Hydrogeologic Sensitivity in Ohio – Identifying Criteria for Pathogen Barriers

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Outline of Talk

- Describe Ohio sensitive aquifers based on nitrate concentration in public water systems;
- Summarize role of hydrogeologic barriers in proposed GW rule;
- Share initial results of approaches to identify/define hydrogeologic barriers in Ohio:
  - Summarize microbiological sampling results in non-vulnerable wells with pathogen sources – documents existence of barriers;
  - Present analysis of existing PWS bacteria monitoring data to determine if data identifies the presence of hydrogeologic barriers.
Sensitive Aquifers in Ohio

- Thin drift over bedrock aquifers
  Nitrate impacted bedrock wells are more common in areas of thin glacial cover. Karst and Fractured Bedrock are sensitive hydrogeologic settings in the GW Rule.

- Buried Valleys
  Distribution of nitrate impacted PWS confirms sensitivity of the sand and gravel aquifers, but sensitivity to nitrate may not mean sensitivity to pathogens; Considered sensitive hydrogeologic setting for GW Rule?????
SW Ohio - PWS Nitrate Concentration
Associated with Sensitive Glacial Settings

PWS Nitrate (mg/L)
- 0.01 - 2.0
- 2.01 - 5
- 5.01 - 10
- > 10.01

Geologic Setting
- Sand and Gravel Aquifers
- Thin Upland and Lacustrine Deposits

Legend:
- Purple: Sand and Gravel Aquifers
- Light Yellow: Thin Upland and Lacustrine Deposits

Compass Scale:
- 0 to 10 Miles
U.S. EPA identifies wells obtaining water from **karst, fractured bedrock,** or **gravel** aquifers as sensitive to fecal contamination unless a hydrogeologic barrier is present;

Hydrogeologic Assessments will identify PWSs sensitive to pathogens.
Hydrogeologic Barrier

- Sensitivity of PWS hinges on presence or absence of a Hydrogeologic Barrier.
- Analysis of nitrate impact suggests:
  - More than 25 feet of till limits rapid infiltration and constitutes a hydrogeologic barrier.
  - Nitrate is frequently present to depths of 75 – 100 feet in S&G aquifers, however the natural filtration in sand and gravel can remove pathogens.
    - Is 25 feet of sand and gravel sufficient to protect production well from pathogen impact?
Design: To confirm the efficiency of hydrogeologic barriers in areas of sensitive aquifers;

Philosophy: To demonstrate that we can identify non-vulnerable wells, i.e. wells in which hydrogeologic barriers are present in areas of sensitive aquifers;

Goal: To support states argument that GW Rule focus should be vulnerable PWSs.

Experiment designed to produce null set results.
Selected Wells - Barriers

- Sand and Gravel Hydrogeologic Barrier
  - 18 wells, 1 confined, 1 Ranney well;
  - Casing length: 27 - 182 feet;

- Glacial Drift Hydrogeologic Barrier
  - 7 wells, 2 tritium non-detect;
  - Casing length: 39 - 100 feet;
GW Rule Samples and Sensitive Hydrogeologic Settings

- GW Rule Samples
- Sand and Gravel
- Thin Glacial Drift
- Counties

Ohio EPA
Division of Drinking and Ground Water Geographic Information Systems
Microbiological Sampling

- Six quarters of sampling completed for 25 wells, 149 samples collected, results for 148 samples;
- Only six samples with detections:
  - One total coliform positive with fecal contamination (Enterococci);
  - Five total coliform positive with no positive fecal indicators; (2 of the 5 attributed to sample contamination).
Microbiological Sampling

Results emphasize the importance of the local setting in S&G aquifers.

- **Adams County Water Co.**
  - Well is 70 feet from Ohio River floodplain on 20-25 foot terrace with 39 feet of casing in 66 foot well. Sample collected at flood stage with water up to base of terrace.

- **Columbus South Wellfield**
  - Well is a ranney well with 5 laterals at depth of 74 feet. Sample was collected when surrounding field was flooded and frozen.

- **Highland County Water Co.**
  - Well is 63 feet deep with 40 feet of casing and is 125 feet from stream. Bedrock is exposed in stream bank. Sample collected during high flow.

- **Millersburg Wellfield**
  - Well 93 feet deep with 73 feet of casing and is located on mound in flood plain behind dike. Sample collected when field was flooded.
Bacteria Compliance Data

- Demonstrate association between sensitive aquifers and detections of bacteria?
- Document associations between well depth/casing length and Total Coliform detections?
Compliance Data Limitations

- Sampling protocol requires repeat sample if detections occur – results in lots of samples from PWS with TC detections;
- Compliance bacteria data are from distribution samples - not raw water data;
- Poor well construction and /or slimes in well/ pipes may contribute to detections.
Analysis – Sensitive Aquifers

- Bacteria data from TNC PWSs with no treatment used as data most representative of raw water samples;
- Associated PWS bacteria data from PWSs with no treatment with location and geology;
- Plotted bacteria ratio of detections over sensitive aquifer distribution;
Total Coliform Positive Ratios Associated With Sensitive Aquifers

Legend

TC+/#BacT

- ▲: 0.00 - 0.05
- ▲: 0.05 - 0.15
- ▲: 0.15 - 0.25
- ▲: 0.25 - 0.40
- ▲: 0.40 - 1.00

- ◇: Sand and Gravel Aquifers
- ◇: Thin Glacial Drift

Miles

0 5 10 20 30 40
Fecal Coliform Positive Ratios Associated With Sensitive Aquifers
Nitrate – Bacteria Correlation

- Poor visual correlation between TC+ ratio and nitrate sensitive aquifers;
- Poor visual correlation between FC+ ratio and sensitive aquifers?
- Statistics (bacteria detections in % of PWSs in glacial lithology categories) confirms lack of correlation of TC+ & FC+ with glacial geology.
- Poor correlation between nitrate concentration and bacteria detections.
NO$_3$ vs Ratio of TC+ to TC Samples

![Graph showing the relationship between NO$_3$ concentration (mg/L) and the ratio of TC+ to TC samples.](image-url)
Analysis - Depth Relationships

- Data associated with average well/casing depth for PWS
- Total coliform detections associated with well depth/casing length;
- Fecal coliform detections associated with well depth/casing length (small PWS set – 158 PWS).
Ratio of TC+ to TC Samples vs Casing Length

The graph shows the ratio of TC+ samples to TC samples plotted against the casing length in feet. The x-axis represents the casing length ranging from 0 to 600 feet, and the y-axis represents the ratio of TC+ to TC samples ranging from 0 to 0.8. The data points are scattered across the graph, indicating the variation in the ratio for different casing lengths.
Analysis - Depth Relationships

- Total coliform detections less frequent at depth;
  - but occur at significant depths.
- No fecal coliform detection below 150 feet;
  - Significant? (small PWS set – 158 PWS);
Conclusions

- Selected GW Rule sampling identifies flooding/saturated settings as likely to increase TC+ detections;
- Poor correlations exist between sensitive aquifers (nitrate) and TC+ compliance results;
- TC+ and FC+ results decrease with depth, but detection depths are much greater than proposed 25 foot thickness as GW Rule barriers;
**Implications/Inferences**

- The lack of lithologic/geologic control suggests that the location (distance to well) of the pathogen sources may be the critical parameter;
- If pathogen source promotes saturation of vadose zone, like septic system or flooding – this increases likelihood of rapid transport of pathogens to the water table;
  - Significant distinction between point and non-point source.
- Emphasizes the site specific nature of determining the presence of barriers for GW Rule.
Unsafe and Safe (count \{ec+fc+tc\} by yearday)

U/Tot (count \{ec+fc+tc/total sample counts\} by yearday)

U/Tot is ratio of unsafe to total sample counts, plotted by day of year sample was taken.

Unsafe sample counts/yearday
Safe sample counts/yearday
total sample counts/yearday
Unsafe count (positive EC+FC+TC) by yearday.

GW temp is mean monthly AGWMP gw temp, plotted mid month.

July 4th holidays

unsafe is FC+EC+TC positives, plotted by day of year sample was taken.