UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

STATEMENT OF BASIS

FOR

U.S. EPA's UNDERGROUND INJECTION CONTROL (UIC) PROGRAM
DRAFT CLASS IID PERMIT NUMBER VAS2D957BDIC

FOR

EnerVest Operating, L.L.C
809 Happy Valley Drive
Clintwood, VA 24228

FOR

The renewal of a permit consisting of one Class IID injection well, P-205 ("Injection Well"), used for the disposal of produced fluids (brine) associated with coal bed methane and conventional gas production located at:

Nora Field, Ervinton District
Dickenson County, Virginia
Latitude 37º 05' 44"N Longitude -82º 16' 30"W

On April 5, 2017, EnerVest Operating, LLC ("the Permittee" or "EnerVest") submitted a UIC permit application for the renewal of a ten-year permit to continue operation of the above referenced Injection Well. On July 19, 2017, EPA sent a Notice of Deficiency (NOD) to EnerVest Operating, LLC requesting additional information. In response to the NOD, EnerVest supplemented the original application with additional information on November 17, 2017. The Permittee's April 5, 2017 and November 17, 2017 submittals are collectively referred to in this Statement of Basis as the "permit application". EPA has deemed the permit application complete.

Pursuant to the federal Safe Drinking Water Act, 42 U.S.C.§§ 300f et seq., and its implementing regulations, 40 CFR Parts 144-146, and § 147.1955, the EPA UIC Program is responsible for regulating, through the issuance of permits, the construction, operation, monitoring and closure of injection wells that place fluids underground for enhanced recovery of oil or natural gas or disposal. Today's draft permit specifies conditions for injection well construction, operation, monitoring, reporting, and plugging and abandonment which are specified so as to protect, and prevent the movement of fluids into, Underground Sources of Drinking Water (USDW). The Permittee's UIC project and the draft permit conditions specific to the project are described below:

Area of Review: Pursuant to the applicable regulations, 40 C.F.R. §§ 144.3 and 146.6(b), the "Area of Review" (AOR) is an area surrounding the project or a well which the applicant must first research then develop a program for corrective action to address any wells which penetrate the injection zone and which may provide conduits for fluid migration. Section 146.06 provides that the area of review for each injection well shall be determined according to either the zone of endangering influence (ZEI) or by a fixed radius. Permittee has proposed a one-quarter mile fixed-radius as the AOR around EnerVest Injection Well No. P-205. Based on the chemistry of the fluid to be injected, the hydrogeology of the location, population (including four surface owners within the AOR) and ground water use and dependence, as well as historical practices in the area (including the injection well's history of operation), EPA has determined that the one-quarter mile AOR is sufficient. The draft permit requires EnerVest to perform corrective action on any unplugged/abandoned wells that penetrate the injection zone within the Area of Review if they are identified at a future date.

Underground Sources of Drinking Water (USDWs): A USDW is defined by the UIC regulations as an aquifer or its portion which, among other things, contains a sufficient quantity of ground water to supply a public water system and which also contains fewer than 10,000 mg/l (milligrams per liter) Total Dissolved Solids, and which is also not an exempted aquifer. While the initial application for reissuance did not identify any USDW's in the area of the Injection Well, drilling records of nearby wells indicate finding fresh water at depths of 49 feet and 1,038 feet. The surface casing of the Injection Well extends from the ground surface to a depth of 2,218 feet. The construction of the Injection Well, as provided in the permit application, meets the requirements of 40 CFR §§ 146.22 and 147.1955.

Injection and Confining Zones: Injection of fluids for disposal is limited by the permit to the Weir Formation in the subsurface intervals between 4,512 feet and 4,542 feet. The Weir formation is approximately 540 feet thick at the injection site, from 4,404 feet to 4,948 feet. Injection will occur in the perforated interval mentioned above, between 4,512 feet and 4,542 feet. The confining zone located immediately above the injection zone, the Big Lime formation, is comprised of approximately 460 feet of dense carbonate (limestone). Multiple additional confining units of shale and other dense rock exist between the injection zone and the surface.

Well Construction: The Injection Well has an $8^{5/8}$-inch string of surface casing cemented from the surface to a depth of 2,218 feet. In addition, the permit application indicates that 4½ inch long-string casing was placed to a depth of 6,095 feet and cemented back to a depth of 3,420 feet as required by 40 C.F.R. § 147.1955(b)(5). In order to isolate the injection zone, a 50-foot cement plug on top of a set solid bridge plug was installed from 4,920 to 4,970 feet below surface. Injection will occur through a 2-inch tubing string installed to a depth of approximately 4,450 feet.

Maximum Injection Pressure: The maximum allowable surface injection pressure for the permitted operation will be 1,068 pounds/square inch (psi) and the maximum bottom-hole pressure will be 3,208 psi. These maximum pressures were developed using a specific gravity for the injection fluid of 1.095 and an injection well depth of 4,512 feet. If the specific gravity of the injection fluid is determined to be greater than 1.095, the Permittee must notify EPA. To inject such fluid, the Permittee must either lower the surface injection pressure so that the bottom-hole pressure of 3,208 psi is not exceeded, or dilutes the fluid so that its specific gravity is no greater than 1.095.

The maximum injection pressure has been calculated to prevent the initiation of new or the propagation of existing fractures in the injection zone during operation of the Injection Well. EPA uses Instantaneous Shut-In Pressure (ISIP) as the basis for determining maximum injection pressure limitations. ISIP represents the minimum downhole injection pressure required to hold cracks in rock open. By setting the maximum injection pressure limit, USDW's are protected as required by 40 CFR § 146.23(a).

The draft permit imposes a lower maximum injection pressure than the injection pressure allowed by the 2007 permit, based on a reevaluation of the maximum injection pressure calculation utilizing the fracture gradient value of 0.79 psi/ft. This fracture gradient value represents an average fracture gradient value of wells that penetrate the Big Lime formation within a one-mile radius of the Injection Well. The Injection Well and many other wells in the surrounding area were fractured using nitrogen foam. EPA evaluated the consistency of the nitrogen foam used in the fracturing by combining fracture gradient values for wells within a one-mile radius of the Injection Well with a table EnerVest provided to EPA in order to evaluate foam density.

The pressure limitation imposed by the draft permit is more conservative than the regulatory criteria of 40 C.F.R. §146.23(a) which limits the injection pressure to a level which would "assure that the pressure during injection does not initiate new fractures or propagate existing fractures in the confining zone adjacent to the USDWs" during operation of the Injection Well. Limiting the maximum injection pressure to 90% of the level which would initiate fractures in the confining formation (Big Lime Formation) is more protective than what the regulations require.

Geologic and Seismic Review: The UIC regulations for Class II wells do not require consideration of seismicity, unlike the UIC regulations for Class I wells used for the injection of hazardous waste. Nevertheless, EPA evaluated factors relevant to seismic activity such as the existence of any known faults and/or fractures and any history of, or potential for, seismic events in the area of the Injection Well as discussed below. See also *"Region 3 framework for evaluating seismic potential associated with UIC Class II permits, September 2013."* EPA also established a maximum injection pressure in the draft permit designed to limit the potential for seismic events.

The region in which the Facility is located consists of an extensive, thick, sedimentary sequence with numerous confining strata between the surface and the existing injection zone. Deep below the sedimentary layers lies the Precambrian, crystalline, igneous/metamorphic bedrock, commonly referred to as "basement rock." Basement rock in the area of the proposed permit is located at depths approximating 16,000 feet, about 11,500 feet below the proposed injection zone.

The permit provides that the Permittee shall inject through the Injection Well only into a formation which is overlain by a confining zone free of known open faults or fractures within the Area of Review as required in 40 C.F.R. § 146.22. The Permittee submitted geologic information that indicates the absence of faults within a one-mile radius of the Injection Well and that the entire Appalachian Plateau, on which the Facility is located, is considered geologically stable with no active faults. The Permittee submitted various historical geologic information including a website on Earthquakes from the Virginia Department of Mines, Minerals and Energy, Division of Geology and Minerals (http://www.dmme.virginia.gov/dgmr/earthquakes.shtml).

The available geophysical and seismic information researched by the Permittee, as well as through EPA's review of published information of seismicity in Virginia (refer to information referenced below),

shows no evidence of faults that reach the land surface from basement rock. The geologic information does identify the presence of the Russell Fork Fault, which is a right-lateral fault located more than four miles east of the Injection Well, forming the eastern boundary of the Pine Mountain Thrust Block with as much as six miles of lateral displacement. Movement along this fault occurred several million years ago and was due to regional compression (sediment deposition). This fault is a shallow sealing or non-transmissive fault. This geologic information also includes geophysical well logs from wells which penetrate the injection zone and which are located on either side of the suspected surficial fault. This geologic information documents that there has been minimal relative displacement or movement of the deeper injection and confining zones across the fault area.

The geological information shows that Appalachian Basin, including southwestern Virginia which lies on the passive continental margin, is not currently seismically active because insufficient pressure exists to cause movement along ancient faults and fractures. These faults and fractures are closed and non-transmissive due in large measure to the tremendous downward pressure exerted by thousands of feet of overlying sediment deposited since their creation.

The United States Geologic Survey (USGS) has not recorded any seismic activity that originated in Buchanan County, Virginia from 1900 through present day (USGS: "Information by Region-Virginia – All Earthquakes 1900-Present": http://earthquake.usgs.gov/earthquakes/byregion/virginia.php). Virginia is located near the center of the North American Plate and, thus, experiences a much lower rate of seismicity in comparison with an area like California, which is located closer to a plate boundary and experiences shallower, more energetic seismic events due in part to less coherency in the basement rock. Additionally, California earthquakes often break the ground surface, while earthquakes in Virginia usually occur on faults at depths from three to fifteen miles below the ground surface. The rare earthquakes felt in Virginia today generally have no relationship with faults seen at surface. Residual stresses from the formation of the Appalachian Range and the Piedmont province hundreds of millions of years ago appear to be the mechanism for Virginia's earthquakes. Earthquake activity in Virginia has been associated with basement rock, either from basement faulting or faulting at a shallower depth caused by tectonic stresses that originated from the basement rock.

In addition, the National Academy of Sciences or National Research Counsel's report, "Induced Seismicity Potential in Energy Technologies", National Academy Press, 2013, indicates that oil and gas production in a reservoir can assist in preventing future impacts from seismicity due to injection because of the reduction in reservoir pore pressure during the years of gas production. EnerVest identified in the Permit Application significant gas production in the vicinity of the proposed Injection Well.

EPA developed the maximum injection pressure for the Injection Well using data submitted by EnerVest in the permit application. EnerVest provided to EPA fracture stimulation data obtained when the well was completed for gas production that included an instantaneous shut-in pressure (ISIP). The ISIP is the minimum pressure necessary to begin to reopen any fractures created during the fracture stimulation process and is significantly lower than the pressure required to fracture the rock. EPA limited in the draft permit both the surface injection pressure and the bottom-hole injection pressure to a level lower than both the ISIP and the fracture pressure to prevent the initiation of new, or the propagation of existing, fractures.

Finally, a number of factors help to prevent injection wells from failing in a seismic event and contributing to the contamination of a USDW. Most Class I or Class II injection wells, including this Injection Well, are constructed to withstand significant amounts of pressure. The EnerVest Injection Well is constructed with multiple steel strings of casing that are cemented in place. Furthermore, both

the existing and the draft Permits require EnerVest to mechanically test the Injection Well to ensure integrity before operations begin and to continuously monitor the Injection Well during operations to detect any potential mechanical integrity concerns. The Injection Well is also designed to automatically shut in and cease operation in the event that the mechanical integrity of the well is comprised, including by a seismic event.

Injection Fluid: The permit limits the Injection Well to the disposal of produced fluids associated with EnerVest's oil and gas production activities. The Injection Well is limited to a maximum injection volume of 36,000 barrels per month, where a barrel is equal to 42 gallons. By limiting disposal volumes, fluid is expected to be contained within the AOR during the ten-year time span during which the permit is in effect. Fluid dispersal is modeled by EPA UIC staff and included as part of the Administrative Record. Analyses of injection fluid will be conducted as stated in Paragraph II.C.3 of the draft permit. The parameters designated for sampling reflect the typical constituents found in Class II injection fluid. Should a ground water contamination incident occur during the operation of the Injection Well, EPA will be able to compare samples collected from ground water with the injection fluid analysis to help determine whether operation of the Injection Well may be the cause of contamination.

Testing, Monitoring, and Reporting Requirements: The permittee will be responsible for monitoring injection pressure, annular pressure, flow rate and cumulative volume on a continuous basis, recording these observations, at a minimum, on a monthly basis and reporting this data to EPA on an annual basis. The permittee is also required to conduct a mechanical integrity test (MIT) once every five years. This test will provide EPA with an evaluation of the integrity of the tubular goods (casing and tubing) as well as documentation as to the absence of fluid movement into or between USDWs and thus help assure that USDWs are protected. Additional pressure testing of the casing, tubing, and packer is required to occur whenever rework on the well requires the tubing and packer to be released and reset. A mechanical integrity test for P-205 was last conducted on May 5, 2017; the next MIT is due by May 5, 2022.

Plugging and Abandonment: The Permittee has submitted a plugging and abandonment plan that is expected to result in an environmentally protective well closure at the time of cessation of operations. The Permittee has also made a demonstration of financial responsibility that verifies that adequate financial resources will be maintained for well closure. The Permittee has submitted surety bond that covers the estimated cost to close, plug and abandon the Injection Well in in the amount of at least $35,000. This figure represents an estimate obtained by the Permittee from an independent third party that budgets out the cost of plugging and abandonment at current Industry costs.

Expiration Date: The final permit, when issued, will be in effect for ten years from the date of permit issuance. Pursuant to 40 C.F.R. § 146.36, EPA expects to review the permit at least once every five years to determine whether it should be modified, revoked and reissued, terminated or a minor modification made as provided in 40 C.F.R. §§ 144.39, 144.40 or 144.41. The final permit will contain essentially the same conditions as the draft permit unless information is supplied to EPA which would warrant alternative conditions or actions on this permit application.

Additional Information: Questions, comments and requests for additional information may be directed to:

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- A public hearing has been tentatively scheduled for June 28th, 2018, at 5:00 PM, at the Dickenson County Judicial Center located at 119 Courthouse Lane, Clintwood, Virginia 24228. Requests to hold a public hearing must be received in the office listed above by June 15, 2018. When requesting a public hearing, please state the nature of the issues you propose to raise. EPA expressly reserves the right to cancel this hearing unless a significant degree of public interest, specific to the above-named proposed UIC brine disposal injection operation, is evidenced by the above date. The Administrative Record for the action will remain open to for public comment until June 15, 2018.

The Administrative Record for this draft permit is available for public inspection during normal business hours at the offices of U.S. EPA Region III, at the address shown above. A copy of the draft permit and the Administrative Record is also available for public inspection during normal business hours at Jonnie B. Deel Memorial Library, located at 198 Chase Street, Clintwood, Virginia 24228. Links to online publications that compose the Administrative Record are also available via our online public notice located at the web address https://www.epa.gov/va/epa-public-notices-virginia.