

Title: Hydrochemical Regions of the Glacial Aquifer System, northern United States, and Implications for Selected Constituents

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I. Abstract

II. Introduction

(Text describing problem statement, background info)

A. Purpose and Scope

Purpose: To identify different types of ground water across the glacial aquifer system based on statistical and spatial analysis techniques and to quantify the characteristics of the different identified ground-water types based on sample chemistry and related environmental characteristics. If a relation can be identified between different types of ground water and the environmental or geologic characteristics of the sample location then these relations can be used to extrapolate estimates of water-quality to unsampled areas.

Scope: The analysis described in this paper includes data from LUS and SUS wells sampled by NAWQA during Cycle 1 and the beginning of Cycle 2. Data is from across the glaciated area of the United States.

B. Description of Study Area (Steve will write)

The study area includes the Northern parts of the United States that were at one time covered with continental or alpine glaciers. The study area includes parts of 26 states including: Alaska, Connecticut, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nebraska, New Hampshire, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Tennessee, Vermont, Washington, Wisconsin. The Glacial aquifer system is one of the principal aquifers in the United States.

Potential Figures:

1. Location of glacial aquifer system in the Northern United States.

1. General glacial history

- a. Glacial Lobes (Cordilleran and Laurentide)
- b. Soils
- c. Surficial Geology
- d. Bedrock Geology

Potential Figures:

2. Map showing the location of Cordilleran and Laurentide ice sheets forming the glacial aquifer system, northern United States.

3. Map showing soil permeability and/or soil type of the glacial aquifer system, northern United States.

4. Map showing surficial geology of the glacial aquifer system, northern United States.

5. Map showing bedrock geology (type of rocks) of the glacial aquifer system, northern United States.

2. Glacial aquifer system framework

The glacial aquifer system framework takes into account the natural characteristics of the glacial aquifer system that are most likely to affect water-quality in the aquifer

Potential Figures:

6. Diagram showing the framework for studying the glacial aquifer system in the northern United States.

a. Natural Vulnerability

This section will discuss the division of glacial aquifer system into regions based on physiography and glacial lobes. Where the glacial material comes from affects its chemical properties. Natural contaminants such as radon, uranium, and arsenic are present in the aquifer material because of glacial source material.

- i. Glacial lobes
- ii. Regions based on physiography

Potential Figures:

7. Map showing the glacial lobes and physiography of the glacial aquifer system, northern United States.

b. Intrinsic Susceptibility

This section will discuss the texture of aquifer material – Water moves faster in coarse-grained material than it does in fine-grained material. Where the water moves the fastest, it is more likely to carry contaminants to the aquifer.

Potential Figures:

8. Map showing the texture of surficial deposits of the glacial aquifer system, northern United States.

c. Physical setting

This section will discuss the aquifer geometry/depositional setting and describe what the boundary constraints are within the aquifer system (Deposits in valley fill or as layer/lens).

Potential Figures:

9. Diagram showing cross-section examples of valley fill and layer/lens deposits.

C. Previous studies (George will write)

There have been several efforts to group the US into regions defining similar characteristics; most are based on physical characteristics of the area only. We will divide area based on physical as well as chemical characteristics.

-- Shacklette (1984) found that there were both large and small regional differences in soil chemistry across the country.

-- Heath (1984) proposed dividing the country into Ground-Water Regions based on geology where composition, arrangement and structure of rock units are similar.

Some References to consider for this section include:

Fenneman, N.M. and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey Special USGS map, scale 1:7,000,000, <http://aa179.cr.usgs.gov/metadata/wrdmeta/physio.htm>

Heath, R.C., 1984, *Ground-water regions of the United States: U.S. Geological Survey Water-Supply Paper 2242*, 78 p. (<http://onlinepubs.er.usgs.gov/djvu/WSP/wsp2242.djvu>)

Heath, R.C., 1988a, *Hydrogeologic map of North American showing the major rock units that underlie the surficial layer*, in Back, W., Rosenshein, J.S., and Seaber, P.R., eds., *Hydrogeology: Boulder, Colorado*, Geological Society of America, *The Geology of North America*, v. O-2, plate 1.

Omerik, J. M., 1987. *Aquatic ecoregions of the conterminous United States. Annals of the Association of American Geographers*, 77:118-125 (map scale 1:7,500,000).

Shacklette, H.T., and Boerngen, J.G., 1984, *Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270*, 105 p. (http://onlinepubs.er.usgs.gov/djvu/PP/pp_1270.djvu)

Wolock, D.M., 2003, *Hydrologic landscape regions of the United States: U.S. Geological Survey Open-File Report 2003-145*, Digital Data (<http://water.usgs.gov/GIS/metadata/usgswrd/XML/hlrus.xml>)

D. Methods and approach (Terri will write)

- Cite references about how NAWQA data is collected
- Describe how data was retrieved from NAWQA data warehouse, what the data consists of, retrieval criteria, etc
- Describe how data was combined to get 1 record per site and how censored data was treated
- Describe briefly the process for making hydrochemical regions: selection of focus constituents, cluster analysis, anova, kriging, principal components, regression/correlation analysis, factor analysis.

III. Hydrochemical Regions (Terri will write)

This section will contain the results

A. Definition of Regions

Discuss the importance of the regions

1. Individual Constituents

Discuss which constituents were selected and why they are important.

Potential Table:

1. Table of focus constituents that were used to form the hydrochemical regions of the glacial aquifer system, northern United States. (Show descriptive statistics of entire data set)

2. Grouping data of similar constituent concentrations

Discuss results of the cluster analysis -- how many groupings of similar concentrations were found, how distinct they were, how many samples per cluster (the statistical distribution of samples).

Potential Tables:

2. Table of principal components that were important for the formation of groupings of similar water-quality data.
3. Table showing the euclidean distances between samples and average shape and distance of groupings.

Potential Figures:

10. Graph showing the groupings of similar water-quality data for the glacial aquifer system, northern United States.

3. Statistical significance among groups of data

Discuss the results of the ANOVA – are the groups identified in #2 above significantly different from each other? What does this imply about the cluster analysis? Are there variations in type of water-quality in the glacial aquifer system?

Potential Table:

4. Table of ANOVA results showing statistical significance of the groupings of similar water-quality data.

4. Spatial aggregation of groups into hydrochemical regions

Discuss the results of the spatial analysis and kriging. What is the spatial distribution of the regions across the glacial aquifer system? Are there spatial variations in type of water-quality across the glacial aquifer system?

Potential Figures:

11. Map showing the hydrochemical regions of the glacial aquifer system, northern United States.

F. Comparison among hydrochemical regions

Discuss how the hydrochemical regions differ from each other. What are the typical ranges of focus constituent concentrations?

Potential Tables:

5. Table of water-quality characteristics for each hydrochemical region of the glacial aquifer system, northern United States. (This will show descriptive statistics for each focus constituent – mean, median, min, max, range, STD).

6. Table of principal components that form each region. (What are the major factors that influenced the formation of each region?)

Potential Figures:

12. Piper diagrams showing water chemistry for each hydrochemical region of the glacial aquifer system, northern United States.

G. Relation between hydrochemical regions and environmental characteristics

Discuss how the hydrochemical regions relate to the glacial framework and other geologic/environmental information – physiography, surficial geology, bedrock geology, soils, glacial lobes, climate, etc. How do the hydrochemical regions relate to the soil chemistry data (RASS, PLUTO, Shacklette?)

Potential Tables:

7. Table of Spearman Rank Correlation Results.

Potential Figures:

13. Map showing the climate of the glacial aquifer system, northern United States. (If climate is highly correlated to the regions)

F. Validation of regions using independent data

Discuss how data that was not used to make the regions was used to see if the regions would correctly classify the water-quality type.

Potential Tables:

8. Table of correlations of the new data and the groups they were assigned to.

Potential Figures:

14. Map showing the distribution of data points used to check the hydrochemical regions of the glacial aquifer system, northern United States.

V. Implications for selected regulated constituents (George and Steve will write; Terri may contribute)

Discuss how hydrochemical regions might imply information about the mobility of regulated/selected compounds?

Potential Figures:

15. Diagram of different constituents and the principal components of the regions and mark which constituents are likely to be affected by the principal components of that region.

VII. Summary and Conclusions

VIII. References

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