Identification of Hydrogeologic Barriers to Pathogen Movement into Sensitive Aquifers

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Division of Drinking
and Ground Waters

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Outline

- Purpose of Hydrogeologic Barrier Study;
- Describe Ohio sensitive aquifers;
- Results of Hydrogeologic Barrier Study;
- Implications for implementation of Ground Water Rule.

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Hydrogeologic Barrier Study

Study Purpose -

Determine whether hydrogeologic barriers to pathogen movement exist for sensitive aquifers, as defined in the proposed, Federal GW Rule.

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Hydrogeologic Barrier

Hydrogeologic barrier definition:

Physical, biological, and chemical factors, singularly or in combination, that prevent the movement of viable pathogens from a contaminant source to a public supply well.

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Sensitive Aquifers

- Proposed GW Rule:
  - Karst (solution enhanced fractures)
  - Fractured rock
  - Gravel

  considered sensitive aquifers, unless a hydrogeologic barrier is present.

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Sensitive Aquifers in Ohio

Two Main settings – based on water quality:

- Thin drift over bedrock aquifers;
- Buried valley sand and gravel aquifers.

Water quality impacts may not indicate pathogen sensitivity?

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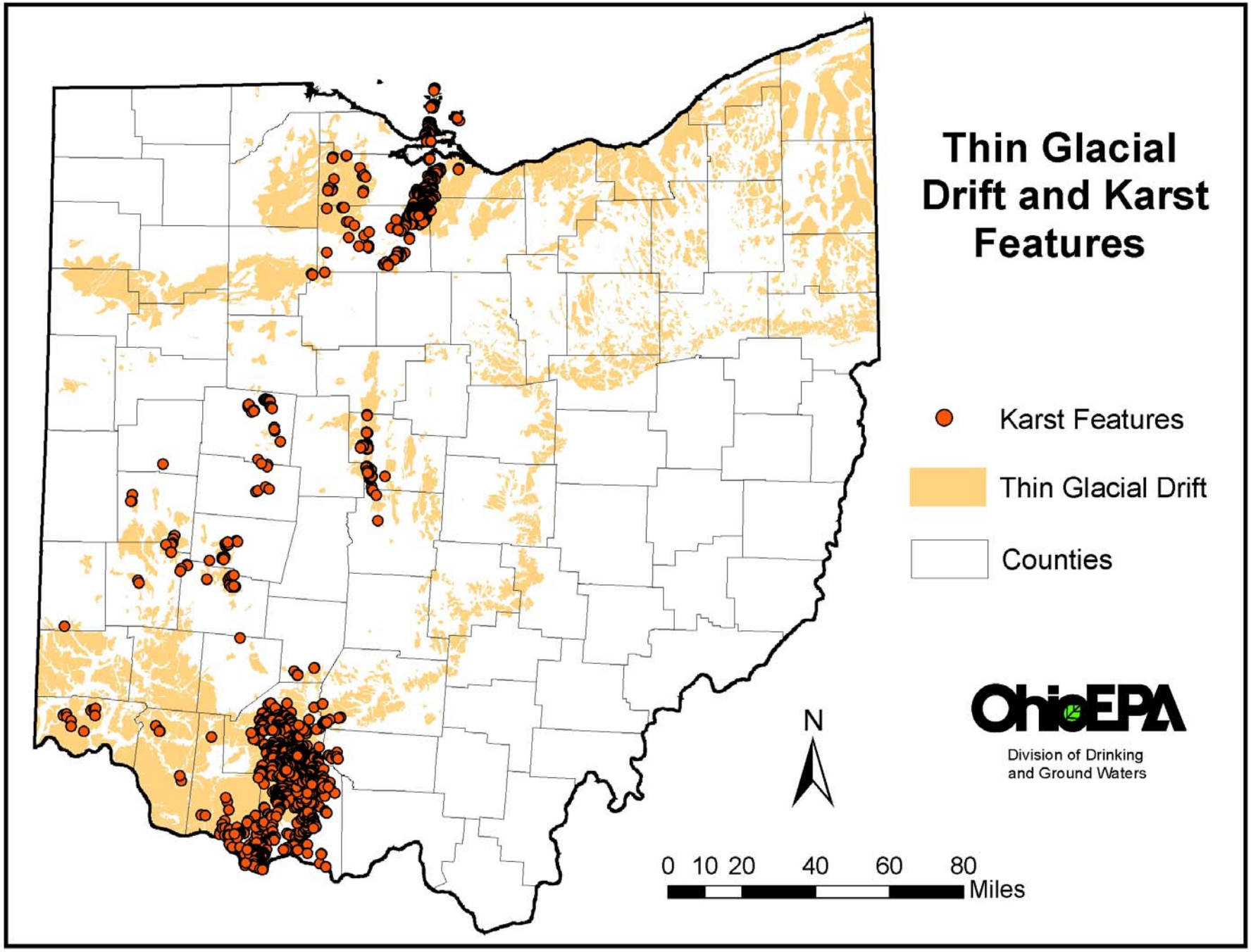
Thin Glacial Drift and Karst Features
Karst Features
Thin Glacial Drift
Counties
N
0 10 20 40 60 80
Miles
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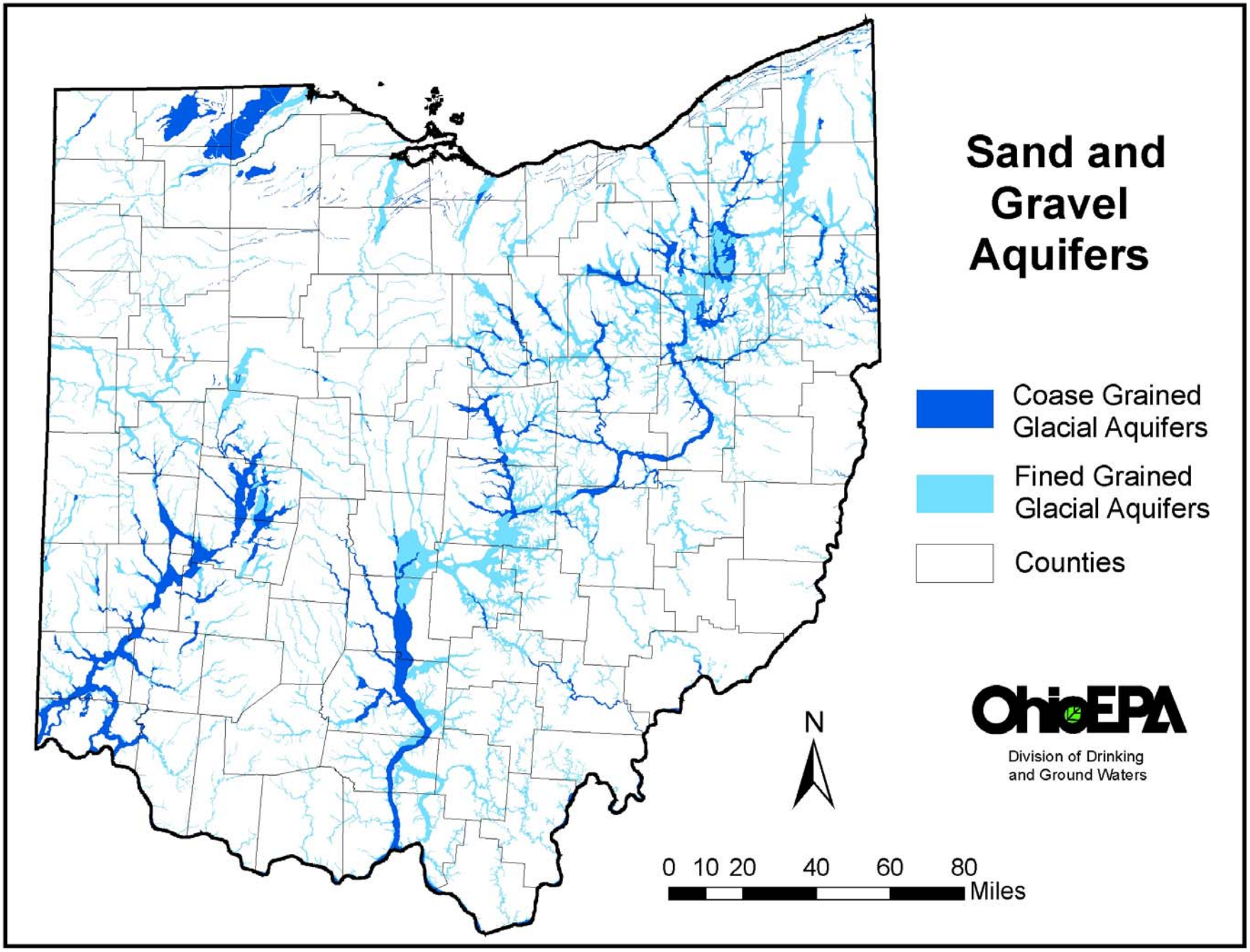
Sand and Gravel Aquifers
Coase Grained Glacial Aquifers
Fined Grained Glacial Aquifers
Counties
N
0 10 20 40 60 80
Miles
OhioEPA
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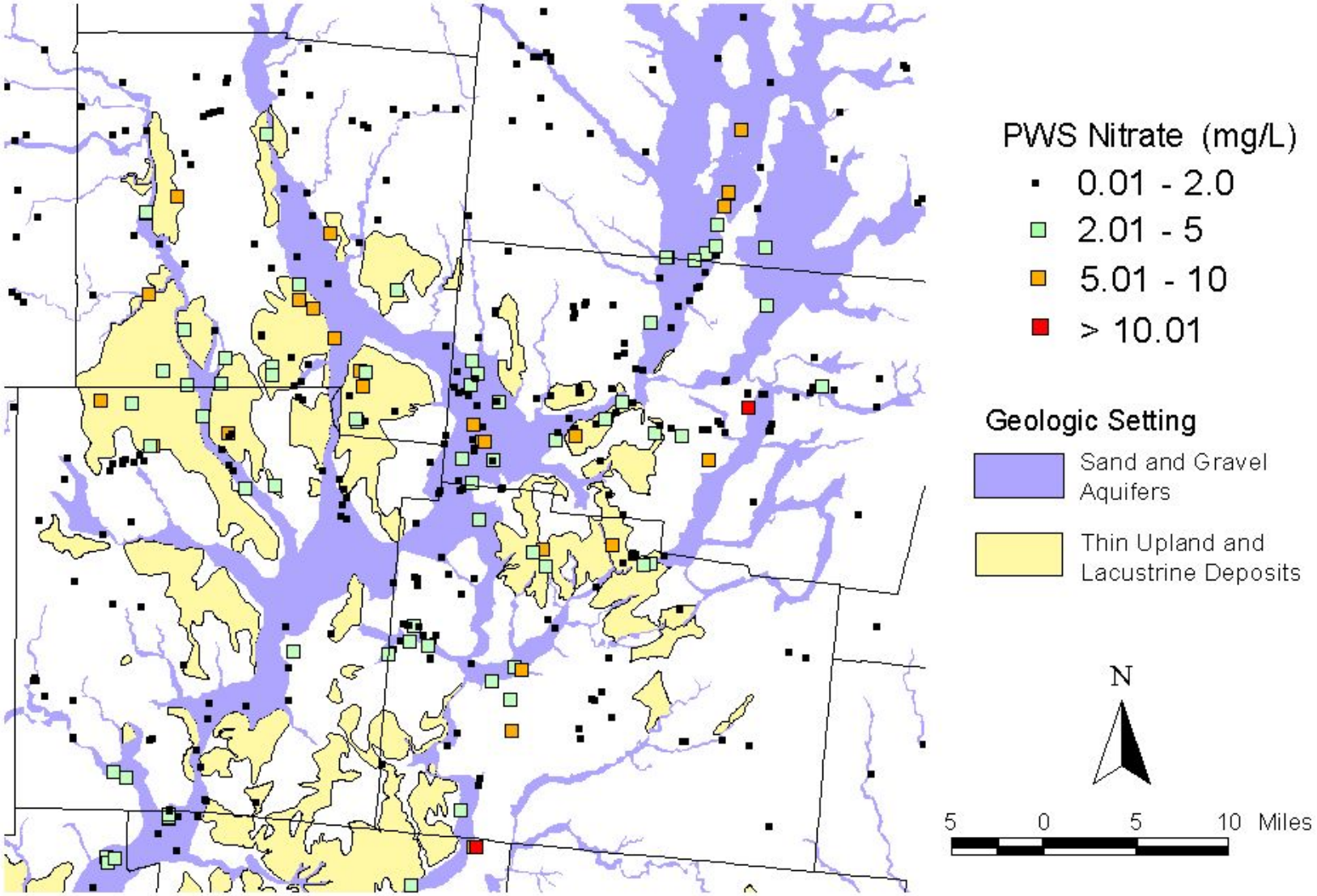
SW Ohio - PWS Nitrate Concentration Associated with Sensitive Glacial Settings



Hydrogeologic Barrier Study

- MDH, Ohio EPA, U.S. EPA;
- Select non-vulnerable wells in sensitive settings;
- Analyze for pathogen indicators;
- To demonstrate presence of hydro-geologic barriers

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Pathogen Indicators

- Coliform Bacteria
- *E. Coli* Bacteria
- *Enterococci* Bacteria
- Coliphage

Aquifer Selection Criterion

- Well Pumps from a Karst, Fractured Rock, or Gravel Aquifer
- Protective Geologic Cover Present
- Potential Pathogen Source Nearby
- Lateral Pathway Not Likely Present

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Well Selection Criteria

- Well Construction Record Available
- Well Met Construction Standards
- No Recent History of Bacterial Contamination
- Owner Consent to Participate

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Ohio's Selected Wells

- Sand and Gravel Hydrogeologic Barrier
  - 23 wells, 3 confined, 1 Ranney well;
  - Casing length: 27 - 182 feet;
- Glacial Drift Hydrogeologic Barrier
  - 9 wells, 2 tritium non-detect;
  - Casing length: 39 - 100 feet;

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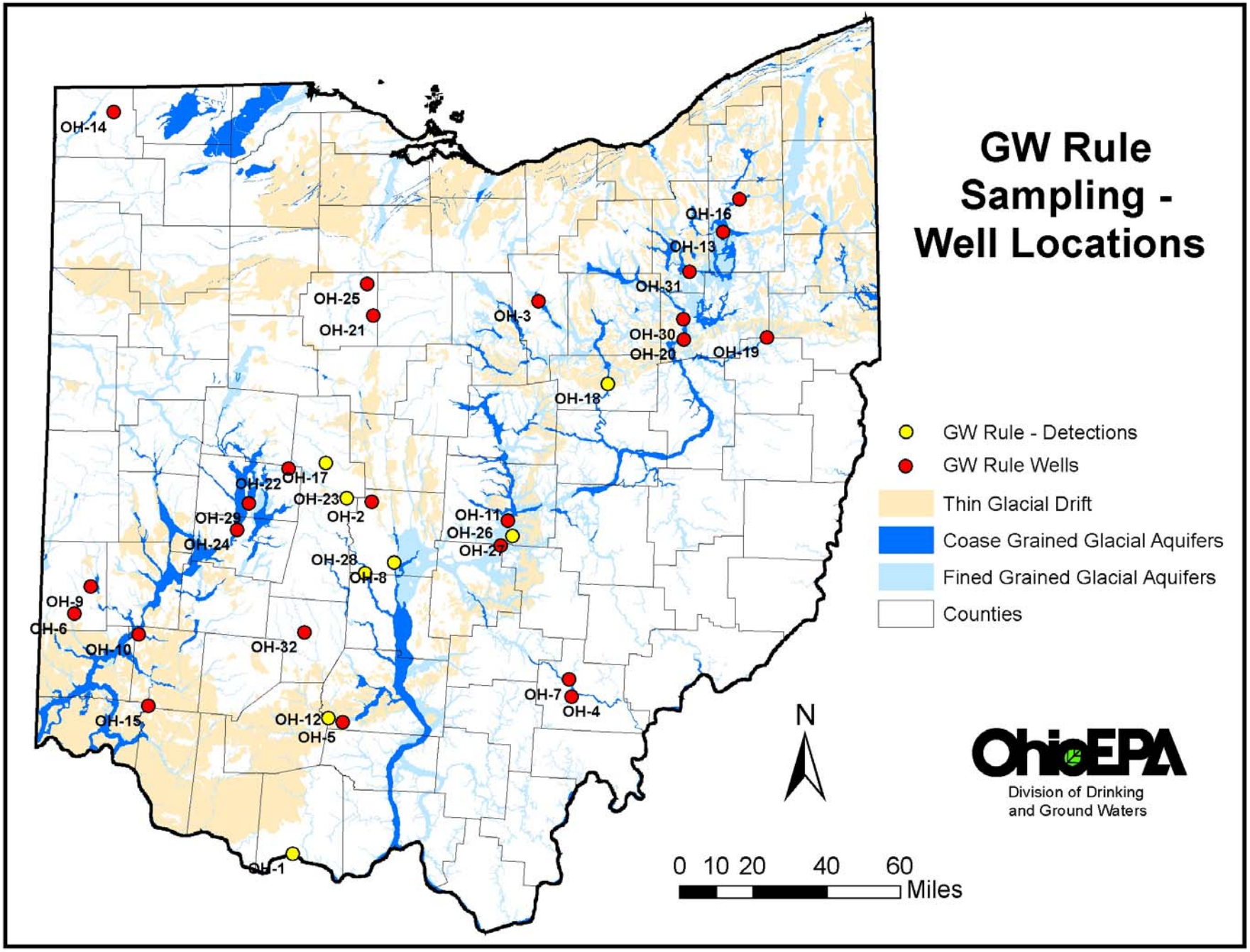
GW Rule Sampling - Well Locations
OH-14
OH-16
OH-13
OH-31
OH-25
OH-21
OH-3
OH-30
OH-20
OH-19
OH-18
OH-17
OH-22
OH-23
OH-2
OH-29
OH-24
OH-11
OH-26
OH-27
OH-28
OH-8
OH-9
OH-6
OH-10
OH-32
OH-7
OH-4
OH-15
OH-12
OH-5
OH-1
GW Rule - Detections
GW Rule Wells
Thin Glacial Drift
Coase Grained Glacial Aquifers
Fined Grained Glacial Aquifers
Counties
N
0 10 20 40 60
Miles
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Microbiological Sampling Results

- 5-9 quarters of sampling completed for 32 wells, 244 samples collected;
- 10 samples with detections from 8 sites:
  - Two total coliform positive sites with fecal contamination (Enterococci, 1 false positive);
  - Two sites with two TC+ results;
  - Six sites with 1 TC + with no positive fecal indicators; (3 of the 6 attributed to sample contamination or distribution issues).

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Microbiological Sampling Results

- Generally sand and gravel aquifers did not exhibit pathogen sensitivity.
  - Except for wells in floodplains during flooding.
- One site in thin till exhibited two TC+ detections.

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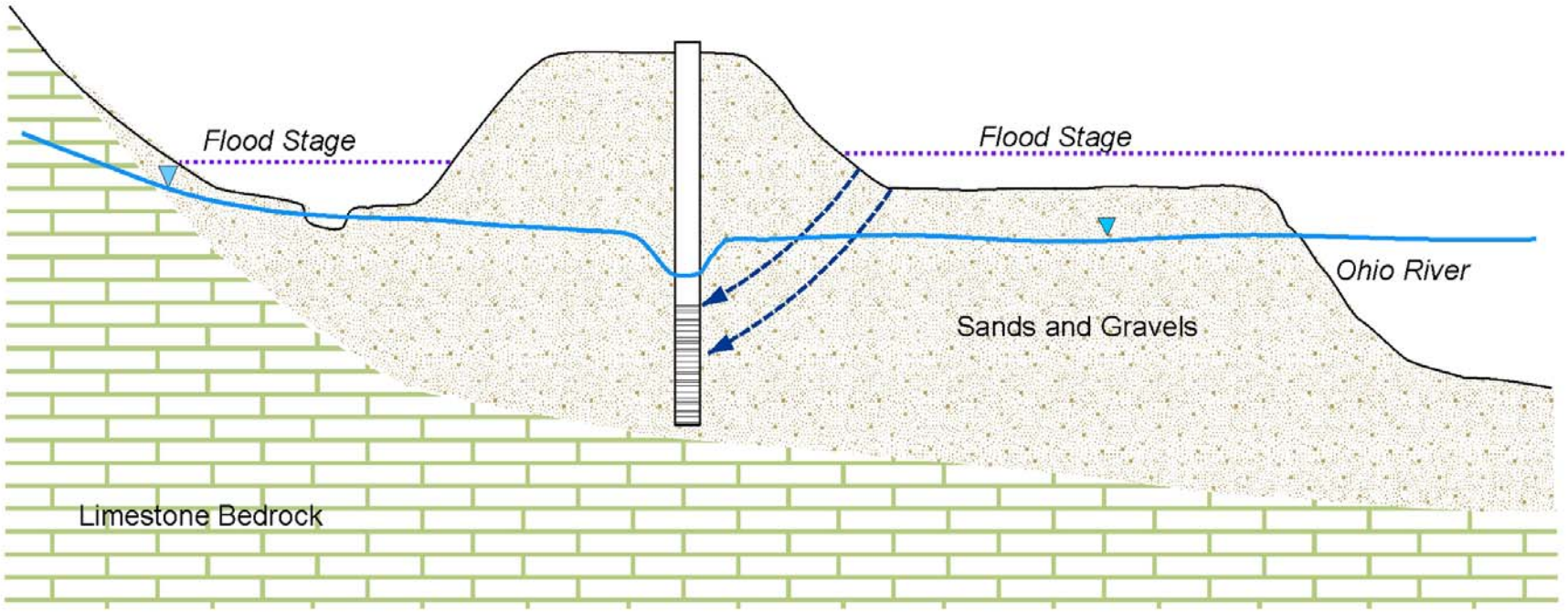

Not drawn to scale. Significant vertical exaggeration.

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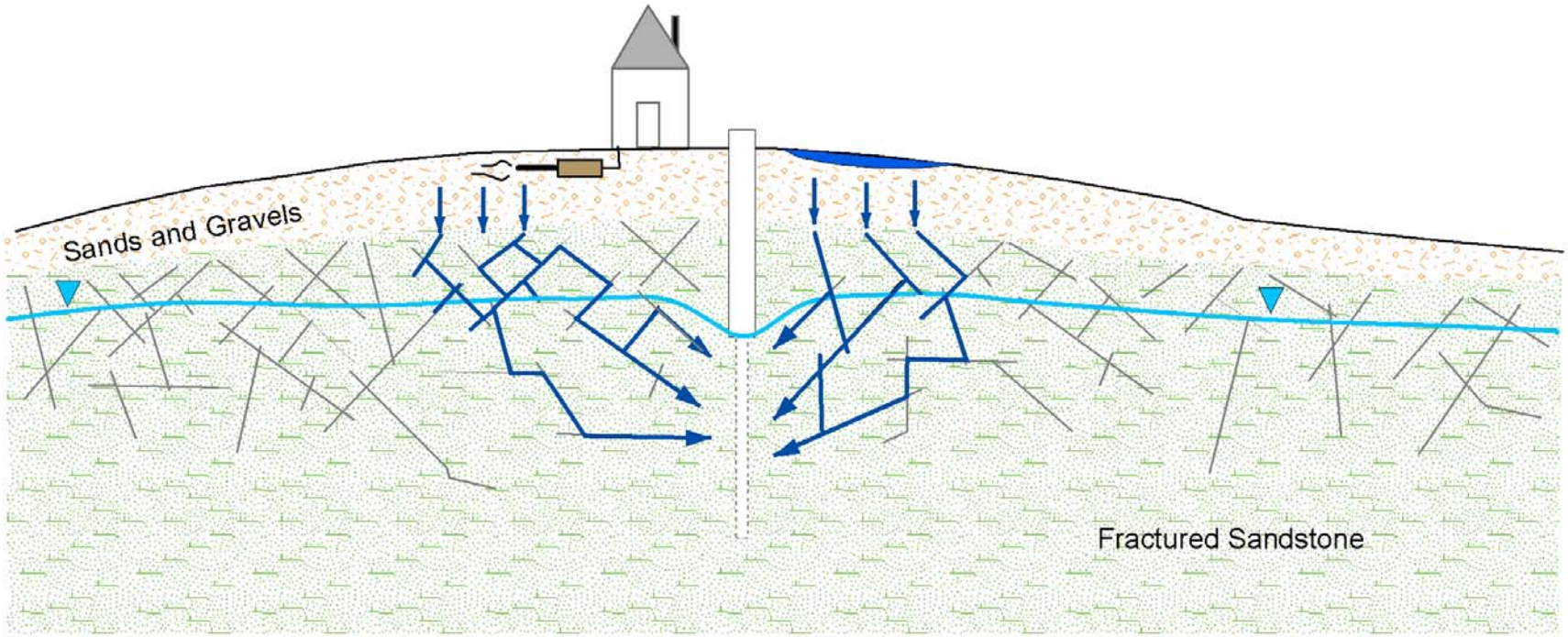

Not drawn to scale. Significant vertical exaggeration.

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DATA ANALYSIS

Use data to evaluate correlations of limited results:

- Determine well attributes that may correlate to indicator presence (casing length, static water...)
- Identify the hydrogeologic barrier attributes where no detections occurred in the source water.
- Goal – to refine selection criteria for identifying hydrogeologic barriers.

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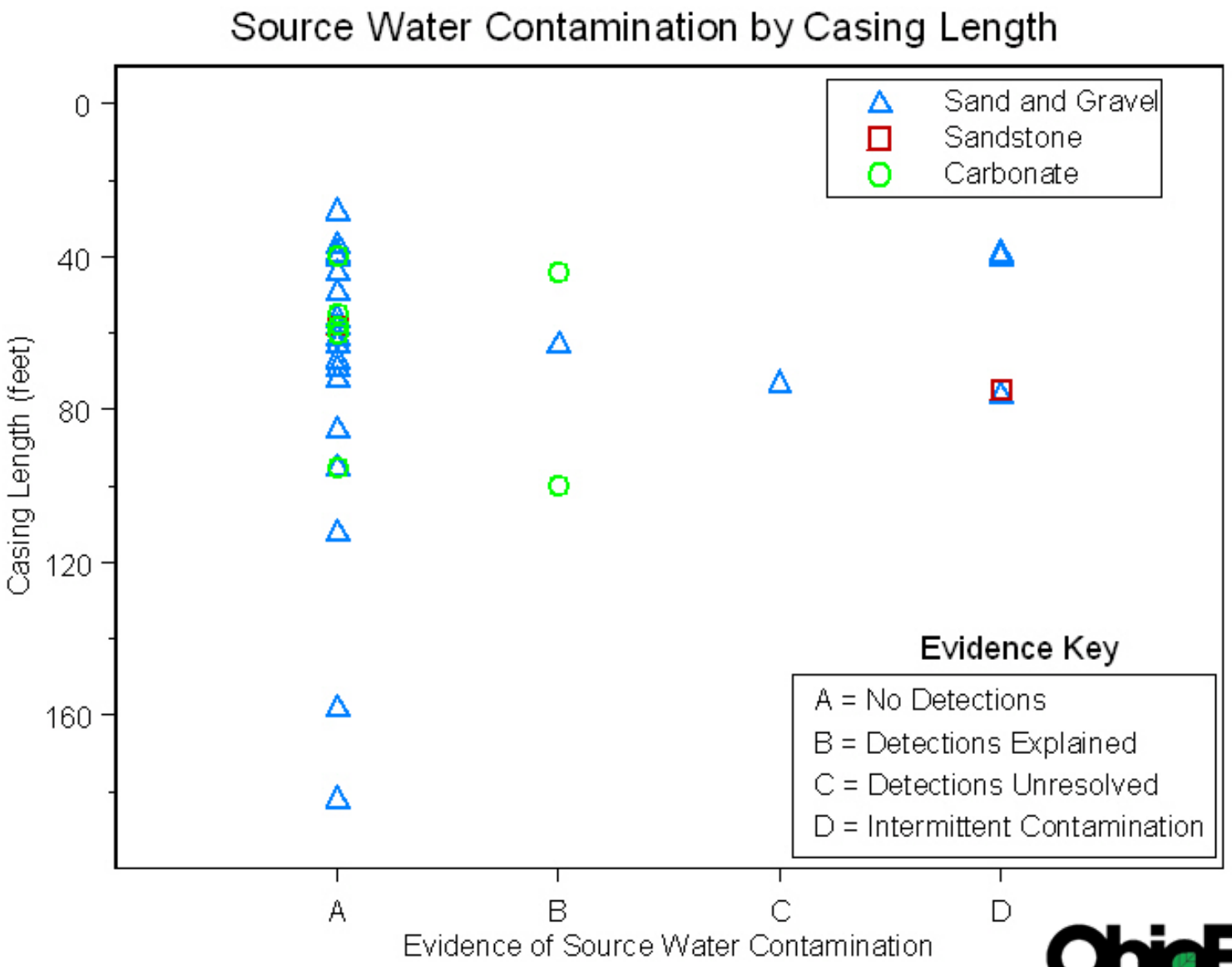
Source Water Contamination by Casing Length
Sand and Gravel
Sandstone
Carbonate
Casing Length (feet)
0
40
80
120
160
A
B
C
D
Evidence of Source Water Contamination
Evidence Key
A = No Detections
B = Detections Explained
C = Detections Unresolved
D = Intermittent Contamination

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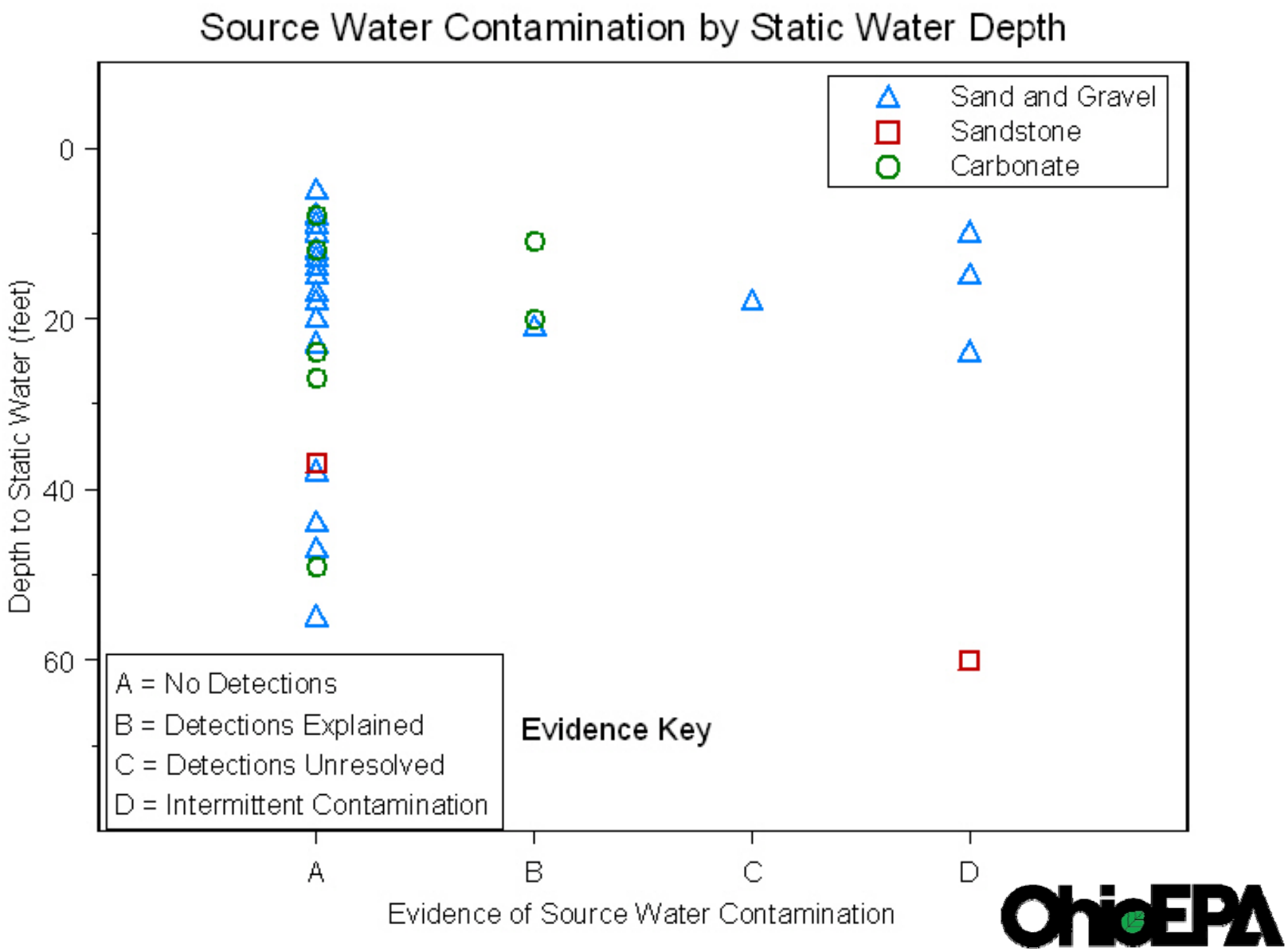
Source Water Contamination by Static Water Depth
Sand and Gravel
Sandstone
Carbonate
Depth to Static Water (feet)
0
20
40
60
A = No Detections
B = Detections Explained
C = Detections Unresolved
D = Intermittent Contamination
Evidence Key
A
B
C
D
Evidence of Source Water Contamination
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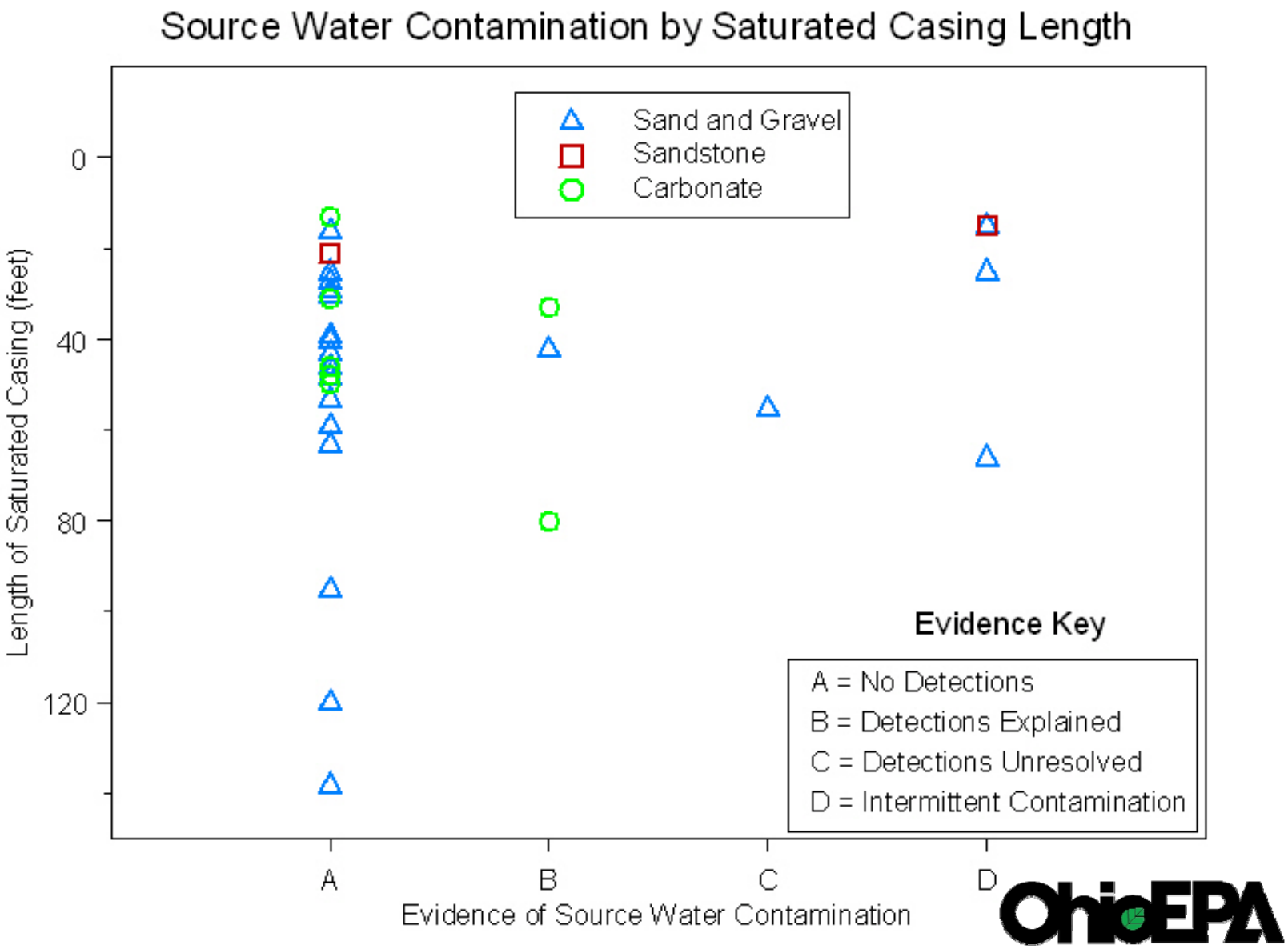
Source Water Contamination by Saturated Casing Length
Sand and Gravel
Sandstone
Carbonate
Length of Saturated Casing (feet)
0
40
80
120
Evidence Key
A = No Detections
B = Detections Explained
C = Detections Unresolved
D = Intermittent Contamination
A
B
C
D
Evidence of Source Water Contamination
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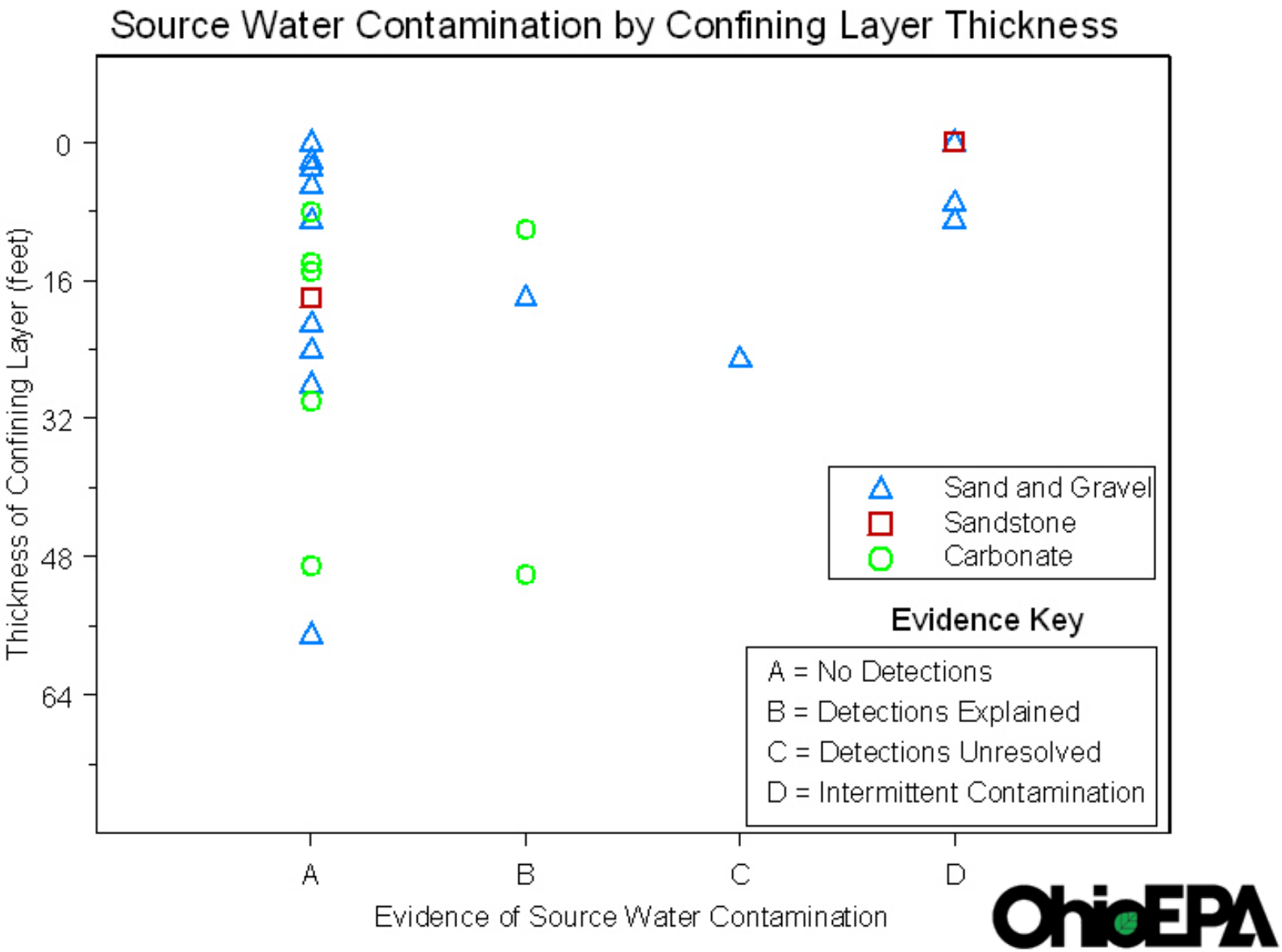
Source Water Contamination by Confining Layer Thickness
Thickness of Confining Layer (feet)
0
16
32
48
64
A
B
C
D
Evidence of Source Water Contamination
Sand and Gravel
Sandstone
Carbonate
Evidence Key
A = No Detections
B = Detections Explained
C = Detections Unresolved
D = Intermittent Contamination
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Study Findings

- No ground water samples tested positive for *E. coli*, male specific coliphage, or somatic coliphage.
- No unexplained pathogen indicators were detected where a saturated, clay-rich barrier is present.

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Study Findings

- Pathogen detections occurred in:
  - S&G wells in flood plains;
    - Detections associated with flooding and horizontal flow paths
  - Fractured bedrock wells below thin drift.
- Concept of a hydrogeologic barrier appears to be sound.

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Implications for GW Rule

- Study confirms that hydrogeologic barriers protect wells in sensitive aquifers;
- Data suggests clay-rich thickness and saturated casing length are useful parameters for identifying hydrogeologic barriers;
- Horizontal flow paths need to be identified in hydrogeologic sensitivity assessment;

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Implications for GW Rule

- GW Rule implementation focus on PWSs vulnerable to pathogens;
- Use pathogen detection data from raw water samples to refine hydro-geologic barrier definition;
- Provides focus on public health protection while collecting data to target additional sampling in cost effective manner.

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Acknowledgments & Information

Grant Activities

- Pathogen analysis completed by MDH Lab;
- Analysis paid for by U.S.EPA;
- Conclusions from Hydrogeologic Barrier Study, completed by MDH and Ohio EPA staff.

Additional Information on GW Rule:

http://www.epa.gov/safewater/disinfection/gwr/index.html

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