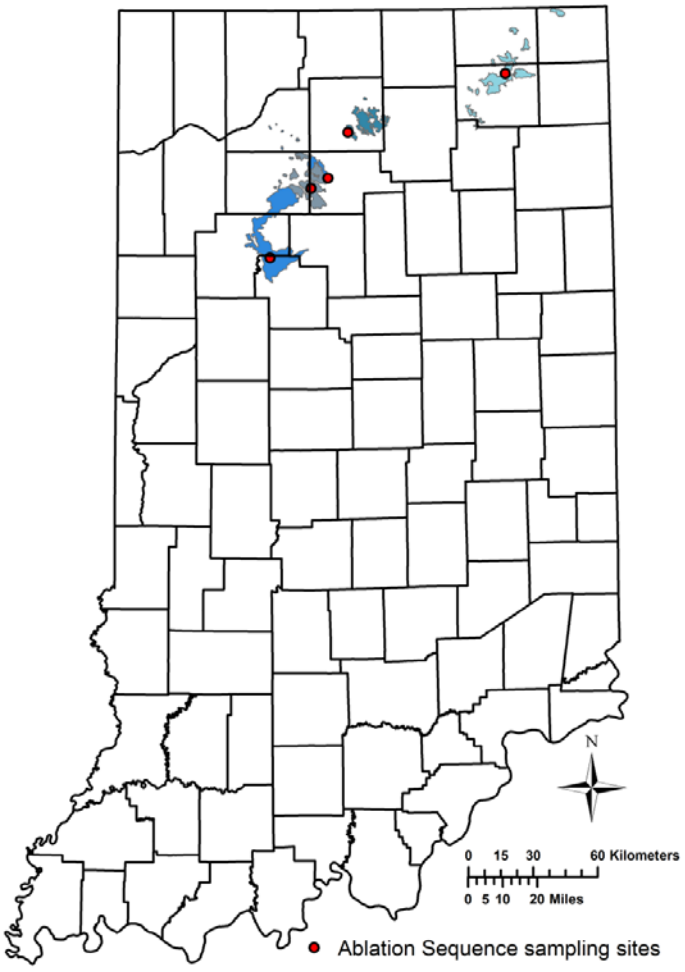
APPENDIX K:
HYDROGEOLOGIC SETTINGS AND GROUND WATER QUALITY SUMMARIES

HYDROGEOLOGIC SETTINGS AND GROUND WATER QUALITY SUMMARIES

The Indiana Geological Survey (IGS) divided the state into hydrogeologic settings to "provide a conceptual model to help interpret the occurrence, movement, and sensitivity to contamination of ground water in relation to … the surface and subsurface environment" (Fleming, 1995). The IGS stratified the state hydrogeologically to over 240 individual hydrogeologic settings across the state, and the settings are largely based on glacial activity. The over 240 individual hydrogeologic settings were grouped by IGS and IDEM scientists into 20 generalized settings that are common throughout the state. The 20 generalized settings were developed as part of the Office of Indiana State Chemist's Pesticide Management Plan.

Using the 20 generalized hydrogeologic settings, it was determined that 398 samples are needed to accurately represent ambient ground water quality across the State for each sampling round. The 398 sampling sites were proportionally distributed throughout the 20 lumped hydrogeologic settings via a weighting procedure (also known as stratified sampling) based on the percentage of located wells in that setting. The weighted number of samples in the generalized settings ranged from 1 to 154 samples. The following narratives are descriptions and ground water quality summary results of the Round 6 sampling for each of the 20 generalized hydrogeologic settings.

Ablation Sequence Setting



Ablation Sequences are composed of various series consisting primarily of ablation till (sometimes referred to as melt-out till). The Ablation Sequences can range from being massive, densely compacted and poorly sorted to thin sequences of sandy to loamy ablation sediments that locally contain significant outwash deposits. These sediments are highly sensitive due to a shallow water table and permeable surface sediments.

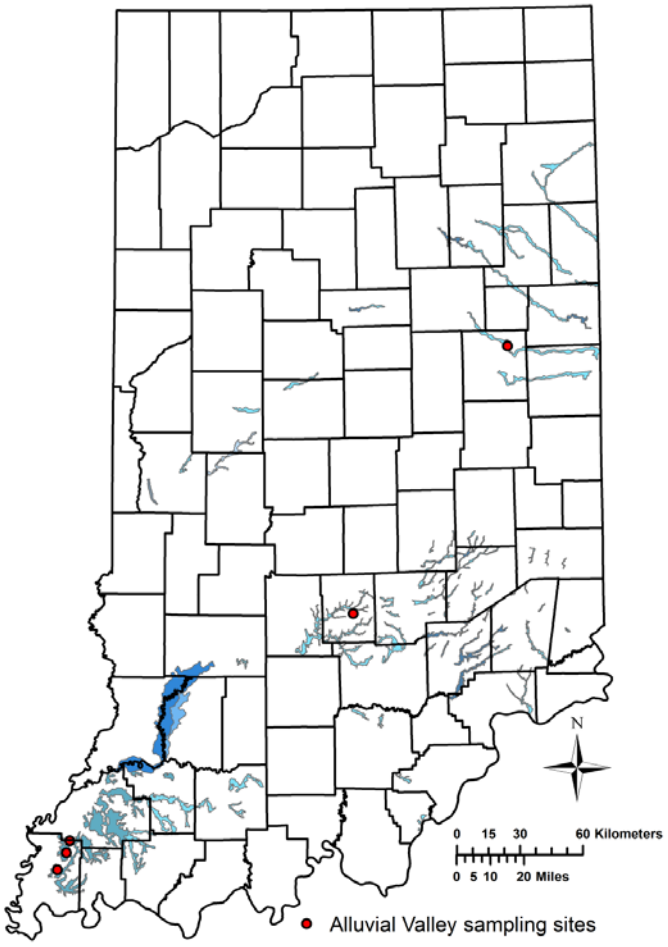
For Sampling Round 6 of the Ground Water Monitoring Network, 5 samples were collected in the Ablation Sequences setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (22.6 mg/L average concentration), Ca (70.0 mg/L), Na (46.9 mg/L), K (1.3 mg/L), SO_4 (48.0 mg/L), and Cl^- (16.8 mg/L).

Arsenic was detected in 3 (60%) of the Round 6 samples from the Ablation Sequences setting, including 1 sample (20%) that exceeded the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Ablation Sequences setting, the highest arsenic concentration was found in the sample from a bedrock well (16 µg/L vs. 2.65 µg/L average for unconsolidated wells). The highest average concentrations were found in wells screened from 100 to 150 ft below the ground surface (9.25 µg/L).

Nitrate was not detected in any of the samples collected from the Ablation Sequences setting.

Iron was also found above the U.S. U.S. EPA's Secondary MCL (0.3 mg/L) in all 5 of the samples from the Ablation Sequences setting. **Pesticide Degradates** for Acetochlor, Alachlor, or Metolachlor were not detected in these samples.

Alluvial Valley Setting



The **Alluvial Valley** setting is made up of modern stream valleys and floodplains that consist of fine to coarse grained alluvial sediments. Aquifers can be narrow in width and deeply incised in bedrock. The water table is quite shallow (less than 5 ft), and often act as local discharge areas for ground water flow.

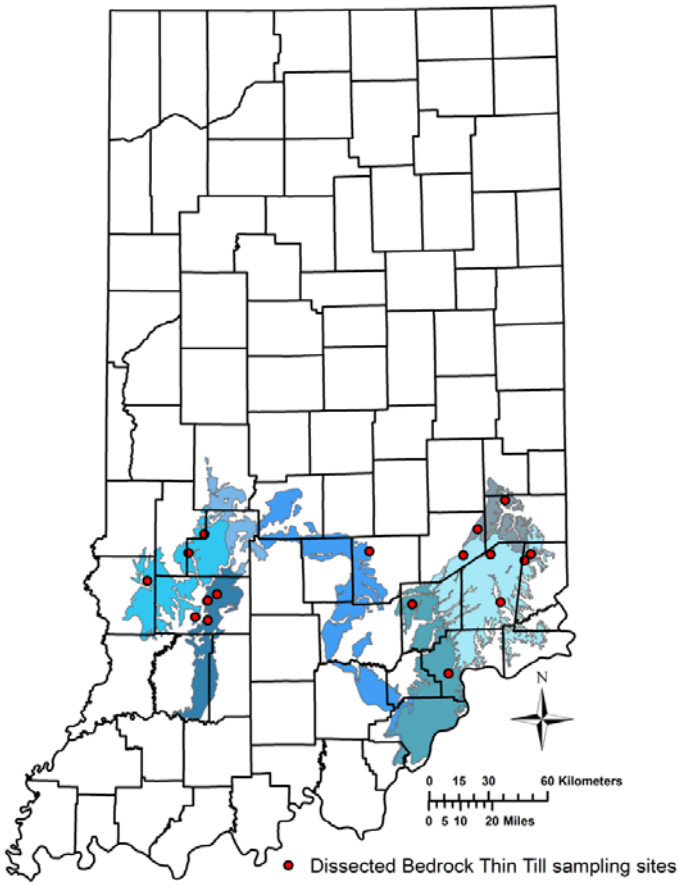
For Sampling Round 6 of the Ground Water Monitoring Network, 5 samples were collected in the Alluvial Valley setting. The water type in this setting is dominated by **calcium** and **sodium/potassium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (24.1 mg/L average concentration), Ca (58.0 mg/L), Na (58.7 mg/L), K (2.1 mg/L), SO_4 (16.8 mg/L), and Cl^- (16.2 mg/L).

Arsenic was detected in one of the Round 6 samples from the Alluvial Valley setting (20%), which exceeded the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L). The arsenic detection occurred in a bedrock well that had a depth of greater than 150 ft below the ground surface.

Nitrate was detected in two of the Round 6 samples from the Alluvial Valley setting; none exceeded the U.S. U.S. EPA's MCL (10 µg/L). In the Alluvial Valley setting, the samples that contained detectable levels of nitrate were found in oxidizing aquifers, with no nitrate detected in aquifers showing reducing conditions.

Iron was also found above the U.S. U.S. EPA's Secondary Maximum Contaminant Level (0.3 mg/L) in three of the five samples (60%). **Pesticide Degradates** for Acetochlor, Alachlor, and Metolachlor were not detected in these samples.

Dissected Bedrock Thin Till Setting



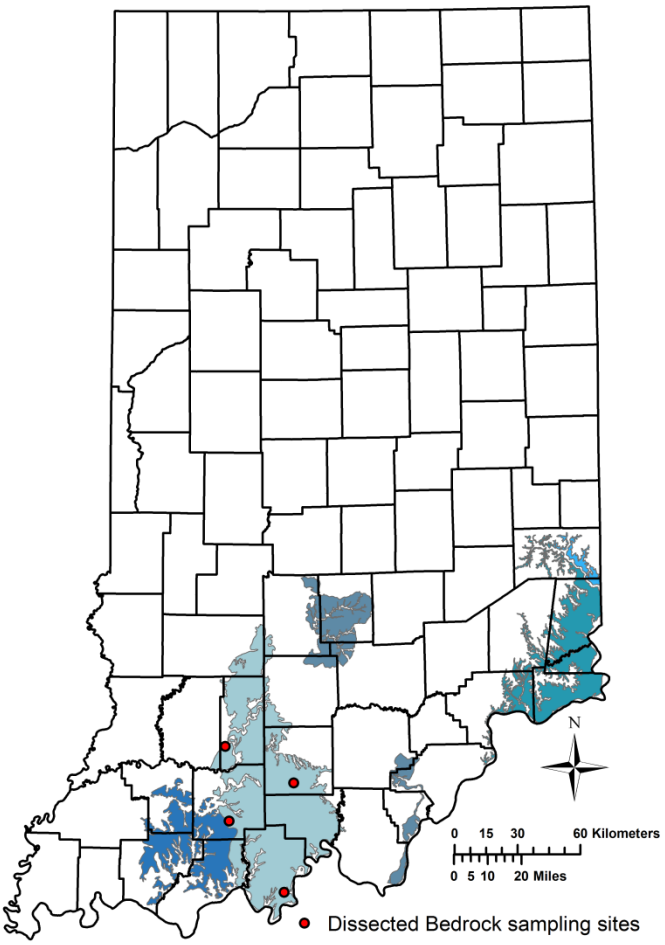
Unconsolidated deposits in the **Dissected Bedrock Thin Till** setting are generally less than 50 ft in thickness over large areas; and laterally extensive sand and gravel units are not common. The unconsolidated deposits overlie moderately to strongly dissected bedrock units, which include interbedded sandstone and mudstone; shale; and karst-forming limestone. Ground water availability in the setting is generally poor, except along bedrock fractures and zones of major solution features.

For Sampling Round 6 of the Ground Water Monitoring Network, 17 samples were collected in the Dissected Bedrock Thin Till setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sodium/potassium types. Major anions and cations detected in this setting include: Mg (20.5 mg/L average concentration), Ca (66.3 mg/L), Na (61.8 mg/L), K (1.1 mg/L), SO_4 (47.9 mg/L), and Cl^- (19.4 mg/L).

Arsenic was detected in three (around 18%) of the Round 6 samples from the Dissected Bedrock Thin Till setting; none of the samples exceeded the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Dissected Bedrock Thin Till setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (1.5 µg/L average vs. 1.1 µg/L average for bedrock wells). The highest average concentrations were found in wells screened from 50 to 100 ft below the ground surface (1.78 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (1.14 µg/L) than aquifers under oxidizing conditions (1.12 µg/L).

Nitrate was detected in 11 (around 65%) of the Round 6 samples from the Dissected Bedrock Thin Till setting, and one of those samples exceeded the U.S. U.S. EPA's MCL (10 µg/L). In the Dissected Bedrock Thin Till setting, the highest average nitrate concentrations were found in samples from unconsolidated wells (3.58 mg/L average vs. 0.45 mg/L average for bedrock wells), and in well screened less than 50 ft below the ground surface (4.97 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (3.13 mg/L) than aquifers under reducing conditions (0.17 mg/L).

Dissected Bedrock Setting



The **Dissected Bedrock** setting is predominantly a broad upland defined by outcrops of several relatively-resistant rock units. Individual hydrogeologic settings within this general setting generally correspond to the major bedrock units in the area, including the siltstone, shale, and interbedded shale and sandstone. Ground water availability tends to be poor in this setting, and occurs in fractures and along bedding plains.

For Sampling Round 6 of the Ground Water Monitoring Network, four samples were collected in the Dissected Bedrock setting. The water type in this setting is dominated by **sodium/potassium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (27.0 mg/L average concentration), Ca (65.3 mg/L), Na (154.6 mg/L), K (2.7 mg/L), SO_4 (194.6 mg/L), and Cl^- (90.1 mg/L).

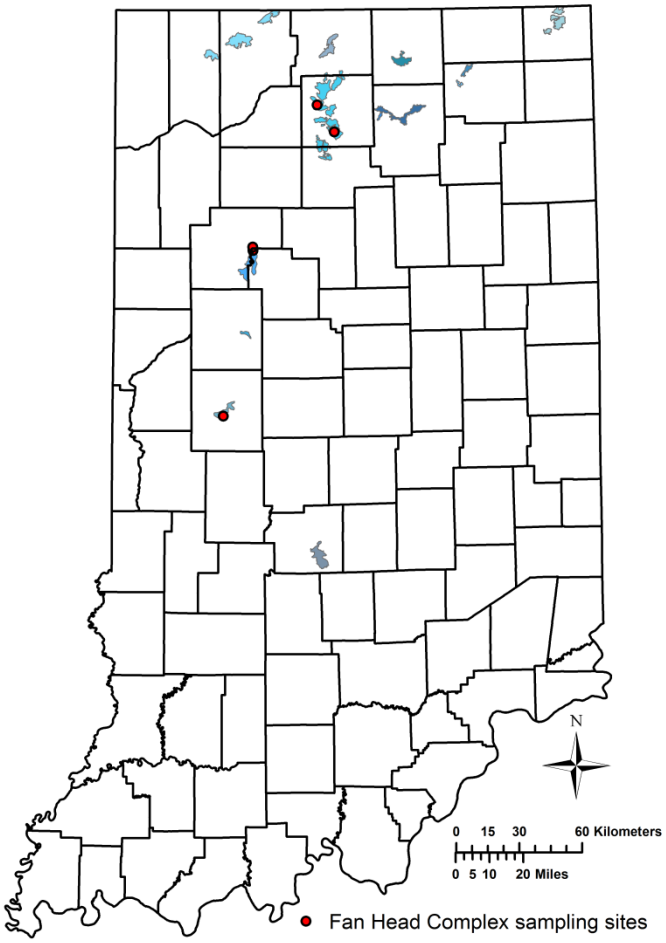
Arsenic was detected in one (25%) of the Round 6 samples from the Dissected Bedrock setting; none of the samples exceeded the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Dissected Bedrock setting, the highest average arsenic concentrations were found in samples from bedrock wells (2.0 µg/L average vs. 1 µg/L average for bedrock wells). The highest average concentrations were found in wells screened greater than150 ft below the ground surface (2.0 µg/L).

Nitrate was detected in two (50%) of the Round 6 Samples from the Dissected Bedrock setting; none exceeded the U.S. U.S. EPA's MCL (10 µg/L).

Iron was also found above the U.S. U.S. EPA's Secondary MCL (0.3 mg/L) in two of the samples from the Dissected Bedrock setting (50%).

Pesticide Degradates of Acetochlor, Alachlor, and Metolachlor were not detected in these samples.

Fan Head Complex Setting



Fan Head Complexes are the near-ice ends of outwash fans, and typically contain a variety of coarse grained sand and gravel deposits. Fan Heads consists of massive high relief terrain composed of both till capped and exposed sand and gravel deposits. Although ground water is present at considerable depth, the setting has variable sensitivity depending on the thickness of surficial till deposits.

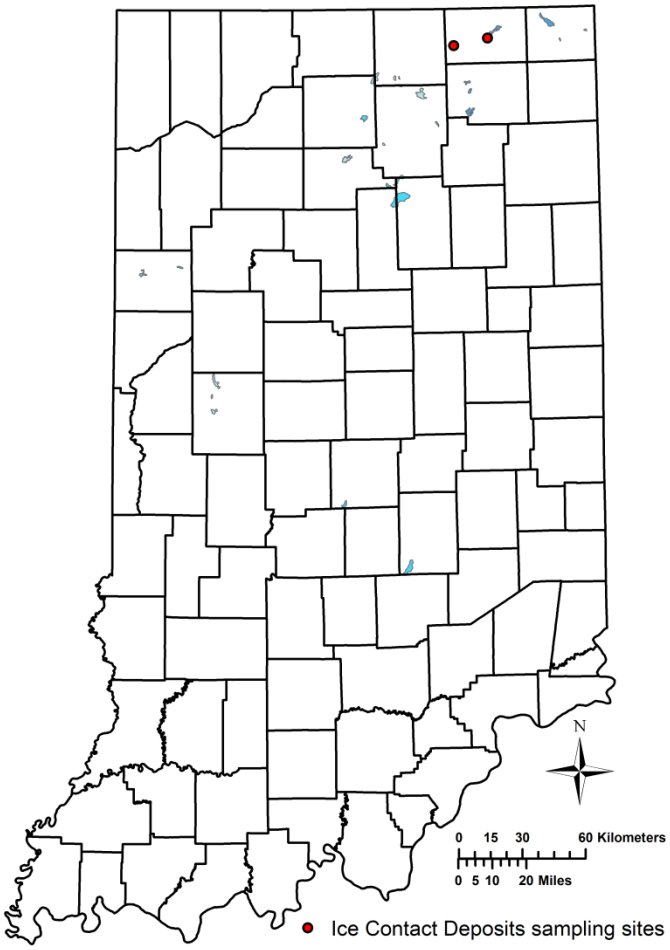
For Sampling Round 6 of the Ground Water Monitoring Network, five samples were collected in the Fan Head Complex setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sodium/potassium types. Major anions and cations detected in this setting include: Mg (26.2 mg/L average concentration), Ca (75.8 mg/L), Na (53.6 mg/L), K (1.1 mg/L), SO_4 (47.9 mg/L), and Cl^- (39.8 mg/L).

Arsenic was detected in one of the Round 6 samples from the Fan Head Complex setting at 3.2 µg/L, and did not exceed the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L).

Nitrate was also detected in one of the Round 6 samples from the Fan Head Complex setting at 0.38 mg/L, and did not exceed the U.S. U.S. EPA's MCL (10 µg/L).

Iron was found above the U.S. U.S. EPA's Secondary MCL (0.3 mg/L) in three of the samples from the Fan Head Complex setting (60%). The **Pesticide Degradate Alachlor ESA** were found in one sample at a concentration of 1.4 µg/L.

Ice Contact Deposits Setting



Ice Contact Deposits are those deposits which were deposited on top, beneath, or on the side of glacial ice. Linear ridges chiefly composed of sand and gravel also known as eskers were deposited along melt water channels on top or within of glacial ice. Irregular, isolated mounds and hummocky elongated ridges that may or may not be isolated features and can be composed entirely of sand and gravel or a chaotic complex of granular and till like units have traditionally been known as kames.

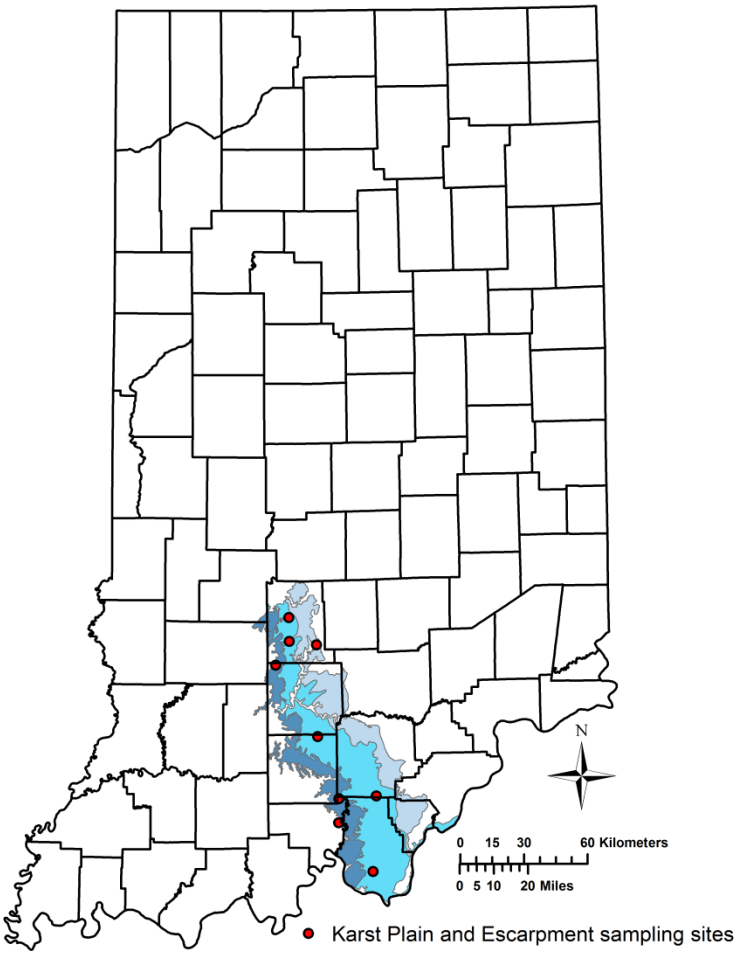
For Sampling Round 6 of the Ground Water Monitoring Network, two samples were collected in the Ice Contact Deposits setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (26.0 mg/L average concentration), Ca (87.0 mg/L), Na (6.7 mg/L), K (3.4 mg/L), SO_4 (16.8 mg/L), and Cl^- (10.8 mg/L).

Arsenic was detected in one of the Round 6 samples from the Ice Contact Deposits setting (50%), which exceeded the U.S. U.S. EPA's Maximum Contaminant Level (10 µg/L) at 12 µg /L.

Nitrate was detected in one of the Round 6 samples from the Ice Contact Deposits setting, which exceeded the U.S. U.S. EPA's MCL (10 µg/L) at 14 mg/L.

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in one of the samples from the Ice Contact Deposits setting (50%). **Pesticide Degradates** for Acetochlor, Alachlor, and Metolachlor were not detected in this sample.

Karst Plain and Escarpment Setting



The primary **Karst Plain** in Indiana is also known as the Mitchell Plain. This is a classic karst region of south-central Indiana that corresponds to the outcrop of middle Mississippian limestone. Secondary permeability is spectacularly developed at many places in the form of caverns, caves and enlarged joints. The Mitchell Plain has a well-developed cap of residual soil known as the "terra rosa" which typically measures between 15 and 30 feet thick. Recharge can be quite rapid in areas with numerous sink holes. Ground water and surface water are intimately interrelated, with many sink holes and sinking streams that contribute to subterranean drainages. Ground water beneath large parts of the Mitchell Plain should be regarded as highly sensitive to contamination from agricultural chemicals.

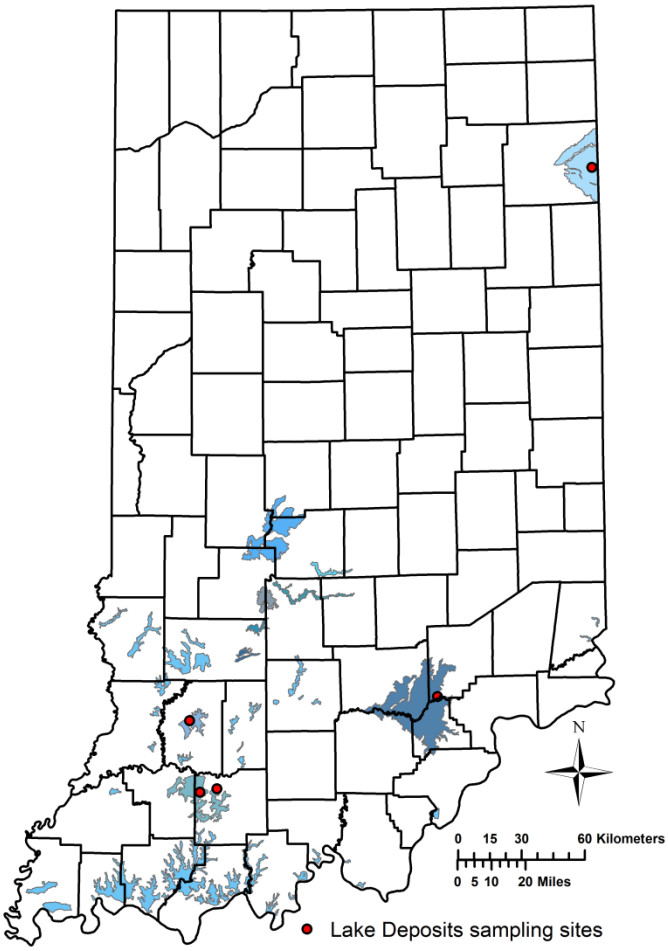
For Sampling Round 6 of the Ground Water Monitoring Network, nine samples were collected in the Karst Plain and Escarpment setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sulfate and sodium/potassium types. Major anions and cations detected in this setting include: Mg (40.7 mg/L average concentration), Ca (109.1 mg/L), Na (31.8 mg/L), K (1.9 mg/L), SO_4 (195.4 mg/L), and Cl^- (25.1 mg/L).

Arsenic was not detected in any of the Round 6 samples from the Karst Plain and Escarpment setting.

Nitrate was detected in seven (around 78%) of the Round 6 samples from the Karst Plain and Escarpment setting; none exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Karst Plain and Escarpment setting, the highest average nitrate concentrations were found in samples from areas with a cultivated crops landuse (7.9 mg/L average), and in well screened less than 50 ft below the ground surface (6.0 mg/L average).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in two of the samples from the Karst Plain and Escarpment setting (22%). The **Pesticide Degradate Metolachlor ESA** was found in one sample at a concentration of 0.9 µg/L.

Lake Deposits Setting



Lake Deposits are formed from sediment-laden meltwater along the margins of glacial ice sheets. Silts and fine sands are the predominant sediment type in this setting. Although the water table is rarely more than a few feet below the ground surface, the fine grain sediments generally have a low-permeability.

For Sampling Round 6 of the Ground Water Monitoring Network, five samples were collected in the Lake Deposits setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sulfate types. Major anions and cations detected in this setting include: Mg (26.3 mg/L average concentration), Ca (70.8 mg/L), Na (42.6 mg/L), K (1.2 mg/L), SO_4 (61.1 mg/L), and Cl^- (18.4 mg/L).

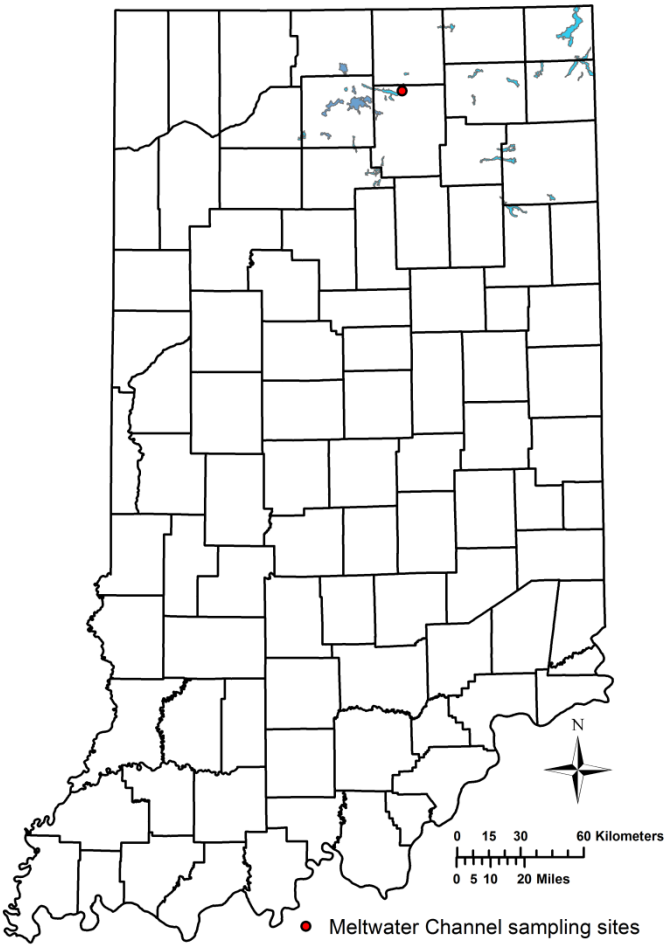
Arsenic was detected in two (40%) of the Round 6 samples from the Lake Deposits setting, including one sample that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L) at 21 µg/L. In the Lake Deposits setting, the arsenic detections were found in bedrock wells screened more than 100 ft below the ground surface.

Nitrate was detected in three (60%) of the Round 6 samples from the Lake Deposits setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Lake Deposits setting, the highest average nitrate concentrations were found in samples from unconsolidated wells (2.0 mg/L average vs. 0.005 mg/L average for bedrock wells). Aquifers that were under reducing conditions had a higher average nitrate concentration (3.85 mg/L) than aquifers under oxidizing conditions (0.12 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in one of the samples from the Lake Deposits setting at 1.5 mg/L.

The **Pesticide Degradate** Metolachlor ESA was found in one sample at a concentration of 0.7 µg/L.

Meltwater Channel Setting



Meltwater Channels are tributary channels that are typically underlain by a mix of granular and till units of widely ranging thicknesses. These channels are sharply entrenched and linear. The channels tend to be poorly drained, and frequently contain wetlands.

For Sampling Round 6 of the Ground Water Monitoring Network, one sample were collected in the Meltwater Channel setting. The water type in this sample consists of **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (44 mg/L), Ca (100 mg/L), Na (8.3 mg/L), K (1.6 mg/L), SO_4 (75 mg/L), and Cl^- (28 mg/L).

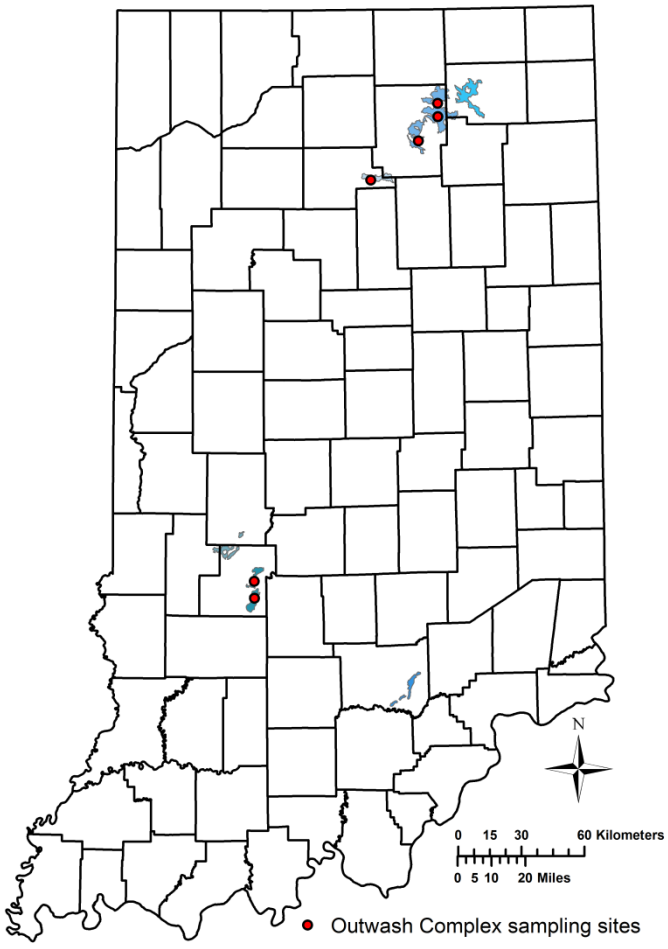
Arsenic was detected the Round 6 sample from the Meltwater Channel setting at a concentration of 6. µg/L, which does not exceed the U.S. EPA's Maximum Contaminant Level (10 µg/L).

Nitrate was not detected in the Round 6 sample from the Meltwater Channel setting.

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in the sample from the Meltwater Channel setting at 1.7 mg/L.

Several **Pesticide Degradates** were found in the sample, including: Acetochlor ESA (0.3 µg/L), Alachlor ESA (0.3 µg/L), and Metolachlor ESA (0.3 µg/L).

Outwash Complex Setting



The **Outwash Complex** setting is comprised of rolling to hummocky landscape and thin units of disconnected sand and gravel. There are discontinuous tills within the sequence. Unconsolidated sediments can be up to 150 ft, but generally range in thickness from 20 to 40 ft. The surface is highly permeable and leads to considerable recharge. The ground water flow is likely to be shallow and has an elevated sensitivity.

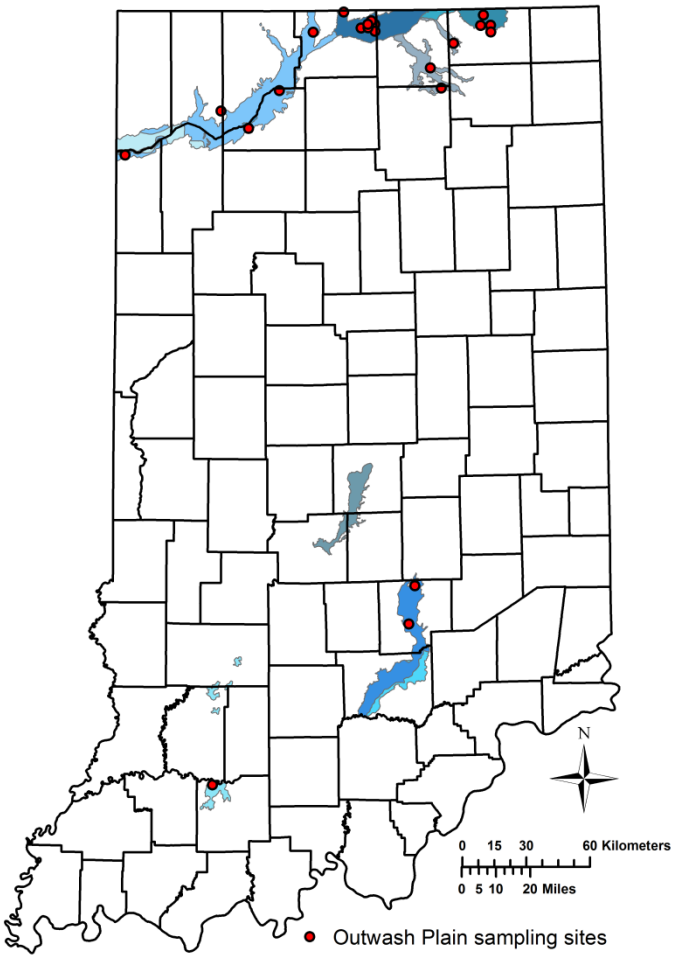
For Sampling Round 6 of the Ground Water Monitoring Network, six samples were collected in the Outwash Complex setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (29.3 mg/L average concentration), Ca (100.5 mg/L), Na (7.6 mg/L), K (1.0 mg/L), SO_4 (56.2 mg/L), and Cl^- (14.5 mg/L).

Arsenic was detected in two (around 33%) of the Round 6 samples from the Outwash Complex setting; none of them exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Outwash Complex setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (3.15 µg/L average vs. non-detect for bedrock wells). The highest average concentrations were found in wells screened from 100 to 150 ft below the ground surface (3.87 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (3.15 µg/L) than aquifers under oxidizing conditions (non-detect).

Nitrate was detected in two (around 33%) of the Round 6 samples from the Outwash Complex setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Outwash Complex setting, the highest average nitrate concentrations were found in samples from bedrock wells (0.37 mg/L average vs. non-detect for unconsolidated wells), and in well screened more than 100 ft below the ground surface. Aquifers that were under oxidizing conditions had a higher average nitrate concentration (0.29 mg/L) than aquifers under reducing conditions (non-detect).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in four of the samples from the Outwash Complex setting (67%). None of the samples contained **Pesticide Degradates** for Acetochlor, Alachlor, or Metolachlor.

Outwash Plain Setting



Outwash Plains are typically broad flat expanses and comprised of thick units of highly permeable outwash sand and gravel. Clay lenses and sheets of till may locally divide the outwash into discrete aquifers. A combination of thick outwash sequences and shallow water table make this setting highly vulnerable to surficial contamination.

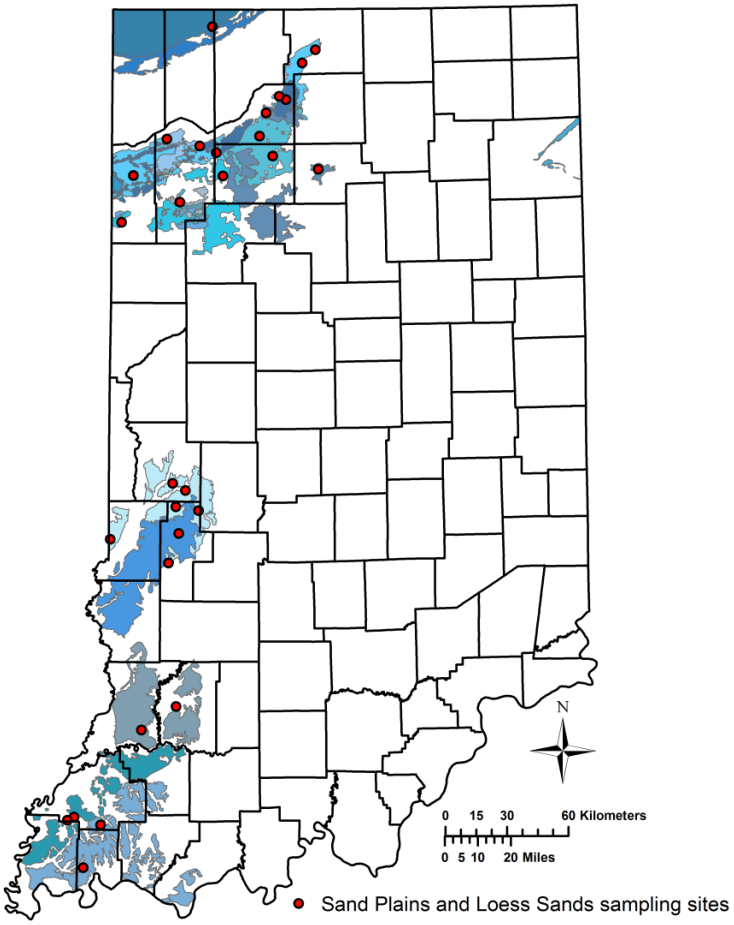
For Sampling Round 6 of the Ground Water Monitoring Network, 22 samples were collected in the Outwash Plain setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (22.4 mg/L average concentration), Ca (73.5 mg/L), Na (13.6 mg/L), K (1.5 mg/L), SO_4 (42.4 mg/L), and Cl^- (23.5 mg/L).

Arsenic was detected in seven (around 32%) of the Round 6 samples from the Outwash Plain setting, including two samples (9%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Outwash Plain setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (3.22 µg/L average vs. non-detect for bedrock wells). The highest average concentrations were found in wells screened from 50 to 150 ft below the ground surface. Aquifers that were under reducing conditions had a higher average arsenic concentration (3.75 µg/L) than aquifers under oxidizing conditions (non-detect).

Nitrate was detected in eight (around 36%) of the Round 6 samples from the Outwash Plain setting, including two samples (9%) that exceeded the MCL (10 µg/L). In the Outwash Plain setting, the highest average nitrate concentrations were found in samples from the Cultivated Crops landuse (4.0 mg/L), and in wells screened less than 50 ft below the ground surface (4.04 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (9.14 mg/L) than aquifers under reducing conditions (0.71 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in 13 of the samples from the Outwash Plain setting (59%). **Pesticide Degradates** were found in several samples, including: Acetochlor ESA (5 samples, 2.1 µg/L max), Acetochlor OA (1 sample, 0.3 µg/L max), Alachlor ESA (8 samples, 2.2 µg/L max), Alachlor OA (1 sample, 0.2 µg/L max), Metolachlor ESA (10 samples, 7.8 µg/L max), and Metolachlor OA (6 samples, 2.9 µg/L max).

Sand Plains and Loess Sands Setting



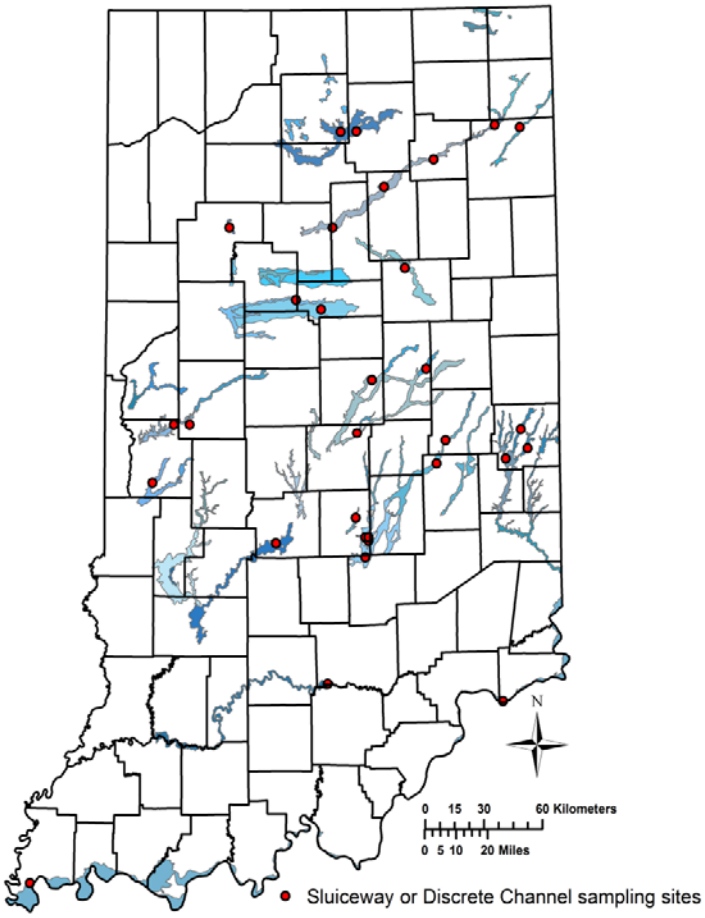
The **Sand Plains and Loess Sands** setting are typified by wind-blown and lake deposited sand and loess (silt) deposits overlying sand and gravel deposits or bedrock. Both sand and loess deposits may reach thicknesses ranging from 10 - 50ft. and possess surficial topographies ranging from flat to rolling dune topographies. Sand and Loess Plains are highly permeable and vulnerable to ground water contamination.

For Sampling Round 6 of the Ground Water Monitoring Network, 30 samples were collected in the Sand Plains and Loess Sands setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sodium/potassium types. Major anions and cations detected in this setting include: Mg (21.8 mg/L average concentration), Ca (59.3 mg/L), Na (36.3 mg/L), K (1.6 mg/L), SO_4 (25.2 mg/L), and Cl^- (18.5 mg/L).

Arsenic was detected in seven (around 23%) of the Round 6 samples from the Sand Plains and Loess Sands setting, including three samples (10%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Sand Plains and Loess Sands setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (6.28 µg/L average vs. non-detect for bedrock wells). The highest average concentrations were found in wells screened from 100 to 150 ft below the ground surface (11.33 µg/L). Areas of high aquifer sensitivity contained a higher average arsenic concentration (6.28 µg/) than low and moderate sensitivity areas. The Cultivated Crops landuse area contained a higher average arsenic concentration (6.28 µg/L) than Deciduous Forest or Developed, Low Intensity categories. Aquifers that were under reducing conditions had a higher average arsenic concentration (5.86 µg/L) than aquifers under oxidizing conditions (1.73 µg/L).

Nitrate was detected in 17 (around 57%) of the Round 6 samples from the Sand Plains and Loess Sands setting; one exceeded the U.S. EPA's MCL (10 µg/L) at 16.0 mg/L. In the Sand Plains and Loess Sands setting, the highest average nitrate concentrations were found in samples from bedrock wells (3.04 mg/L average vs. 0.83 mg/L average for unconsolidated wells. The Cultivated Crops landuse area contained a higher average nitrate concentration (2.30 µg/L) than Deciduous Forest or Developed, Low Intensity categories.

Sluiceway or Discrete Channel Setting



The **Sluiceway and Discrete Channel** settings are very similar to Outwash Plains, but differ by being more channelized, narrower and are essentially
well developed troughs that are significantly entrenched into surrounding terrains. Like outwash plains, sluiceways contain abundant sand and gravel deposits reaching significant depths. A combination of thick outwash sequences and shallow water table make this setting highly vulnerable to surficial contamination.

For Sampling Round 6 of the Ground Water Monitoring Network, 34 samples were collected in the Sluiceway and Discrete Channel setting. The water type in this setting is dominated by **calcium** and **bicarbonate-type**. Major anions and cations detected in this setting include: Mg (26.1 mg/L average concentration), Ca (77.0 mg/L), Na (29.0 mg/L), K (1.3 mg/L), SO_4 (28.4 mg/L), and Cl^- (14.7 mg/L).

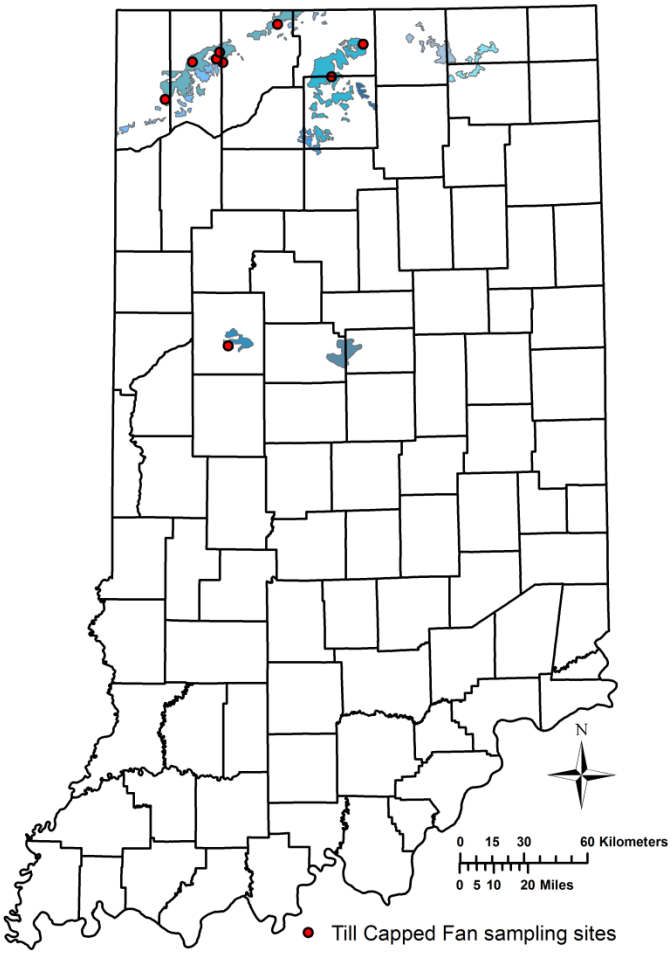
Arsenic was detected in 13 (around 38%) of the Round 6 samples from the Sluiceway and Discrete Channel setting, including three samples (9%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Sluiceway and Discrete Channel setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (6.67 µg/L average vs. 2.1 µg/L average for bedrock wells). The highest average concentrations were found in wells screened from 50 to 100 ft below the ground surface (9.67 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (8.87 µg/L) than aquifers under oxidizing conditions (non-detect).

Nitrate was detected in 15 (around 44%) of the Round 6 samples from the Sluiceway and Discrete Channel setting, including two of the samples that exceeded the U.S. EPA's MCL (10 µg/L). In the Sluiceway and Discrete Channel setting, the highest average nitrate concentrations were found in samples from unconsolidated wells (2.18 mg/L average vs. 0.02 mg/L average for bedrock wells), and in well screened less than 50 ft below the ground surface (3.87 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (4.70 mg/L) than aquifers under reducing conditions (0.008 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in 20 of the samples from the Sluiceway and Discrete Channel setting (59%).

Pesticide Degradates were found in several samples, including: Alachlor ESA (1 sample, 0.6 µg/L), Metolachlor ESA (1 samples, 0.4 µg/L), and Metolachlor OA (1 sample, 0.2 µg/L).

Till Capped Fan Setting



The **Till Capped Fan** setting consists of a thin to thick cap of silt loam till atop thin to very thick sequences of sand and gravel. The principal aquifers in this setting are the various sand and gravel units below the till cap. The depth to water is shallow due to perching on the fine-grained capping units.

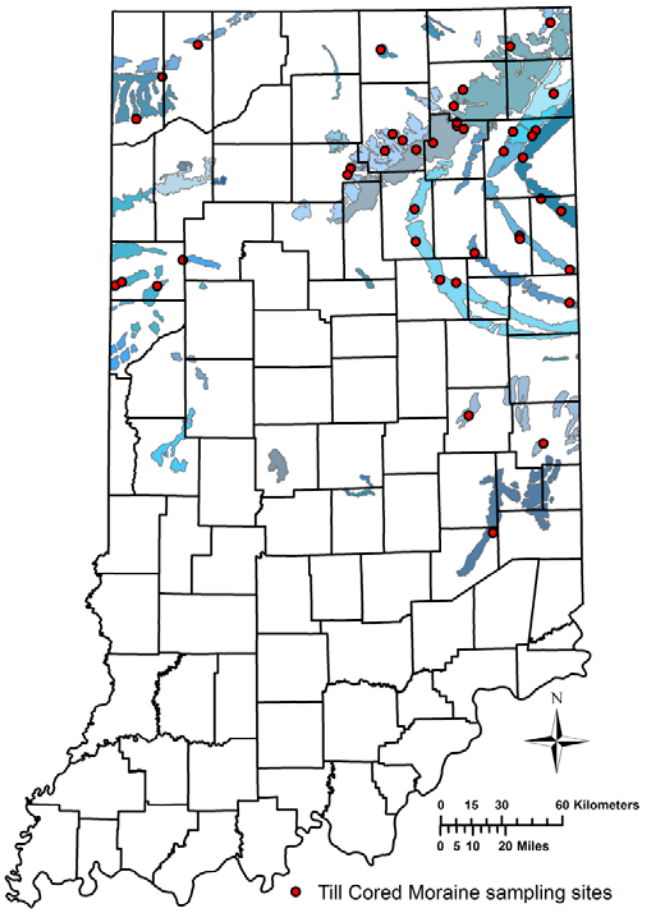
For Sampling Round 6 of the Ground Water Monitoring Network, 9 samples were collected in the Till Capped Fan setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (33.1 mg/L average concentration), Ca (89.3 mg/L), Na (46.8 mg/L), K (3.5 mg/L), SO_4 (61.9 mg/L), and Cl^- (46.5 mg/L).

Arsenic was detected in three (around 33%) of the Round 6 samples from the Till Capped Fan setting, including one sample that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Till Capped Fan setting, the highest average arsenic concentrations were found in samples from low sensitivity areas (15.15 µg/L average). The highest average concentrations were also found in wells screened from 100 to 150 ft below the ground surface (8.15 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (6.4 µg/L) than aquifers under oxidizing conditions (1.4 µg/L).

Nitrate was detected in four (around 44%) of the Round 6 samples from the Till Capped Fan setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Till Capped Fan setting, the highest average nitrate concentrations were found in samples from the Cultivated Crops land-use (0.81 mg/L average) and in well screened between 100 to 150 ft below the ground surface (1.04 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (1.4 mg/L) than aquifers under reducing conditions (0.008 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in six of the samples from the Till Capped Fan setting (67%). **Pesticide Degradates** of Acetochlor, Alachlor, and Metolachlor were not detected in these samples.

Till Cored Moraine Setting



The **Till Cored Moraine** setting consists of morainal ridges typical cored by loam till and till-like sediments. The morainal sediments range between 25 and 75 ft thick and commonly overlie a zone of fairly thick outwash. Aquifers are generally limited to confined sand and gravel units below the till, as well as the limestone or sandstone bedrock.

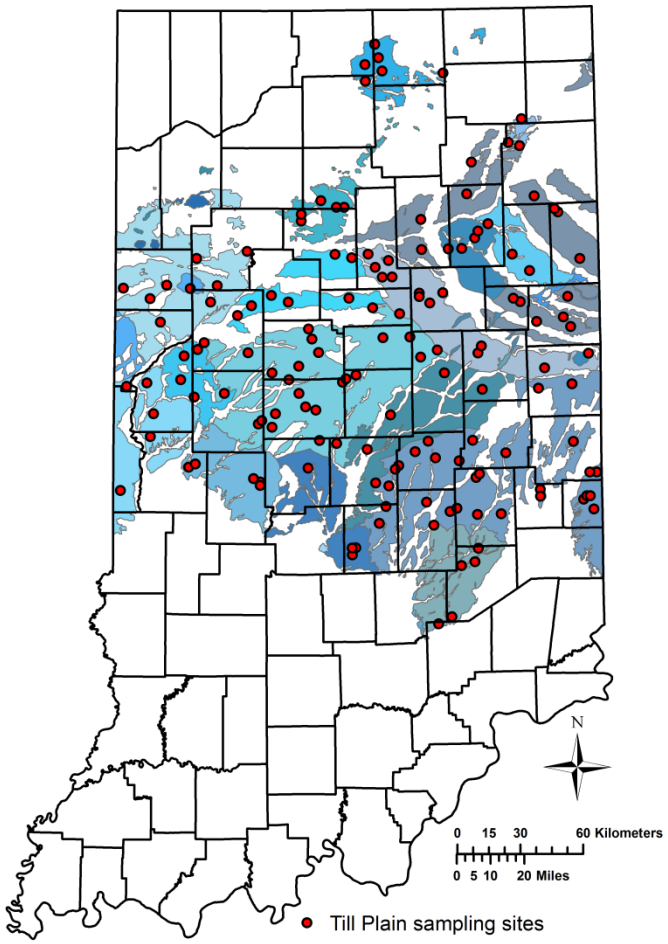
For Sampling Round 6 of the Ground Water Monitoring Network, 42 samples were collected in the Till Cored Moraine setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sulfate and sodium/potassium types. Major anions and cations detected in this setting include: Mg (50.5 mg/L average concentration), Ca (103.6 mg/L), Na (32.1 mg/L), K (2.3 mg/L), SO_4 (180.2 mg/L), and Cl^- (15.4 mg/L).

Arsenic was detected in 20 (around 45%) of the Round 6 samples from the Till Cored Moraine setting, including two samples (5%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Till Cored Moraine setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (3.5 µg/L average vs. 2.0 µg/L average for bedrock wells). The highest average concentrations were found in wells screened more than 150 ft below the ground surface (4.1 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (3.43 µg/L) than aquifers under oxidizing conditions (1.58 µg/L).

Nitrate was detected in nine (around 20%) of the Round 6 samples from the Till Cored Moraine setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Till Cored Moraine setting, the highest average nitrate concentrations were found in samples from wells screened less than 50 ft below the ground surface (1.4 mg/L average).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in 37 of the samples from the Till Cored Moraine setting (84%). **Pesticide Degradates** were found in several samples, including Alachlor ESA (3 samples, 0.3 µg/L max) and Metolachlor ESA (3 samples, 1.6 µg/L max).

Till Plain Setting



The **Till Plain** general hydrogeologic setting is a vast region of predominantly low relief that covers virtually all of central Indiana. Sediments are typified by several till-dominated sequences deposited during numerous glacial events. Ground water is present in unconsolidated or bedrock aquifers at depths ranging from less than 30 ft to hundreds of feet. Most aquifers in the central Till Plain are confined or semi-confined.

For Sampling Round 6 of the Ground Water Monitoring Network, 151 samples were collected in the Till Plain setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sulfate and sodium/potassium types. Major anions and cations detected in this setting include: Mg (32.9 mg/L average concentration), Ca (82.2 mg/L), Na (32.7 mg/L), K (1.5 mg/L), SO_4 (56.1 mg/L), and Cl^- (16.1 mg/L).

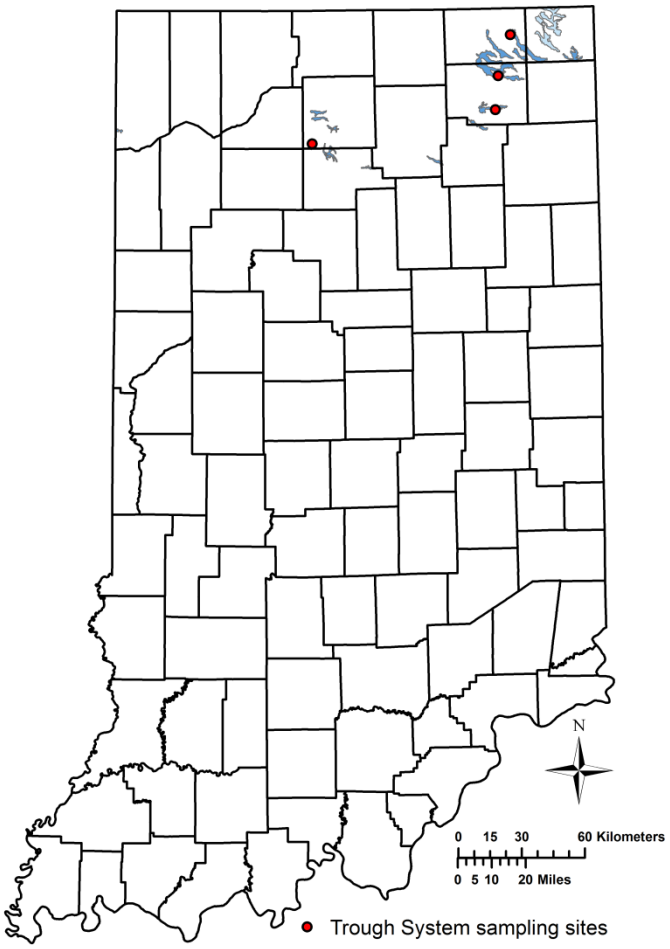
Arsenic was detected in 67 (around 44%) of the Round 6 samples from the Till Plain setting, including 25 samples (17%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Till Plain setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (5.8 µg/L average vs. 3.9 µg/L average for bedrock wells). The highest average concentrations were found in wells screened from 100 to 150 ft below the ground surface (8.5 µg/L). Areas of low and variable aquifer sensitivity contained a higher average arsenic concentration (5.6 and 6.6 µg/) than high sensitivity areas (3.7 µg/L average). Aquifers that were under reducing conditions had a higher average arsenic concentration (5.88 µg/L) than aquifers under oxidizing conditions (1.24 µg/L).

Nitrate was detected in 40 (around 26%) of the Round 6 Samples from the Till Plain setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Till Plain setting, the highest average nitrate concentrations were found in samples from unconsolidated wells (0.20 mg/L average vs. 0.14 mg/L average for bedrock wells), and in wells screened less than 50 ft below the ground surface (0.59 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (0.97 mg/L) than aquifers under reducing conditions (0.04 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in 121 of the samples from the Till Plain setting (80%).

Pesticide Degradates were found in several samples, including: Acetochlor OA (1 sample, 0.2 µg/L max), Alachlor ESA (7 samples, 0.6 µg/L max), Alachlor OA (1 sample, 1.4 µg/L max), Metolachlor ESA (3 samples, 0.6 µg/L max), and Metolachlor OA (4 samples, 0.3 µg/L max).

Trough System Setting



The **Trough System** setting consists of entrenched troughs of various lake sediments within morainal areas that range in width from 500 ft to 2 miles. The depth to water tends to be shallow in these areas (less than 5 ft).

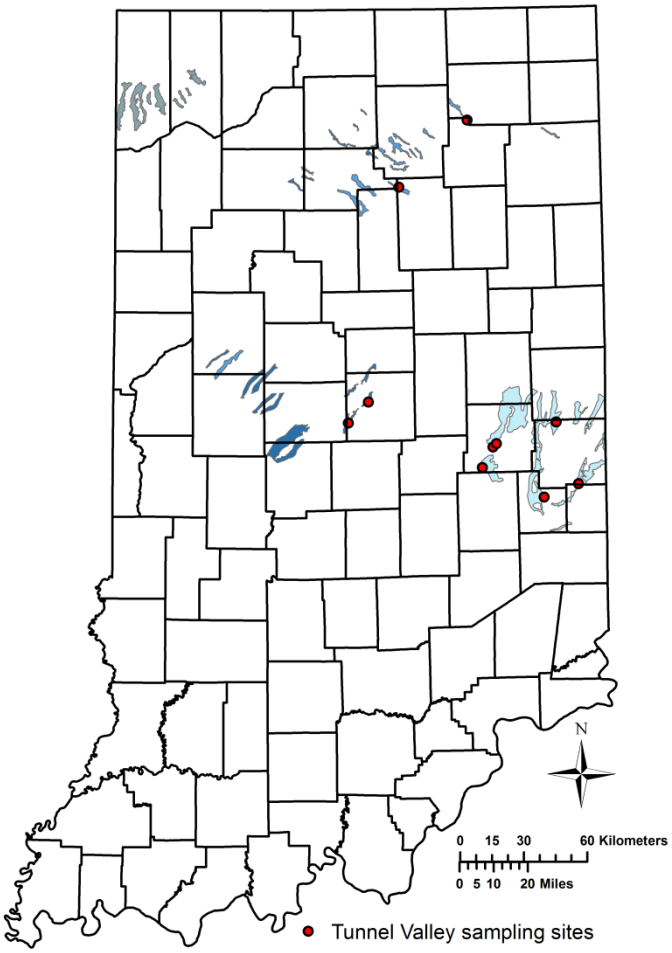
For Sampling Round 6 of the Ground Water Monitoring Network, four samples were collected in the Trough System setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**, with some sodium/potassium types. Major anions and cations detected in this setting include: Mg (17.3 mg/L average concentration), Ca (56.5 mg/L), Na (46.1 mg/L), K (1.3 mg/L), SO_4 (29.6 mg/L), and Cl^- (12.4 mg/L).

Arsenic was detected in one (25%) of the Round 6 samples from the Trough System setting, at a concentration that did not exceed the U.S. EPA's Maximum Contaminant Level (10 µg/L).

Nitrate was detected in one (25%) of the Round 6 samples from the Trough System setting, at a concentration that did not exceed the U.S. EPA's MCL (10 µg/L).

Iron was found above the U.S. EPA's Secondary MCL (0.3 mg/L) in two of the samples from the Trough System setting (50%). **Pesticide Degradates** for Acetochlor, Alachlor, and Metolachlor were not observed in these samples.

Tunnel Valley Setting



Tunnel Valleys are melt water discharge channels which formed at the base of the ice sheet and carried away melt water and deposits to the front of the glacier. Tunnel valleys may possess a highly variable sequence of deposits ranging from thick sand and gravel at one location and thick till only a short distance away. Vulnerability to ground water contamination can be highly variable within a tunnel valley depending upon the nature of deposits along that length.

For Sampling Round 6 of the Ground Water Monitoring Network, 10 samples were collected in the Tunnel Valley setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (30.2 mg/L average concentration), Ca (88.1 mg/L), Na (16.0 mg/L), K (1.7 mg/L), SO_4 (24.7 mg/L), and Cl^- (18.7 mg/L).

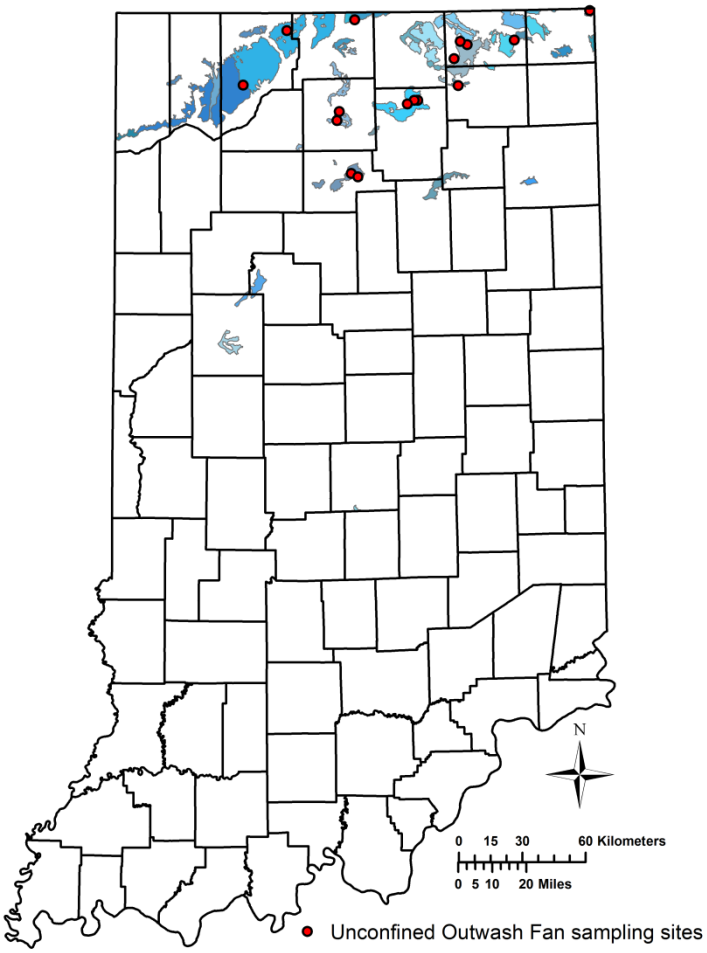
Arsenic was detected in four (40%) of the Round 6 samples from the Tunnel Valley setting, including one sample (10%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Tunnel Valley setting, the highest average arsenic concentrations were found in samples from unconsolidated wells (5.1 µg/L average vs. 1.67 µg/L average for bedrock wells). The highest average concentrations were found in wells screened from 50 to 100 ft below the ground surface (5.62 µg/L). Aquifers that were under reducing conditions had a higher average arsenic concentration (5.4 µg/L) than aquifers under oxidizing conditions (non-detect).

Nitrate was detected in three (30%) of the Round 6 samples from the Tunnel Valley setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Tunnel Valley setting, the highest average nitrate concentrations were found in samples from bedrock wells (1.73 mg/L average vs. 0.016 mg/L average for unconsolidated wells). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (1.73 mg/L) than aquifers under reducing conditions (0.016 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in eight of the samples from the Tunnel Valley setting (80%).

Several **Pesticide Degradates** were found, including Acetochlor OA (1 sample, 0.3 µg/L) and Alachlor ESA (1 sample, 0.2 µg/L).

Unconfined Outwash Fan Setting



Unconfined Outwash is a generic term referring to surficial sand and gravel outwash deposits which have no limiting clay or till cover restricting infiltration. These deposits are generally found along valley train sluiceways and outwash plain settings and on unconfined fan and fan head settings. Outwash deposits relatively close to the source of the meltwater is commonly quite coarse grained (sand and abundant gravel), whereas outwash deposited farther from the ice source is often fine grained (sand and lesser gravel). All these deposits are highly permeable and are vulnerable to surficial contamination.

For Sampling Round 6 of the Ground Water Monitoring Network, 16 samples were collected in the Unconfined Outwash Fan setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (22.6 mg/L average concentration), Ca (78.8 mg/L), Na (19.7 mg/L), K (1.2 mg/L), SO_4 (47.6 mg/L), and Cl^- (30.0 mg/L).

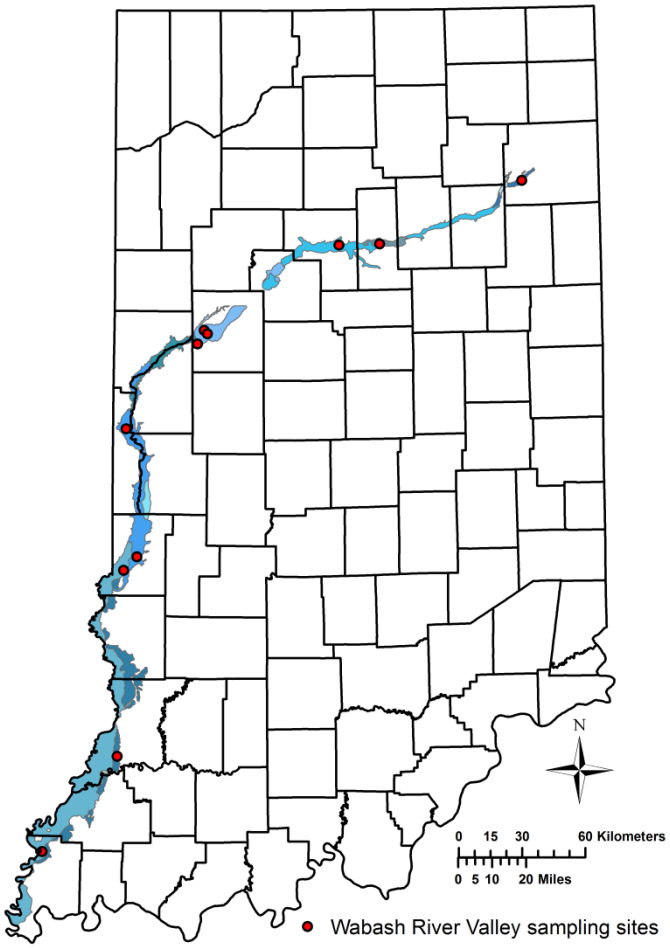
Arsenic was detected in eight (50%) of the Round 6 samples from the Unconfined Outwash Fan setting, including one sample (6%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Unconfined Outwash Fan setting, the highest average arsenic concentrations were found in wells screened from 50 to 100 ft and 100 to 150 ft below the ground surface (5.66 and 5.2 µg/L, respectively). Aquifers that were under reducing conditions had a higher average arsenic concentration (4.96 µg/L) than aquifers under oxidizing conditions (non-detect).

Nitrate was detected in six (around 38%) of the Round 6 samples from the Unconfined Outwash Fan setting; none exceeded the U.S. EPA's MCL (10 µg/L). In the Unconfined Outwash Fan setting, the highest average nitrate concentrations were found in were found in wells screened from 50 to 100 ft and 100 to 150 ft below the ground surface (0.35 and 0.62 mg/L, respectively). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (0.85 mg/L) than aquifers under reducing conditions (0.27 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in 13 of the samples from the Unconfined Outwash Fan setting (81%).

Several **Pesticide Degradates** were detected, including: Alachlor OA (1 sample, 1.8 µg/L), and Metolachlor ESA (1 sample, 1.2 µg/L).

Wabash River Valley Setting



The **Wabash River Valley** is the largest and longest glacial sluiceway/outwash plain system within Indiana. The Wabash River Valley has thick deposits of sand and gravel along its length with shallow bedrock outcropping at several areas as well. The Wabash River Valley is a major ground water discharge point for vast areas of Indiana and is a very significant ground water resource.

For Sampling Round 6 of the Ground Water Monitoring Network, 11 samples were collected in the Wabash River Valley setting. The water type in this setting is dominated by **calcium** and **bicarbonate-types**. Major anions and cations detected in this setting include: Mg (32.7 mg/L average concentration), Ca (100.8 mg/L), Na (13.7 mg/L), K (5.6 mg/L), SO_4 (53.8 mg/L), and Cl^- (15.4 mg/L).

Arsenic was detected in two (around 18%) of the Round 6 samples from the Wabash River Valley setting, including one sample (9%) that exceeded the U.S. EPA's Maximum Contaminant Level (10 µg/L). In the Wabash River Valley setting, the highest average arsenic concentrations were found in samples from bedrock wells (10.43 µg/L average vs. non-detect for unconsolidated wells). The highest average concentrations were found in wells screened from greater than 100 ft below the ground surface. Aquifers that were under reducing conditions had a higher average arsenic concentration (6.2 µg/L) than aquifers under oxidizing conditions (1.38 µg/L).

Nitrate was detected in seven (around 64%) of the Round 6 samples from the Wabash River Valley setting, including two samples (18%) that exceeded the U.S. EPA's MCL (10 µg/L). In the Wabash River Valley setting, the highest average nitrate concentrations were found in samples from unconsolidated wells (6.9 mg/L average vs. 0.006 mg/L average for bedrock wells), and in well screened less than 50 ft below the ground surface (8.52 mg/L average). Aquifers that were under oxidizing conditions had a higher average nitrate concentration (6.36 mg/L) than aquifers under reducing conditions (3.4 mg/L).

Iron was also found above the U.S. EPA's Secondary MCL (0.3 mg/L) in four of the samples from the Wabash River Valley setting (36%). The **Pesticide Degradate** Metolachlor ESA was found in one sample at a concentration of 0.8 µg/L.