STATEMENT OF BASIS

FOR

U. S. EPA’s UNDERGROUND INJECTION CONTROL (UIC) PROGRAM
DRAFT CLASS IID PERMIT NUMBER VAS2D947BDIC

TO BE ISSUED TO

Enervest Operating, LLC
809 Happy Valley Drive
Clintwood, VA 24228

FOR

A project consisting of one Class II-D (produced fluid disposal) injection well that will be used for the continued disposal of fluids produced in association with coal bed methane and conventional natural gas production operations (hereinafter, “EnerVest Injection Well No. P-132” or “the Facility”). The proposed well to be covered by this permit is located in the following location:

Nora and Haysi Fields
Dickenson County, Virginia (Ervinton District)
Latitude 37° 05' 30.2" N Longitude - 82° 16' 53.0" W

Background: In 1982 EnerVest Injection Well No. P-132 was drilled to a depth of 5,148 feet and construction was completed resulting in a producing natural gas well, which produced from the Berea formation. The Facility was converted into an injection well in 2006, at which point it was initially covered by a UIC permit issued to its previous owner and operator, Equitable Production Company. It has been operating as an injection well since 2006. The permit was transferred to Range Resources, Inc. – Pine Mountain on June 17, 2014. As of December 31, 2015, pursuant to 40 C.F.R. § 144.38(b), the Facility and permit was acquired by EnerVest Operating, LLC (“Permittee”), which applied to the U.S. Environmental Protection Agency, Region III (“EPA”) for permit renewal under a UIC permit in January 2016.

Following its initial review of the January 2016 permit renewal application, EPA sent a Notice of Deficiency (NOD) dated June 23, 2016 to Permittee requesting additional information. In response to the June 23, 2016 request, Permittee supplemented the original application with an initial response to the NOD dated July 22, 2016, and additional information on September 14, 2016, and December 8, 2016. The Permittee’s submittals dated January 15, 2016, July 22, 2016, September 14, 2016, and December 8,
EPA has reviewed the renewal permit application and determined that no impacts to Underground Sources of Drinking Water (“USDWs”) are expected to result from the continued operation of EnerVest Injection Well No. P-132. Accordingly, EPA intends to reissue a UIC permit for EnerVest Injection Well No. P-132, with conditions and terms as stated in the accompanying draft permit, unless information is received during the public comment period indicating that modifications to this draft Statement of Basis or the draft permit are warranted. Pursuant to 40 C.F.R. Parts 144 and 146, the draft permit specifies conditions for construction, operation, monitoring, reporting and plugging and abandonment of injection wells in order to prevent the movement of fluid into any USDW. The Permittee’s UIC project and the draft permit conditions specific to the project are further described below.

**Area of Review**: Pursuant to the applicable regulations, the Area of Review (“AOR”) is “the area surrounding an injection well described according to the criteria set forth in § 146.06...” 40 C.F.R. §§ 144.3. 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-132. Based on the chemistry of the fluid to be injected, hydrogeology, 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. Two additional UIC Class II-D injection wells are located within one-half mile of the EnerVest Injection Well No. P-132, both of which are also operated by EnerVest Operating, LLC; Permittee has submitted an application to renew one of those wells in addition to the one described herein (Permit No. VAS2D937BDIC).

The permit also requires Permittee to perform corrective action on any unplugged or abandoned wells that penetrate the Area of Review if they are identified at a future date, or if surface injection pressure exceeds the permitted values.

**Underground Sources of Drinking Water (USDW)**: 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 “[c]ontains fewer than 10,000 mg/l [milligrams per liter] total dissolved solids”, and which is also “not an exempted aquifer” 40 C.F.R. § 144.3. Permittee has indicated that there are no USDWs located within the one-quarter mile AOR. The only groundwater source in the AOR was recorded by the well driller at 1700 feet below ground surface and indicated as “damp” “saltwater” in the drilling log for Virginia well permit No. VC-535727. According to the Permittee, this damp saltwater is located in the Pocohontas formation, a sand and shale, red rock formation multiple geologic layers above the proposed injection zone. As this damp saltwater source is unlikely to contain a sufficient quantity of ground water to supply a public water system, it is not considered a USDW.

**Well Construction**: This well has an 11 3/4-inch string of ground water protective casing running from the surface to a depth of 12 feet, and an 8 5/8 inch string of ground water protective casing running from the surface to a depth of 2046 feet. This well construction exceeds the technical and generally-accepted criteria of surface casing placement at no less than 50 feet below the lowermost USDW. See EPA, “Cementing Records Requirements in Direct Implementation Programs to Achieve Part II of Mechanical Integrity in Class II Injection Wells” (Jan. 27, 1999).
In addition, the renewal permit application indicates that 4½-inch long string casing was placed to a depth of 5,109 feet and cemented back to a depth of 4,150 feet. This exceeds the standard practice of cementing long string casing back to no less than 100 feet above the injection zone. A bridge plug and 50 feet of cement have been placed in the 4½ inch casing at a depth of 4,915 feet to isolate the injection formations from lower formations, which EPA finds to be consistent with the practice in other states. See 40 C.F.R. §§ 147.2104(d)(2) (South Dakota); 147.1655(b)(5) (New York); 147.1154(b)(2) (Michigan); 147.904 (b)(2) (Kentucky); and 147.1955(b)(5) (Pennsylvania). The EnerVest Injection Well is located in the Appalachian Plateau Geologic Province, which bears similar geology to that of Kentucky and New York state; therefore, Kentucky and New York UIC regulations are particularly relevant to this analysis. According to the renewal permit application, injection will continue to occur according to the method currently used at the Facility. Fluid will be injected via a 2 inch tubing string installed to a depth of approximately 5046 feet.

EPA has included a provision requiring the Permittee to ensure the security of the Injection Well in order to prevent unauthorized fluid discharge due to vandalism or other third-party actions.

Injection and Confining Zones: The EnerVest Injection Well No. P-132 was drilled to a total depth of 5,148 feet. Injection of fluids for disposal is limited by the permit to the Weir Formation. The Weir Formation is composed of fine-grained siltstone, which is favorable for injection due to its highly permeable, porous structure that allows for the storage and accumulation of fluids under adequate confining conditions. This layer has been depleted of fluid and pressure via oil and gas production, adding to its capacity to store fluid. The Permittee is authorized to dispose into the Weir (a/k/a Mississippian Price) Formation at a depth of 4,474 to 4,506 feet. The injection zone is separated from a source labeled “saltwater” via the driller’s log, by 2,774 feet. As indicated in the USDW section above, the driller’s log labeled the zone “damp”, and that it was not flowing. Given the information available, EPA does not consider this zone a USDW and has not found evidence of any other USDW’s in the AOR.

According to the applicant, the driller’s log shows that the confining zone located immediately above the injection zone, the Big Lime formation, is comprised of approximately 549 feet of dense carbonate (limestone). Multiple additional confining units of shale and other dense rock exist between the injection zone and the surface and include the Mauch Chunk Formation, a formation comprised of over 1,000 feet of low permeability, tight sands, siltstones and limestones. Above the Mauch Chunk is another large interval of siltstone, tight sands and coal beds that provide additional inhibition of the migration of injected fluid.

Geophysical well logging data, including gamma ray logs, from multiple wells in the area identify additional confining units of shale and limestone between the lowermost USDW and the confining formations immediately above the injection zone. The Weir Formation consists of oil and gas reservoir rock with sufficient porosity and permeability to allow fluids to pass through them; a significant hydrocarbon accumulation; and an impermeable cap rock or geologic structure which impedes further hydrocarbon migration. Depleted oil and gas reservoirs (geologic formations which have produced substantial volumes of hydrocarbons and the associated brine water over many years) are desirable brine disposal formations. These formations are desirable disposal targets because the injected fluid is compatible chemically with the fluid remaining in the reservoirs, the reservoir pressure has been
significantly reduced, and the presence of multiple confining zones above the Weir Formation present a barrier to upward fluid migration.

**Maximum Injection Pressure:** The maximum allowable surface injection pressure for the permitted operation has been limited to 1,109 pounds/square inch (psi) at the surface which equates to a pressure of 3,181 psi at a depth of 4,474 feet, where the top of the injection zone meets the bottom of the confining zone. This represents 90% of the calculated pressure that could potentially initiate fractures in the overlying confining formation. A specific gravity for the injection fluid of 1.070 was used in the calculation. This value is based on the maximum specific gravity of fluid EnerVest has been injecting into EnerVest Injection Well No. P-132 at the time of permit reapplication. The maximum injection pressure has been lowered between the 2005 permit issuance and 2017 reissuance due to reevaluation and use of a fracture gradient value of 0.79 psi/ft. This value represents an average fracture gradient value of wells that penetrate the Big Lime within a one-mile radius of EnerVest Injection Well P-132. EnerVest Injection Well No. P-132 and many other wells in the surrounding area were fracked using nitrogen foam, which EPA evaluated the consistency of by combining fracture gradient values for wells within a one-mile radius of the Enervest Injection Well P-132 with a table EnerVest provided EPA with to evaluate foam density, *Halliburton Nitrogen Data for Oil Well Servicing Table VI*. This pressure limitation exceeds 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. If the specific gravity of the injection fluid is determined to be greater than 1.070, the Permittee is required to dilute the fluid so that its specific gravity is no greater than 1.070; however, the dilution solution must be a produced fluid. The permit requires both injection pressure and annular pressure to be continuously monitored.

**Geologic and Seismic Review:** The SDWA regulations for Class II wells do not require consideration of seismicity; unlike the SDWA regulations for Class I wells used for the injection of hazardous waste. Nevertheless, EPA has 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 EnerVest Injection Well as discussed below and addressed more fully in “Region 3 framework for evaluating seismic potential associated with UIC Class II permits, September, 2013.” The maximum injection pressure in the draft permit is also 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 underground sources of drinking water and the existing injection zone. The permit provides that the Permittee shall inject through the EnerVest Injection Well No. P-132 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 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*), which contains a description of Seismic Zones in Virginia that points to residual stresses from the formation of the Appalachian Range and the Piedmont province hundreds of millions of years ago as the mechanism for Virginia’s earthquakes. Earthquake activity in Virginia has been associated with the Precambrian, crystalline, igneous/metamorphic bedrock, sometimes referred to as “basement rock”, which is located below sedimentary bedrock, either from basement faulting or faulting at a shallower depth caused by tectonic stresses that originated from the basement rock. 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. 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 Permittee has indicated that there are no identified faults within the AOR and that the entire Appalachian Plateau, where the Facility is located, is considered geologically stable with no active faults since Virginia lies on a passive continental margin. However, 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.

As noted, the 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 removal of oil, natural gas and brine from deep formations reduces the reservoir pressure resulting in increased fault and fracture-sealing downward stresses. The maximum pressure and injection rate allowable under this permit will not result in an appreciable pressure increase in the injection formation.

The United States Geologic Survey (USGS) has not recorded any seismic activity that originated in Dickenson County, Virginia from 1900 through present day - Source: 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. Another difference between the states is that California earthquakes often break the ground surface, while earthquakes in Virginia usually occur on faults at depths of from three to fifteen miles. The rare earthquakes felt in Virginia today generally have no relationship with faults seen at the surface.

In addition, the National Academy of Sciences 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. In the renewal permit application, the Permittee documented significant gas production in the vicinity of the proposed Injection Well (gas pays at depths similar to the proposed injection zone). EnerVest Injection Well P-132 has been used to dispose of large quantities of produced fluid since 2006 when it was converted from its former status as a production well. The well’s track record of successful use as an injection well combined with the reasons described above make the risk of seismic activity in Dickenson County resulting from operation of the EnerVest Injection Well No. P-132 very low.
Finally, a number of factors help to prevent injection wells from failing in a seismic event and contributing to the contamination of a USDW. First, most Class I or Class II deep injection wells (including the Enervest Injection Well No. P-132), are constructed to withstand significant amounts of pressure. The ongoing injection will occur into an injection well that has been constructed with multiple steel strings of casing that are cemented in place. Furthermore, both the existing and the draft permits require Permittee to mechanically test the Enervest Injection Well No. P-132 to ensure structural integrity before operations begin and to continuously monitor the Injection Well during operations to detect any potential mechanical integrity concerns. The Enervest Injection Well No. P-132 is also designed to automatically shut in and cease operation in the event that the mechanical integrity of the well is compromised, including by a seismic event.

**Injection Fluid:** The permit limits the EnerVest Injection Well No. P-132 to disposal of produced fluids associated with EnerVest oil and gas production activities. The maximum volume EnerVest Well No. P-132 will be permitted to dispose of is 36,000 barrels per month (where a barrel consists of 42 gallons). By limiting disposal to this volume, fluid is expected to be contained within the AOR during the ten-year timespan during which the permit is in effect. Fluid dispersal is modeled, in part, by the ZEI calculation, which is performed by EPA UIC staff and included as part of the Administrative Record. The sources of the disposal fluids are limited to oil and gas production wells owned and operated by the Permittee. Analyses of injection fluid will be conducted as stated in Part II, paragraph B.3 of the draft permit. The parameters chosen for sampling reflect the typical constituents found in Class II injection fluid. Should a ground water contamination incident occur during the operation of the EnerVest 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 for the contamination.

**Testing, Monitoring and Reporting Requirements:** The Permittee is required to conduct a two-part mechanical integrity test (MIT) at least once every five years. The two-part MIT consists of a pressure test to make sure the casing, tubing and packer in the well do not leak and a fluid movement test to ensure that any movement of fluid does not occur outside the injection zone. In addition to the monitoring described above, additional pressure testing of the casing, tubing and packer is required to occur whenever a rework on the well requires the tubing and packer to be released and reset. The Permittee will continue to be responsible for monitoring injection pressure, annular pressure, flow rate and cumulative volume on a continuous basis, and reporting this data to EPA on an annual basis. The purpose of these tests, as well as the monitoring requirements, is to detect the absence of fluid movement into or between USDWs and flow conditions that exist in the injection zones during operation, thus helping assure that USDWs are protected.

The Permittee is further required to measure the specific gravity from each truck load of injection fluid. If the specific gravity exceeds 1.070 the Permittee will be required to implement measures described previously to ensure the specific gravity does not exceed 1.070. As noted above, the 1.070 figure is based on the maximum specific gravity of fluid EnerVest has been injecting into EnerVest Injection Well No. P-132 at the time of permit reapplication.

**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 resources will be maintained for well closure by demonstrating financial responsibility and resources 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 that budgets out the cost of plugging and abandonment at current Industry costs. According to the EnerVest Injection Well No. P-171 well parameters, this amount would be $35,000. EPA anticipates that these provisions should preclude the possibility of abandonment without proper closure.

**Expiration Date:** Pursuant to 40 C.F.R. § 144.36, a final permit, when issued, will be in effect for ten years from the date of permit issuance, unless it is modified, revoked and reissued, or terminated during that time-frame. During the life of the permit, EPA may conduct an annual review of the Permittee’s operation at the Facility. This proposed draft permit contains the same conditions as the final permit, and would only be changed if information is supplied to EPA which would warrant alternative conditions or actions on this renewal 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 April 13th, 2017 at 7:00 PM, at the Dickenson County Courthouse in Clintwood, Virginia. Requests to hold a public hearing must be received in the office listed above by March 31st, 2017. When requesting a public hearing, please state the nature of issues proposed to be raised. EPA expressly reserves the right to cancel this hearing unless a significant degree of public interest, specific to the proposed UIC brine disposal injection operation, is evidenced by the above date. The Administrative Record for this action will remain open for public comment until March 31st, 2017.

The Index to the Administrative Record is attached hereto, and the actual 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. Links to those online publications that partially compose the Administrative Record are also available via EPA’s online public notice located at the web address https://www.epa.gov/uic/underground-injection-control-epa-region-3-de-dc-md-pa-va-and-wv.