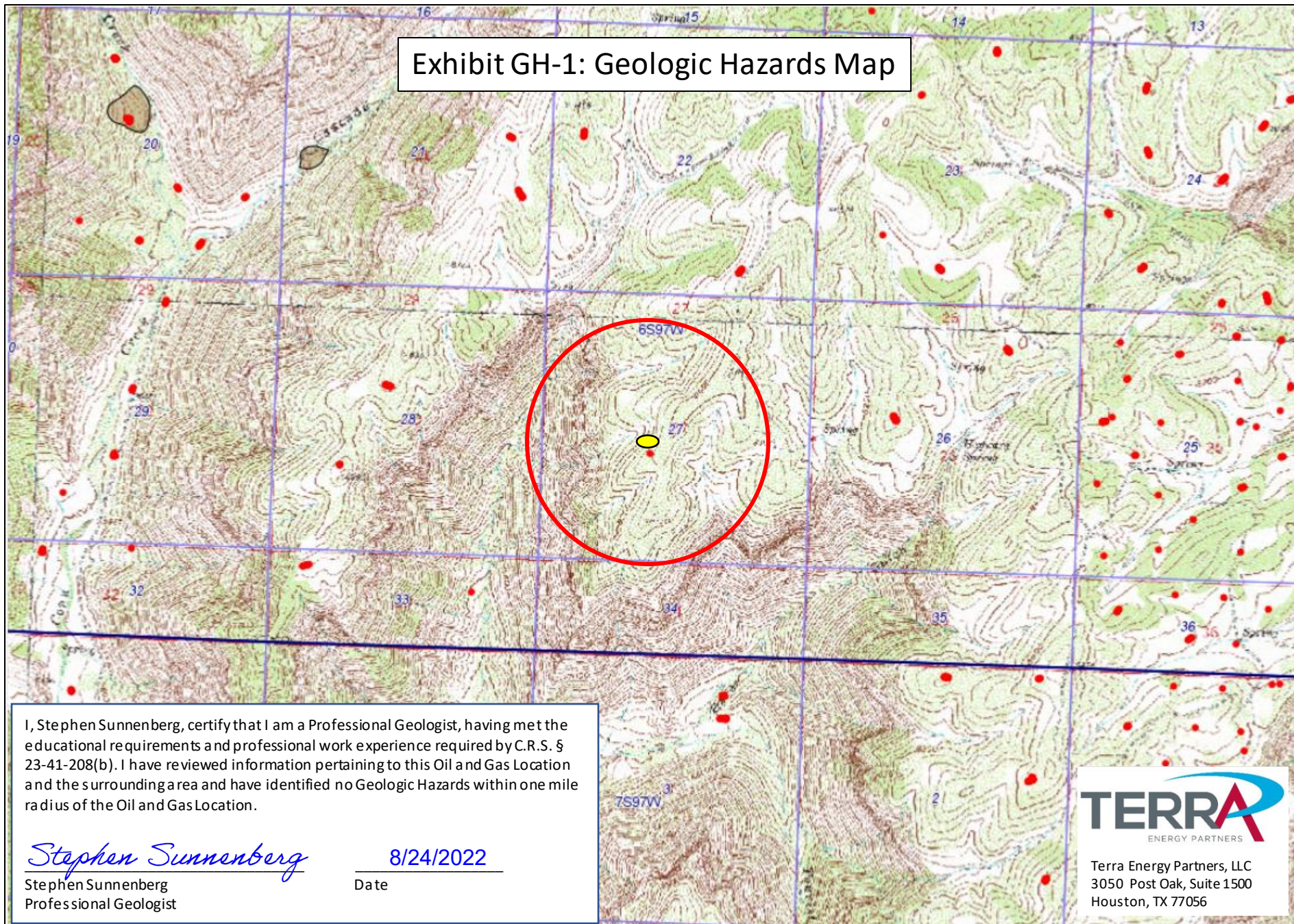


# Exhibit GH-1: Geologic Hazards Map



I, Stephen Sunnenberg, certify that I am a Professional Geologist, having met the educational requirements and professional work experience required by C.R.S. § 23-41-208(b). I have reviewed information pertaining to this Oil and Gas Location and the surrounding area and have identified no Geologic Hazards within one mile radius of the Oil and Gas Location.

*Stephen Sunnenberg*

Stephen Sunnenberg  
Professional Geologist

8/24/2022

Date



Terra Energy Partners, LLC  
3050 Post Oak, Suite 1500  
Houston, TX 77056

## Arco Deep 1-27 Pad

NE ¼ SW ¼ of Section 27, T6S, R97W 6<sup>th</sup> P.M.  
N: 1615686.6 E: 2235946.9  
Garfield County, Colorado

## Legend

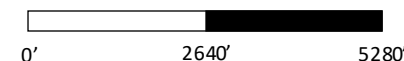
- Colorado Geological Survey Landslide Inventory Areas
- Arco Deep 1-27 Pad Site
- 1 Mile Radius

Source: USGS Base Map with Colorado Geological Survey Landslide Inventory Dataset (COGCC GIS)

North



Scale





# **Geologic Hazard Report**

**Arco Deep 1-27 Oil and Gas Location**

**Loc ID #: 322539**

**December 2022**



## **INTRODUCTION**

This document was prepared to address the requirements of Sections 304.b.(7).I. and 304.c.(21), of the Colorado Oil and Gas Conservation Commissions rules, effective January 15, 2021. TEP Rocky Mountain LLC (“TEP”) is proposing to revisit the Arco Deep 1-27 well pad (COGCC Loc ID# 322539) to drill 16 oil and gas wells and place necessary production equipment.

COGCC Rule 304.b.(7).I. requires the Operator to submit a map identifying any geologic hazards within a 1-mile radius of the proposed working pad surface. For any identified geologic hazard that extends beyond the 1-mile radius, a second map scaled to show the extent of that hazard in relation to the proposed oil and gas location shall be submitted. If the Operator identifies any Geologic Hazards pursuant to Rule 304.b.(7).I, the Operator will submit a Geologic Hazard plan per Rule 304.c.(21) describing proposed mitigation measures.

This report summarizes TEP’s investigation into potential geologic hazards associated with the existing Arco Deep 1-27 well pad. The purpose of the study was to review available geologic maps and reports, Colorado Geologic Survey mapping, Garfield County’s 2017 Multi-Jurisdictional Hazard Mitigation Plan, and data from a National Resource Conservation Service’s (“NRCS”) Customized Soil report.

The Arco Deep 1-27 pad will be located at an elevation of 8,382 ft. MSL in the NW¼SE¼ of Section 27, Township 6 South, Range 97 West, of the 6<sup>th</sup> P.M., in Garfield County, Colorado. The site sits atop the Douglas-Plateau Area, 10.5 miles North of De Beque, and 8.5 West of Parachute, CO.

This existing oil and gas location is located in an area surrounded by mountain shrublands, sagebrush shrublands, and aspen woodlands. The mountain shrublands are composed primarily of Utah serviceberry intermixed with mountain snowberry, Gambel oak, and mountain big sagebrush. Sagebrush shrublands are composed primarily of mountain sagebrush and mountain snowberry with an understory of native perennial grasses and forbs. North-facing slopes in the surrounding area support patchy aspen woodlands composed of quaking aspen, mountain snowberry, and chokecherry. The slope gradient, dipping from Northeast to the Southwest averages 11% for approximately 0.25 miles in both directions. Localized drainage is provided by sheet flow across native vegetation.

## **GEOLOGY**

The USGS Geologic map of the North Mamm Peak Quadrangle, by John Donnell, et al, 1989, indicates that the Arco Deep 1-27 pad is generally situated on gray and yellow-brown marlstone, siltstone, sandstone and tuff of the Evacuation Creek Member, Green River Formation. Mapping indicates a maximum thickness of approximately 50 feet.

Underlying the Evacuation Creek member, is the Green River Parachute Creek Member consisting of gray and yellow-brown marlstone and tuff and dark gray and blue-gray oil shale. Maximum thickness is reported to be approximately 850 feet.

## **SOILS**

The NRCS classifies the soil within the Arco Deep 1-27 pad as Parachute-Rhone loams. The Parachute Loam is described as colluvium over residuum weathered from sandstone and shale. The Parachute Loam

has a low water capacity of about 3.9 inches, and a low to moderately high capacity of the most limiting layer to transmit water, 0.01 to 0.57 inches per hour. The Parachute Loam is classified as hydrologic soil Group C - having a low infiltration rate when thoroughly wet. The typical 5 foot soil profile is 0 to 10 inches: Loam; 10 – 25 inches: very channery loam; 25 to 59 inches: bedrock.

The Rhone Loam is described as colluvium over residuum weathered from sandstone and shale. The Rhone Loam has a moderate available water capacity of about 8.3 inches, and low to moderately high capacity of the most limiting layer to transmit water, 0.01 to 0.57 inches per hour. The Rhone Loam is classified as hydrologic soil Group B - having a moderate infiltration rate when thoroughly wet. The typical 5 foot soil profile is 0 to 10 inches: loam; 10 – 39 inches: channery loam; 39 to 55 inches: very channery loam; 55 – 60 inches: bedrock.

## **GEOLOGIC HAZARDS**

Colorado Revised Statute (C.R.S.) 24-65.1-103(8) defines a Geologic Hazard as a “geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health, safety, or to property.” Additionally, the Colorado State legislature in 1974 passed House Bill 1041 defining geologic hazards that, if present, may pose a threat to life or property. For the purposes of this report, geologic hazards, as outlined in House Bill 1041, are discussed below.

1. **Radioactivity:** Radon is a naturally occurring, odorless and colorless radioactive gas that is produced by the radioactive decay of radioactive minerals present in the soils and bedrock. Although no radiological or radon testing was conducted, other than the initial drilling activities, the Pad does not have buildings or areas that will be occupied throughout the workday. The potential presence of radon is not expected to represent a geologic hazard or a significant worker exposure issue that would affect the design or operations of the Pad.
2. **Seismic Considerations:** According to the Colorado Geological Survey, there have been 88 earthquakes in or near Garfield County between 1973 – 2017. There were no reported damages or injuries associated with these minor earthquake events. Earthquakes usually occur near fault lines. Colorado Geological Survey and Ogden Tweto’s geologic mapping indicates that the crystal creek anticlinal nose and associated fault is just outside of a half mile from the pad location. There have been hundreds of wells drilled on the nose, but none have contributed to any seismicity. Seismic activity is not expected to impact the design or operations of the Pad.
3. **Ground Subsidence:** Ground subsidence is the sinking of land over human caused or natural underground voids and the settlement of native low-density soils. As noted in the NRCS soils report, bedrock is located 25 to 55 inches below the surface at the Pad. No mining claims or public record of mining are associated with the Pad. The Colorado Geological Survey’s Collapsible Soils mapping indicates that the Pad is not within a collapsible soils hazard area. Ground subsidence is not a geologic hazard at this site.
4. **Landslides:** Figure 23 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Landslide, Debris Flow & Rockfall” indicates that the Pad site is not within a landslide area. Landslides are not a geologic hazard at this site.
5. **Avalanche:** Based on Garfield County Multi-Jurisdictional Hazard Mitigation Plan, steeply sloped areas (30 to 45 degrees) are highly subject to avalanches primarily on south exposed slopes where unstable snow conditions are likely to occur. Figure 31 of the Plan entitled “Avalanche Forecast” indicates the Pad site has a “No Rating” avalanche probability.
6. **Rockfall:** Figure 23 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Landslide, Debris Flow & Rockfall” indicates that the Pad site is not within a rockfall area. There

are no rock outcroppings adjacent to or upland of the Pad site. Rockfall is not a geologic hazard at this site.

7. Flood: Figure 16 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Flood Hazard” indicates that the Pad site is not within a Flood Hazard. The site may be subject to sheet flow from precipitation events, however, storm water control measures are in place to mitigate or prevent storm water from entering the facility and disrupting operations. Flooding is not a geologic hazard at this site.
8. Mudflow and Debris Fans: Figure 23 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Landslide, Debris Flow & Rockfall” indicates that the Pad site is not within a mudflow or debris fan area. No natural drainages are located within the facility boundary. Figure 16 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Flood Hazard” indicates that the Pad site is not within a Flood Hazard. Mudflow and debris fans are not a geologic hazard at this site.
9. Expansive Soil and Rock: Figure 23 of Garfield County Multi-Jurisdictional Hazard Mitigation Plan, entitled “Soil Hazards” indicates that the Pad site is not within a Soils Hazard area. The proposed uses, design and operations at the Pad are not impacted by expansive soils or rock.
10. Unstable Slopes: As noted in the NRCS soils report, bedrock is located 25 to 55 inches below the surface at the Pad. The facility is constructed on an upland site with natural side slopes of 5 to 30%. There are no severe slopes within the Pad site. Unstable slopes are not a geologic hazard at this site.

## **ADDITIONAL SOIL CONSIDERATIONS**

NRCS reports that the Erosion factor K (whole soil) of 0.20 for the site, or low to moderate susceptible to erosion by water. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. Stormwater BMPs will be implemented to control soil erosion.

NRCS mapping indicates that none of the soils within the footprint of the Arco Deep 1-27 pad are hydric. Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation. The proposed development is not impacted by hydric soils.

## **COGCC GEOLOGIC HAZARD REQUIREMENTS**

**Rule 304.b.(7).I Geologic Hazard Map**: A map identifying any Geologic Hazards within a 1-mile radius of the proposed Working Pad Surface. For any identified Geologic Hazard that extends beyond the 1-mile radius, a second map scaled to show the extent of that Hazard in relation to the proposed Oil and Gas Location.

- TEP has prepared one map showing the pad site in relation to all Geologic hazards within a 1-mile radius. The second map was not necessary, because there are no hazards.
  - Exhibit GH-1 shows a 1-mile radius around the proposed working pad surface.

**Rule 304.c.(21) Geologic Hazard Plan:** If the Operator identifies any Geologic Hazards pursuant to Rule 304.b.(7).I, the Operator will submit a Geologic Hazard plan describing proposed mitigation measures.

- TEP did not find any risk of Geologic Hazard(s)

## CONCLUSION

Based on TEP's preliminary review of published geologic data, information obtained from the Colorado Geological Survey and Garfield County, along with NRCS soils data, it is TEP's opinion that there are no known geologic hazards within the proposed site of the Arco Deep 1-27 Pad.

## LIMITATIONS

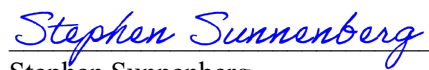
This report is intended for preliminary evaluation purposes only for geologic hazards, as contained in this report, in the project vicinity.

## REFERENCES

- GARCO: JEO Consulting Group Inc, Wright Water Engineers Inc., and Garfield County, Colorado. (August 2017), Garfield County Hazard Mitigation Plan  
<https://s3.amazonaws.com/online.pubhtml5.com/lcrb/zxbu/index.html>
- NCRS: National Resources Conservation Service (2021). Web Soil Survey  
<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>
- CGS: Colorado Geological Survey, (2021) Hazards.  
<https://coloradogeologicalsurvey.org/hazards/>
- Yeend, W.E., 1969, Quaternary Geology of the Grand and Battlement Mesas Area, Colorado: Geological Survey Professional Paper 617
- City of Rifle, Colorado Ordinance No. 7, Series 2018, dated June 6, 2018

## CERTIFICATION

I, Stephen Sunnenberg, certify that I am a Professional Geologist, having met the educational requirements and professional work experience required by C.R.S. § 23-41-208(b). I certify that the Geologic Hazard Report described herein is, to the best of my knowledge, accurate and complete.

  
\_\_\_\_\_  
Stephen Sunnenberg  
Professional Geologist

8/24/2022  
\_\_\_\_\_  
Date