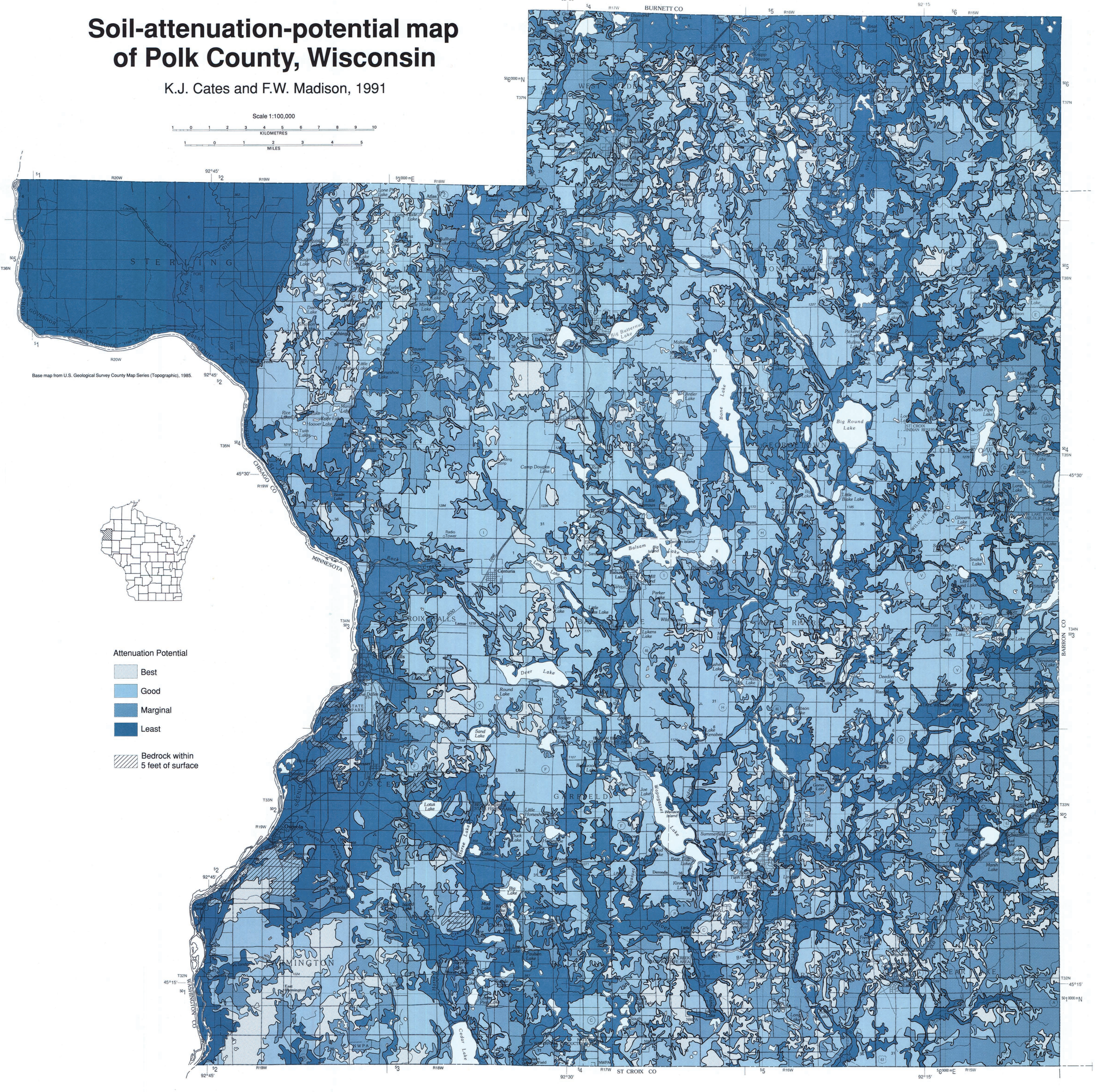
Soil-attenuation-potential map of Polk County, Wisconsin

K.J. Cates and F.W. Madison, 1991



Introduction

Soils usually compose only the upper 2 to 4 feet of unlithified material at the earth's surface; they are underlain by their parent materials, which may be rock or unlithified materials that can extend to great depths. Soils and their parent materials are the basis of agricultural production; they provide the foundation for buildings and roads; and, if properly used, they aid in the treatment and recycling of wastes from homes, from the production of livestock and poultry, and from municipal and industrial sewage-treatment plants. Soil and parent-material characteristics (thickness, texture, rock type, and permeability) are among those natural factors that help determine the rate and extent of groundwater recharge and the degree of natural protection against groundwater contamination. Land characteristics such as slope and type of vegetation will, in conjunction with soil and parent-material characteristics, determine the overall potential of the environment to protect groundwater.

Many factors influence the type of soil that develops in an area: the parent material from which the soil formed, relief, climate, natural vegetation, drainage, and the time that the soil has had to form. In Polk County, the modern landscape was most strongly influenced by the glaciers that invaded the county from about 25,000 to 15,000 years ago from the northwest and north, and by a glacier that moved into the county from the west about 12,300 years ago. These glaciers eroded the land and left behind till (a poorly sorted mixture of sand, silt, clay, and boulders) and outwash (sand and gravel carried away from the ice by meltwater). In the northwestern part of the county, large glacial lakes formed when ice blocked the St. Croix River drainageway. Flat-lying deposits of sand, silt, and clay now occupy those former lakebeds (Muldoon and others, 1990).

Loess (windblown silt) was deposited on part of the land surface; coniferous and deciduous forests developed; organic material was deposited in depressions in the till and outwash. Glacial material is generally more than 100 feet thick; bedrock is found within 5 feet of the land surface in less than 1 percent of the land area of the county.

Flat-lying outwash plains and the gently rolling till plains in the county are intensively farmed. Because of the sandiness of the subsurface material in many of these areas, agrichemical inputs must be carefully managed to prevent groundwater contamination. Threats to groundwater also may be posed by improperly installed or leaking septic systems or by overuse of chemicals on lawns and gardens, particularly around the county's many recreational lakes.

Nearly 37 percent (220,000 acres) of the land area of Polk County is forested. This, combined with the approximately 24,000 acres of water in the county, forms the basis for a strong recreation and tourism industry. Land uses associated with forested areas are relatively benign environmentally; however, improperly managed timber harvesting can create surface-water problems.

Most groundwater used in Polk County comes from the sand and gravel aquifer (that is, the glaciofluvial sediment and till) that overlies the bedrock, which consists of Precambrian basaltic rock and of Cambrian and Ordovician sandstone and dolomite. Although the sandstone and dolomite generally yield sufficient water for domestic use, the basalt, which is locally known as traprock, does not. Although the basalt does contain water, it generally does not yield sufficient water for domestic use unless a well happens to hit a large fissure or crack. In those areas underlain by basaltic rocks, preservation of the quality of the water in the sand and gravel aquifer is extremely important; if the groundwater in that aquifer becomes contaminated, alternative sources of water are limited.

Capacity of soils to attenuate contaminants

Attenuation is a series of complex physical, chemical, and biological processes, many of which are not fully understood. During attenuation, the soil holds essential plant nutrients for uptake by agronomic crops, immobilizes metals that might be contained in municipal sewage sludge, or removes bacteria contained in animal or human wastes. The soil is an integral part of the natural protection of groundwater from surface-applied contaminants. However, the purification capacity of the soil, like that of any other natural resource, is limited, and sometimes soil can become contaminated. Cleaning contaminated soil can be as difficult as cleaning contaminated groundwater.

For mapping, classification, and interpretive purposes, soils are grouped into soil series on the basis of similar physical and chemical characteristics, type of parent material, and arrangement of horizons or layers. An evaluative system that groups individual soils solely on the basis of physical and chemical characteristics was developed to assess those soil properties that play a role in the attenuation of potential groundwater contaminants resulting from land-use activities.

The evaluation system presented here must be looked upon as a supplemental planning tool only, as a time- and cost-saving guide for preliminary screening of the county for areas sensitive to the impact of normal land-use activities. The soil-attenuation-potential map presented here does not replace the need for detailed on-site investigations. It does, however, reduce the number of areas that need to be studied in detail by identifying the areas of best, good, marginal, and least attenuation potential. Local details have been generalized to fit the mapping scale, which cannot accommodate small, local variations in soil characteristics.

This system evaluates the ability of the soil solum (the A and B horizons) to attenuate potential contaminants resulting from activities above or within the soil zone. Soil-attenuation capacity is considered here only in general terms and is not contaminant-specific. Different contaminants may behave differently — some may be completely eliminated by soil organisms, some may be used by plants, some may be adsorbed on soil particles, and some may eventually pass through the soil solum unchanged.

Physical and chemical characteristics to establish soil ratings

For assessing soil potential for attenuation of contaminants in Polk County, seven physical and chemical characteristics were selected for each soil series and were given weighted values (table 1). Values assigned to each characteristic were determined subjectively, with 1 being the poorest and 10 the best attenuation potential. These values were summed, and soils with total point scores within certain ranges were grouped into four soil associations, which, in turn, reflect different attenuation potentials (table 2). Soil associations consist of two or more dissimilar soil series that occur on the landscape in a regularly repeating pattern.

Information needed for this assessment was taken entirely from the Polk County Soil Survey (Soil Conservation Service, 1979). All soil series mapped in the county were ranked on the basis of their physical and chemical characteristics in a natural state. Man-induced changes, such as tiling and ditching in areas of agricultural activity, may affect the attenuation potential of a particular soil or soils. In those instances where alteration has been extensive, a reassessment may be required; the effects of these changes cannot be determined from the soil survey report but must be assessed in the field.

Soil-attenuation potential

Only a small percentage of the soils (9%) in Polk County are rated as having the **best** potential for contaminant attenuation (table 2). Santiago soils, which formed in 15 to 30 inches of loess over a very dense, sandy loam till, predominate. Contaminant attenuation in soils is greatly affected by the contact between percolating (moving) water, which contains contaminants, and mineral and organic soil particles. In medium-textured soils like the Santiago silt loam, well structured surface horizons allow water to enter the soil easily; water percolates through the soil reasonably slowly and contact between the percolating water and soil particles is maximized. Although the till that underlies Santiago soils is coarse textured, it is dense, which means that the particles within it are tightly packed together; this slows water movement and increases contaminant attenuation.

Other soils shown to have the **best** contaminant attenuation potential include those formed in 20 to 40 inches of silty lacustrine materials (Campia) or in 20 to 40 inches of loamy materials over a loam till (Cushing Loam). Both are naturally well drained, deep soils.

Soils that have **good** potential to attenuate contaminants are primarily those formed in 20 to 36 inches of loess over outwash (Antigo) or 20 to 40 inches of loamy materials over outwash (Rosholt). The outwash sand and gravel that underlies these soils has limited ability to attenuate contaminants. Because of the coarse texture of the outwash, water moves through it rapidly; contact between the percolating water and the outwash particles is brief and attenuation is minimal. Where these soils are farmed intensively, chemical inputs, including nutrients and pesticides, must be carefully managed; chemicals and nutrients not utilized for crop production or attenuated by the finer-textured materials at the surface will move rapidly through the outwash to contaminate groundwater.

Other soils that have **good** potential to attenuate contaminants are those formed in thin loess (<15 inches) over sandy loam till (Amery). In Polk County, the attenuation potential of these soils is classified as good instead of best because the loess mantle is thin and the underlying till is coarse textured. Cushing soils, which are severely eroded and thus have lost some of their ability to attenuate contaminants or which are found on steep slopes where runoff is increased and infiltration is significantly reduced, are also included in this group.

Soils that have **marginal** potential to attenuate contaminants are primarily those formed in less than 15 inches of sandy loam material over sandy loam till (Amery), in 15 to 30 inches of loess over sandy loam till (Magnor), or in less than 20 inches of loamy material over outwash (Rosholt-Cromwell complex). Because of the coarse texture of the Amery soils and the Roshalt-Cromwell complex, water moves through them rapidly and attenuation is limited. Magnor soils are somewhat poorly drained, which means that the lower part of the soil solum is saturated for at least part of any given year. Saturation in the soil profile reduces attenuation and may lead to the direct introduction of contaminants to the groundwater.

Soils that have the **least** potential to attenuate contaminants are primarily peat and muck (Markey, Rifle, Cathro). Organic soils (Histosols), which occupy about 8 percent of the county's land area, are formed in areas where water is at or near the land surface most of the time and where organic matter accumulates more rapidly than it decomposes. These soils may play an important role in preventing sediments and nutrients from entering surface water; however, because they generally occur in areas of groundwater discharge where the water table is at or near the land surface, their role in attenuating contaminants is limited. Other soils in this association are primarily sands (Chetek, Menahga, Omega), which, because of their coarse texture, are not able to effectively attenuate contaminants.

References

Muldoon, M.A., F.W. Madison, and M.D. Johnson, 1990, Soils, Geologic, and Hydrogeologic Influences on Lake Water Quality in Northwestern Wisconsin: Wisconsin Geological and Natural History Survey Open-File Report 90-1, 74 p.

Soil Conservation Service, 1979, Soil Survey of Polk County, Wisconsin: U.S. Department of Agriculture, 203 p. plus maps (scale 1:15,840).

Table 1. Ranking system for evaluating the attenuation potential of soils

Physical/chemical characteristics	Classes	Weighted values
Texture[1] of surface (A) horizon	l, sil, scl, si	9
	c, sic, cl, sicl, sc	8
	lvfs, vfsl, lfs, fsl	4
	s, sl, ls, organic materials, and all textural classes with coarse fragment class modifiers	1
Texture[1] of subsoil (B) horizon	c, sic, sc, si	10
	scl, l, sil, cl, sicl	7
	lvfs, vfsl, lfs, fsl	4
	s, ls, sl, organic materials, and all textural classes with coarse fragment class modifiers	1
Organic matter content[2]	Mollisols	8
	Alfisols	5
	Entisols; Inceptisols; Spodosols	3
	Histosols; Aquic suborder; and Lithic, Aquollic, and Aquic subgroups	1
pH-Surface (A) horizon	≥6.6	6
	<6.6	4
Depth of soil solum[3] (A + B horizons)	>40 in.	10
	30-40 in.	8
	20-30 in.	3
	<20 in.	1
Permeability[4]-subsoil (B) horizon	very low	10
	moderate	8
	high	4
	very high	1
Soil drainage class	well drained	10
	well to moderately well drained	7
	moderately well drained	4
	somewhat poorly, poorly, and very poorly drained; excessively well drained	1

[1] Soil textural classes: l = loam, sil = silt loam, scl = sandy clay loam, si = silt, c = clay, sic = silty clay, cl = clay loam, sicl = silty clay loam, sc = sandy clay, lvfs = loamy very fine sand, vfsl = very fine sandy loam, lfs = loamy fine sand, fsl = fine sandy loam, s = sand, ls = loamy sand, sl = sandy loam.

[2] Based on the ordinal, subordinal, or subgroup levels of the soil classification system; soils are assigned a lower number if they are wet or less than 20 inches thick over bedrock; see county soil survey report.

[3] Assign next lower value if bedrock is within 30 to 40 inches of the soil surface; this takes into account erosion that may have decreased soil depth. See descriptions of soil map units in county soil survey report.

[4] Based on the particle-size class at the family level of the soil classification system, type, and grade of structure, and consistence; with strongly contrasting particle-size classes, the most permeable size class should be used. See soil profile descriptions and classification table in county soil survey report.

Table 2. Soil series in Polk County listed by attenuation potential

	Least potential	Marginal potential	Good potential	Best potential
Sum of weighted values	**0-30**	**31-40**	**41-50**	**>51**
	Adolph Burkhardt Cathro Chetek Cromwell Cromwell Variant sandy loam Croswell Emmert Fluvaquents* Fluvaquents, wet* Hubbard Lino Markey Menahga Mora Newson Nymore Omega Pits, gravel* Plover Rifle Saprists and Aquents* Seelyeville Udorthents, sandy* Udorthents, loamy* Warman Variant sandy loam	Alban Amery Amery-Rock outcrop complex Antigo silt loam, eroded† Aurburndale Barronett Barronett Variant fine sandy loam Bluffton Brill Comstock Dakota Variant silt loam Magnor Poskin Rosholt-Cromwell complex	Alstad Amery silt loam† Amery complex Antigo Campia Variant loam Comstock Variant loam Crystal Lake Cushing Cushing soils* Cushing complex Dakota loam, limestone substratum† Freeon Rosholt Rosholt Variant silt loam Santiago-Antigo silt loams*	Campia Campia Variant loam, 2 to 6 percent slopes† Cushing loam, 2 to 6 percent slopes† Dakota Santiago
Acreage	181,900	131,730	228,590	53,620
Percent of total land area	30.5	22.1	38.4	9.0

*map unit
†soil phase

Drafting by K.J. Cates
Cartography by D.L. Patterson and G.A. Burton

Soil Map 12

University of Wisconsin–Extension
Published by and available from
Geological and Natural History Survey
Ronald Hennings, Acting Director and State Geologist
3817 Mineral Point Road, Madison, Wisconsin 53705