Resource Report 6

Geological Resources

Permian Basin Expansion Project

FERC Docket No. CP26-____-000

May 2026

RESOURCE REPORT 6 - GEOLOGICAL RESOURCES	
MINIMUM FILING REQUIREMENTS	
INFORMATION	**DATA SOURCE**
1. Identify the location (by milepost) of mineral resources and any planned or active surface mines crossed by the proposed facilities – 18 CFR § 380.12 (h)(1 & 2)	Section 6.3
2. Identify any geologic hazards to the proposed facilities – 18 CFR § 380.12 (h)(2)	Section 6.4
3. Discuss the need for and locations where blasting may be necessary in order to construct the proposed facilities – 18 CFR § 380.12 (h)(3)	Section 6.2
4. For liquefied natural gas (LNG) projects in seismic areas, the materials required by "Data Requirements for the Seismic Review of LNG Facilities," National Bureau of Standards Information Report 84-2833 – 18 CFR § 380.12 (h)(5)	Not applicable
ADDITIONAL INFORMATION OFTEN MISSING AND RESULTING IN DATA REQUESTS	
Identify any sensitive paleontological resource areas crossed by the proposed facilities. (Usually only if raised in scoping or if the project affects federal lands.)	Section 6.7
Briefly summarize the physiography and bedrock geology of the project area.	Section 6.1
If proposed pipeline crosses active drilling areas, describe plan for coordinating with drillers to ensure early identification of other companies' planned new wells, gathering lines, and aboveground facilities.	Not applicable
If the application is for underground storage facilities:	Not applicable
describe monitoring of potential effects of the operation of adjacent storage or production facilities on the proposed facility, and vice versa;	Not applicable
describe measures taken to locate and determine the condition of old wells within the field and buffer zone and how the applicant would reduce risk from failure of known and undiscovered wells; and	Not applicable
identify and discuss safety and environmental safeguards required by state and federal drilling regulations.	Not applicable

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Abbreviations and Acronyms

CFR	Code of Federal Regulations
EI	Environmental Inspector
EMNRD	Energy, Minerals, and Natural Resources Department (New Mexico)
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
fbg	feet below ground
FIS	Flood Insurance Study
g	unit of standard gravity
HDD	horizonal directional drill
NMBGMR	New Mexico Bureau of Geology and Mineral Resources
Northern	Northern Natural Gas Company
PGA	peak ground acceleration
Plan	FERC Upland Erosion Control, Revegetation, and Maintenance Plan
Project	Permian Basin Expansion Project
USGS	U.S. Geological Survey

6.0 GEOLOGICAL RESOURCES

Northern Natural Gas Company (Northern) owns and operates a natural gas transmission pipeline system and associated aboveground facilities in New Mexico and Texas. Northern is seeking a Certificate of Public Convenience and Necessity from the Federal Energy Regulatory Commission (FERC) under Section 7(c) of the Natural Gas Act, as amended, for its Permian Basin Expansion Project (Project).

The Project includes constructing approximately 15.1 miles of 24-inch-diameter and 1.1 miles of new 16-inch-diameter pipelines, a new International Organization for Standardization-rated 7,700 horsepower compressor station, one interconnect with Transwestern Pipeline Company, LLC within the existing Phillips 66 Linam Ranch Plant, one bi-directional receiver within Northern's existing launcher facility, replacing a recycle valve at Northern's Plains compressor station, and one new delivery point for the customer at the Gaines County Generating Station.

In accordance with the FERC regulations at 18 Code of Federal Regulations (CFR) 380.12(h), *Resource Report 6 – Geological Resources* describes geological resources and hazards in the Project area that might be directly or indirectly affected by the proposed action or that could place the proposed facilities at risk, the potential effects of those hazards on the facility, and methods proposed to reduce the effects or risks.

6.1 GEOLOGY AND PHYSIOGRAPHY

The Project is mostly located in Lea County, New Mexico, with a small portion in Gaines County, Texas, and Yoakum County, Texas. The Project is located within the High Plains section of the Great Plains physiographic province (Fenneman, 1928). The Great Plains province is characterized by a plateau-like terrain with little topographic relief (National Park Service, 2017). The High Plains section covers the eastern portion of New Mexico and the Texas panhandle then extends north to Nebraska (Fenneman, 1928). The Ogallala Formation is a major aquifer that underlies the High Plains. The southern High Plains are also rich in oil, gas, and coal-bed methane resources (New Mexico Bureau of Geology and Mineral Resources [NMBGMR], 2026).

Bedrock geology in the Project area consists of Tertiary and Quaternary-aged unconsolidated materials eroded off the High Plains (NMBGMR, 2003). The majority of the Project is underlain by the Ogallala Formation, which consists of alluvial and eolian clastic sediments. The remaining Project area, east of Eunice Highway, consists of slightly younger Quaternary-aged eolian deposits (NMBGMR, 2003; Barnes et al., 1976). Bedrock geology for the Project area is depicted on Figure 6.1-1.

6.2 BLASTING

Geotechnical borings encountered areas of bedrock at depths that may impact open-cut trenching. Based on the geotechnical boring log data, bedrock is anticipated to be found at depths as shallow as 13 feet below ground; however the bedrock is relatively soft sedimentary formations, that typically do not require blasting. These units would be weathered within excavation depths and, therefore, could be removed using conventional excavation methods. Should blasting be required, Northern would seek approval from FERC.

6.3 MINERAL RESOURCES

New Mexico produces the second most amount of oil in the United States, behind only Texas, and the third most natural gas (New Mexico Energy, Minerals, and Natural Resources Department [EMNRD], 2025). The Project is within a region known as the Permian Basin, which spans across western Texas and southeastern New Mexico. The Permian Basin accounts for approximately 40 percent of oil production in the United States and nearly 15 percent natural gas production (Railroad Commission of Texas, 2026).

Northern reviewed GIS data from the New Mexico Oil Conservation Division and the Railroad Commission of Texas to identify wells within 0.25 mile of the Project's construction workspaces. A list of wells identified within 0.25 mile of the Project is provided in table 6.3-1.

Table 6.3-1 Oil and Gas Wells Within 0.25 Mile of the Construction Workspaces

State	Approximate Milepost	Well Type	Well Status	Drilled Date
New Mexico	12.2	Oil	Active	6/11/2013
New Mexico	12.3	Oil	Active	6/11/2013
New Mexico	3.2	Injection	Active	1/1/2001
New Mexico	2.8	Injection	Temporary Abandonment	1/1/2001
New Mexico	2.5	Injection	Active	1/1/2001
New Mexico	2.5	Oil	Active	1/29/2013
New Mexico	1.7	Oil	Plugged	1/1/1900
New Mexico	2.4	Oil	Active	1/29/2013
New Mexico	1.1	Gas	Plugged	1/1/1900
New Mexico	0.4	Oil	Active	1/4/2018
Texas	14.5	Unknown	Unknown	Unknown

Mining is also a significant contributor to the economies of New Mexico and Texas. Mining activities occur across both states and resources consist of industrial sand, crushed stone, silver, uranium, and other rare earth elements. Mining in the Project vicinity is dominated by aggregate/stone mining. Northern reviewed GIS data from the New Mexico Mining and Minerals Division and the Railroad Commission of Texas for surface and underground mines or mineral excavation within 0.25 mile of the Project (New Mexico Mining and Minerals Division, 2026). No mining sites were identified within 0.25 mile of the Project.

The Project does not cross any active or abandoned mineral mines; therefore, construction of the Project is not expected to impact mineral resources. Operation of the Project is not expected to impact active mining operations. Based on the above information, construction and operation of the Project will have no impact on mineral resources.

6.4 GEOLOGIC HAZARDS

6.4.1 Seismicity

An assessment of the potential for seismic ground motions within the Project area was conducted using data available from the United States Geologic Survey (USGS) National Seismic Hazard Model (Petersen et al., 2023). According to the model, the Project area has a peak ground acceleration (PGA) of 0.04 standard gravity (g) with a 2 percent probability of exceedance in 50

years. For reference, PGA of 0.1 g is generally considered the minimum threshold for damage to older structures or structures not constructed to resist earthquakes.

The Project is within a seismically active part of the world. The closest recorded earthquake to the Project area was a 2.7 magnitude earthquake located approximately 12.5 miles northwest of Monument, New Mexico, in 2020 (USGS, 2026a). Since 1900 there have been 44 recorded earthquakes within 30 miles of the Project area. Twelve of those earthquakes had magnitudes greater than 3.0 and only one had a magnitude greater than 4.0. Based on the minor strength of the recorded earthquakes, seismicity is anticipated to have negligible impacts on the Project.

Northern compared the Project footprint to the USGS Fault Map (USGS, 2026b). Most faults in New Mexico follow a north to south trend in the central portion of the state. Most faults in Texas are located near the border with Mexico in west Texas or in the Gulf margin fault zone in the central and southeastern portion of the state. There are no mapped faults in or near the Project area. Northern does not anticipate any impacts associated with active fault lines.

6.4.2 Landslides

Assessment of the landslide incidence and susceptibility for the Project area was conducted using data available from the USGS National Landslides Hazards Program. According to the USGS, the Project is located in an area of low landslide susceptibility. Susceptibility to a landslide is defined as the probable degree of response of the area (e.g., rocks and soils) to natural or artificial cutting or loading of slopes. The USGS Landslide Inventory did not indicate the presence of landslides within the Project area (USGS, 2025).

Soil liquefaction occurs when a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress. Deposits most susceptible to liquefaction are sands and non-plastic silty soils deposited within the last 10,000 years and saturated with water. Due to the minor strength of seismicity in the Project area, the potential for soil liquefaction within the Project area is minimal.

Northern has reviewed site-specific civil survey elevation data to identify steep slopes present in the Project area. Northern has not identified any steep slopes that necessitate the use of best management practices as outlined in FERC's Upland Erosion Control and Revegetation Plan (Plan). Due to the lack of steep slopes, the risk of soil piping and slope instability is unlikely.

6.4.3 Karst Topography and Ground Subsidence

Ground subsidence can occur due to a variety of factors, including natural processes and human activities. Collapsible soils, or hydrocompactive soils, are commonly found in arid regions of the southwestern United States. These soils compact and then collapse when they get wet. Collapsible soils are most commonly found on valley margins as a result of sediment being transported from higher elevations. Collapsible soils can damage foundations, roads, underground storage tanks, and other infrastructure. Based on the soil borings performed on the site, the strata that may be encountered by construction of the Project are clayey sand, caliche, sandstone, and poorly graded sand. These units have a range of textures and strength properties, but the less cemented and more sand or silt dominated units are more prone to potential collapse. Geotechnical testing during construction should be performed to minimize the risk of encountering collapsible soils.

Another natural process that can cause ground subsidence is erosion of carbonate, evaporite, or less commonly volcanic bedrock. These types of bedrock are prone to forming karst topography, which is characterized by sinkholes, caves, and springs. According to the USGS, the Project area is not within a mapped karst area (USGS, 2020). Furthermore, the bedrock in the Project area consists of silt and sand deposits that are less susceptible to karst formation.

Land subsidence can also occur as a result of oil and gas extraction. The Permian Basin has been a vital source of oil and natural gas for over a century, but recent improvements in petroleum extraction has increased production exponentially (Karanam and Lu, 2023). A recent study by Karanam and Lu (2023) indicated that the Permian Basin deforms at an average rate of 3 to 4 centimeters per year. The highest amounts of land subsidence were localized to the Delaware Basin, a subbasin within the Permian Basin. Several areas in the Permian Basin were also found to show uplift due to wastewater injection. The Central Basin, where the Project is located, experienced the least amount of ground deformation. This is likely because compared to the other two subbasins, there is significantly less petroleum extraction in the Central Basin. The study concluded that the relatively close patterns of subsidence and uplift are a result of petroleum extraction and associated wastewater injection (Karanam and Lu, 2023). The geotechnical investigation completed for the Project will be used to aid engineers when determining factors of safety for land subsidence.

Excessive groundwater pumping can also lead to land subsidence. When groundwater is drawn faster than it is recharged the soil can collapse and compact. The Project area is on top of the southern extent of the High Plains Aquifer. This aquifer extends from Nebraska to Texas and provides drinking water for 2.3 million people (Houston et al., 2013). As the aquifer is depleted, there is potential for land subsidence; however, the Project facilitates will be part of a natural gas transportation system and will not conduct high-capacity groundwater extraction or use water for any industrial purposes.

6.4.4 Flooding and Scour

The Federal Emergency Management Agency (FEMA) published a Flood Insurance Study (FIS) for Lea County, New Mexico, in December 2008 (FEMA, 2008). This study focused on the five incorporated cities and townships in Lea County, while most of the unincorporated areas were not assessed. Portions of the Project area are included in Flood Insurance Rate Map numbers 35025C1365D and 35025C1345D; however, the Project area is mapped as Zone D. The rest of the Project area is not mapped. Zone D areas are zones that are unstudied, so flood hazards are undetermined but possible. The Project areas in Gaines County and Yoakum County, Texas, are also unmapped and there are no associated FIS reports.

Field surveys were conducted in December 2025 and January 2026 to delineate waterbodies within the environmental survey boundary. No waterbodies were identified, and no waterbodies will be impacted by the Project.

6.5 AVOIDANCE AND MINIMIZATION OF ADVERSE EFFECTS

The overall effects of construction and operation of Project facilities on topography and geology will be minor. Primary impacts will be limited to construction activities and include temporary

disturbance to slopes within the right of way resulting from grading and trenching operations. Northern will minimize impacts by returning contours to preconstruction conditions to the extent practicable with the exception of the above-grade facilities, where grading and filling will be required to create a safe and stable land surface, and to support facility drainage.

Project facilities will be designed and installed in accordance with the U.S. Department of Transportation's standards found in 49 CFR Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards, to provide adequate protection from hazards that could cause the pipe and facilities to move or to sustain abnormal loads such as washouts, floods, subsidence, landslides, and earthquakes. Minimal geologic hazards exist in the Project area and no impacts are anticipated.

The majority of the proposed Project will be constructed with the conventional open-cut and cover technique, where a length of trench is excavated, the pipe is installed, and the trench is backfilled. The Project is located in areas with low potential for karst features and Northern does not anticipate encountering unknown karst features during construction of the Project due to lack of suitable geological formations necessary for karst formation.

6.6 LNG FACILITIES IN SEISMIC RISK AREAS

The Project does not involve a liquified natural gas facility.

6.7 PALEONTOLOGY

A review of existing paleontological information for the Project area was conducted. According to the Paleobiology Database (2026) there have been 26 recorded collections in Lea County, New Mexico. None of the 26 recorded collections were found in the Project area. One recorded collection was found for Gaines County, Texas, but it is not located within the Project area. There were no recorded collections in Yoakum County, Texas.

In the event that paleontological resources (e.g., fossilized vertebrate remains such as bones and teeth) are encountered during construction, the construction contractor would report the finding to Northern's on-site environmental inspector (EI). The EI would temporarily suspend construction activities in the immediate area of the paleontological finding while a qualified paleontologist is consulted. The on-site EI would coordinate with Northern's environmental compliance manager to determine the appropriate actions if the find is determined to be a significant paleontological resource. Northern's initial action would be to contact the EMNRD, if found in New Mexico, Bureau of Economic Geology, if found in Texas, and FERC. Northern will comply with applicable laws, regulations, procedures, and recommendations from the regulatory agencies.

6.8 GEOTECHNICAL INVESTIGATIONS

Northern has completed a geotechnical investigation for the Project. Specifically, Northern completed geotechnical borings in the vicinity of the four proposed horizontal directional drills (HDD). The geotechnical reports are included with Northern's HDD Plan in Resource Report 1, Appendix 1A.

Northern has completed eight geotechnical borings to depths between 15 and 85 feet below ground

(fbg). The borings were completed along the pipeline centerline in the vicinity of proposed HDDs. The most prevalent soil types at the surface were clayey sand and caliche. These units were found in all borings from the surface to a depth of 7 to 30 fbg. Sandstone was observed below the caliche and poorly graded sand was observed below the sandstone layer or alternating with the sandstone.

Northern evaluated HDDs along the Project. The mileposts, depth to bedrock, where encountered, and the maximum depth of the HDD for each HDD location are listed in Table 6.8-1. The following geotechnical testing was completed during the geotechnical investigation.

Table 6.8-1 Geotechnical Testing Results

HDD Drawing Number	Maximum Depth HDD (feet)	Approximate Depth to Bedrock (feet)	Begin Milepost	End Milepost
Segment 1				
P4-1	58.5	25	0.6	0.8
P4-2	15.8	18	1.5	1.5
P4-3	61.0	13	9.6	9.8
P4-4	59.5	25	10.5	10.8

Based on the results above, all of the HDDs are expected to encounter bedrock. Due to the shallow sandstone bedrock, Northern designed the HDD to meet the parameters of the bedrock layer.

6.9 REFERENCES

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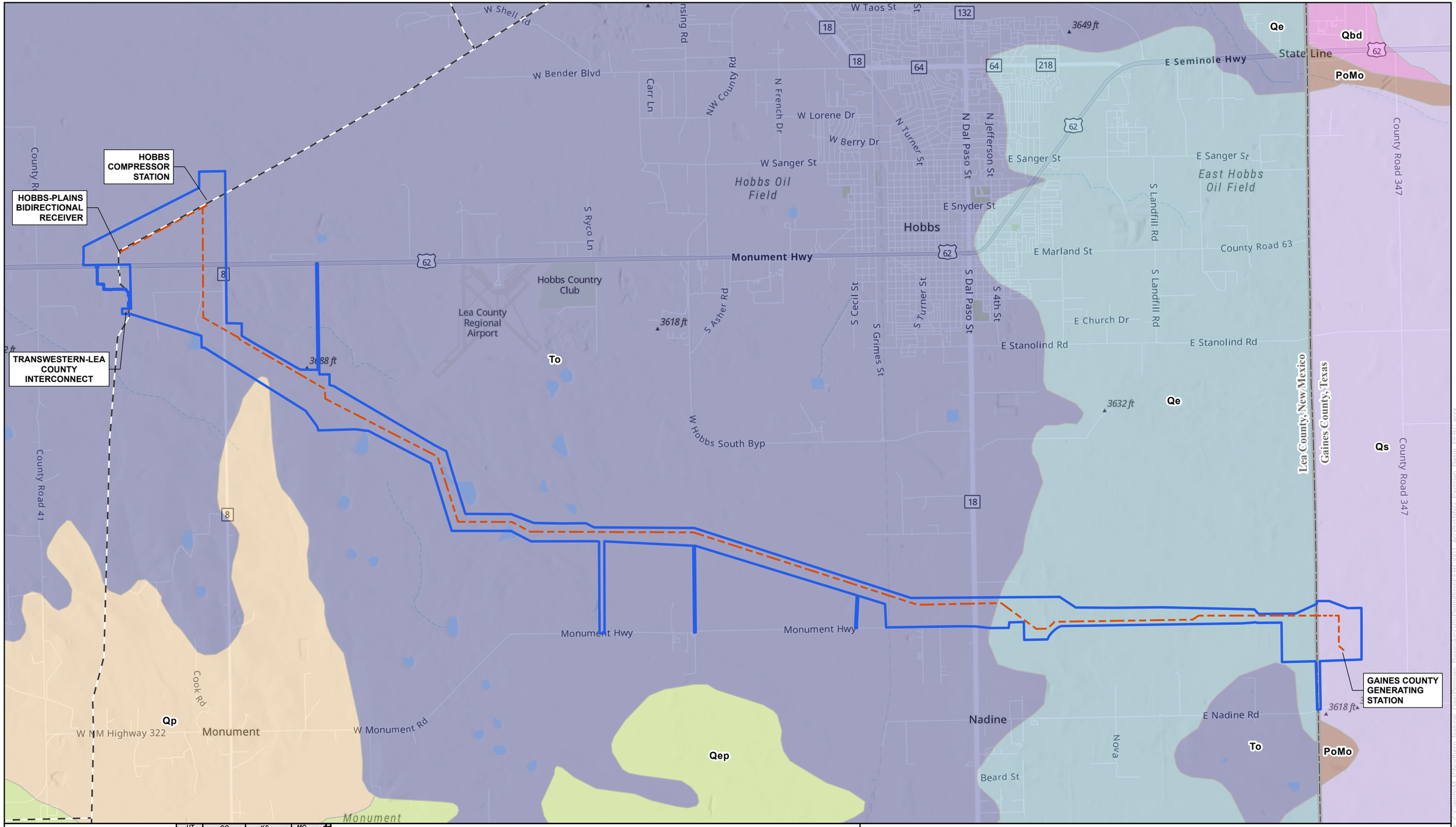
Figure



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For Environmental Review Purposes Only

Figure 6.1-1: Bedrock Geology

Permian Basin Expansion Project
Northern Natural Gas
Lea County, New Mexico
Gaines and Yoakum Counties, Texas

- Environmental Survey Boundary
- County Boundary
- Proposed Pipeline
- Existing Pipeline

Bedrock Type

- Blackwater Draw Formation, Qbd
- Eolian and piedmont deposits, Qep
- Eolian deposits, Qe
- Ogallala Formation, PoMo
- Ogallala Formation, To
- Piedmont alluvial deposits, Qp
- Sand sheet deposits, Qs

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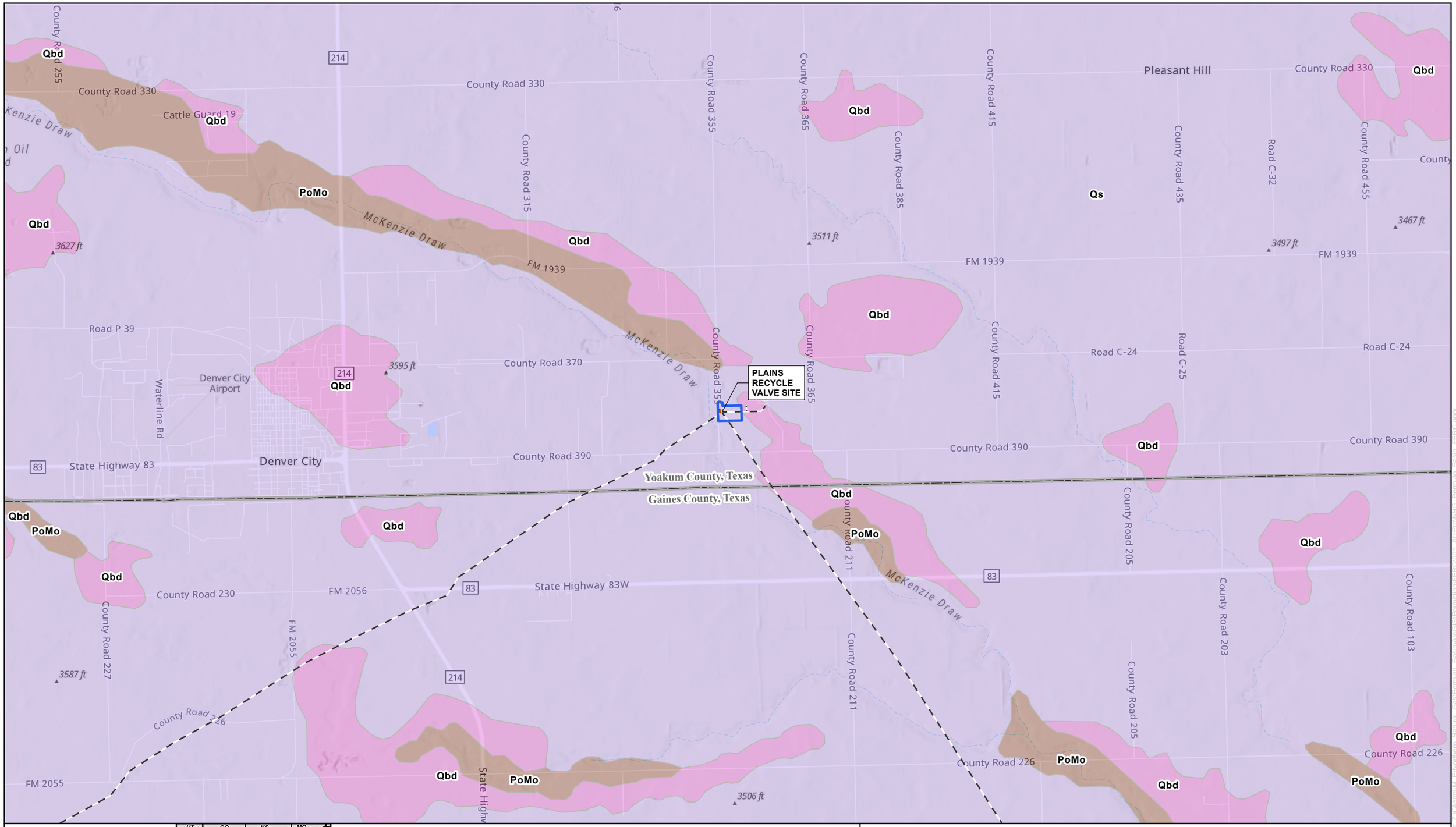

Figure 6.1-1: Bedrock Geology

Permian Basin Expansion Project
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