

**MEMO**

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**From:** Andrea McGill, P.G. *ACM* 1/4/24  
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**Through:** Susan Price, P.G. *SGP* 1/4/24  
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**Date:** January 4, 2024

**Re:** Geological Review of UIC Disposal Application  
Catalyst Energy, Inc  
Lot 580-1 Well, API 083-46237  
McKean County, Keating Township

### **Introduction**

This technical review assesses the suitability of the geologic structure and setting for waste disposal via injection into the Lot 580-1 gas well in Keating Township, McKean County, Pennsylvania, owned and operated by Catalyst Energy, Inc (Catalyst). The conclusions of this report are based on a review of all documents submitted by Catalyst, published maps and reports from the DCNR and others, and my experience as a licensed professional geologist.

### **Background**

The Lot 580-1 well (API # 083-46237) was originally drilled in 1990 by Belden and Blake (original operator) as a gas well to a Total Depth of 5,420 ft targeting the Onondaga Formation with perforations from 5170 to 5188 ft. The last recorded production from this well was in 2007.

### **Review Process**

Catalyst submitted a permit application to the Department of Environmental Protection (DEP) on May 4, 2023. The purpose of the application is to change the use of the Lot 580-1 well from a conventional gas well to a disposal well. In accordance with the 25 Pa. Code, Chapter 91.51, DEP Licensed Professional Geologists conducted a geologic review of the change of use application, the EPA permit and its accompanying materials, and additional geological information requested by the DEP from Catalyst including information on the potential for induced seismicity. Numerous GIS layers were reviewed as well, which include: Oil and Gas Wells, Gas Storage Fields, Public Water/PAGWIS, Mining, Geology Basement Contours, and Pennsylvania Faults and Earthquakes.

### **Geologic Setting and Structure**

The well lies within the Appalachian Plateau Physiographic Province. Mapping indicates the closest earthquake to the well occurred in 1995, approximately 25 miles away. Precambrian basement rocks are found approximately 6,000 feet below the base of the deepest injection formation, the Middle Devonian Onondaga Limestone. No wells in the area of review (AOR) penetrate the Precambrian basement. Any faulting in the Precambrian basement is not expected to be of concern at this location.

### **Water and Groundwater Resources**

The Lot 580-1 well is located within the Deep Valleys Section of the Appalachian Plateau Physiographic Province. The closest drinking water well identified in the EPA application was drilled to a Total Depth of 172 ft. and produces water from the Pennsylvanian Pottsville Formation. According to the EPA UIC application the base of the underground sources of drinking water (USDW) is estimated at 350 ft. based on the depth of the drinking water wells in the area and regional hydrogeological conditions. An additional seven private water wells were identified in the DEP application within 1000 feet of the Lot 580-1 well.

The surface casing of the Lot 580-1 well extends to a depth of 425.9 ft, approximately 75 ft. below the base of the USDW. The injection interval, the Onondaga formation, is overlain by confining layers of predominantly Middle and Upper Devonian shales with an approximate thickness of 4,500 ft. which provides sufficient separation between the USDW and the Onondaga.

Given the distances and depths, and absent any mechanical integrity issues of the Lot 580-1, the private water supplies are unlikely to be affected from the associated UIC activities. However, because domestic use water wells are within the quarter mile AOR, additional monitoring is warranted. The Catalyst Amoco-Witco 1 (API # 083-30629) is located approximately 1,000 ft southeast and proposed as a monitoring well for the injection formation. The well was drilled in 1974 to a depth of 7015 ft, plugged back to 6448 ft and perforated from 5184 to 5270 ft in the Onondaga Formation. I recommend implementing the monitoring of the Amoco-Witco 1 well outlined in the permit condition in Appendix C.

### **Potential Migration Pathways**

The area is historically rich with shallow oil and gas wells. There are several wells within the 1/4 -mile AOR drilled to the Upper Devonian Bradford Sands. Based on well logs and historical records of the stratigraphy, the base of the Bradford Sands is separated from the Onondaga formation by approximately 3,000 feet of predominately shale confining layers.

The base of the injection formation, the Onondaga Reef Formation, is separated from the brittle crystalline basement rock by approximately 6,000 feet. The Bass Island, Salina, and Queenston formations all act as confining layers between the Onondaga formation and the basement rock. These confining layers should prevent downward migration of fluids into the layers below the Onondaga.

Additionally, the Enervest Lot 581 ON-1 well (API # 083-40667) located within the 1/4 – mile AOR, must be drilled out and (re) plugged or converted to a monitoring well prior to injection

commencing. The specific permit condition addressing this well listed in Appendix B should be implemented.

There are no underground mines or underground gas storage fields within a mile of the well that could potentially transmit fluid.

There are no local mapped faults or lineament with the 1-mile buffer zone that could potentially transmit fluid.

### **Seismic Review**

A review of the well location was completed to determine the risk of induced seismicity from injection of fluid into the Onondaga Reef Formation. The following factors indicate that this location has a low risk of induced seismicity:

1. Because the Onondaga Formation is a depleted reservoir, the reservoir pressure will be low.
2. The Onondaga Formation is approximately 6,000 feet above the Precambrian basement rock with several confining layers in between. Studies, including the *Potential Injection-Induced Seismicity Associated with Oil & Gas Development: A Primer on Technical and Regulatory Considerations Informing Risk Management and Mitigation* (Second Edition, 2017) indicate that larger, potentially damaging induced seismic events are often associated with movement along faults in the basement rock. According to Hincks et al., “the injection depth above the crystalline basement was the most important parameter when considering the potential for release of seismic energy” (*Oklahoma’s induced seismicity strongly linked to wastewater injection depth*, SCIENCE, 1 Feb 2018).
3. There are no known faults within the 1-mile buffer zone, or any other structural geologic features of concern.
4. No reported earthquakes were identified within McKean County. The closest reported earthquake was in Warren County, a 2.4 magnitude earthquake in 1995. This earthquake was approximately 25 miles away from the Lot 580-1 well location and is not considered a seismically active area.
5. The applicant has demonstrated that the Onondaga formation is geologically suitable for injection and that injection pressures will be below the fracture gradient of the formation.
6. Case studies in other states have indicated that large volumes of fluid over 100,000 bbls/month are more likely to cause induced seismicity. According to Weingarten et al., “One previous study...found that earthquakes are commonly found near wells injecting more than 150,000 barrels per month.” Weingarten et al. indicates that wells operating at maximum injection rates less than 100,000 bbl/month “mostly fall within the bounds of random association” (*High-rate injection is associated with the increase in U.S. mid-continent seismicity*, SCIENCE, 19 June 2015). In this case, the injection volume will not exceed 100,000 bbls/month.

This geologic review has not revealed indicators suggestive of a heightened potential for induced seismicity; however it is recommended that to better understand the response of the Onondaga

Formation to injection fluids and to best manage any seismic risk, the application of the specific permit conditions addressing seismic monitoring and mitigation listed in Appendix A should be implemented.

### **Conservation Law**

The Lot 580-1 well was originally drilled and permitted as a Conservation Well. Pursuant to Section 4 of the Conservation Law, waste of oil and gas is prohibited. During my review of the change of use application, DEP requested Catalyst provide evidence the well will not be wasting oil and gas pursuant to the law.

Catalyst provided a response along with a graph showing gas decline curves for both the Lot 580-1 well and the Amoco-Witco #1 well (monitoring well) “consistent with reservoirs near their economic limit. When wells reach their economic limit, they can no longer be operated profitably, and the pool is deemed depleted.” The gas decline curves matched production reports I evaluated for both wells.

“Catalyst is the sole owner of the once productive wells in this pool. Additionally, Catalyst owns 100% of the mineral rights for this pool. Thus, we would not be limiting third-party operators from producing from this pool”.

Catalyst concluded with these 4 additional responses:

In addition to the saleable gas as alluded to in the conservation law, we have a few comments regarding the other aspects of section 4

*Prohibitive is: Permitting the migration of oil, gas or water from the stratum in which it is found to other strata, if such migration would result in the loss of recoverable oil or gas, or both;*

**Catalyst’s Response:** The injection well has three strings of casing that were cemented. These cemented strings were placed to inhibit the migration of fluids from the Onondaga to other strata.

*C. The unnecessary or excessive surface loss or destruction of oil or gas:*

**Catalyst’s Response:** Catalyst’s facility has been designed to prevent the unnecessary or excessive surface loss or destruction of oil or gas

*D. The inefficient or improper use, or unnecessary dissipation of reservoir energy.*

**Catalyst’s Response:** The Catalyst injection well was depleted by previous operators. The fluids permitted by the DEP for injection will not dissipate reservoir energy.

*(ii) The drilling of more wells than are reasonably required to recover, efficiently and economically, the maximum amount of oil and gas from a pool.*

**Catalyst’s Response:** The high flowrate that is characteristic of pinnacle reefs negates the need for dense drilling patterns.

### **Conclusions and Recommendations**

The Lot 580-1 well proposes to inject into the Onondaga Formation, which is approximately 6,000 ft above basement rock, and is not located within a mile of any mapped faults. Seismic risk of injection into the Onondaga Formation is therefore low. The Onondaga Formation is overlain by confining layers of predominantly Middle and Upper Devonian shales with an approximate thickness of 4,500 ft. which provides sufficient separation from the USDW.

There are several oil & gas wells within the 1/4 -mile AOR drilled to the Upper Devonian Bradford Sands. Based on well logs and historical records of the stratigraphy, the base of the

Bradford Sands is separated from the Onondaga formation by approximately 3,000 feet of predominately shale confining layers. The risk of fluid migration through known oil & gas wells to USDWs is therefore low.

Due to the low risk of fluid migration to USDWs and induced seismicity, operation of the Lot 580-1 well as a Class II disposal well is unlikely to be prejudicial to the public interest. However, to mitigate risks, and out of an abundance of caution, I recommend the special conditions outlined in Appendix A, B, and C to be included in the permit. I hold these opinions with a reasonable degree of scientific certainty.

#### **Appendix A.**

##### **Seismic Monitoring and Mitigation**

An operator must employ local seismic monitoring or rely on the Pennsylvania State Seismic Network (PASEIS), as currently configured, to continuously monitor for induced tectonic seismic events during injection activities.

##### **Special Permit Conditions if local seismic monitoring is chosen:**

The permittee shall prepare and implement a seismic Monitoring and Mitigation Plan. The seismic Monitoring and Mitigation Plan shall be submitted to the Department of Environmental Protection (“Department”) at least 30 days prior to the anticipated start date of disposal activities in an existing well. This plan, or the plan as modified by the Department, shall be fully implemented at the time disposal activities begin and thereafter and shall include the following components:

(1) Installation of a seismometer that, at minimum, includes the following:

a. One 3-component velocity sensor (X, Y, and Z axes), high-frequency seismometer or a local network consisting of a minimum of four high-frequency seismometers that have 3-component velocity sensors.

b. For purposes of this seismic Monitoring and Mitigation Plan, a “seismic event” shall mean circumstances which reflect tectonic seismic activity above the thresholds and within the distances set forth in Paragraphs (11) or (12) below.

c. For purposes of this seismic Monitoring and Mitigation Plan, an “Injection-Induced Seismic Event” shall mean circumstances which reflect seismic activity that may be directly attributable to the permitted injection activities. Raw seismic data gathered by the seismometer(s) described in (1) a. will be processed to calculate event location (epicenter/hypocenter) and magnitude. Events attributable to surface activities (such as, but not limited to, mining or blasting) or system noise will not be considered potential Injection-Induced Seismic Events.

d. If the one sensor option is chosen, and an Injection-Induced Seismic Event occurs at or above the thresholds specified in (11) c and d below, the operator will mobilize a local network consisting of a minimum of four (4) high-frequency seismometers that have 3-component velocity sensors within 48 hours of the event.

e. All seismometers shall be installed in accordance with the manufacturer’s instructions prior to operation of the disposal well.

(2) A description of and specification sheet for the seismometer installed at the disposal well site.

- (3) The installation of a recorder that, at a minimum, continuously records 100 samples per second using a data logger with 24-bit digitizer and Global Positioning System (GPS) timing, in accordance with the manufacturer's instructions prior to operation of the disposal well.
- (4) A description of and specification sheet for the seismic recorder installed at the disposal well site.
- (5) A description of the protocol for operating and completing calibration of the seismometer and seismic recorder installed at the disposal well site demonstrating that it conforms with the standards employed by the Pennsylvania State Seismic Network (PASEIS) and the manufacturer's instructions.
- (6) A description of the routine maintenance and service checks that will be implemented to monitor the operability or running condition of the seismometer and seismic recorder installed at the disposal well site. The description should detail how the checks satisfy the manufacturer's instructions.
- (7) Verification that tectonic seismic event data will be captured at the disposal well site electronically and in a manner that is suitable for tectonic seismic event recordation and analysis.
- (8) Verification that seismic data will be provided to the Incorporated Research Institutions for Seismology (IRIS) Network in real time and that the continuous, real time data conforms to the data format required by IRIS for archiving under PASEIS' network code (PE) and open distribution. If data transmission is interrupted, notification will be provided to the Department verbally within 24 hours and in writing within seven (7) days.
- (9) A description of measures that will be taken to install the seismometer in a manner that will minimize interference from background sources and allow for optimal Seismic Event identification and location (epicenter and hypocenter). This shall include a plan view map of proposed seismometer location(s).
- (10) Contact information for the responsible person in charge of conducting seismic monitoring activities at the disposal well site.
- (11) If the one sensor option is chosen, a tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:
  - a. Immediate electronic notification to the Department and the Department of Conservation and Natural Resources' Bureau of Topographic and Geologic Survey (BTGS) of detection of any measurable event, within six (6) miles measured radially from the disposal well.
  - b. Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department's statewide toll-free number in the case of seismic activity referenced in a. above will include filtering/processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).
  - c. Should an Injection-Induced Seismic Event occur (i.e., not a surface-related event or system noise), the Operator will reduce the well's operating injection rates. Reduction of the disposal well's operating injection rates in use at the time of the Injection-Induced Seismic Event by 50% within 48 hours of the occurrence of 3 or more consecutive Injection-Induced Seismic Events greater than 1.0 and less than 2.0 on the Richter Scale over a seven (7) day period occurring within three (3) miles measured radially from the disposal well. The seven (7) day period is defined as starting with the occurrence of any Injection-Induced Seismic Event of magnitude 1.0 or greater. Reduced operating injection rates shall be maintained until the Department provides written notice addressing injection rates.

d. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of magnitude 2.0 or greater within three (3) miles measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:

- i. Magnitude and frequency of events detected;
- ii. Operational history prior to the event and operating conditions at the time of the event (rates, volumes, pressures);
- iii. Any mitigation/intervention attempts made prior to termination of activities;
- iv. Ability of permittee to identify another potential source for the event based on data processing and analysis of conditions.

(12) If the local network option is chosen, a tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:

a. Immediate electronic notification to the Department and the BTGS of detection of any measurable event, within three (3) miles measured radially from the disposal well.

b. Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department's statewide toll-free number in the case of seismic activity referenced in a. above will include filtering/processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).

c. Should an Injection-Induced Seismic Event occur (i.e., not a surface-related event or system noise), the Operator will reduce the well's operating injection rates. Reduction of the disposal well's operating injection rates in use at the time of the Injection-Induced Seismic Event by 50% within 48 hours of the occurrence of 3 or more consecutive Injection-Induced Seismic Events greater than 1.0 and less than 2.0 on the Richter Scale over a seven (7) day period occurring within three (3) miles measured radially from the disposal well. The seven (7) day period is defined as starting with the occurrence of any Injection-Induced Seismic Event of magnitude 1.0 or greater. Reduced operating injection rates shall be maintained until the Department provides written notice addressing injection rates.

d. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of magnitude 2.0 or greater within two (2) miles measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:

- i. Magnitude and frequency of events detected;
- ii. Operational history prior to the event and operating conditions at the time of the event (rates, volumes, pressures);
- iii. Any mitigation/intervention attempts made prior to termination of activities;
- iv. Ability of permittee to identify another potential source for the event based on data processing and analysis of conditions.

(13) The permittee shall submit an updated seismic Monitoring and Mitigation Plan as needed or as may be required by the Department. Updates may be necessary in cases where the risk profile associated with injection activities changes. A signed and certified statement by a qualified professional person responsible for preparing the seismic Monitoring Plan that the plan is true and accurate and includes the components outlined above. The certification shall provide: "I, (insert name), hereby certify, under penalty of law as provided in 18 Pa.C.S. § 4904 (relating to

unsworn falsification to authorities) that I prepared the seismic Monitoring Plan for (insert facility name) and the information provided is true, accurate and complete to the best of my knowledge and belief.”

(14) Upon commencement of disposal activities at the disposal well, the permittee shall record tectonic seismic event data electronically in an appropriate format for analysis (event location and magnitude) and maintain daily records of tectonic seismic event data electronically for review at the request of the Department. Tectonic seismic event records must be maintained for one (1) year.

(15) The permittee shall maintain all calibration, maintenance and repair records for the seismometer for at least five (5) years.

(16) The permittee shall maintain all calibration, maintenance and repair records for the seismic recorder for at least five (5) years.

(17) The permittee may submit a summary report and plan for modification or discontinuation of the seismic Monitoring Plan five (5) years after injection activities commence. The Department’s review will be completed as soon as practicable after receipt of the summary report and a written response will be provided to the operator. DEP’s assessment of the report will be dependent on, but not limited to, the following criteria:

- a. Magnitude and frequency of any events during the monitoring period;
- b. Operational history during the monitoring period (rates, volumes, pressures);
- c. Planned operational conditions moving ahead (rates, volumes, pressures);
- d. Demonstration through pressure fall-off that system is at equilibrium and behaving in as a homogenous reservoir;
- e. Need for any mitigation/intervention during the monitoring period.

**Special Permit Conditions if the PASEIS option is chosen:**

(18) A tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:

- a. Immediate electronic notification to the Department and the BTGS of detection of any measurable event, within 6 miles (9.6 km) measured radially from the disposal well.
- b. Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department’s statewide toll-free number in the case of seismic activity referenced in a. above will include filtering/processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).
- c. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of magnitude 2.0 or greater within three miles (4.8 km) measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:
  - i. Magnitude and frequency of events detected;
  - ii. Operational history prior to the event and operating conditions at the time of the event (rates, volumes, pressures);
  - iii. Any mitigation/intervention attempts made prior to termination of activities;



- iv. Ability of permittee to identify another potential source for the event based on data processing and analysis of conditions. This analysis could include, but is not limited to, installation of a local network to provide additional monitoring of the area around the injection well.

### **Appendix B**

Injection operations are prohibited until the Permittee drills out and re-plugs well Lot 581 ON-1 (API No. 37-083-40667) and provides a Certificate of Well Plugging on form 8000-FM-OOGM0006 and it is reviewed and not denied by the Department, *or* until the Permittee converts well Lot 581 ON-1 (API No. 37-083-40667) to a monitoring well. If the well is converted to a monitoring well, the permittee shall obtain a permit to change its use. The Lot 581 ON-1 Well shall be open to the injection formation to allow for monitoring of injected fluid. Permittee shall monitor fluid levels in the Lot 581 ON-1 Well on a monthly basis and submit the monitoring data to the Department the month after it is obtained. Permittee shall stop disposal operations immediately and notify the Department's Oil & Gas Inspector verbally within twenty-four (24) hours and the Department's Program Manager in writing within seven (7) days if fluid levels are observed to rise to within 100 ft. of the base of the Underground Source of Drinking Water (USDW) identified in the EPA UIC permit application.

### **Appendix C**

Prior to initiating injection procedures, the permittee shall obtain a permit to change the use of the Amoco-Witco 1 (API # 083-30629) well to a monitoring well. Permittee shall monitor fluid levels on a monthly basis and submit the monitoring data to the Department the month after it is obtained. Permittee shall stop disposal operations immediately and notify the Department's Oil & Gas Inspector verbally within twenty-four (24) hours and the Department's Program Manager in writing within seven (7) days if fluid levels are observed to rise to within 100 ft. of the base of the Underground Source of Drinking Water (USDW) identified in the EPA UIC permit application.