



December 7, 2022

Colorado Oil and Gas Conservation Commission
1120 Lincoln Street, Suite 801
Denver, CO 80203

**RE: Geological Hazards Map and Geological Hazards Report
COGCC Rule 304.b.(7).I and Rule 304.c.(21)
PCU A27 Well Pad Site, Rio Blanco County, Colorado**

Dear COGCC Representative,

Attached you will find Geological Hazard Map and a Geological Hazards Plan for the PCU A27 Central Delivery Point (CDP) and Hydraulic Fracturing Pad. Caerus Oil and Gas LLC (Caerus) retained Entrada Consulting Group, Inc. (Entrada) to assess geologic hazards within one mile of the Working Pad Surface (WPS) of the PCU A27 Pad.

The PCU A27 Pad Geologic Hazards Plan addresses “Geologic Hazards” as outlined by COGCC’s Rules and Regulations and Colorado Revised Statutes (C.R.S.) § 24-65.1-103(8):

“Geologic hazard” means 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 and safety or to property. The term includes but is not limited to:

- (a) Avalanches, landslides, rock falls, mudflows, and unstable or potentially unstable slopes;*
- (b) Seismic effects;*
- (c) Radioactivity; and*
- (d) Ground subsidence.*

The PCU A27 Pad Geologic Hazards Map was prepared in accordance with COGCC 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.

Based on the definition of the geologic hazards stated above, the Geologic Hazard Map, and the references below, geologic hazards were identified within one mile of the WPS. Per COGCC Rule 304.c.(21), a Geologic Hazards Plan is required.



*I 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 the following Geologic Hazards: **Steel Corrosion Due to Corrosive Soils.***

Please see the attached Geological Hazard Maps and Geological Hazard Plan for additional details.

Sincerely,

S. Reed Johnson
Senior Project Geologist
Entrada Consulting Group
Date: December 7, 2022
Wyoming Licensed Professional Geologist #4165

Geological Hazards Map and Report References:

Duncan, D.C., 1976, Preliminary Geologic Map of the Square S Ranch Quadrangle, Rio Blanco County, Colorado, 1 map sheet.

Nelson-Moore, J.L., Bishop C.D., and Hornbaker, A.L., 2005, Colorado Geologic Survey, Bulletin 40, *Radioactive Mineral Occurrences of Colorado*, 1054 p.

Duncan, D.C., 1976, Preliminary Geologic Map of the Square S Ranch Quadrangle, Rio Blanco County, Colorado, 1 map sheet.

White, J. L., and Greenman, C., 2008, *EG-14 Collapsible Soils in Colorado*, Colorado Geological Survey, Department of Natural Resources, 108p, 1 map sheet

Online References:

American Geosciences Institute/Colorado Division of Reclamation Mining and Safety. Interactive Map of Mines in Colorado.

<https://www.americangeosciences.org/critical-issues/maps/interactive-map-mines-colorado>

American Institute for Avalanche Research and Education

<https://avtraining.org/>



Colorado Abandoned Mine Land Map

<https://erams.com/aml/>

Colorado Department of Public Health and Environment – Radon

<https://cdphe.colorado.gov/understanding-radon>

COGCC Online Interactive Map

https://cogccmap.state.co.us/cogcc_gis_online/

Colorado Geological Survey Statewide Landslide Inventory Map ON-006-01

<https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=9dd73db7fbc34139abe51599396e2648>

Radioactive Mineral Occurrence in Colorado

<https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=c5381e1335284d63bfa5d4b018b3372f>

Oregon State University - Prism Climate Group

<https://prism.oregonstate.edu/>

USDA Natural Resources Conservation Service, Web Soil Survey

<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>

USGS Earthquake Hazards Program

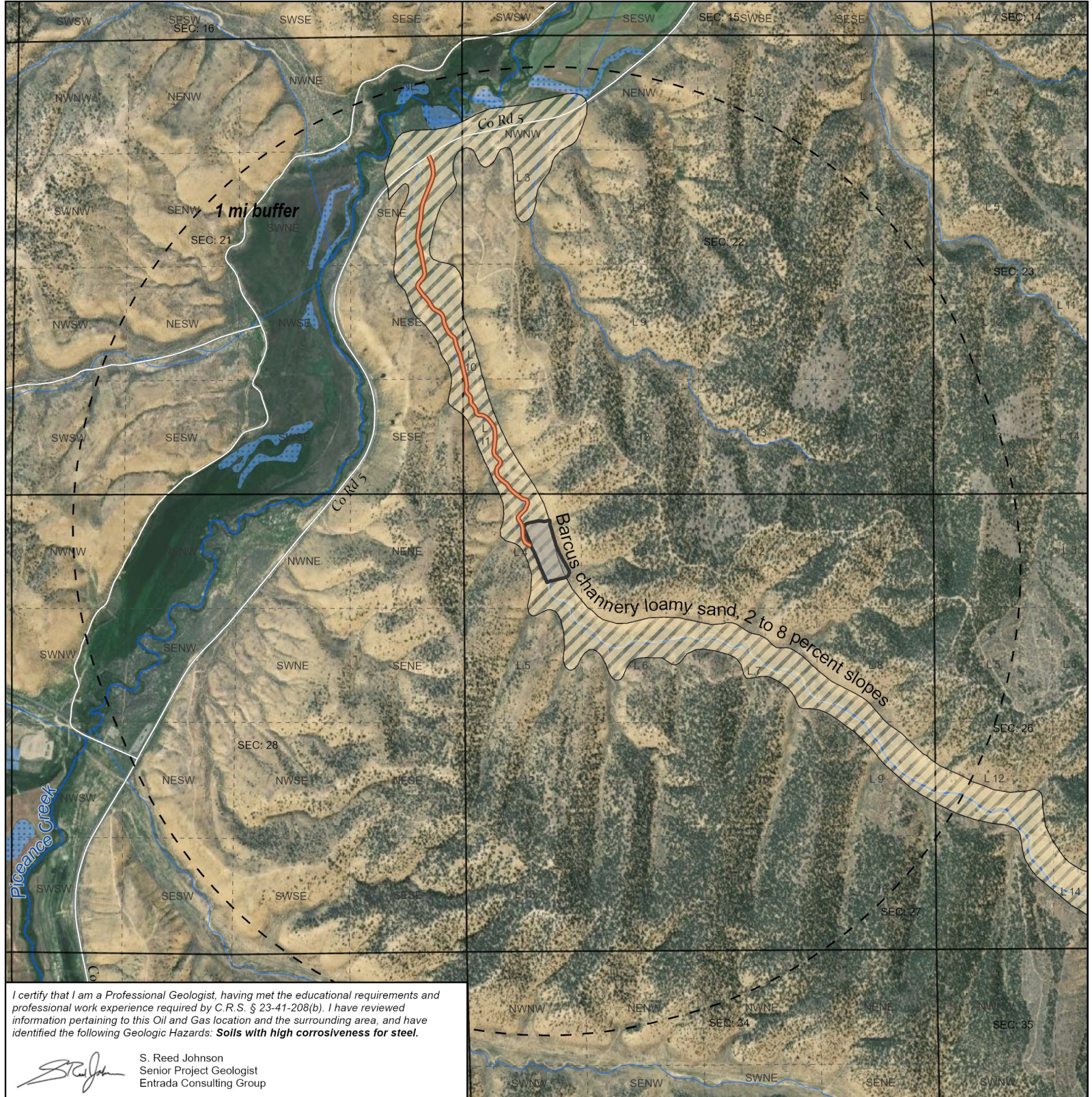
<https://earthquake.usgs.gov/>

USGS Quaternary Faults Database


<https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf>


USGS Mine Related Features


<https://mrdata.usgs.gov/usmin/map-us.html>





I 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 the following Geologic Hazards: **Soils with high corrosiveness for steel.**


 S. Reed Johnson
Senior Project Geologist
Entrada Consulting Group


 PCU A27 197 Access Road


 PCU A27 197 Pad


 Coal Mines (None)


 Updated Statewide Undermined Areas (None)


 100-Year Floodplain (COGCC, None)


 Bercus channery loamy sand, 2 to 8 percent slopes


 Wetland


 Lake/Pond


 Canal Ditch


 Intermittent

 Ephemeral


 Perennial


 Local Road


 High confidence in extent or nature of landslide (None)

 Confident consequential landslide at this location (None)

 Likely landslide at or near this location (None)

 Probable landslide in the area (None)

 Possible landslide in the area (None)



0

1,000

2,000

ft





Figure 1

PCU A27 197 Geologic Hazard and Soils Map

Lot 4, Section 27, T1S R97W, 6th P.M.

Rio Blanco County, Colorado

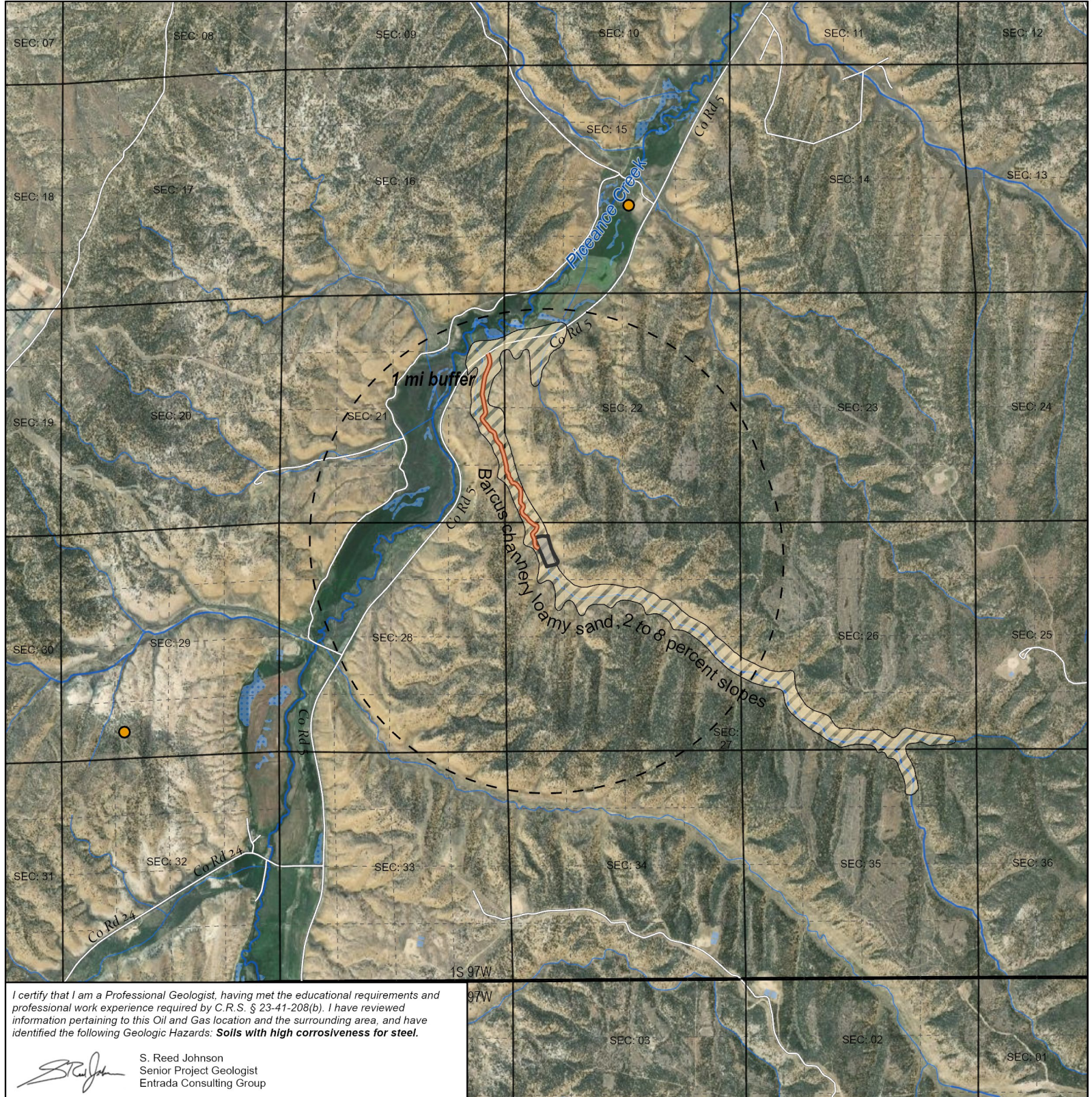


330 Grand Avenue, Unit C

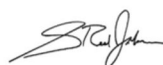
Grand Junction, CO 81501

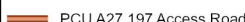
970-549-1015


Survey Date:	
Date Drawn:	12/1/2022
Drawn By:	Nathan Baier
Scale:	1 inch = 2,000 ft





I 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 the following Geologic Hazards: **Soils with high corrosiveness for steel.**


 S. Reed Johnson
Senior Project Geologist
Entrada Consulting Group

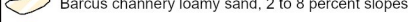

PCU A27 197 Access Road



PCU A27 197 Pad



Coal Mines (None)



Updated Statewide Undermined Areas (None)



100-Year Floodplain (COGCC, None)



Barcus channery loamy sand, 2 to 8 percent slopes



DRMS Mine (2)

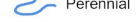

Wetland



Lake/Pond



Canal Ditch



Intermittent

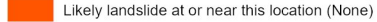

Ephemeral



Perennial

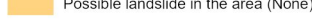

Local Road


High confidence in extent or nature of landslide (None)


Confident consequential landslide at this location (None)


Likely landslide at or near this location (None)


Probable landslide in the area (None)


Possible landslide in the area (None)


N
W E
S

02,0004,000

ft




CAERUS
OIL AND GAS LLC

Figure 2

PCU A27 197 Geologic Hazard and Soils Map
Lot 4, Section 27, T1S R97W, 6th P.M.
Rio Blanco County, Colorado


ENTRADA

330 Grand Avenue, Unit C
Grand Junction, CO 81501
970-549-1015

Survey Date:	
Date Drawn:	12/1/2022
Drawn By:	Nathan Baier
Scale:	1 inch = 4,000 ft

Geologic Hazard Plan
Caerus Oil and Gas LLC
PCU A27 197



Project Number 022-121

December 7, 2022

Table of Contents

1.0	INTRODUCTION	3
2.0	SITE OVERVIEW	3
3.0	GEOLOGIC HAZARDS	3
3.1	AVALANCHES.....	3
3.2	LANDSLIDES.....	3
3.3	ROCKFALLS	3
3.4	MUDFLOWS OR DEBRIS FLOWS	4
3.5	UNSTABLE OR POTENTIALLY UNSTABLE SLOPES	4
3.6	SEISMIC EFFECTS	4
3.7	RADIOACTIVITY	4
3.8	GROUND SUBSIDENCE	5
3.9	CORROSIVE SOILS.....	5
4.0	MEASURES TO AVOID, MINIMIZE, OR MITIGATE IMPACTS OF GEOLOGIC HAZARDS	5
4.1	CORROSIVE SOILS.....	5
5.0	CONCLUSIONS AND SUMMARY	5
6.0	REFERENCES	5

1.0 INTRODUCTION

Caerus Oil and Gas (Caerus) retained Entrada Consulting Group, Inc. (Entrada) to develop a Limited Desktop Geological Hazard Assessment for submittal to the Colorado Oil and Gas Conservation Commission(COGCC) for the proposed PCU A27 197 Well Pad (the Site). This report was developed using publicly available information and no Site visit was performed. This report does not cover subsurface geological hazards that may impact drilling or subsurface operations.

2.0 SITE OVERVIEW

The Site is located in the northern Piceance Basin, atop the Roan Plateau in Rio Blanco County, Colorado. Elevation for the site is approximately 6196 feet above mean sea level (famsl). The Site is located in Lot 4 of section 27, range 97W, township 1S and Latitude and Longitude for the Site are 39.940748°, -108.274369° respectively.

The topography of the area consists of rolling hills and incised valleys and gulches. The Site is located within the canyon of Lee Gulch, an ephemeral drainage that connects to Piceance Creek. Bedrock across the area is comprised of the sandstones and siltstones of the Eocene Uinta Formation.

The Site will be developed on undisturbed ground. The proposed area of disturbances is approximately 5.8 acres.

3.0 GEOLOGIC HAZARDS

A geologic hazard assessment was conducted within a one-mile radius of the proposed site location. In accordance with COGCC Rule 304.b.(7).I., **Geological Hazard Maps (Figure 1 and Figure 2)** were developed for the Form 2A Location Assessment. This Geologic Hazard Plan addresses “Geologic Hazards” as outlined by COGCC’s Rules and Regulations and Colorado Revised Statutes § 24-65.1-103(8).

3.1 AVALANCHES

According to the American Institute for Avalanche Research and Education (AIARE) most avalanches occur on slopes from 30 to 45 degrees. Slope angles in the Site vicinity do not exceed 30 degrees. Furthermore, the Site is not within the higher precipitation and mountainous areas of Colorado where avalanches tend to occur. **Avalanches are not a significant geological hazard at this Site.**

3.2 LANDSLIDES

The Site is not located in a known Landslide Hazard area. The closest landslide deposits that have been mapped are along Piceance Creek and White River near their confluence nine miles north of the Site. **Landslides are not a significant geological hazard at this Site.**

3.3 ROCKFALLS

The Site is not located in a known Rockfall Hazard area. All outcrops capable of producing damaging

rockfalls are sufficient distance from the site as to not pose a hazard. **Rockfalls are not a significant geological hazard at this Site.**

3.4 MUDFLOWS OR DEBRIS FLOWS

Debris flows are common in Colorado and can occur in many locations following heavy precipitation events. However, the Site is not located in a known Mudflow or Debris Flow Hazard area. The Site does underlie relatively steep walled ravines. However, these ravines have very limited catchment areas. **Mudflows and Debris Flows are not significant geological hazards at this Site.**

3.5 UNSTABLE OR POTENTIALLY UNSTABLE SLOPES

The Site will be constructed in a relatively flat-bottomed valley and not on high angle slopes. **Unstable slopes are not a significant geological hazard at this Site.**

3.6 SEISMIC EFFECTS

The Site is 2.95 miles north of a small graben that is bounded by normal faults. The closest faults known to have shown surface deformation due to large earthquakes in the last 2.58 million years are the Redlands Fault Complex, 60 miles away in Fruita, CO. The Site not located above any known mapped faults.

The United States Geological Survey (USGS) Earthquake Hazards Program online records were researched for seismic activity greater than magnitude 2.5 in this area dating back to 1973. The closest recorded earthquake in this dataset was a magnitude 3.4 that occurred on November 3rd 1994 and was located seven miles north of the Site. There was also a magnitude 4.1 that occurred 14.5 miles southwest of the Site on August 24th, 2018. The USGS rates this quake as “low likelihood of casualties and damage.” While significant, properly constructed facilities should suffer no damage in an earthquake of this size. **Earthquakes and seismic effects are not a significant geological hazard at this Site.**

3.7 RADIOACTIVITY

Review of the Colorado Department of Public Health and Environment website for Radon information indicates that Rio Blanco County has high radon potential. It is anticipated that based on the proposed project for the Site, that limited structures and buildings will be developed, and workers will predominantly be outside during the normal work shifts; therefore, radon is not expected to represent a significant geologic or worker exposure health hazard.

Naturally occurring radioactive minerals are common in Rio Blanco County. However, they typically occur in Miocene and Jurassic strata and are therefore not anticipated in the geologic section exposed at this Site. The Site is located 11.4 miles northeast of the Project Rio Blanco Nuclear Test Site and is outside of the COGCC Tier 2 boundary. **Radioactivity is not a significant geological hazard at this Site.**

3.8 GROUND SUBSIDENCE

Two historic mines exist within the vicinity of the Site, Yankee Gulch minerals project 1.60 miles north of the Site and the Horse Draw Oil shale mine 2.01 miles southwest of the Site. While these mines do not present a geologic hazard for the surface operations of the Site, they may constitute a drilling hazard. Please ensure that wellbores are sufficient distance from mining operations.

The Site is not located in an area that is known to have been impacted by karst dissolution, groundwater related subsidence, or known collapsible soils. **Ground Subsidence is not a significant geological hazard at this Site.**

3.9 CORROSIVE SOILS

A soils report from the Natural Resource Conservation Service (NRCS) indicates that the proposed Oil and Gas Location will be located on Barcus channery loamy sand (2-8% slopes) and Torriothents-Rock outcrop complex (15-90% slopes). Barcus channery loamy sand has high a corrosiveness rating for uncoated steel and a low corrosiveness rating for concrete per the NRCS. Torriorthents-Rock outcrop complex has a moderate corrosiveness rating for uncoated steel and a low corrosiveness rating for concrete. Corrosiveness to concrete does not constitute a geological hazard. **However, Steel corrosion due to corrosive soils is a geological hazard at this Site.** The risk associated with this hazard is **low**.

4.0 MEASURES TO AVOID, MINIMIZE, OR MITIGATE IMPACTS OF GEOLOGIC HAZARDS

4.1 CORROSIVE SOILS

Caerus will use coatings on subsurface pipe, sacrificial anodes, and/or cathodic protection to mitigate the risk of steel pipe failure due to corrosive soils.

5.0 CONCLUSIONS AND SUMMARY

Based on this Geological Hazards review of publicly available information, it is Entrada's opinion that the Site can be safely developed. To safely develop, the operator should follow the measures described in section four of this report.

6.0 REFERENCES

Please see the cover letter for a reference list for the Geological Hazard Map and this report.

Sincerely,

A handwritten signature in black ink, appearing to read "S. Reed Johnson". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

S. Reed Johnson
Senior Project Geologist
Entrada Consulting Group
Phone: 720-253-2940
Email: rjohnson@entradainc.com

C.R.S. § 23-41-208(b) Professional Geologist Qualifications:

S. Reed Johnson

**Entrada Consulting Group, 330 Grand Ave., Grand Junction, CO 81501
720-253-2940 | rjohnson@entradainc.com**

Relevant Employment History:

Entrada Consulting Group, Denver, CO and Grand Junction, CO:
Senior Project Geologist.

July 2019 - Present

Vermilion Energy USA Inc., Denver, CO:
Senior Geologist.

February 2015 - October 2018

Resolute Energy, Denver, CO:
Geologist.

December 2013 - February 2015

Comet Ridge Resources LLC, Denver CO:
Geologist.

August 2011 - November 2013

Encana Oil and Gas Inc., Denver, CO:
Geologist.

January 2007 - August 2011

Cabot Oil and Gas Corporation, Denver, CO:
Geology Intern.

May 2006 - August 2006

Education:

West Virginia University, Morgantown, WV, Master of Science, Geology
Western Carolina University, Cullowhee, NC, Bachelor of Science, Geology

May 2007
December 2003