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Project Summary

DRASTIC: A Standardized System for Evaluating Groundwater Pollution Potential Using Hydrogeologic Settings

A methodology is described that will allow the pollution potential of any hydrogeologic setting to be systematically evaluated anywhere in the United States. The system has two major portions: the designation of mappable units, termed hydrogeologic settings, and the superposition of a relative rating system called DRASTIC.

Hydrogeologic settings are described for different regions in the United States. These settings incorporate the major hydrogeologic factors that affect and control ground-water movement including depth to water table, net recharge, aquifer media, soil media, topography, impact of the Vadose zone and hydraulic conductivity of the aquifer. These factors are used to infer the potential for contaminants to enter ground water. These settings form the basis for the entire system, and create units that can be graphically displayed on a map.

The relative ranking scheme uses a combination of weights and ratings to produce a numerical value, called the DRASTIC INDEX, which helps prioritize areas with respect to ground-water contamination vulnerability. The entire system optimizes the use of existing data and provides an evaluation which can be used to direct resources and waste disposal activities to appropriate areas.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This research project was designed to create a methodology that will permit the ground-water pollution potential of any hydrogeologic setting to be systematically evaluated anywhere in the United States. The project design also included the development of a standardized system that can be displayed on maps. Therefore, a set of demonstration maps will be prepared to show how the system could display the information on maps. Inherent in this demonstration project is the idea that the standardized system cannot be finalized until it has been extensively tested in a wide variety of representative settings. Thus, this system and the setting descriptions will be continually evolving until the demonstration project is complete.

Results

The system that has been developed has two major parts: the designation of mappable units, termed hydrogeologic settings; and the superposition of a relative ranking system, called DRASTIC, which helps the user evaluate the relative ground-water pollution potential of any hydrogeologic setting.

A *hydrogeologic setting is a composite* description of all the major geologic and hydrologic factors which affect and control ground-water movement into, through and out of an area. It is defined as a mappable unit with common hydrogeologic characteristics, and as a consequence, common vulnerability to contamination.

The standardization system for evaluating ground-water pollution potential has been developed within the framework of an existing classification system

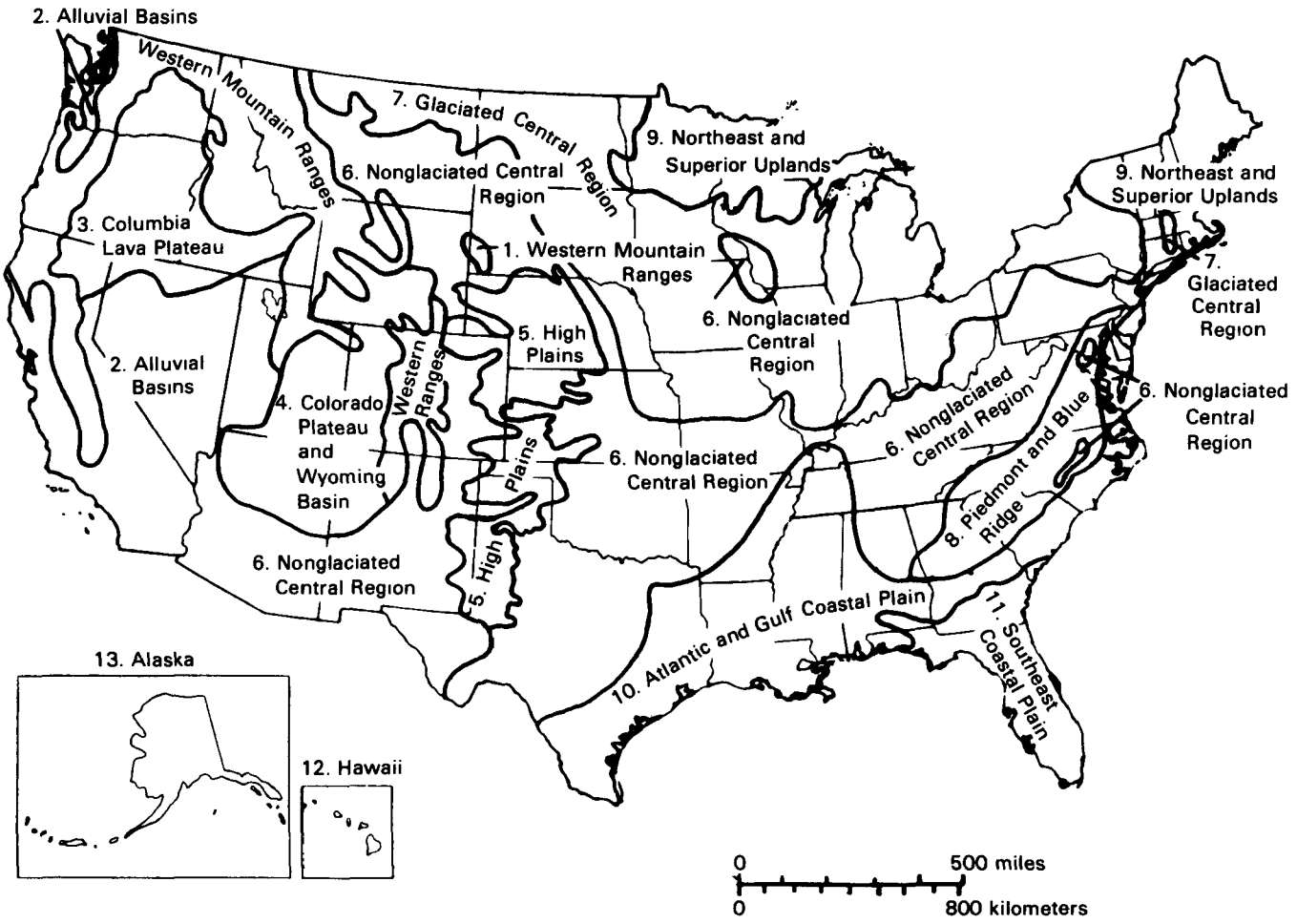

Figure 1. Ground-water regions of the United States (After Heath, USGS, Water Supply Paper No. 2242, 1984).

of ground-water regions of the United States (Figure 1). These regions include:

1. Western Mountain Ranges
2. Alluvial Basins
3. Columbia Lava Plateau
4. Colorado Plateau and Wyoming Basin
5. High Plains
6. Nonglaciated Central Region
7. Glaciated Central Region
8. Piedmont and Blue Ridge
9. Northeast and Superior Uplands
10. Atlantic and Gulf Coastal Plain
11. Southeast Coastal Plain
12. Alluvial Valleys
13. Hawaiian Islands
14. Alaska
15. Puerto Rico and Virgin Islands

For the purpose of the present system, Region 12 (Alluvial Valleys) has been incorporated into each of the other regions and Region 15 (Puerto Rico and Virgin Islands) has been omitted.

Because pollution potential cannot be determined on a regional scale smaller "hydrogeologic settings" were developed within each region. These hydrogeologic settings create units which are mappable and, at the same time, permit further delineation of the factors that affect pollution potential (Figure 2).

Inherent in each hydrogeologic setting are the physical characteristics that affect the pollution potential of ground water. After evaluating a number of factors, the most important mappable factors that control ground-water pollution potential were determined to be:

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

The DRASTIC factors represent measurable parameters for which data are generally available from a variety of sources without detailed reconnaissance. Sources of this information are listed in Table 1.

Each DRASTIC factor has been evaluated with respect to each other to determine the relative importance of each factor. Each DRASTIC factor has been assigned a relative weight ranging from 1 to 5 (Table 2), with the most significant factors having a weight of 5 and the least significant a weight of 1.

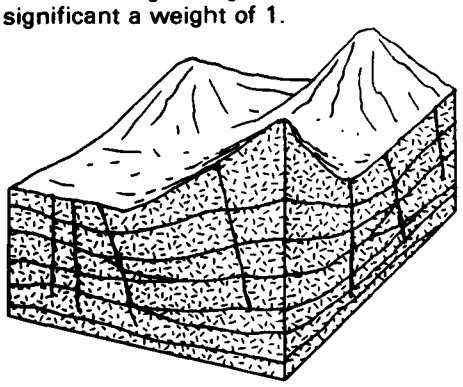

Figure 2. Format of hydrogeologic setting.

Table 1. Sources of Hydrogeologic Information

Source	Depth to Water Table	Net Recharge	Aquifer Media	Soil Media	Topography	Impact of the Vadose Zone	Hydraulic Conductivity of the Aquifer
U.S. Geological Survey	X	X	X		X	X	X
State Geological Surveys	X	X	X			X	X
State Department of Natural/Water Resources	X	X	X			X	X
U.S. Department of Agriculture-Soil Conservation Service		X		X	X		
State Department of Environmental Protection	X	X	X			X	X
Clean Water Act "208" and other Regional Planning Authorities	X	X	X			X	X
County and Regional Water Supply Agencies and Companies (private water suppliers)	X		X			X	X
Private Consulting Firms (hydrogeologic, engineering)	X		X			X	X
Related Industry Studies (mining, well drilling, quarrying, etc.)	X		X			X	
Professional Associations (Geological Society of America, National Water Well Association, American Geophysical Union)	X	X	X			X	X
Local Colleges and Universities (Departments of Geology, Earth Sciences, Civil Engineering)	X	X	X			X	X
Other Federal/State Agencies (Army Corps of Engineers, National Oceanic and Atmospheric Administration)	X	X	X			X	

A special case for the DRASTIC INDEX was developed for agricultural areas where herbicides and pesticides are applied. The weights assigned for each agricultural use are shown in Table 3.

Each DRASTIC factor has been divided into either ranges or significant media types which have an impact on pollution potential and each range has been evaluated with respect to each other to determine the relative significance of each range with respect to pollution potential (Tables 4-10).

Once the DRASTIC INDEX has been computed, it is possible to identify areas which are more likely to be susceptible to ground-water contamination relative to one another. The higher the DRASTIC INDEX, the greater the ground-water pollution potential.

Conclusion

The system presents a simple and easy-to-use approach to assess the ground-water pollution potential of any area. Although the final system appears simplistic, the system actually includes many complex concepts and relationships. Before an attempt is made to make full use of this system, the user must develop an appreciation for the complexity of evaluating ground-water pollution potential. It is not necessary to understand every concept in detail, but the greater the depth of understanding, the more useful the system becomes.

The DRASTIC INDEX provides only a relative evaluation tool and is not designed to provide absolute answers. Therefore, the numbers generated in the DRASTIC INDEX and in the agricultural DRASTIC INDEX cannot be equated.

DRASTIC provides mappable results that can be used to provide a quick reference of relative pollution potential of different areas. DRASTIC is designed to be used as a planning or screening tool. DRASTIC and associated maps cannot be used exclusively in site specific evaluations because of local complexities in geologic conditions.

Table 2. Assigned Weights for Drastic Features

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

Table 3. Assigned Weights for Agricultural Drastic Features.

Feature	Agricultural Weight
Depth to Water Table	5
Net Recharge	4
Aquifer Media	3
Soil Media	5
Topography	3
Impact of the Vadose Zone	4
Hydraulic Conductivity of the Aquifer	2

Table 4. Ranges and Ratings for Depth to Water

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

Table 5. *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	*Agricultural Weight: 4*

Table 6. *Ranges and Ratings for Aquifer Media*

Aquifer Media		
Range	*Rating*	*Typical Rating*
Massive Shale	1-3	2
Metamorphic/Igneous	2-5	3
Weathered Metamorphic/Igneous	3-5	4
Thin Bedded Sandstone, Limestone, Shale Sequences	5-9	6
Massive Sandstone	4-9	6
Massive Limestone	4-9	6
Sand and Gravel	6-9	8
Basalt	2-10	9
Karst Limestone	9-10	10
Weight: 3		*Agricultural Weight: 3*

Table 7. *Ranges and Ratings for Soil Media*

Soil Media	
Range	*Rating*
Thin or Absent	10
Gravel	10
Sand	9
Shrinking and/or Aggregated Clay	7
Sandy Loam	6
Loam	5
Silty Loam	4
Clay Loam	3
Nonshrinking and Nonaggregated Clay	1
Weight: 2	*Agricultural Weight: 5*

Table 8. *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	*Agricultural Weight: 3*

Table 9. *Ranges and Ratings for Impact of Vadose Zone Media*

Impact of Vadose Zone Media		
Range	*Rating*	*Typical Rating*
Silt/Clay	*1-2*	*1*
Shale	*2-5*	*3*
Limestone	*2-7*	*6*
Sandstone	*4-8*	*6*
Bedded Limestone, Sandstone, Shale	*4-8*	*6*
Sand and Gravel with significant Silt and Clay	*4-8*	*6*
Metamorphic/Igneous	*2-8*	*4*
Sand and Gravel	*6-9*	*8*
Basalt	*2-10*	*9*
Karst Limestone	*8-10*	*10*
Weight: 5	*Agricultural Weight: 4*	

Table 10. *Ranges and Ratings for Hydraulic Conductivity*

Hydraulic Conductivity (gpd/ft²)	
Range	*Rating*
1-100	*1*
100-300	*2*
300-700	*4*
700-1000	*6*
1000-2000	*8*
2000+	*10*
Weight: 3	*Agricultural Weight: 2*

This Project Summary was prepared by staff of Robert S. Kerr Environmental Research Laboratory, U.S. Environmental Protection Agency, Ada, OK 74820.
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The complete report, entitled "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings," (Order No. PB 85-228 146/AS; Cost: $17.50, subject to change) will be available only from:
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