GROUND WATER POLLUTION POTENTIAL
OF LUCAS COUNTY, OHIO

BY

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ABSTRACT

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

Ground water pollution potential analysis in Lucas County resulted in a map with symbols and colors that illustrate areas of varying ground water contamination vulnerability. Eight hydrogeologic settings were identified in Lucas County with computed ground water pollution potential indexes ranging from 71 to 191.

Lucas County lies almost entirely within the Glaciated Central hydrogeologic setting. Three distinct types of aquifers occur within the county. Shale bedrock is the principal aquifer in the northwest corner of the county. Wells drilled into this formation typically yield less than 10 gallons per minute (gpm). A limestone and dolomite aquifer with yields of 25 to 500 gpm underlies the remainder of the county. The third aquifer consists of thin sand and gravel lenses scattered through the glacial drift covering the county. These lenses are somewhat more prevalent within a buried valley that cuts diagonally across the county from Maumee Bay to Toledo Express Airport. Yields from the sand and gravel units range from five to 15 gpm.

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

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INTRODUCTION

The need for protection and management of ground water resources in Ohio has been clearly recognized. Approximately 42 percent of Ohio citizens rely on ground water for drinking and household use from both municipal and private wells. Industry and agriculture also utilize significant quantities of ground water for processing and irrigation. In Ohio, approximately 750,000 rural households depend on private wells; over 9000 of these wells exist in Lucas County.

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

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

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

APPLICATIONS OF POLLUTION POTENTIAL MAPS

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

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

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

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

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

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

SUMMARY OF THE DRASTIC MAPPING PROCESS

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

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

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

Hydrogeologic Settings and Factors

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

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

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

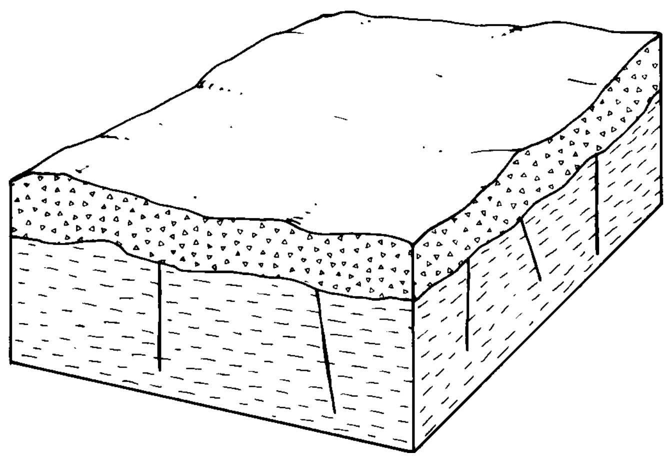
- **D** – Depth to Water
- **R** – Net Recharge
- **A** – Aquifer Media
- **S** – Soil Media
- **T** – Topography
- **I** – Impact of the Vadose Zone Media
- **C** – Conductivity (Hydraulic) of the Aquifer

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

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

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

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



7Ae-Glacial Till over Shale

This hydrogeologic setting is common in the northwestern portion of Lucas County. The area is characterized by flat-lying topography and very low relief. The vadose zone is composed of loamy to clayey glacial till and clayey to silty lacustrine deposits. The till and clayey lacustrine sediments may be fractured or jointed, particularly in areas where it is predominantly thin and weathered. Depth to water is moderate. Soils vary from shrink/swell clay, often found in soils of lacustrine origin, to sandy loams adjacent to beach ridges. The aquifer is either fractured, massive black Devonian-age shale, or thin lenses of dirty, shale–rich gravel that directly overly the shale bedrock. Yields from the shale are typically less than 5 gpm and range from 5 to 25 gpm for the shaley gravel lenses. Recharge is generally low because of the clayey vadose zone and soils.

Figure 1. Format and description of the hydrogeologic setting - 7Ae Glacial Till over Shale.

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

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

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

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

Weighting and Rating System

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

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

Pesticide DRASTIC

A special version of DRASTIC was developed 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**
Shale	1-3	2
Glacial Till	4-6	5
Sandstone	4-9	6
Limestone	4-9	6
Sand and Gravel	4-9	8
Interbedded Ss/Sh/Ls/Coal	2-10	9
Karst Limestone	9-10	10
Weight: 3	Pesticide Weight: 3	

Table 5. Ranges and ratings for soil media

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

Table 6. Ranges and ratings for topography

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

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

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

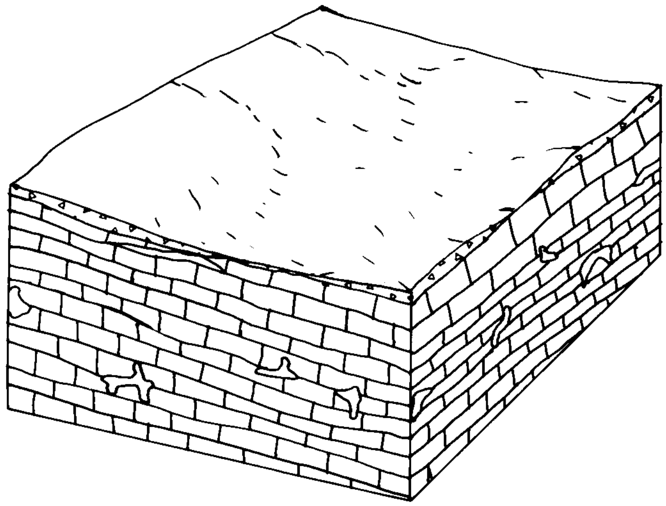
Table 8. Ranges and ratings for hydraulic conductivity

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

Figure 2 illustrates the hydrogeologic setting 7Gb1, identified in mapping Lucas 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 160. This numerical value has no intrinsic meaning, but can be readily compared to a value obtained for other settings in the county. DRASTIC indexes for typical hydrogeologic settings and values across the United States range from 45 to 223.

The diversity of hydrogeologic conditions in Lucas County produces settings with a wide range of vulnerability to ground water contamination. Calculated pollution potential indexes for the eight settings identified in the county range from 71 to 191.

Hydrogeologic settings identified in an area are combined with the pollution potential indexes to create units that can be graphically displayed on maps. Pollution potential analysis in Lucas 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 Lucas County is included with this report.



SETTING 7Gb1		GENERAL		
FEATURE	RANGE	WEIGHT	RATING	NUMBER
Depth to Water	15-30	5	7	35
Net Recharge	7-10	4	8	32
Aquifer Media	Limestone	3	8	24
Soil Media	Sandy Loam	2	6	12
Topography	0-2%	1	10	10
Impact of Vadose Zone	Limestone	5	7	35
Hydraulic Conductivity	300-700	3	4	12
		DRASTIC	INDEX	160

Figure 2. Description of the hydrogeologic setting - 7Gb1 Thin Till Over Limestone.

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:

7Gb1 - defines the hydrogeologic region and setting
160 - defines the relative pollution potential

Here the first number (**7**) refers to the major hydrogeologic region and the upper and lower case letters (**Gb**) 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 (**160**) is the calculated pollution potential index for this unique setting. The charts for each setting provide a reference to show how the pollution potential index was derived.

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

The map 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.

GENERAL INFORMATION ABOUT LUCAS COUNTY

Lucas County occupies an area of about 343 square miles in the northeast portion of Ohio (Figure 3). The county is bordered on the north by the state of Michigan, on the west by Fulton and Henry Counties, on the South by Wood and Ottawa Counties and on the east by Lake Erie. The County seat is Toledo. According to the U.S. Census Bureau, the population of Lucas County in 2000 was 455,054.

Physiography and Climate

Lucas County lies within the Eastern Lakes Section of the Central Lowlands Province. Topography is nearly flat throughout most of the county, except in the Oak Openings sand belt. Low rolling and undulating hills characterize the topography in this portion of western Lucas County.

All of Lucas County is within the Lake Erie drainage basin. The largest stream in the county is the Maumee River, which forms the southwestern boundary between Lucas and Wood Counties and flows into Maumee Bay. Other significant streams in the county include the Ottawa River, which flows into Maumee Bay and Swan Creek, a tributary of the Maumee River. A portion of northeastern Lucas County is drained by tributaries of the Raisin River, which flows into Lake Erie in southwestern Michigan.

The climate of Lucas County is cold in the winter, and warm to occasionally hot in the summer (Stone et al., 1980). NOAA (National Oceanic and Atmospheric Administration) data for the thirty-year period from 1961 to 1990 show an average annual temperature of 58.6 degrees Fahrenheit at Toledo Express Airport and 60.0 degrees Fahrenheit at the offices of the Toledo Blade (Owenby and Ezell, 1992). January is the coldest month of the year and July is the warmest at both stations.

Precipitation for the 1961 to 1990 period averaged 32.37 inches per year at Toledo Express Airport and 33.71 inches at the Toledo Blade. June is typically the wettest month and January the driest month (Owenby and Ezell, 1992).

Figure 3. Location of Lucas County, Ohio.

Pre-Glacial Drainage

Prior to Pleistocene glaciation, the Napoleon River was the dominant stream in Lucas County (Stout et al., 1943). This stream flowed in a northeasterly direction, into the Lake Erie Basin, following the general direction of the modern Maumee River. Tributary to the Napoleon River in Lucas County was the Whitehouse River, which drained most of the central portion of the county. Both the Napoleon River and the Whitehouse River eroded broad shallow valleys into the bedrock underlying Lucas County (Leow, 1985).

Glacial Geology

During the Pleistocene Epoch (2 million to 10,000 years before present or Y.B.P) several episodes of ice advance occurred in northwest Ohio. Ice advances older than approximately 730,000 Y.B.P. are now typically referred to as pre-Illinoian (formerly Kansan) in age. Evidence that pre-Illinoian glaciers passed through Ohio is found in ancient soil deposits located west of Cincinnati. Evidence for the Illinoian ice advance (at least 130,000 Y.B.P.) can be found at many locations along the margin between glaciated and nonglaciated areas in northeastern, central and southwestern Ohio. The most recent period of glaciation (Wisconsinan) had the most profound effect on the current topography of Lucas County. Wisconsinan glaciation occurred between 15,000 and 25,000 Y.B.P.

Glacial deposits in Lucas County are composed primarily of three types of sediments: till, outwash, and lacustrine. Till consists of an unsorted mixture of silt, sand, clay, and gravel. By definition, till is deposited directly by glacial ice. Basal or lodgment till is deposited under an actively moving ice sheet. Basal tills tend to be hard and compact and are often referred to as "hardpan" by water well drillers or excavation equipment operators. Till trapped inside a glacier and left behind by melting ice is called ablation till. This type of till is much softer and less compact than basal till. Till deposits are found throughout almost all of Lucas County; however, in most of the county the tills are buried under a layer of lacustrine deposits. Tills are found at the surface only in the northwest and southwest corners of the county and along a thin strip bordering the Maumee River (Pavey and Goldthwait, 1993).

Lacustrine sediments reflect lakeshore and lake-bottom deposition. As the Wisconsinan glacier retreated to the north, meltwater pooled in the Lake Erie basin; however, the outlets for Lake Erie were still blocked by ice. Meltwater, trapped between the glacier to the north and the Lake Erie and Ohio River drainage divide to the south, flooded a large portion of northern Ohio and southeastern Michigan. At various times near the end of the Wisconsinan, the glacier advanced or retreated slightly, covering or uncovering outlets for the trapped meltwater. Water levels in the basin, therefore, varied considerably over time.

During the late Wisconsinan, water at one time or another covered all of Lucas County. Evidence for this can be found in the mantle of lake bottom deposits and wave planed till which cover the county (Pavey and Goldthwait, 1993). Lake bottom deposits typically consist of silt and clay that were washed into the pooled water by surface runoff. These sediments eventually settled to the bottom of the lake forming the deposits. Often the silt and clay settle at different rates forming thin stratified layers.

In addition to the lake bottom deposits, beaches are also associated with lacustrine environments. The Oak Openings sand body is believed by many to be a beach deposit. Some controversy exists, however, as to the true depositional environment of this deposit. The topographic elevation of the sand seems to coincide with the known elevation of one of the late Pleistocene Lake Erie levels (Forsyth, 1959; Hilty, 1971; Kunkle, 1971). In addition, Burke (1973) performed a stratigraphic analysis of the Oak Openings sand and concluded it was most likely of beach origin. Grube (1980) performed field and laboratory studies on the sand body and also concluded the sand was of beach origin. Both Grube and Burke stated the beach deposits had been extensively reworked by wind action after Lake Erie levels had receded.

The beach origin for the Oak Openings sand has been challenged by Anderhalt et al. (1984). Anderhalt et al. (1984) found ripple marks and cross bedding in the sand body that are inconsistent with a beach environment. Based largely upon these textural features, along with some reevaluation of pre-existing data, a deltaic environment was proposed for the sand unit.

Outwash consists of sediments (typically sand and gravel) that have been sorted and deposited by water flowing from melting glacial ice. Outwash deposits in Lucas County are limited to lenses within the till deposits, especially in the buried preglacial valleys, and to a layer of sand and gravel which often occurs just above the bedrock surface (Breen and Dumouchelle, 1991, Smith and Sabol, 1994).

Bedrock Geology

Bedrock underlying Lucas County belongs to the Silurian, Devonian and Mississippian Systems (Table 9). The Silurian formations that underlie the eastern two-thirds of the county consist primarily of dolomite with some limestone sandstone and shale. The Devonian and Mississippian rocks are shales and interbedded shales and thin sandstones, respectively.

The Bowling Green Fault is the major structural feature in Lucas County. The fault begins in southeastern Hancock County, trends to the north passing five miles west of Bowling Green and continuing into Lucas County. Rocks on the western side of the fault are displaced downward with the maximum displacement of 200 feet occurring just west of Bowling Green (ODNR, 1970). In Lucas County the fault is exposed in the France Stone Quarry near the city of Waterville. At this location the Tymochtee Formation is directly adjacent to the Undifferentiated Salina formation (Larson, 1994b). In the northern portion of Lucas County, where younger formations crop out, the fault is expressed as a monocline or down dipping of the rocks of about 6 to 8 degrees to the west (Venturoli, 1978).

Table 9. Bedrock Stratigraphy Of Lucas County, Ohio

System	Group	Formation
Mississippian		Sunbury- Berea-Bedford Undifferentiated
Devonian		Antrim Shale
Silurian	Traverse Group	Ten Mile Creek Dolomite
		Silica Shale
		Dundee Limestone
	Detroit River Group	Lucas Dolomite
		Amherstburg Dolomite
		Sylvania Sandstone
	Bass Islands Group	Raisin River Dolomite
		Put-In-Bay Dolomite
	Salina Group	Undifferentiated Salina Dolomite
		Tymochtee Dolomite
		Greenfield Dolomite
		Lockport Dolomite

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APPENDIX A

DESCRIPTION OF THE LOGIC IN FACTOR SELECTION

Depth to Water

Depth to water was evaluated using information obtained from well log data on file with the Ohio Department of Natural Resources, Division of Water, and from potentiometric surface maps and information contained in Breen and D.H. Dumouchelle (1991), Breen (1989), and Venturoli (1978). Additional depth to water data was obtained from the relative topographic position of the land surface.

Depth to water in the carbonate aquifer ranged from 5-15 feet (DRASTIC rating of 9) to 75-100 feet (2). While most of the carbonate is semi-confined, there is a high degree of hydraulic connection between the aquifer and the overlying till. The depth to water used for the carbonate aquifer represents the saturated material overlying the actual aquifer. Shallow depths to water reflect factors such as proximity to streams and low elevations. Deep depths to water are generally found at high elevations where relief is pronounced and occasionally where the till is thick. Substantial cones of depression have developed around several large ground water pumping centers in the carbonate aquifer. Because pumping could cease at any time, the depth to water in these areas was evaluated as natural pre-pumping levels.

For the Oak Openings sand aquifer, the depth to water is in the range of 5-15 feet (9). Permeable soils, limited discharge, and abundant precipitation are the principal factors that cause the high water table.

Net Recharge

Recharge to the carbonate bedrock aquifer in the Glacial Lake Deposits setting (7F) was generally 2 to 4 inches (3) (Petteyjohn and Henning, 1979). In some portions of this setting where the bedrock was shallow or the soil was especially permeable or both, recharge was evaluated as 4 to 7 inches (6). The Thin Till over Limestone setting (7Gb) received a recharge rating of 7 to 10 inches (8) because of the close proximity of the carbonate bedrock to the surface and therefore the ease with which precipitation can percolate directly into the aquifer. Recharge to the Alluvium over Till setting (7Ed) was rated as 4 to 7 inches (6) because of the abundance of available recharge from flooding of nearby streams and the generally high water tables.

The Oak Openings sand aquifer receives more than 10 inches of recharge per year (9) (Hallfrisch, 1987, McAvey, 1976). High water tables and permeable soils are the chief reasons for the abundance of recharge.

Aquifer Media

The carbonate bedrock is the major aquifer underlying most of Lucas County. Because of the high degree of ground water flow along open fractures and solution channels, this aquifer received relatively high ratings of seven (7) and eight (8). Areas with high potential well yields as depicted on Hallfrisch (1986) received the higher rating (8).

The Oak Openings sand unit consists of relatively fine grained sand with zones of significant silt and clay. For this reason, the sand aquifer received the relatively low rating (for sand) of 7.

The shale aquifer in the northwest portion of the county has some limited fracture permeability in the upper few feet of the aquifer and a high clay content. This aquifer received a low rating of only 2.

Soils

Data for evaluating this factor was derived from the Soil Survey of Lucas County (Stone et al., 1980). Individual soil units were classified according to the methodology described in Aller et al., 1987. The Ohio Capability Analysis Program (OCAP) then created individual 1:24,000 scale maps showing Aller et al. (1987) classified soil distributions. Table 10 lists the soil ratings for the county.

Topography

Land surface slopes (topography) were determined by using the topographic contour lines depicted on the USGS quadrangle maps for Lucas County.

Table 10. DRASTIC RATINGS FOR LUCAS COUNTY SOILS

Soil Name	Soil Media	DRASTIC Rating
Bixler Series	sandy loam	6
Ceresco Series	sandy loam	6
Colwood Series	loam	5
Del Ray Series	clay loam	3
Digby Series	sandy loam	6
Dixboro Series	sandy loam	6
Dunbridge Series	sandy loam	6
Eel Series	loam	5
Fulton Series	shrink/swell clay	7
Gilford Series	sandy loam	6
Granby Series	sand	9
Haskins Series	shrink/swell clay	7
Hoytville Series	shrink/swell clay	7
Lamson Series	sandy loam	6
Latty Series	shrink/swell clay	7
Lenawee Series	clay	1
Mermill Series	loam	5
Metamora Series	clay loam	3
Muskego Series	muck	2
Nappanee Series	shrink/swell clay	7
Oakville Series	sand	9
Ottokee Series	sand	9
Rimer Series	sandy loam	6
Ross Series	sandy loam	6
Seward Series	shrink/swell clay	7
Shoals Series	loam	5
Sisson Series	silt loam	4
Sloan Series	loam	5
Spinks Series	sand	9
St. Clair Series	shrink/swell clay	7
Tedrow Series	sand	9
Toledo Series	shrink/swell clay	7
Wauseon Series	sandy loam	6

Impact of the Vadose Zone Media

The vadose zone is the layer of unsaturated material between the ground surface and the water table. Information used to evaluate the vadose zone included, Brockman (1990), Leow 1985, Stone et al. 1980, Trexler and Ruedisili (1976), Venturoli (1978), Forsyth (1968) and Kunkle (1971).

In the portions of Lucas County underlain by shale and carbonate aquifers, the vadose zone is comprised of glacial till or a combination of till and lacustrine deposits. Till is an unsorted mixture of silt, clay, sand, and gravel with a low matrix hydraulic conductivity. Often, vertical fractures are present in till which may significantly increase the local hydraulic conductivity. Lacustrine deposits consist primarily of silt and clay, which have very low hydraulic conductivity. Vertical fracture development may be less in lacustrine deposits than in tills. The till/lacustrine deposit vadose zone in Lucas County received ratings ranging from 2 to 4 depending on such factors as depth to water, weathering, and sand and gravel content.

The vadose zone above the Oak Openings sand aquifer consists of fine-grained sand with some silt and clay. The high water table and the relatively high permeability of this material result in the rapid percolation of precipitation (or a contaminant) to the water table. Therefore, the vadose zone in the beach ridge hydrogeologic setting (7H) received a rating of 7.

Hydraulic Conductivity

Hydraulic conductivity is a measure of the ease with which water moves through the aquifer. In the carbonate bedrock water moves primarily through fractures and solution channels. In the sand aquifer of the Oak Openings area, ground water moves between the individual particles of sand. Ground water in the shale aquifer in the northwest corner of the county occurs in a limited number of small fractures in the upper few feet of the formation.

The carbonate aquifer received ratings of 100 to 300 gpd/ft^2 (2) or 300 to 700 gpd/ft^2 (4) based on pumping test analyses (ODNR, 1969a, b), yield (Hallfrisch, 1986), and the evaluations received by similar formations in other nearby counties (e.g. Smith and Sabol, 1994). Tests performed on the Oak Openings sand revealed hydraulic conductivities in the range of 100 to 300 gpd/ft^2 (2) (Hallfrisch, 1987, Trexler and Ruedisili, 1976). The generally impermeable nature of the shale bedrock resulted in a rating in the range of 1 to 100 gpd/ft^2. (1).

APPENDIX B

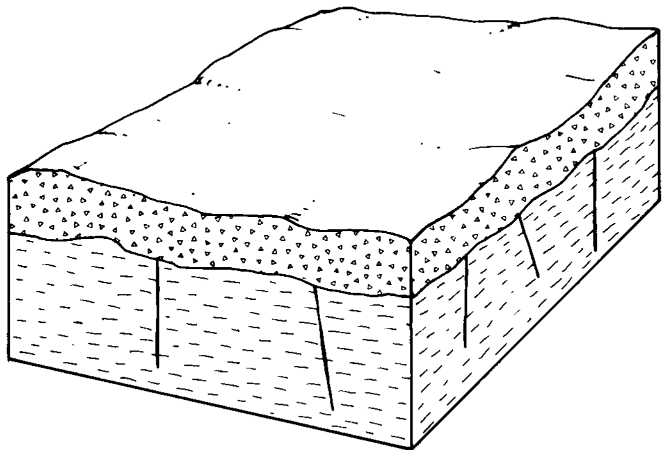
DESCRIPTION OF HYDROGEOLOGIC SETTINGS AND CHARTS

Ground water pollution potential mapping in Lucas County resulted in the identification of eight 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 Lucas County range from 71 to 191.

Table 11. Hydrogeologic Settings Mapped in Lucas County, Ohio

Hydrogeologic Settings	Range of GWPP Indexes	Number of Index Calculations
7Ae - Glacial Till Over Shale	98 - 115	8
7Ea - River Alluvium With Overbank Deposits	159	1
7Ec - Alluvium Over Sedimentary Rock	126-137	4
7Ed - Alluvium Over Glacial Till	90-168	13
7F - Glacial Lake Plain Deposits	71-144	67
7Gb - Thin Till Over Limestone	131-172	7
7H - Beaches, Beach Ridge and Sand Dunes	165-191	4
7I - Marshes and Swamps	157-172	2

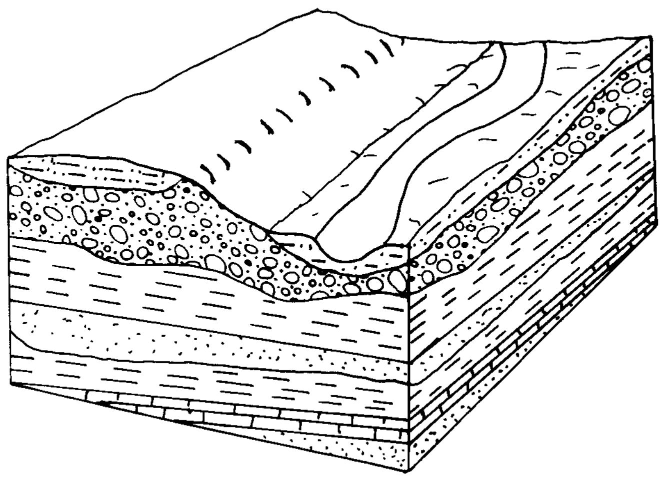
The following information provides a description of each hydrogeologic setting identified in the county, a block diagram illustrating the characteristics of the setting, and a listing of the charts for each unique combination of pollution potential indexes calculated for each setting. The charts provide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



<u>7Ae-Glacial Till over Shale</u>

This hydrogeologic setting is common in the northwestern portion of Lucas County. The area is characterized by flat-lying topography and very low relief. The vadose zone is composed of loamy to clayey glacial till and clayey to silty lacustrine deposits. The till and clayey lacustrine sediments may be fractured or jointed, particularly in areas where it is predominantly thin and weathered. Depth to water is moderate. Soils vary from shrink/swell clay, often found in soils of lacustrine origin, to sandy loams adjacent to beach ridges. The aquifer is either fractured, massive black Devonian-age shale, or thin lenses of dirty, shale–rich gravel that directly overly the shale bedrock. Yields from the shale are typically less than 5 gpm and range from 5 to 25 gpm for the shaley gravel lenses. Recharge is generally low because of the clayey vadose zone and soils.

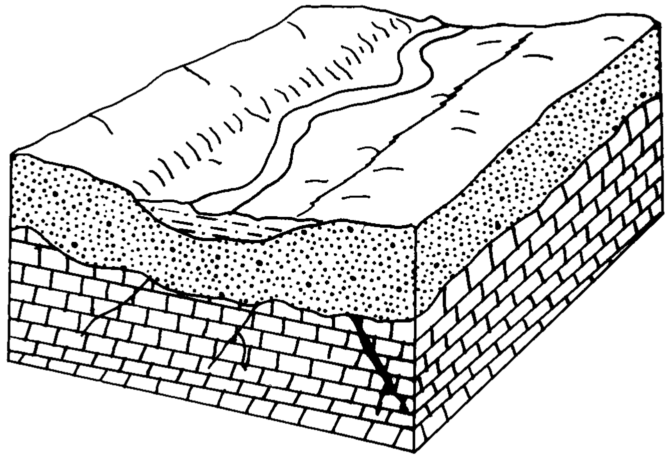
GWPP index values for the hydrogeologic setting of Glacial Till over Shale range from 98 to 115 with the total number of GWPP index calculations equaling 8.



7Ea-River Alluvium with Overbank Deposits

This hydrogeologic setting is associated with Swan Creek in the Oak Openings area of western Lucas County. Relatively narrow, flat-lying floodplains and low terraces characterize this setting. Soils are clay loam derived from the floodplain deposits; the vadose zone is the underlying Oak Openings sand deposit. Depth to water is very shallow, averaging less than 15 feet. Recharge is high because of the shallow depth to water, flat topography, presence of an overlying stream and the high permeability of the soils and vadose zone materials.

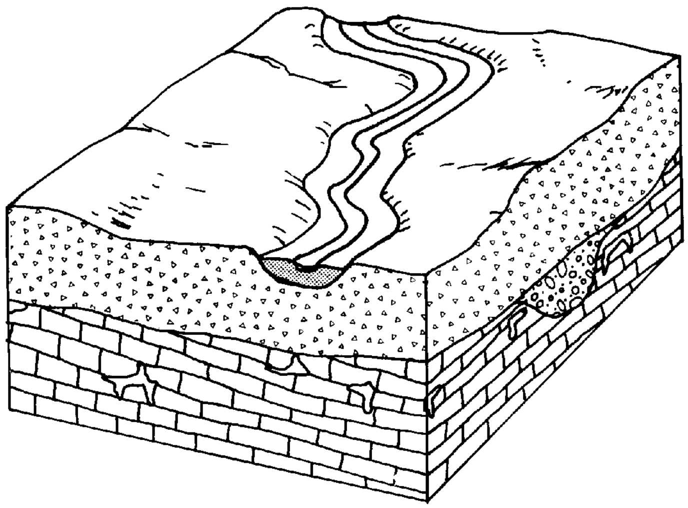
The GWPP index value for the hydrogeologic setting of River Alluvium with Overbank Deposits is 159 with the total number of GWPP index calculations equaling 1.



7Ec-Alluvium over Sedimentary Rock

This hydrogeologic setting is limited to the floodplain immediately adjacent to the Maumee River. This setting is similar to the 7Ea-River Alluvium with Overbank Deposits except that the alluvial deposits overlie the limestone bedrock. The vadose zone consists of the silty to clayey alluvial deposits. The aquifer is the underlying limestone bedrock. The limestone is likely to be fractured and contain solution features. Soils on the floodplain are typically sandy loams or loams derived from the alluvium. Recharge is typically moderate due to the flat-lying topography, shallow depth to water, the moderate permeability of the soils, and the relatively high permeability of the limestone.

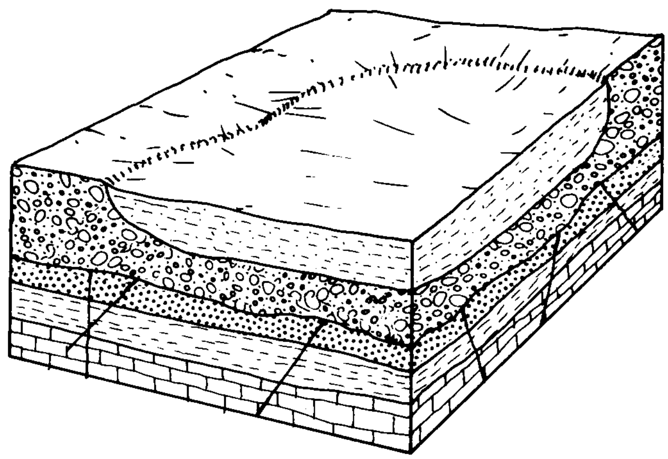
The GWPP index values for the hydrogeologic setting Alluvium over Sedimentary Rocks range from 126 to 137 with the total number of GWPP index calculations equaling 4.



7Ed Alluvium Over Glacial Till

This hydrogeologic setting is comprised of flat-lying floodplains and stream terraces containing thin to moderate thicknesses of modern alluvium. Aquifer media in most cases is the limestone bedrock. This setting is found along portions of Swan Creek and the Ottawa River, and the lower reaches of the Maumee River. Vadose media is typically the silty/clayey alluvial material. Soils are typically developed from the alluvial parent material. Depth to water is highly variable. Recharge is dependent upon the depth to the aquifer, the permeability of the vadose zone, soil type and whether the stream is in hydraulic connection with the underlying aquifer.

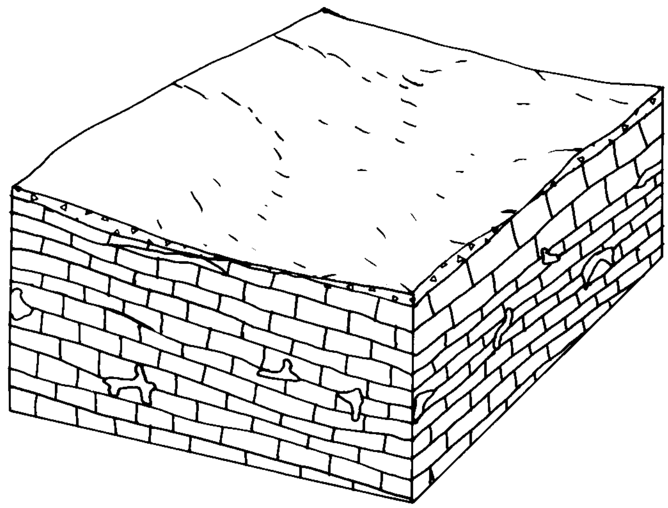
GWPP index values for the hydrogeologic setting of Alluvium over Glacial Till range from 90 to 168 with the total number of GWPP index calculations equaling 13**.**



7F Glacial Lake Plains Deposits

This hydrogeologic setting is characterized by flat-lying topography and varying thicknesses of fine-grained lacustrine sediments. These sediments were deposited by a sequence of ancestral lakes and deltas. This setting is common in eastern Lucas County. The vadose zone media consists of silty to clayey lacustrine sediments that overlie glacial till. The aquifer is the limestone bedrock or shale bedrock. Depth to water is highly variable, and dependant on such factors as the thickness of the unconsolidated material and the proximity to the Maumee River. Soils are shrink-swell (aggregated) clays, clay, or clay loams derived from clayey lacustrine sediments and silt loams or sandy loams derived from deltaic sediments. Recharge is typically low due to the impermeable nature of the soils and vadose zone.

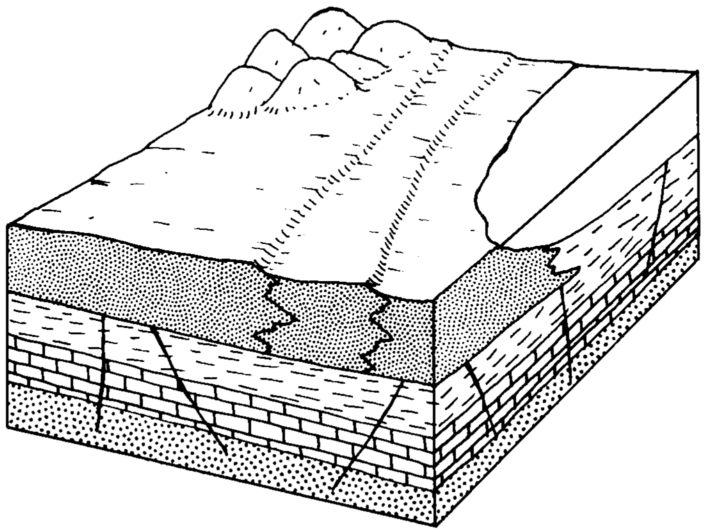
GWPP index values for the hydrogeologic setting of Glacial Lake Plains Deposits range from 71 to 144 with the total number of GWPP index calculations equaling 67.



7Gb Thin Till Over Limestone

A thin mantle of glacial till overlying limestone bedrock characterizes this hydrogeologic setting. This setting is found in only a few locations in the western portion of the county. Soils are typically clays or clay loams derived from the surficial till deposits. Recharge is high because of the proximity of the bedrock aquifer to the surface.

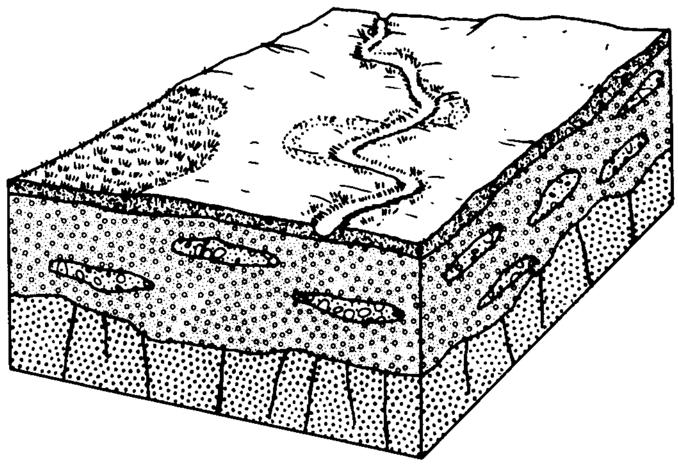
GWPP index values for the hydrogeologic setting of Thin Till Over Limestone range from 131 to 172 with the total number of GWPP index calculations equaling 7.



7H-Beaches, Beach Ridge, and Sand Dunes

Thick beach / deltaic deposits of fine to medium grained sand characterize this setting. These deposits occur in a wide belt running diagonally from the Michigan border in the north-central portion of Lucas County, to the Fulton and Henry county line in the southwestern part of the county. This band of sediments is named the Oak Openings Sand. In addition to the Oak Openings Sand unit, the 7H setting is found in a narrow band along Lake Erie at the eastern tip of the county. Soils are sands or sandy loams formed from the beach / deltaic deposits. The vadose material and the aquifer are typically composed of the sand. Depth to water is shallow because of the permeable nature of the soils and the till deposits underlying the sand that forms a nearly impermeable barrier baring downward movement of ground water. Recharge is high because of the permeable nature of the deposits and the high water table.

GWPP index values for the hydrogeologic setting of Beaches, Beach Ridges, and Sand Dunes range from 165 to 191 with the total number of GWPP index calculations equaling 4.



7I-Marshes and Swamps

Extremely low topographic relief, high water table, and poor drainage characterize this hydrogeologic setting. This setting is limited to low marshy areas along Lake Erie and an island in the Maumee River. The aquifer is limestone bedrock. Depth to water is very shallow due to the high water table.

The GWPP index values for the hydrogeologic setting of Marshes and Swamps range from 157 to 172 with the total number of GWPP index calculations equaling 2.

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topo (%Slope)	Vadose Zone Media	Hydro. Cond. (gpd/ft^2)	General Rating	Pesticide Rating
7Ae1	15-30	2-4	Sand and Gravel	Shrink/Swell Clay	0-2	Silt/Clay	100-300	115	150
7Ae2	15-30	2-4	Sand and Gravel	Loam	0-2	Silt/Clay	100-300	111	140
7Ae3	15-30	2-4	Sand and Gravel	Sandy Loam	0-2	Silt/Clay	100-300	113	145
7Ae4	15-30	2-4	Shale	Loam	0-2	Silt/Clay	1-100	96	126
7Ae5	15-30	2-4	Shale	Shrink/Swell Clay	0-2	Silt/Clay	1-100	100	136
7Ae6	15-30	2-4	Shale	Clay Loam	0-2	Silt/Clay	1-100	92	116
7Ae7	15-30	2-4	Sand and Gravel	Clay Loam	0-2	Silt/Clay	1-100	104	128
7Ae8	15-30	2-4	Shale	Sandy Loam	0-2	Silt/Clay	1-100	98	131
7Ea1	5-15	10+	Sand & Gravel w/ Silt & Clay	Clay Loam	0-2	Sand and Gravel	100-300	159	179
7Ec1	15-30	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	100-300	128	160
7Ec2	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	100-300	126	155
7Ec3	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	135	162
7Ec4	15-30	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	137	167
7Ed01	30-50	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	125	152
7Ed02	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	135	162
7Ed03	5-15	4-7	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	149	182
7Ed04	0-5	4-7	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	154	187
7Ed05	5-15	4-7	Limestone	Loam	2-6	Silt/Clay	300-700	144	169
7Ed06	15-30	4-7	Limestone	Loam	2-6	Silt/Clay	300-700	129	155
7Ed07	15-30	4-7	Limestone	Clay	0-2	Silt/Clay	300-700	127	142
7Ed08	15-30	4-7	Limestone	Clay Loam	0-2	Silt/Clay	300-700	131	152
7Ed09	5-15	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	145	172
7Ed10	5-15	7-10	Limestone	Loam	0-2	Limestone	300-700	168	192
7Ed11	30-50	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	104	126
7Ed12	30-50	2-4	Limestone	Clay Loam	0-2	Silt/Clay	100-300	90	115
7Ed13	15-30	4-7	Sand and Gravel	Loam	0-2	Silt/Clay	100-300	123	152
7F01	15-30	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	700-1000	128	160
7F02	5-15	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	700-1000	138	170
7F03	30-50	2-4	Limestone	Sand	0-2	Silt/Clay	300-700	116	156
7F04	30-50	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	107	142
7F05	50-75	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	97	132
7F06	50-75	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	100-300	88	125
7F07	50-75	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	100-300	86	120
7F08	50-75	2-4	Limestone	Loam	0-2	Silt/Clay	100-300	84	115
7F09	50-75	2-4	Limestone	Clay Loam	2-6	Silt/Clay	100-300	79	102
7F10	50-75	2-4	Limestone	Clay Loam	0-2	Silt/Clay	100-300	80	105
7F11	75-100	2-4	Limestone	Clay Loam	0-2	Silt/Clay	100-300	75	100
7F12	75-100	2-4	Limestone	Shrink/Swell Clay	2-6	Silt/Clay	100-300	82	117
7F13	75-100	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	100-300	81	115
7F14	75-100	2-4	Limestone	Clay	0-2	Silt/Clay	100-300	71	90
7F15	75-100	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	92	127
7F16	75-100	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	84	107
7F17	50-75	2-4	Limestone	Clay	0-2	Silt/Clay	300-700	85	102

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topo (%Slope)	Vadose Zone Media	Hydro. Cond. (gpd/ft^2)	General Rating	Pesticide Rating
7F18	50-75	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	89	112
7F19	50-75	2-4	Limestone	Loam	0-2	Silt/Clay	300-700	93	122
7F20	50-75	2-4	Limestone	Clay	0-2	Silt/Clay	300-700	90	106
7F21	50-75	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	94	116
7F22	50-75	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	100	131
7F23	50-75	2-4	Limestone	Clay	0-2	Silt/Clay	100-300	76	95
7F24	30-50	2-4	Limestone	Clay	0-2	Silt/Clay	100-300	91	109
7F25	30-50	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	100-300	103	139
7F26	30-50	4-7	Limestone	Clay	0-2	Silt/Clay	100-300	108	125
7F27	30-50	4-7	Limestone	Clay	0-2	Silt/Clay	300-700	117	132
7F28	30-50	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	104	126
7F29	30-50	2-4	Limestone	Clay Loam	0-2	Silt/Clay	100-300	95	119
7F30	30-50	2-4	Limestone	Clay	0-2	Silt/Clay	300-700	100	116
7F31	30-50	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	112	146
7F32	30-50	2-4	Limestone	Loam	0-2	Silt/Clay	300-700	108	136
7F33	15-30	4-7	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	139	172
7F34	15-30	4-7	Limestone	Clay	0-2	Silt/Clay	300-700	127	142
7F35	15-30	4-7	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	100-300	130	165
7F36	15-30	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	137	167
7F37	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	135	162
7F38	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	100-300	126	155
7F39	15-30	4-7	Limestone	Clay Loam	0-2	Silt/Clay	300-700	131	152
7F40	15-30	4-7	Limestone	Sandy Loam	2-6	Sand & Gravel w/ Silt & Clay	100-300	132	161
7F41	15-30	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	114	136
7F42	30-50	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	117	150
7F43	30-50	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	100-300	108	143
7F44	30-50	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	110	141
7F45	30-50	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	122	153
7F46	30-50	4-7	Limestone	Sandy Loam	2-6	Silt/Clay	300-700	121	150
7F47	15-30	4-7	Limestone	Sandy Loam	2-6	Silt/Clay	300-700	136	164
7F48	50-75	2-4	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	100-300	88	125
7F49	15-30	4-7	Shale	Sandy Loam	0-2	Sand & Gravel w/ Silt & Clay	1-100	120	151
7F50	50-75	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	95	127
7F51	30-50	2-4	Limestone	Clay Loam	0-2	Silt/Clay	300-700	99	122
7F52	30-50	2-4	Limestone	Clay	0-2	Silt/Clay	300-700	95	112
7F53	30-50	2-4	Limestone	Silty Loam	0-2	Silt/Clay	300-700	106	131
7F54	15-30	2-4	Limestone	Clay	0-2	Silt/Clay	300-700	110	126
7F55	15-30	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	120	151
7F56	50-75	2-4	Limestone	Clay Loam	2-6	Silt/Clay	300-700	93	113
7F57	15-30	2-4	Shale	Sandy Loam	0-2	Silt/Clay	1-100	98	131
7F58	15-30	4-7	Limestone	Loam	0-2	Silt/Clay	300-700	140	166
7F59	15-30	4-7	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	144	176
7F60	15-30	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	142	171
7F61	15-30	2-4	Limestone	Loam	0-2	Silt/Clay	100-300	109	139
7F62	15-30	2-4	Limestone	Sandy Loam	0-2	Silt/Clay	100-300	111	144
7F63	15-30	2-4	Limestone	Loam	0-2	Silt/Clay	300-700	118	146
7F64	15-30	4-7	Limestone	Silty Loam	2-6	Silt/Clay	300-700	127	150
7F65	15-30	4-7	Limestone	Sand	0-2	Silt/Clay	300-700	143	182
7F65	15-30	4-7	Limestone	Sand	0-2	Silt/Clay	300-700	143	182

Setting	Depth to Water (feet)	Recharge (In/Yr)	Aquifer Media	Soil Media	Topo (%Slope)	Vadose Zone Media	Hydro. Cond. (gpd/ft^2)	General Rating	Pesticide Rating
7F66	50-75	2-4	Limestone	Silty Loam	0-2	Silt/Clay	300-700	91	117
7F67	50-75	2-4	Limestone	Silty Loam	0-2	Silt/Clay	300-700	96	121
7Gb1	15-30	7-10	Limestone	Sandy Loam	0-2	Limestone	300-700	160	187
7Gb2	15-30	7-10	Limestone	Loam	0-2	Limestone	300-700	158	182
7Gb3	5-15	7-10	Limestone	Shrink/Swell Clay	0-2	Limestone	300-700	172	202
7Gb4	5-15	7-10	Limestone	Clay Loam	0-2	Limestone	300-700	164	182
7Gb5	15-30	7-10	Limestone	Clay	0-2	Limestone	300-700	150	162
7Gb6	30-50	7-10	Limestone	Clay	0-2	Limestone	300-700	140	152
7Gb7	30-50	7-10	Limestone	Clay	0-2	Limestone	100-300	131	145
7H1	5-15	10+	Sand and Gravel	Sand	0-2	Sand & Gravel w/ Silt & Clay	100-300	171	209
7H2	5-15	10+	Sand and Gravel	Sandy Loam	0-2	Sand & Gravel w/ Silt & Clay	100-300	165	194
7H3	5-15	10+	Sand and Gravel	Sand	2-6	Sand & Gravel w/ Silt & Clay	100-300	170	206
7H4	0-5	7-10	Limestone	Sand	2-6	Sand & Gravel w/ Silt & Clay	700-1000	191	222
7I1	0-5	7-10	Limestone	Shrink/Swell Clay	0-2	Silt/Clay	300-700	172	203
7I2	0-5	4-7	Limestone	Sandy Loam	0-2	Silt/Clay	300-700	157	186

Ground Water Pollution Potential of Lucas County

by
Kathy Sprowls

After Michael Hallfrisch, 2002

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

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

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Cartography edited by Robert Baker
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Description of Map Symbols

Hydrogeologic Region → 7D24 ← Hydrogeologic Setting
170 ← Relative Pollution Potential

Legend

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

- Roads
- Streams
- Lakes
- Townships

Index Ranges

- Not Rated
- Less Than 79
- 80 - 99
- 100 - 119
- 120 - 139
- 140 - 159
- 160 - 179
- 180 - 199
- Greater Than 200

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

Miles: 0 1 2 3 4 5

Kilometers: 0 1 2 4 6 8