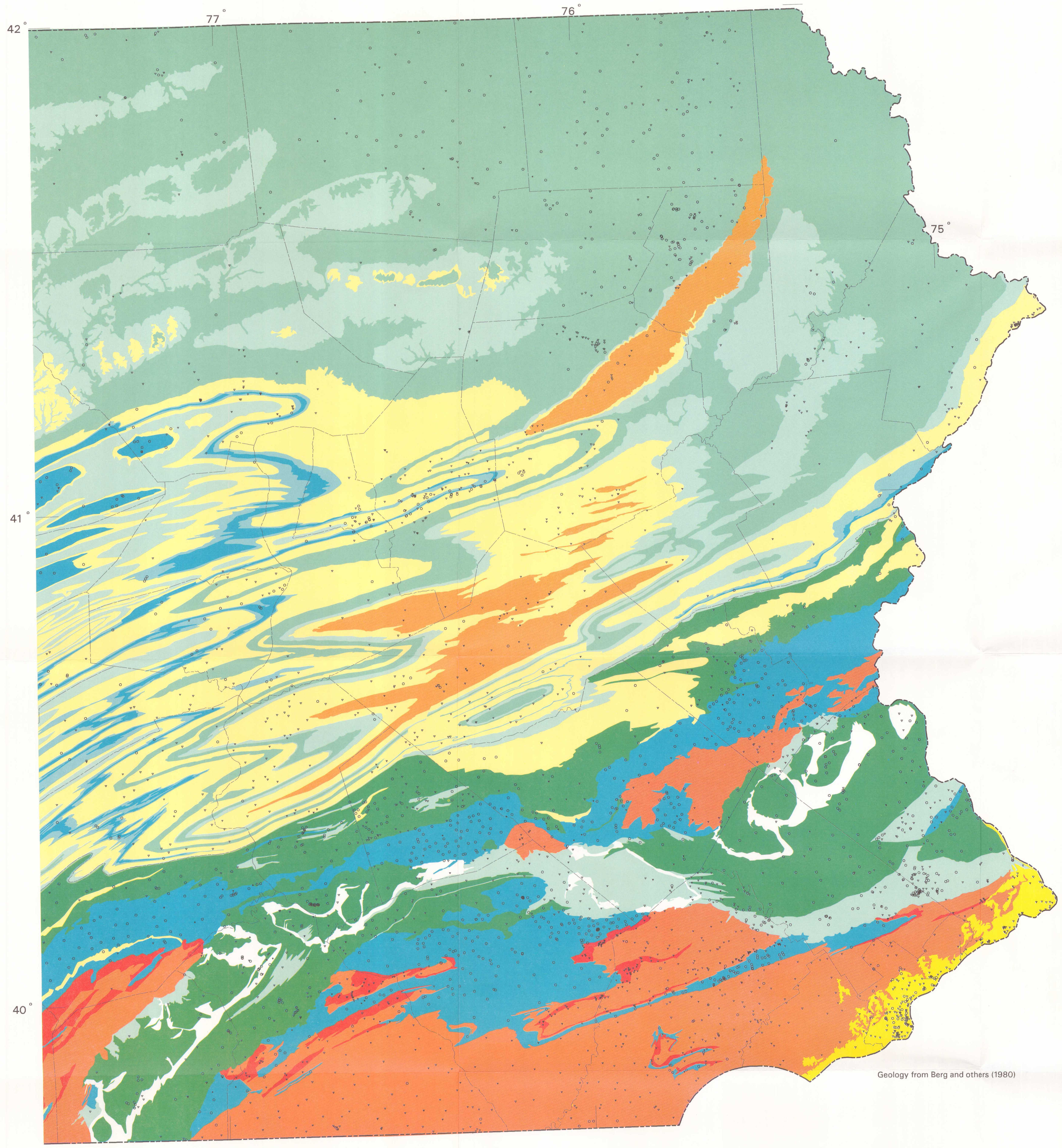
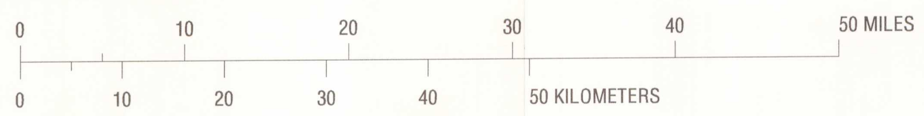
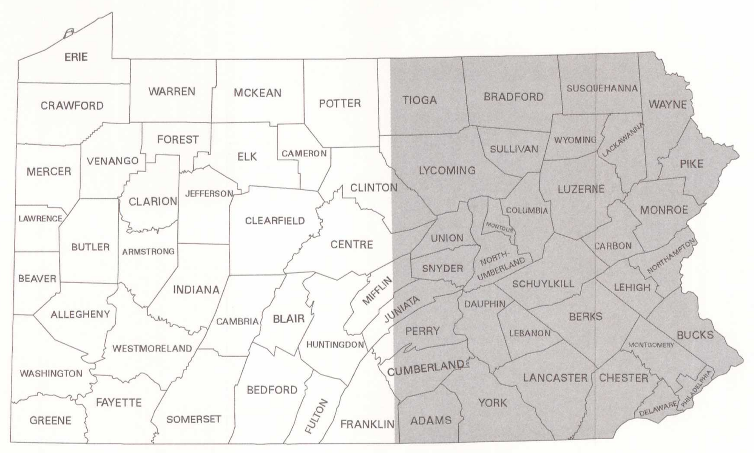
PREPARED IN COOPERATION WITH THE
PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER SUPPLY AND COMMUNITY HEALTH
DIVISION OF DRINKING WATER MANAGEMENT






Base from U. S. Geological Survey 1:100,000 Digital Line Graphs




# EXPLANATION

AREAS OF BEDROCK GEOLOGY

- QUARTZITE
- CRYSTALLINE ROCKS, EXCLUDING DIABASE AND QUARTZITE
- ANTHRACITE-BEARING SILICICLASTICS ROCKS
- UNCONSOLIDATED SEDIMENTS
- PREDOMINANTLY SHALE WITH OTHER SILICICLASTIC ROCKS
- PREDOMINANTLY SANDSTONE WITH OTHER SILICICLASTIC ROCKS
- DIABASE
- MIXED SILICICLASTIC ROCKS WITH BITUMINOUS COAL, INCLUDING MIXED SILICICLASTICS AND MIXED SILICICLASTIC ROCKS WITH LIMESTONE AND BITUMINOUS COAL
- SHALE
- LIMESTONE-BEARING SILICICLASTIC ROCKS
- CARBONATE ROCKS

WELL LOCATIONS AND MODIFIED LANGELIER INDEX VALUES

- ▼ LESS THAN -4.0 (EXTREMELY CORROSIVE)
- ▽ EQUAL TO OR GREATER THAN -4.0 AND LESS THAN -2.0 (HIGHLY CORROSIVE)
- ▽ EQUAL TO OR GREATER THAN -2.0 AND LESS THAN -0.5 (MODERATELY CORROSIVE)
- ○ EQUAL TO OR GREATER THAN -0.5 AND LESS THAN 0.5 (IDEAL RANGE)
- ◆ EQUAL TO OR GREATER THAN 0.5 ($CaCO_3$ PRECIPITATION)

The percentage of LSIsn values for the lithologic subgroups in the five Medlar corrosivity classifications are summarized in table 2. The carbonate subgroup has the least corrosive waters; approximately 85 percent of the LSIsn values are in the ideal range (table 2). The carbonate subgroup also has the highest median values for measured pH, alkalinity, and calcium. In contrast, approximately 98 percent of the LSIsn values from the quartzite subgroup have corrosive water; 62 percent are in the extremely corrosive range. Approximately 40 percent of the LSIsn values from the mixed siliciclastics with bituminous coal subgroup, which underlies approximately 54 percent of the state, are in the ideal (noncorrosive) range. The anthracite-bearing siliciclastic subgroup has the greatest variation in LSIsn values; at least 10 percent of the values are in each of four of the five corrosivity classifications.

Spatial distribution of the 11 lithologic subgroups and corrosivity values are shown on the statewide map of Pennsylvania. Median LSIsn values for each of the 11 lithologic subgroups were used to color code resultant polygon areas on the map from the most corrosive (red) to the least corrosive (blue). Locations of each of the 4,839 wells are represented on the map by one of five symbols used to classify the LSIsn values according to the Medlar corrosivity scale. By use of corrosivity ranges within the lithologic subgroups, potential areas of corrosive ground water are delineated and identified. Because of the variability existing between the corrosivity range and lithologic subgroup, use of the map to predict the corrosivity of a certain location is somewhat limited. However, some measure of reliability can be obtained by examination of the percentages of the LSIsn values classified within each lithologic subgroup. For example, the chances that water will have an ideal LSIsn value are greater if the well is completed in carbonate rock than if it were completed in quartzite rock because 85 percent of the carbonate LSIsn values are within the ideal range, whereas only 2.4 percent of the quartzite LSIsn values are within the ideal range. Thus, the statewide map broadly indicates areas of relatively more or less corrosive ground water on the basis of approximated LSIsn values and lithologic subgroups.

***Table 2.*** *Percentage of distribution of LSIsn values among 5 Medlar (1989) corrosivity classifications for each of 11 lithologic-subgroup units in Pennsylvania*

| Corrosivity classification | Carbonate | Crystalline, excluding diabase and quartzite | Diabase | Quartzite | Anthracite-bearing siliciclastic | Limestone-bearing siliciclastic | Mixed siliciclastic with bituminous coal, including mixed siliciclastics and mixed siliciclastic with limestone and bituminous coal | Shale | Predominantly shale siliciclastic | Predominantly sandstone siliciclastic | Unconsolidated |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of wells | 748 | 447 | 50 | 166 | 66 | 78 | 1,566 | 505 | 483 | 500 | 228 |
| Extremely corrosive | 1.0 | 16.5 | 0 | 62.1 | 28.9 | 0 | 4.7 | 1.2 | 3.9 | 4.4 | 2.6 |
| Highly corrosive | 1.6 | 50.8 | 12.0 | 30.1 | 34.8 | 6.4 | 15.4 | 7.3 | 26.1 | 17.4 | 23.3 |
| Moderately corrosive | 8.2 | 23.5 | 50.0 | 5.4 | 25.7 | 20.5 | 38.8 | 30.1 | 43.5 | 47.6 | 61.0 |
| Ideal range | 84.5 | 9.2 | 32.0 | 2.4 | 10.6 | 71.8 | 39.1 | 59.6 | 26.1 | 28.8 | 12.7 |
| $CaCO_3$ precipitation | 4.7 | 0 | 6.0 | 0 | 0 | 1.3 | 2.0 | 1.8 | .4 | 1.8 | .4 |

## SUMMARY

Water-quality data from 4,839 wells in Pennsylvania were used to calculate a corrosivity index and to build a point dataset in ARC/INFO. The index used is a modified version of the Langelier Saturation Index (LSIsn). A polygon dataset of geologic contacts in Pennsylvania including attributes for 4 rock types and 11 lithologic subgroups was created by use of a GIS. Statistical tests indicated significant differences in LSIsn values among the 4 rock types and 11 lithologic subgroups in Pennsylvania. Data for pH, alkalinity, and calcium also support the differences in lithologic subgroups. Approximately 58 percent of the LSIsn values were corrosive. The least corrosive waters were in the carbonate lithologic subgroup and the most corrosive waters were in the quartzite lithologic subgroup. A state-wide map was produced from the point (LSIsn) and polygon (geologic contacts) datasets by use of a GIS. The map shows spatial distribution of LSIsn values in relation to the lithologic subgroup color, which was coded from most to least corrosive. The map will be useful for identifying potential corrosive ground-water areas in Pennsylvania.

## REFERENCES

Barringer, J.L., Kish, G.R., and Velnich, A.J., 1990, Corrosiveness of ground water in the Kirkwood-Cohansey aquifer system of the New Jersey coastal plain: U.S. Geological Water-Resources Investigations Report 90-4180, folded map in pocket.

Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, 1980, Geologic map of Pennsylvania (2nd ed.): Pennsylvania Topographic and Geologic Survey, map 1, scale 1:250,000.

Berg, T.M., Barnes, J.H., Sevon, W.D., and others, 1989, Physiographic provinces of Pennsylvania (2nd ed.): Pennsylvania Topographic and Geologic Survey, map 13, scale 1:2,000,000.

Harrision, R.M., and Laxen, D.P.H., 1980, Physiochemical speciation of lead in drinking water: Nature, v. 286, p. 791-793.

Hem, J.D., and Duram, W.H., 1973, Solubility and occurrence of lead in surface water: Journal of the American Water Works Association, v. 65, no. 8, p. 562-568.

Kish, G.R., Barringer, J.L., and Ulrey, R.L., 1989, Corrosive ground water in the Kirkwood-Cohansey aquifer system in the vicinity of Ocean County, East-Central New Jersey: U.S. Geological Water-Resources Investigations Report 87-4181, folded map in pocket.

Langelier, W.F., 1936, The analytical control of anticorrosion water treatment: Journal of the American Water Works Association, v. 28, no. 10, p. 1,500-1,521.

Medlar, S., 1989, Corrosion control in drinking water systems reference manual: Camp, Dresser, and McKee, Inc., for the Pennsylvania Department of Environmental Resources, Bureau of Community Health, Division of Water Supplies.

Millette, J.R., Hammonds, A.F., Pansing, M.F., Hansen, E.C., and Clar, P.J., 1980, Aggressive water— Assessing the extent of the problem: Journal of the American Water Works Association, May, p. 262-266.

Rossum, J.R., and Merrill, D.T., 1983, An evaluation of the calcium carbonate saturation indices: Journal of the American Water Works Association, v. 75, no. 2, p. 95-100.

SAS Institute, Inc., 1990a, SAS procedures guide (3rd ed.): Cary, North Carolina, SAS Institute, Inc., version 6, 705 p.

_____1990b, SAS/STAT users guide (4th ed.): Cary, North Carolina, SAS Institute, Inc., version 6, 846 p.

Schock, M.R., 1980, Response of lead solubility to dissolved carbonate in drinking water: Journal of the American Water Works Association, v. 72, no. 12, p. 695-704.

Schock, M.R., 1990, Internal corrosion and deposition control, *in* Pontius, F.W., ed., Water quality and treatment: New York, American Water Works Association, p. 997-1,111.

U.S. Environmental Protection Agency, 1991, Maximum contaminant level goals and primary drinking water regulations for lead and copper, Final Rule: U.S. Code of Federal Regulations, Title 40.

U.S. Geological Survey, 1984, National Water Summary 1984—Hydrologic events and selected water-quality trends and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

_____1986, National Water Summary 1986—Hydrologic events and ground-water quality: U.S. Geological Survey Water-Supply Paper 2325, 560 p.

Viessman, W., Jr., and Hammer, M.J., 1985, Water supply and pollution control (4th ed.): New York, Harper and Row, 797 p.

# ASSESSMENT OF SEVERITY AND DISTRIBUTION OF CORROSIVE GROUND WATER IN PENNSYLVANIA

by Michael J. Langland and Diana L. Dugas
1996