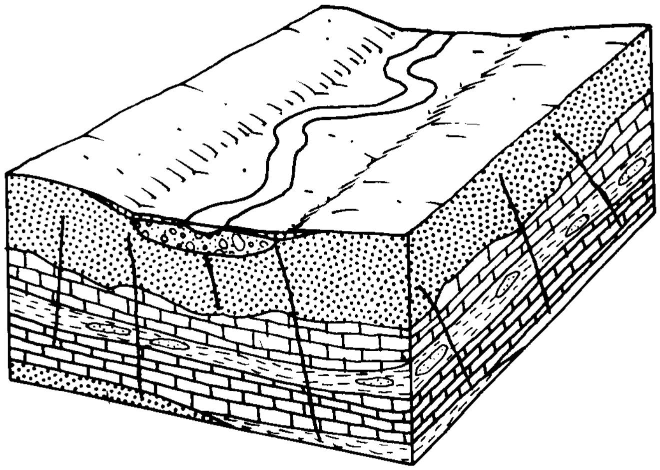
Setting: 7D87		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Sand	2	9	18
Topography	2-6	1	9	9
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	134

Setting: 7D88		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	2-4	4	3	12
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	6-12	1	5	5
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	112

Setting: 7D89		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	4	12
Soil Media	Loam	2	5	10
Topography	2-6	1	9	9
Impact of Vadose Zone	Till	5	5	25
Hydraulic Conductivity	100-300	3	2	6
		GWPP	INDEX	131

Setting: 7D90		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	4-7	4	6	24
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Clay Loam	2	3	6
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	153

Setting: 7D91		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Sand and Gravel	3	8	24
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	6	30
Hydraulic Conductivity	1000-2000	3	8	24
		GWPP	INDEX	173



7Ea River Alluvium With Overbank Deposits

This hydrogeologic setting is characterized by low topography and thin to moderately thick deposits of flood-deposited alluvium along portions of river valleys. The alluvium is underlain by fractured bedrock of sedimentary origin. The floodplain is covered by varying thicknesses of fine-grained silt and clay called overbank deposits. Water levels are moderately shallow. Ground water may be in direct hydraulic contact with the surface stream. The alluvium may serve as a significant source of water and may also be in direct hydraulic connection with the underlying sedimentary rocks.

Setting: 7Ea1		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Limestone and Shale	3	3	9
Soil Media	Silty Loam	2	4	8
Topography	0-2	1	10	10
Impact of Vadose Zone	Silt/Clay	5	4	20
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	119

Setting: 7Ea2		**GENERAL**		
FEATURE	RANGE	WEIGHT	RATING	INDEX
Depth to Water	5-15	5	9	45
Net Recharge	4-7	4	6	24
Aquifer Media	Limestone and Shale	3	3	9
Soil Media	Sand	2	9	18
Topography	0-2	1	10	10
Impact of Vadose Zone	Sand and Gravel w/Silt and Clay	5	5	25
Hydraulic Conductivity	1-100	3	1	3
		GWPP	INDEX	134

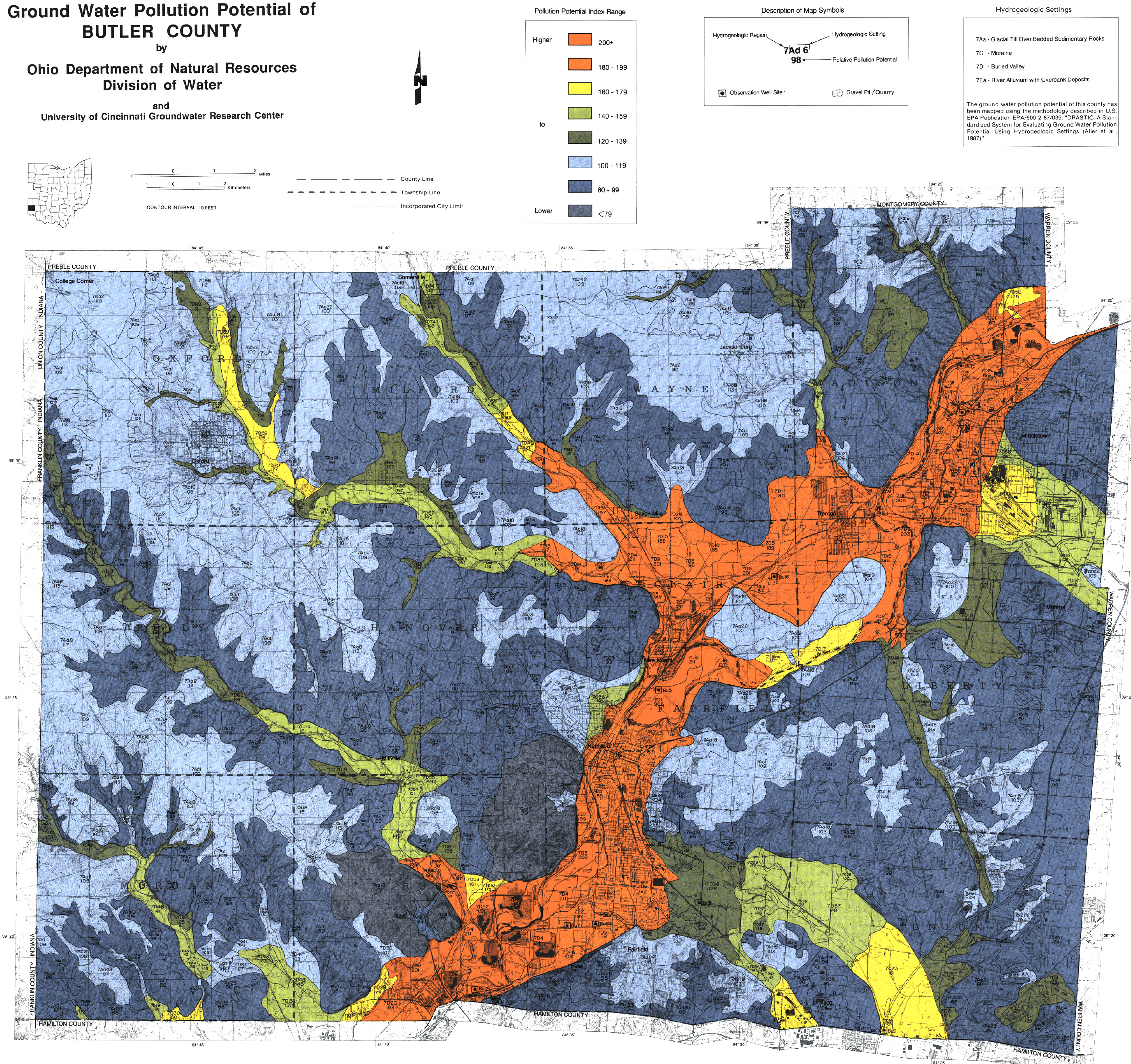
Ground Water Pollution Potential of BUTLER COUNTY

by

Ohio Department of Natural Resources
Division of Water

and

University of Cincinnati Groundwater Research Center



Hydrogeologic Settings

7Aa - Glacial Till Over Bedded Sedimentary Rocks

7C - Moraine

7D - Buried Valley

7Ea - River Alluvium with Overbank Deposits

The ground water pollution potential of this county has been mapped using the methodology described in U.S. EPA Publication EPA/600-2-87/035, "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings (Aller et al., 1987)".

* Observation well sites indicate the location of wells used to collect ground water level information. These wells are part of the State observation well network. Hydrographs of the water levels recorded in these and other State observation wells can be obtained through ODNR-Division of Water.

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A more detailed description of the hydrogeologic settings and the evaluation of the pollution potential may be found in the publication "Ground Water Pollution Potential of Butler County," GWPP Report No. 11, Ohio Department of Natural Resources, Division of Water.

David S. Orr, Cartographer

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George V. Voinovich, Governor
Frances S. Buchholzer, Director

ERRATA SHEET BUTLER COUNTY
Ground Water Pollution Potential No. 11

The following typographical errors occur on the printed map of the Ground Water Pollution Potential of Butler County. Please refer to the tables in the back of the report for the corrected settings. The corrected settings may also be found in the digital coverage of the Ground Water Pollution Potential of Butler County.

Areas labeled on Map as	Correct Label
7Ae28	7Aa28
7Ae22	7Ea2
7Ae21	7Aa21
7Ae9	7Aa9