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Use of Historical Water-Quality Data in the Contiguous United States to Guide the Development and Testing of Sensors for Streams and Aquifers Used for Military and Civilian Water Supplies

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USE OF HISTORICAL WATER-QUALITY DATA IN THE CONTIGUOUS UNITED STATES TO GUIDE THE DEVELOPMENT AND TESTING OF SENSORS FOR STREAMS AND AQUIFERS USED FOR MILITARY AND CIVILIAN WATER SUPPLIES

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Concern about the security of civilian and military water supplies has accelerated the development of new sensors for monitoring contaminants in water. The U.S. Geological Survey (USGS), in cooperation with the Department of Defense Joint Agency Water Monitoring Program, is currently working to enhance sensor development through an analysis of the chemical and physical characteristics of source waters (untreated water from streams and aquifers) used for civilian and military supplies. Knowledge of source-water characteristics can (a) aid in the development of appropriate testing designs and criteria, (b) ensure that sensors will function in accordance with performance criteria, (c) illuminate sensor capabilities or limitations, including the potential for false positives or negatives, and (d) increase operator confidence in sensor technologies designed to protect human life or otherwise monitor source-water quality.

The USGS National Water-Quality Assessment (NAWQA) Program was first implemented in 1992. A major objective of this program is to collect water-quality data from selected streams and aquifers in representative areas (Study-Unit basins) throughout the Nation (fig. 1). These data are used to address regional and national water-resources issues and concerns. A large National NAWQA database that contains ground- and surface-water data collected with consistent methods during a 10-year (1992-2001) period is available (U.S. Geological Survey, 2003a). Available source-water data include (a) bulk property measurements (such as pH, specific conductance, temperature, and dissolved oxygen), (b) inorganic constituents (major ions, nutrients, and trace elements), and (c) synthetic organic compounds (chiefly volatile organic compounds, and organophosphate or organochlorine pesticides, and selected metabolites).

Single- and multi-variate population statistics and graphical analyses of NAWQA data are being used to characterize general chemical and physical characteristics of source-water aquifers and streams in the contiguous United States. For example, the frequency of detection can indicate highly probable (or improbable) source-water characteristics and constituents (Table 1). Percentiles reveal the variability and range in measured values for a given property or constituent among ground-water sources (Table 1). Trilinear or Piper diagrams help identify general types of ground water that currently are used for water supplies (Figure 2).

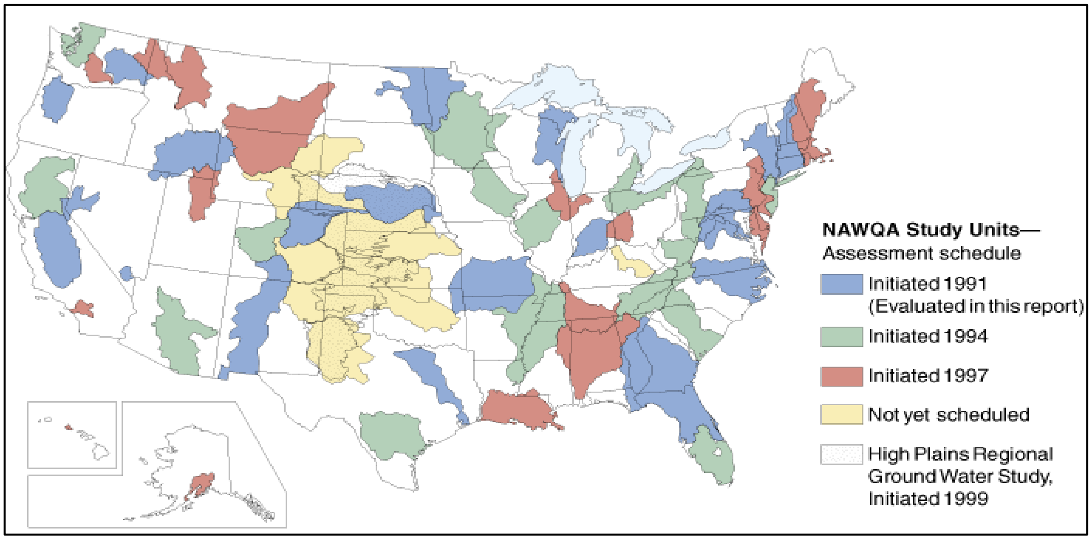

Figure 1. Study Units (basins) of the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program (U.S. Geological Survey, 2003b).

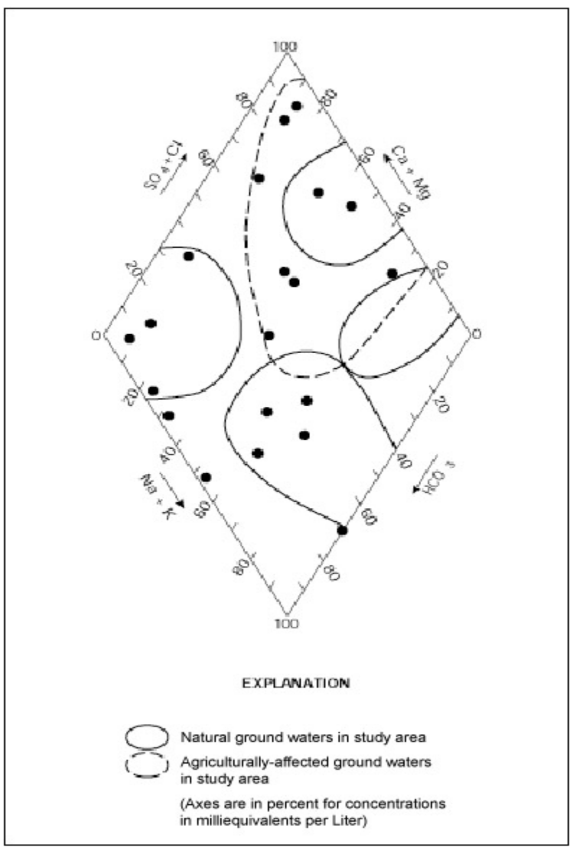

Figure 2. Use of a partial trilinear diagram to help identify different types of ground water (sample matrices) on the basis of the relative proportions of major ions. [From Koterba and others, 1995.]

Table 1. Partial listing of frequency of detection and percentiles for bulk properties, major ions, trace elements, pesticides, and volatile organic compounds (VOCs) for ground-water samples obtained by the U.S. Geological Survey National Water-Quality Assessment Program from 1992-99 at approximately 1, 500 private and public supply wells.

Water Property or Constituent	Detection frequency[1] (%)	Percentiles[2] 5th	25th	50th	75th	95th
Bulk Properties						
Temperature, ºC	100	10.0	12.0	15	20	25
Turbidity, NTU	96	0.1	0.3	1.1	3.2	16
Conductivity, µS/cm	100	64.7	244	469	663	1,302
Dissolved oxygen, mg/L	89	----	0.2	2.8	6.0	8.8
pH, standard units	100	5.09	6.83	7.2	7.60	8.1
Major Ions						
Calcium, mg/L	100	1.7	20	46	74	120
Magnesium, mg/L	100	0.7	4.5	12	25	47
Sulfate, mg/L	97	0.2	5.2	17	41	190
Nitrate+Nitrite-N, mg/L	71	----	----	0.6	3.4	14
Trace Elements						
Barium, µg/L	97	2.0	20	45	113	369
Chromium, µg/L	75	----	----	2.0	4.0	7.8
Iron, µg/L	70	----	----	11	200	2,400
		Min	**25th**	**50th**	**75th**	**Max**
Pesticides						
Desethylatrazine, µg/L	24	0.001	0.004	0.011	0.067	2.0
Atrazine, µg/L	23	0.001	0.005	0.017	0.081	2.8
Diazinon, µg/L	8	0.001	0.003	0.007	0.021	4.99
VOCs						
Chloroform, µg/L	20	e 0.003	0.02	0.08	0.31	74.0
Tetrachloroethene, µg/L	10	e 0.003	e 0.010	e 0.060	0.2	29.0
1,2,4-Trimethylbenzene, µg/L	9	e 0.004	0.01	0.02	0.05	12.0

[%, percent; ºC, degrees Celsius; NTU, Nephelometric turbidity unit; µS/cm, microsiemens per centi-meter at 25 ºC; mg/L, milligrams per liter; µg/L, micrograms per liter; ----, cannot be determined; Min, minimum; Max, maximum; e, estimated]

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[1] Detection frequency is the ratio of the number of samples with values at or above the analytical method reporting level divided by the total number of samples for that constituent, to nearest whole percent. Values for pesticides and VOCs are from Squillace and others (2002).

[2] Percentiles for bulk properties, major ions, and trace elements are calculated from all samples with a determined value "less than"(treated as tied values), at, or above, the method reporting level. Percentiles for pesticides and VOCs were determined by Squillace and others (2002), and only included samples with values at or above the method reporting level or estimated (e) values, with low precision, between the method detection and reporting levels. Extreme percentile data for pesticides and VOCs also only were available for the 1st (Minimum) and 100th (Maximum) percentiles.

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