UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

To: Well files
IN-165-6A-0001, WVCCS#1, Vermillion County, Indiana
39.624411, -87.488658

IN-167-6A-0001, WVCCS#2, Vigo County, Indiana
39.551033, -87.487944

From: Marc Fisher, UIC Branch

Re: Summary of Geology and MIP Calculations

Date: May 31, 2023

In accordance with 40 CFR 146.22(a) and 146.82, EPA reviewed site geology to determine that the wells are sited in such a fashion that they can inject into a formation which is separated from any USDW by a confining zone that is free of known open faults or fractures within the area of review, identification of confining and injections zones and calculation of surface and injection zone maximum injection pressures (MIPs).

EPA Action

EPA received an application to permit two Class VI UIC wells for geosequestration of carbon dioxide from Wabash Carbon Services, LLC (WCS). The wells are proposed to be constructed upon permit issuance in Vermillion and Vigo Counties, Indiana. EPA's action is to approve or deny a permit based on reviewing the proposed construction and operating conditions for suitability for this type of injection well.

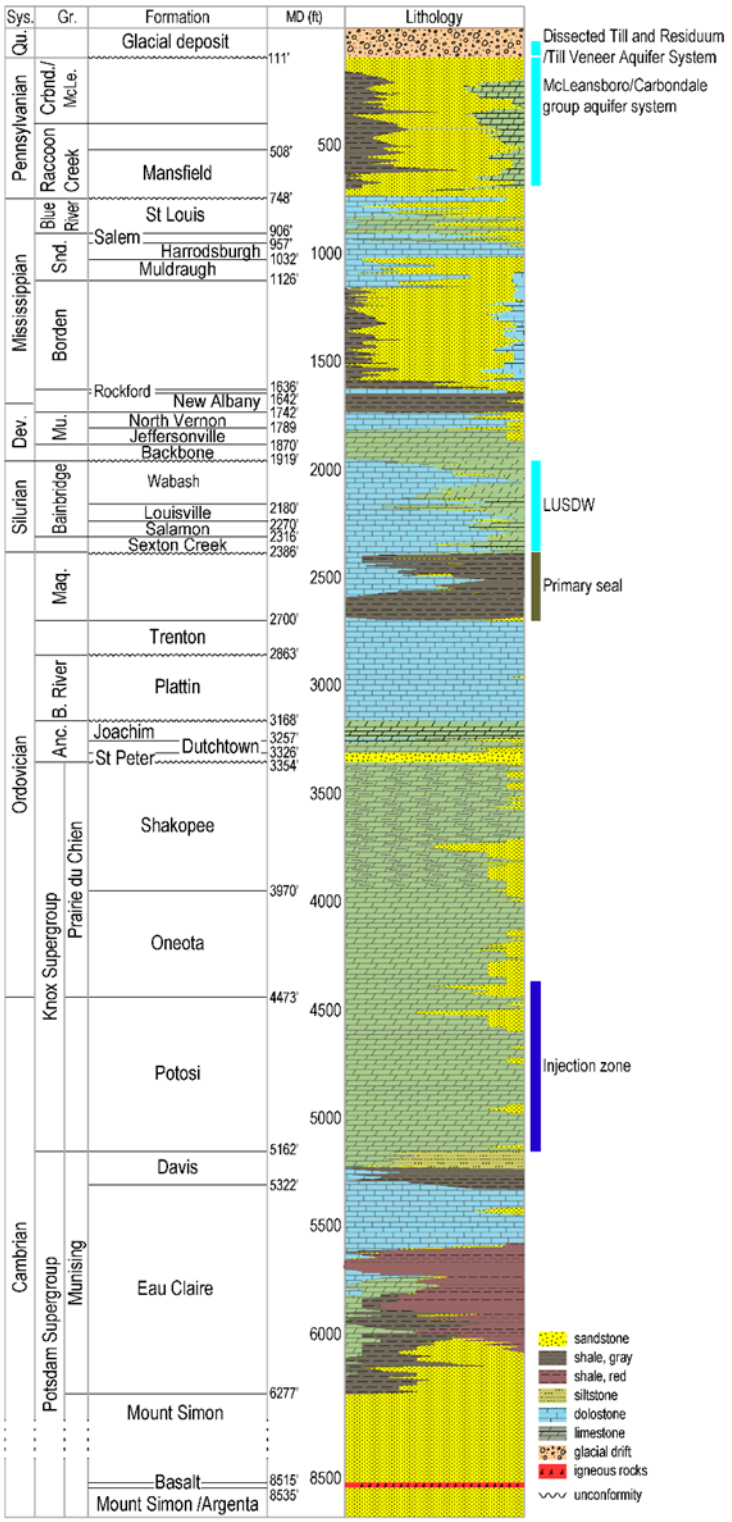
Evaluation

EPA considered reviewed the geology and modeling documents submitted by the applicant along with regional geologic publications pertinent to this action. Materials reviewed:

- Bedrock Aquifer Systems of Vermillion County, September 2009, IDNR, Division of Water, Resources Assessment Section;
- Bedrock Aquifer Systems of Vigo County, September 2009, IDNR, Division of Water, Resources Assessment Section;
- Generalized Stratigraphic Column of Indiana Bedrock, ISGS, 2016;
- Environmental Geology of Vigo County – An Aid to Planning, 1983, Special Report 31, Environmental Study 18, ISGS;
- Multiple resources from Indiana Interactive GISMap, ISGS; and
- USGS Earthquake Hazard Maps and Recorded Seismic Events.

Geology

The proposed well locations are within the Illinois Basin and are characterized by this geologic stratigraphic column showing the confining and injection zones and Underground Sources of Drinking Water (USDWs):



The injection zone is considered to be both the Oneota and Potosi Formations. The Oneota Formation consists predominantly of fine-to medium-grained dolomite but includes chert and, particularly near its base in some places, sporadic quartz sand and thin interbeds of

green shale. In the test well conducted by WCS, the Oneota Dolomite is a primarily carbonate with a few interbedded shale intervals.

The Potosi Dolomite is a relatively pure dolomite unit that conformably overlies and underlies, respectively, the relatively impure Franconia and Eminence formations (in Illinois). Throughout Indiana, and observed at the WCS test well, the dolomitic upper Franconia, Potosi, and Eminence stratigraphic units cannot easily be differentiated with confidence; thus, in Indiana the Potosi is recognized as a combined stratigraphic unit comprising these three units.

Generally, the Potosi is a fine to coarsely crystalline, commonly dense, dolomite, but contains characteristic drusy quartz and intercalations of vugular, brecciated, fractured, and/or cavernous intervals. The pore spaces are generally lined with diagenetic quartz, calcite, or dolomite. The following tables summarizes the geologic units:

Overlying Zone	Formation Thickness (ft)	Depth MD (ft)	Avg. Porosity (%) derived from logs	Estimated Avg. Permeability (mD)	Shale Thickness (ft)	Cumulative Shale Thickness (ft)
Maquoketa Group	314	2,386	3.0	0.0001	314	314
Trenton Limestone	163	2,700	1.3	0.00000273	3.5	317.5
Platteville Group	379	2,863	1.2	0.00000475	16	333.5
Dutchtown Limestone	84	3,242	2.8	0.0000840	70.5	404
St. Peter Sandstone	28	3,326	4.0	0.0039	3.5	407.5
Shakopee Dolomite (upper)	346	3,354	2.8	0.022360406	101	508.5
Shakopee Dolomite (lower)	270	3,700	9.1	0.098032	71	579.5

Injection zone	Formation Thickness (ft)	Depth MD (ft)	Avg. Porosity %	Avg. Permeability mD	Reservoir Thickness (ft)
Oneota Dolomite	408	3,970	7.1	2.585488	408 (porosity not differentiated by depth)
Potosi Dolomite	784	4378	30 for tested interval (4,505 to 4,525 ft)	24,000 mD-ft over 10 ft (2,400 mD) from early short well test* Later and longer well tests suggest 45,000 mD or higher.	Total of 149.5 ft greater than 10% porosity

Model results indicate that the injected carbon dioxide pressure and saturation front will move up into the Oneota Formation (approximately 95 feet) from the injection interval in the Potosi Formation (from 4396 to 5037 feet bgs).

The lowest geologic units considered to be USDWs is the Silurian System that includes the Bainbridge Group (Wabash, Louisville, and Salamon Formations) and the Sexton Creek Formation with depth ranging from 1,919 to 2,386 feet bgs.

The Maquoketa Group is a massive shale unit with low permeability that directly underlies the lowest USDW. Based upon its proximity to the injection zone, the Shakopee Formation is identified as the lowest geologic unit with confining properties. It has relatively low permeability and has many interbedded shale units within the carbonate layers (172 total feet of shale interbeds).

MIP Calculations

The MIP for carbon dioxide injection and sequestration is derived from the following equation:

{Depth to Top of Injection Zone * fracture gradient} * 90% (per 40 CFR 146.88(a))

{3,970 ft (top of Oneota) * 0.71 (measured fracture gradient)}* 0.90 = **2,537 psig**

The following equation was used to derive the maximum surface injection pressure (to ensure that the MIP at depth isn't exceeded):

Conversion factors and variables:
2.3 Feet H2O = 1 PSIG
H2O = 1000 Kg/M3
Supercritical CO_2 = 712 Kg/M3

712/1000 = Supercritical CO_2 is 0.712 (71.2%) of H_2O Density

2.3 ft H_2O/0.712= 3.2 Feet CO_2 per PSIG

3,970ft (top IZ)/ 3.2 Feet CO_2 per psig = 1,241 psig static head
2,537 psig maximum downhole pressure - 1,241 psig static head = **1,296 psig surface wellhead**

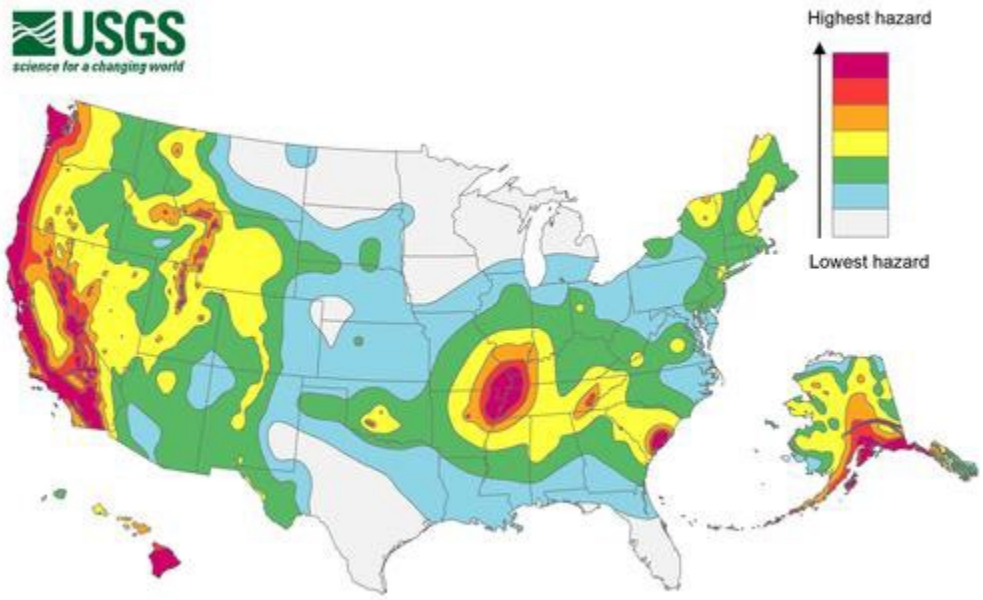
Fractures, Faults and Seismic Potential

For a detailed discussion of faults and fractures, please refer to the document 146.82a_Narrative Template.doc pages 20 through 24.

Based upon the WCS test hole, the Maquoketa Group and the upper portion of the Shakopee Formation are free of faults and fractures that cross contacts between geologic formations and that could potentially expose the lowest USDW to potential fluid migration. Additionally, between the top of the injection zone (Oneota Formation at 3970 ft bgs) and the bottom of the lowest USDW (Sexton Creek Formation bottom at 2386 ft bgs) there is 1,586 feet of rock (alternating carbonates and shales, with minor sandstone layers) of the Maquoketa Group, Trenton Limestone, Platteville Group, Dutchtown Limestone, St. Peter Sandstone, and Shakopee Dolomite.

Occurrence of earthquakes magnitude 3.0 Mw and larger in central Indiana are typically rare. Since 1817 there have been only 44 recorded seismic events greater than 3.0 Mw in the State of Indiana. Using the USGS tools available online, a search was done for all seismic activity greater than intensity 2.5 for an area ~100 miles from the injection location in the last 20 years. Eighty seismic events were recorded for this time period. These earthquakes are summarized in 146.82a_Narrative Template.doc Tables 10 and 11 on pages 57 through 59.

The USGS seismic hazard maps indicate the area around WCS facility and the AoR to be less than 20% (Peak acceleration expressed as a percent of gravity (%g) based on the 2018 USGS Long-Term Seismic Hazard Map (depicted below). There is a 2% probability that the Peak Ground Acceleration due to seismic activity would approach 13% G within 50 years (USGS, 2014; based on 2014 long-term model. The relative seismic risk at the site conveyed by the blue-green colors is considered to be on the lower half of the seismic hazard color scale.



Determination

Based on the above-listed information, EPA found that the confining zone is free of known open faults or fractures in the Area of Review. We also find that the potential for seismicity is negligible in the area surrounding the well, so the well is unlikely to be negatively affected by seismic activity. The Area of Review for the wells is without known large-scale, regional geologic faults or fractures, and is therefore unlikely to allow the transmission of fluids through fractures in the area or in the designated confining zone. We also find that the well is not associated with any of the components that may contribute to induced seismicity.