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Aquifer Sensitivity of Carroll County, Illinois

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INTRODUCTION

The Illinois State Geological Survey (ISGS), with funding by the Illinois Department of Commerce and Community Affairs and the Carroll County Board, has conducted a study to map the shallow geology and characterize the potential for aquifer contamination (or aquifer sensitivity) of Carroll County, Illinois (ISGS Open File Series 1997- 13). This map classifies areas within Carroll County according to the potential for aquifers to become contaminated from surface disposal of municipal waste. For this study, an aquifer is defined as a geologic material that readily supplies useful volumes of water to wells or streams. Using this definition, coarse- grained unconsolidated materials and very permeable bedrock are considered aquifers, while fine-grained unconsolidated materials and impermeable bedrock are not considered aquifers.

AQUIFER (high permeability)	NON- AQUIFER (low permeability)
well sorted fine sand	lake silt and clay
river sand and gravel	loess (wind- blown silt)
dolomite	silty river deposits
sandstone	clay- rich bedrock soils
	peat
	glacial till
	shale

PRINCIPLES OF AQUIFER SENSITIVITY

Studies (Berg and Kempton 1984; Keefer and Berg 1990; Berg and Abert 1994) have shown that the properties of geologic materials overlying an aquifer directly influence the probability for aquifer contamination. The thickness and character of these deposits thus, are a basic tenet when determining the potential for aquifer contamination via a rules- based sensitivity model, such as that described by Soller and Berg (1992). Several assumptions were made during production of this aquifer sensitivity map which are similar to those used by Berg and Abert (1994).

1. Aquifer materials have high sensitivity to contamination while non- aquifer materials have low sensitivity.

2. Where bedrock is fractured dolomite or sandstone, thinner drift increases the potential for contamination in bedrock aquifers. Contaminant travel time to bedrock will be shorter through thinner drift. (e.g., sensitivity classification A1 > A3 > C > D)

3. Where bedrock is shale, thinner drift decreases the potential for contamination of drift aquifers. This is due to the decreased likelihood that a large sand and gravel aquifer exists within thin drift (Soller and Berg 1992). (e.g., sensitivity classification E3 < E2 < E1)

4. Coarse- grained unconsolidated aquifer materials may act as groundwater conduits to the underlying fractured dolomite or sandstone. Although water wells may not be screened in these units, contaminants may rapidly pass through these materials and enter the underlying bedrock. Fine- grained unconsolidated non- aquifer materials have a lesser probability to act as conduits to the underlying bedrock. However, fractures in fine- grained drift can transmit potential contaminants to the bedrock aquifers. The degree of fracturing of drift materials must be evaluated in site- specific investigations for landfill siting or other activities that could adversely impact groundwater quality. (e.g., sensitivity classification A2, A4, C, D)

5. Thicker sand and gravel deposits have a greater groundwater resource potential than thin deposits. Thinner sand and gravel aquifers cannot serve a large population. Therefore, it is more important to protect thick aquifers and thick aquifers receive a higher sensitivity category. (e.g., sensitivity classification A2 > A5 or A5 > B1)

Many other factors can affect aquifer sensitivity, but were not used for model simplicity. These factors include field measured hydraulic conductivity of bedrock and unconsolidated deposits, dye tracer tests to determine groundwater flow direction, piezometric surface mapping, surface slope, textural variation in till (see Grimley [1997]), organic carbon content of soils, soil permeability, land use, recharge rates, and the orientation and connectivity of the fracture network within the dolomite units. The incorporation of these factors would improve the quality of the model for site specific studies.

METHODOLOGY

Components used to map aquifer sensitivity in Carroll County include bedrock geology (McGarry 1997a), Quaternary deposits (Grimley 1997), and thickness of Quaternary deposits (McGarry 1997b). Areas were ranked according to the sensitivity of aquifer materials to contamination from surface disposal of municipal waste. Criteria used to determine the relative rank were the depth to the uppermost aquifer, thickness of aquifer materials, and type of aquifer. Depth to sand and gravel aquifers and sand and gravel aquifer thicknesses were determined from maps of Quaternary deposits. In areas where the bedrock aquifer is the uppermost aquifer, the map showing thickness of Quaternary deposits was used. The type of aquifer was determined from maps of the Quaternary geology and the bedrock geology. See inset maps under map components.

Examples of specific map areas within aquifer sensitivity classes are:
A1: Areas in the northern part of the county (e.g. near Lake Carroll) where fractured dolomite is very near the surface.
A2: Along the Savanna Terrace between Savanna and Thomson where coarse- grained sand and gravel glacial outwash (Henry Frm.) is very near the surface.
A3: Broad areas in the northern part of the county (e.g. north of Savanna) where loess covers fractured dolomite.
A4: Southwest of Mt. Carroll where loess overlies thick sand and gravel glacial outwash (Pearl Frm.) and fractured dolomite.
A5: Johnson Creek valley where thin alluvium and loess overlie thick glacial outwash (Pearl Frm.) and shale.
B1: Areas on the southeast side of the Johnson Creek valley where thin eolian sand (Parkland Sand) overlies shale.
B2: Along the base of the East Plum River valley where thin buried sand (outwash?) is overlain by fine- grained alluvium and underlain by shale. This is similar to A4, but underlain by shale.
C: Broad areas between Lanark and Milledgeville where loess and moderately thick Ogle Member till overlie sand and gravel and/or fractured dolomite.
D: Areas south of Lanark where loess and thick Ogle Member till overlie sand and gravel and/or fractured dolomite.
E1: Areas near Chadwick where loess and thick Ogle Member till overlie shale.
E2: Broad areas south and west of Chadwick where loess and moderately thick Ogle Member till overlie shale.
E3: Areas between Savanna and Mt. Carroll where shale is very near the surface.

AQUIFER SENSITIVITY TO CONTAMINATION FROM MUNICIPAL SOLID WASTE SITES

Map Units A, B, and C: High potential for aquifer contamination from waste disposal facilities. Regions designated as A, B, and C, all containing sand and gravel and/or bedrock aquifers within 50 feet of land surface, are extremely sensitive to potential contamination from waste disposal facilities. Waste buried in a pit or trench up to 50 feet deep may be placed in direct contact with sand and gravel deposits or bedrock aquifers, therefore, there is little or no natural protection of an aquifer by overlying finer- grained materials. Trench depths of 50 feet are now fairly common (and some up to 100 feet have been proposed) because operators desire to maximize their landfill capacities due to difficulties in obtaining permits for new facilities. In B areas, where the thin sand and gravel is underlain by fine- grained deposits, it may be possible to remove the sand and gravel to the top of the fine- grained deposit, however waste and effluent could still be in contact with sand and gravel at the sides of the trench.

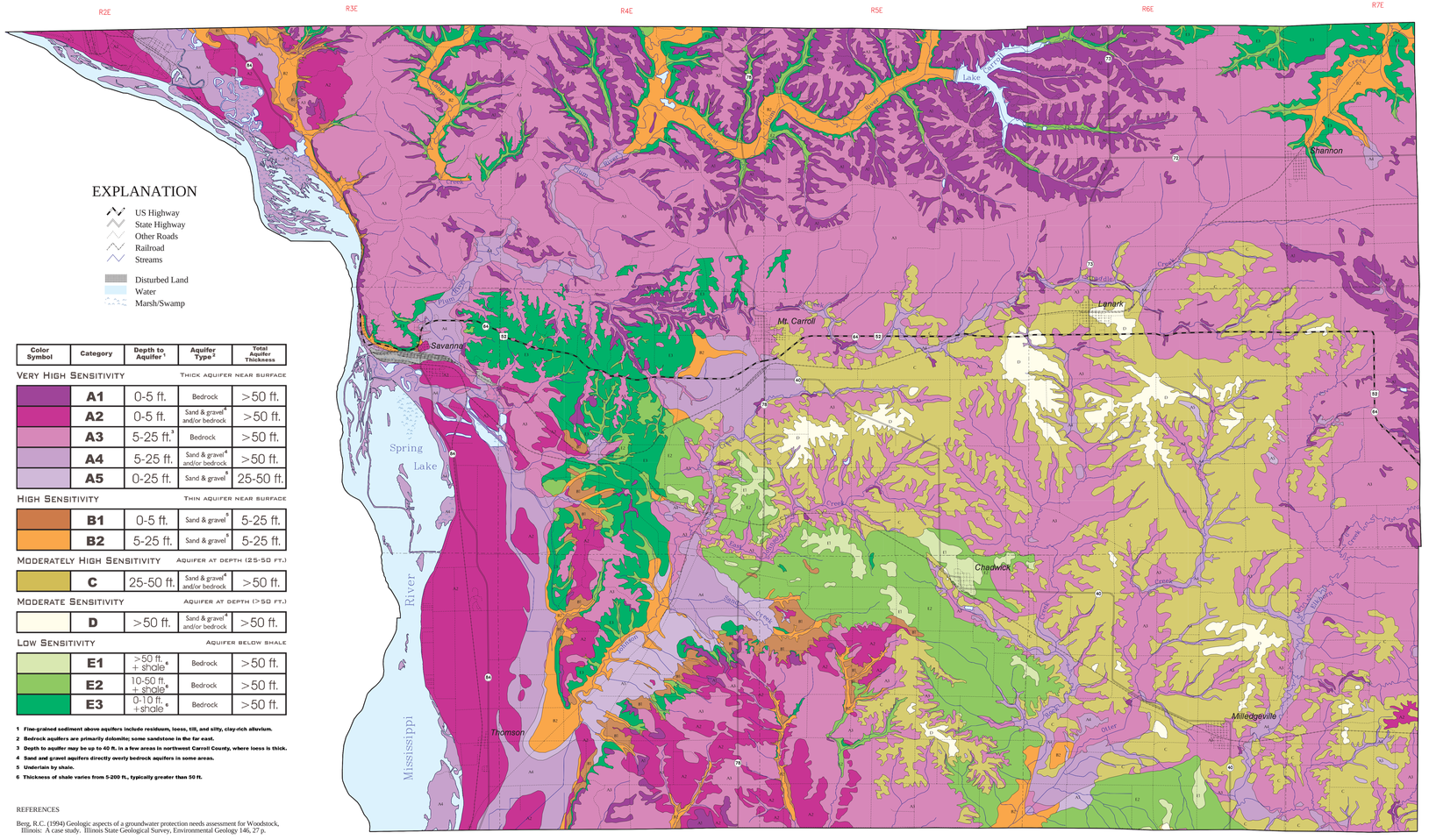
Map Unit D: Moderate potential for aquifer contamination from waste disposal facilities. This unit includes areas where sand and gravel and/or bedrock aquifers are present and are overlain by >50 feet of fine- grained deposits. Although the aquifer sensitivity is relatively low because fine- grained materials separate the aquifer from land surface, aquifers can be as shallow as 50 feet from land surface. Areas mapped as D should not be used for hazardous waste disposal. Municipal waste disposal may be acceptable if site- specific investigations show that the aquifer is closer to a 100- foot depth maximum (Berg 1994). At least 50 feet of undisturbed fine- grained materials should remain between the bottom of the landfill trench and the aquifer.

Map Unit E: Low potential for aquifer contamination from waste disposal facilities. This unit exists where shale is present and overlain by fine- grained deposits. The potential for contamination of aquifers from waste disposal facilities is low because of the lack of aquifers. Such areas have less potential to suffer groundwater contamination from municipal or, perhaps, hazardous wastes, but, waste disposal facilities must always be designed, constructed, and carefully monitored to minimize their potential for groundwater contamination.

Significant parts of both D and E areas may have poor surface drainage conditions or may be subject to a seasonally high water table. Although thick fine- grained deposits reduce the potential for aquifers to become contaminated, a potential for surface water contamination exists, and landfills may be troublesome to design, engineer, and operate in poorly- drained areas. The soil survey of Carroll County (Ray 1975) provides delineation of poorly- drained soils and should be consulted when siting a municipal waste disposal facility. In addition, detailed site- specific investigations must be conducted to verify the absence of aquifer materials in these map areas.

SUMMARY

The largest percentage of Carroll County, Illinois is characterized as having very high aquifer sensitivity due to the shallow position of fractured dolomite bedrock. Areas where dolomite or sandstone bedrock is exposed are most sensitive. In addition, several areas of thick coarse- grained unconsolidated sediments found in outwash, eolian sand, and kames have high sensitivity. These regions contrast with areas underlain by shale bedrock, which has a low sensitivity to aquifer contamination. Areas of thick fine- grained unconsolidated deposits overlying dolomite or sandstone bedrock (such as till- dominated landscapes in the center of the county) or areas with thin coarse- grained unconsolidated deposits overlying shale (such as areas with outwash overlying shale) are characterized as having a more moderate sensitivity to aquifer contamination.



EXPLANATION

- US Highway
- State Highway
- Other Roads
- Railroad
- Streams
- Disturbed Land
- Water
- Marsh/Swamp

Color Symbol	Category	Depth to Aquifer [1]	Aquifer Type [2]	Total Aquifer Thickness
VERY HIGH SENSITIVITY			THICK AQUIFER NEAR SURFACE	
	A1	0-5 ft.	Bedrock	>50 ft.
	A2	0-5 ft.	Sand & gravel [4] and/or bedrock	>50 ft.
	A3	5-25 ft. [3]	Bedrock	>50 ft.
	A4	5-25 ft.	Sand & gravel [4] and/or bedrock	>50 ft.
	A5	0-25 ft.	Sand & gravel [5]	25-50 ft.
HIGH SENSITIVITY			THIN AQUIFER NEAR SURFACE	
	B1	0-5 ft.	Sand & gravel [5]	5-25 ft.
	B2	5-25 ft.	Sand & gravel [5]	5-25 ft.
MODERATELY HIGH SENSITIVITY			AQUIFER AT DEPTH (25-50 FT.)	
	C	25-50 ft.	Sand & gravel [4] and/or bedrock	>50 ft.
MODERATE SENSITIVITY			AQUIFER AT DEPTH (>50 FT.)	
	D	>50 ft.	Sand & gravel [4] and/or bedrock	>50 ft.
LOW SENSITIVITY			AQUIFER BELOW SHALE	
	E1	>50 ft. + shale [6]	Bedrock	>50 ft.
	E2	10-50 ft. + shale [6]	Bedrock	>50 ft.
	E3	0-10 ft. + shale [6]	Bedrock	>50 ft.

1 Fine-grained sediment above aquifers include residuum, loess, till, and silty, clay-rich alluvium.
2 Bedrock aquifers are primarily dolomite; some sandstone in the far east.
3 Depth to aquifer may be up to 40 ft. in a few areas in northwest Carroll County, where loess is thick.
4 Sand and gravel aquifers directly overly bedrock aquifers in some areas.
5 Underlain by shale.
6 Thickness of shale varies from 5-200 ft., typically greater than 50 ft.

REFERENCES

Berg, R.C. (1994) Geologic aspects of a groundwater protection needs assessment for Woodstock, Illinois: A case study. Illinois State Geological Survey, Environmental Geology 146, 27 p.

Berg, R.C. and C.C. Abert (1994) Large-scale aquifer sensitivity model. Environmental Geology, v. 24, no. 1, p. 34- 42.

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Keefer, D.A. and R.C. Berg (1990) Potential for aquifer recharge in Illinois. Illinois State Geological Survey Map, scale 1:1,000,000.

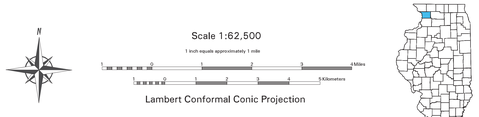
Grimley, D.A. (1997) Quaternary deposits of Carroll County, Illinois. Illinois State Geological Survey, Open File Series 1997- 13o, scale 1:62,500.

McGarry, C.S. (1997a) Thickness of Quaternary deposits of Carroll County, Illinois. Illinois State Geological Survey, Open File Series 1997- 13c, scale 1:62,500.

McGarry, C.S. (1997b) Bedrock geology of Carroll County, Illinois. Illinois State Geological Survey, Open File Series 1997- 13d, scale 1:62,500.

Ray, B.W. (1975) Soil Report 98: Soil Survey of Carroll County, Illinois. United States Department of Agriculture, 138 p.

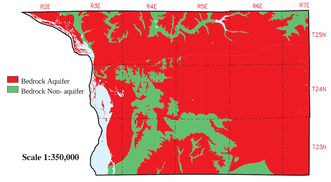
Soller, D.R. and R.C. Berg (1992) A model for the assessment of aquifer contamination potential based on a regional geologic framework. Environmental Geology and Water Sciences, v. 19, p. 205- 213.



This map was prepared by the Illinois State Geological Survey, in cooperation with the Illinois Department of Commerce and Community Affairs and the Carroll County Board. It is part of a suite of maps created to assist county officials in addressing geologic questions concerning capable sites for landfill development. Maps produced for this study are intended for regional land use planning purposes. More detailed mapping is needed for site specific considerations. This map has been reviewed for scientific accuracy and has been edited to meet the quality standards of maps in the ISGS Map Series.

MAP COMPONENTS

Bedrock Aquifers at the Bedrock Surface of Carroll County, Illinois

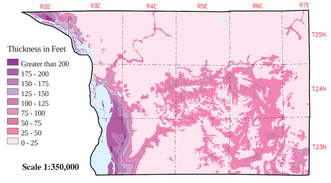


Scale 1:350,000

from McGarry (1997a)

This map was used to determine the presence of bedrock aquifers within a given area. Dolomite and sandstone are considered aquifers; shale is considered a non- aquifer.

Thickness of Quaternary Deposits of Carroll County, Illinois

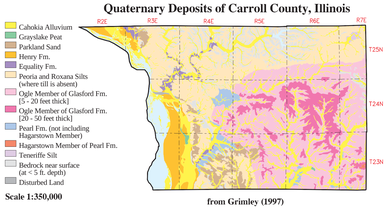


Scale 1:350,000

from McGarry (1997b)

This map was used to determine the depth to aquifers (either bedrock or drift) and thickness of unconsolidated materials (both aquifer and non- aquifer).

Quaternary Deposits of Carroll County, Illinois



Scale 1:350,000

from Grimley (1997)

This map was used to determine the presence of drift aquifers and thickness of unconsolidated materials (both aquifer and non- aquifer).