R. T. HICKS CONSULTANTS, LTD.

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Artesia ▲ Carlsbad ▲ Durango ▲ Midland

January 17, 2018

Mr. Mike Bratcher, Ms. Crystal Weaver
New Mexico Oil Conservation Division
811 S. 1st Street
Artesia, NM 88210
Via E-Mail

Ms. Shelly Tucker
Bureau of Land Management
620 E. Greene Street
Carlsbad, NM 88220
Via E-mail

RE: Chi Operating – Benson Delaware Unit #6 Battery (32.67997, -103.93143)
Request for Reconsideration of Denial of Remediation Plan **2RP-4251**

Dear Mr. Bratcher, Ms. Weaver, and Ms. Tucker:

On behalf of Chi Operating, Inc. (operator), Hicks Consultants submits this response to the December 2017 BLM/OCD denial of the November 2017 Corrective Action Plan and request for reconsideration. Given the 295+ foot depth to the groundwater surface, the sandy nature of the near-surface soil, the decreasing concentration of hydrocarbons with depth and the low chloride concentrations in the samples, we did not consider karst as a factor in decision making. We did not examine the karst potential map and that was our mistake.

High Karst Potential and Proposed Remedy

We understand and support the BLM/OCD policy of using the Karst Potential Map as a triage technique to rapidly deny certain proposals. In the absence of mitigating site-specific data, which we did not provide in the November submission, the denial based upon karst potential is appropriate. Throughout the years, we have made proposals for drilling pits, produced water containments and other activities in areas mapped as high karst. In these submissions, we presented site-specific evidence that either caused BLM to modify the karst map or aapprove the proposal.

Soluble rocks (Rustler Formation) exist beneath the BDU #6 location at a depth of more than 100 feet; these soluble rocks may be the rationale for BLM's mapping of this area as high karst potential. Based upon our December 2017 examination of the geology of the BDU #6 area, we cannot justify a classification of high karst potential as it relates to ground instability, enhanced transmission of fluids from the surface to groundwater, or a threat to cave resources by surface activities. The rationale for this conclusion is outlined below.

Geology and the Karst Potential Map

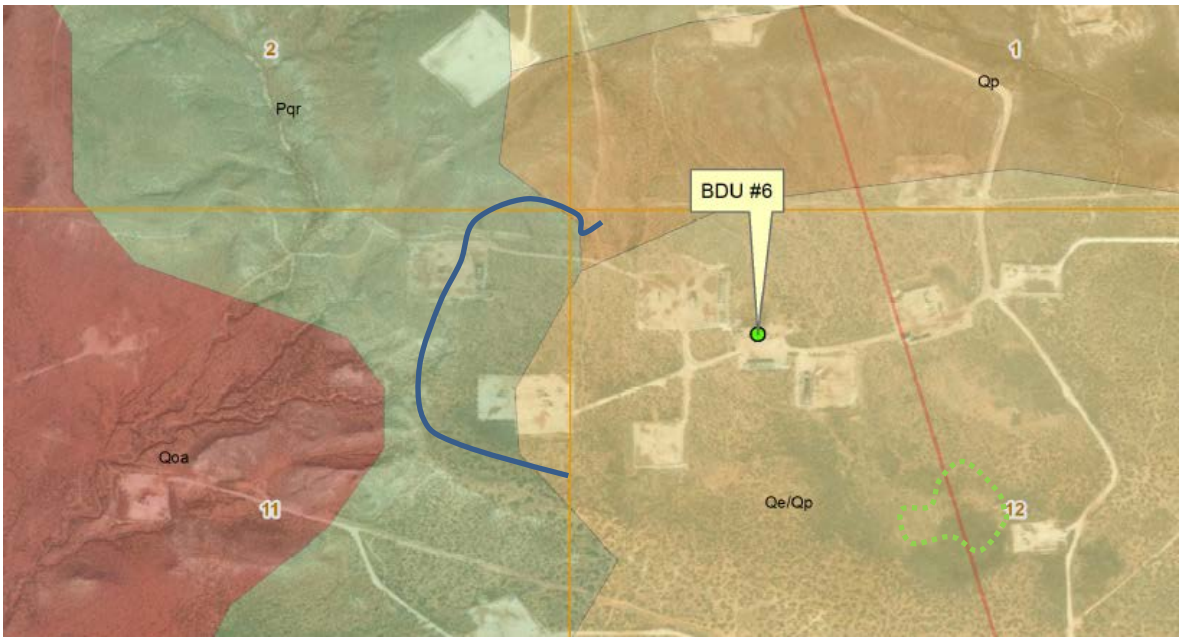
Plate 1 presents the geologic surface map of the area around BDU #6 with the BLM Karst Potential Map overlain. Note the following characteristics about the map:

1. The contacts between the geologic units are not straight lines, but the contact between moderate karst potential and high karst potential is a straight line. The karst boundary line is artificial. Because the karst potential map for the Carlsbad district is at a large scale, mapping the boundary at the scale shown in Plate 1 is neither necessary nor cost-effective. Showing where the boundary exists to 2,000+ feet is all that is

required for the BLM map. Small-scale examination by a Professional Geologist provides in the best assessment in these situations.

2. The New Mexico Geologic Map that is part of Plate 1 is not 100% accurate for the same reasons that the BLM Karst Potential Map is not accurate at small scales. Our walking survey shows that the Quartermaster Formation (Pqr) not Quaternary Piedmont (Qp) crops out on the south-facing slope of the southernmost portion of Section 1 (north of the BDU #6 location as shown in the attached site photographs). <u>The geology observed on the ground, not always on a map, determines the karst potential of a site.</u>

   Plate 2 is an aerial image at the same scale as Plate 1 with the geology of Plate 1 overlain. The straight-line contact between High and Moderate Karst is the red line east of the BDU #6 location. This map shows more clearly the break in slope that defines the contact between the thin veneer of Quaternary Eolian and Piedmont sediments (Qe/Qp) and the underlying Quartermaster Formation (Pqr) – this contact is "erroneously" mapped about 300 feet east where this contact exists on the ground (blue line on inset map below).



3. The Quartermaster Formation in New Mexico was first called the Pierce Canyon Redbeds, then renamed Dewey Lake Formation until the late 1990s when correlation with the Quartermaster in Texas was accepted. Publications describe the Quartermaster Formation as a red/maroon sandstone with interbedded siltstone (or a red/maroon siltstone with interbedded sandstone). Soluble evaporite, such as gypsum, is described as a minor component or the cement of the sandstone layers. Detailed descriptions of the Quartermaster in Eddy County (Geology of Nash Draw[1]) do not describe evaporite beds.

[1] https://pubs.usgs.gov/bul/1141b/report.pdf

This unit is 200-250 feet thick. Excellent exposures of the Quartermaster are present in the area of BDU #6 and are described in the next sections. We saw no evidence of soluble rock units in these exposures.

4. Plate 2 (and Google Earth images) clearly shows two different types of vegetation in the area mapped as Qe/Qp. Within the footprint of the release and surrounding area, the surface consists of 1-5 feet wind-blown sand that is characterized by small shrubs with some grass. Downhill from the release, within a small closed depression, large shrubs exist at the edge of the depression and the interior is fine-grained soil with some grass (see the green dotted line in the southeastern corner of the inset above). Based upon the hand auger borings in the area of BDU #6 and observation of small gulleys in the area, the Quartermaster lies about 1-5 feet below the surface material. The area around BDU #6 exhibits the same geologic characteristics as the area mapped as moderate karst to the east.

5. The closed depressions in the areas mapped as high and moderate karst near BDU #6 are not sinkholes or surface indications of buried karst features. Rather, we believe these small depressions are formed in the same manner as similar features in Lea County (so-called playa lakes overlying the Ogallala Formation) that are mapped as low karst potential. A reasonable explanation of the origin of these depressions and true playa lakes are summarized in USGS Open File Report 94-702-W and presented below with *emphasis* added.

> Numerous theories have been proposed to account for the origin and growth of playa basins. A popular explanation is deflation, or wind erosion. Several authors have suggested that the presence of dunes or lunettes near playas indicates the importance of this process (Reeves, 1966; Price, 1972; Gustavson and others, 1994). However, Osterkamp and Wood (1987) point to the location of playa basins over inferred *bedrock fractures* and in existing and abandoned stream channels as evidence to support the domination of a different process of formation. They propose that surface *depressions of eolian and other origins collect water, which then infiltrates and transports organic material into the unsaturated zone. Oxidation of the organic matter results in the production of carbonic acid, causing dissolution of carbonates and increased permeability. Movement of particulates with descending ground water increases subsurface voids and allows for the subsidence or compaction of near-surface beds, resulting in the deepening and expansion of basins radially*. Some clay-sized material accumulates on the playa floor, reducing permeability beneath the basin. Over time, this material develops into the deep, practically impermeable layer of Randall clay that is characteristic of playa basins.

For the small circular depressions observed near BDU #6, the origin described above makes much more sense than calling upon solution of gypsum beds in the underlying Rustler.

6. West of the BDU #6 location, soluble rocks of the underlying Rustler Formation are either exposed at the surface or are near the ground surface. Karst features, including

> cave resources, are expected at and near the surface in these areas mapped as high karst. The area around BDU #6 does not share these karst features and certainly there are no cave resources within the fluvial siltstone and sandstone of the Quartermaster Formation.

I spoke with Kyle Rybachi of BLM about how BLM handles issues of Karst and he confirmed what is in the most recent description of BLM's cave and karst program (that we could readily find via a Google search) is in the 1997 Carlsbad Area RMP, Appendix 3 PRACTICES FOR OIL AND GAS DRILLING AND OPERATIONS IN CAVE AND KARST AREAS. This document states the following as it relates to mapping cave and karst potential [*emphasis* added].

> Areas that contain *known cave or karst features are in the high potential zone*. Areas containing known soluble rock formations *with the potential for cave or karst development are in the medium potential zone*. These zones were identified using geologic maps and existing information on caves and karst. All other lands fall into the low potential zone. These zones may be increased or decreased in size as new information from drilling, cave exploration or other sources becomes available.

Description of Area Geology

Plate 3 shows the general location of the images described below.

Image 1
This southeast facing image was taken in the area of the northeastern circle in Plate 3 where the character of the Quartermaster is best displayed. The BDU #6 tank battery is behind the battery in the foreground. The images below provide more detail relating to the character of the Quartermaster.

Image 2
This image shows the nature of the Quartermaster exposed on the south-facing slope that is north of BDU #6. Although the rock units in these images have been removed by erosion at the BDU #6, the nature of the Quatermaster in general is well displayed in this outcrop.

All of the red rock in the foreground is a silty sandstone. The ridge is capped by a white sandstone shown at the top of the image and in the image below.

Image 3
The red silty sandstone in the bottom 1/3 of the image is overlain by thin horizons of red mudstone and silty sandstone that are overlain by the white sandstone.

Note that the thin mudstone and sandstone units bend in the central portion of the image. The “bend” does not occur in the sandstone beds above. This “bend” is not a fault movement but is contemporaneous with deposition of the sandstone.

Image 4
This image and the three below are taken from the west-facing slope of exposed Quartermaster Formation that is shown in the circle due west of BDU #6 in Plate 3.

Red siltstone is in the foreground and white sandstone beds are in the center of the image. The rig is a workover at the well site west-southwest of BDU #6.

Image 5
This image is a closer view of the sandstone beds shown in the image above. In this portion of the section, the sandstones are inter-bedded with thin red siltstone.

Image 6
The uppermost prominent sandstone bed in the images above is shown to the left. Note that above and below the white sandstone horizon are gray rock units that appear quite different. This weathering may be due to evaporitic cement in the sandstone as decribed in #3 on page 2.

Image 7
The image below is looking east from near the center of the closed depression that is south-southeast of BDU #6. The foreground is an area mapped as high karst potential and the upper ½ of the image is mapped as moderate karst potential.

Image 8
The panorama presented below is a north facing view taken from the south-western circled area in Plate 3 and the red lines on Plate 3 show the area of view. In this image, the mesa in the center of the image, on the horizon, is composed of the Quartermaster Formation and it slopes (dips) gently to the southeast (right). The Quartermaster mesa to the left dips (slopes) to the west. The geologic map shows no faults in this area and we believe that solution of the underlying Rustler Formation may have caused slumping of the surface and these apparent diverging slopes (dips).

The image also shows the workover rig mast on the right (east) side. The conical hill in the left center of the image above is essentially the same section of Quartermaster observed in Images 4, 5 and 6.

Conclusions Regarding Karst and Geology

Our geologic mapping in the area of BDU #6 did suggest the presence of known cave or karst features. We do not see any evidence to support a conclusion that there is potential for cave or karst development in the Quartermaster Formation. Solution cavities in the Rustler Formation could have occurred during deposition of the fluvial Quartermaster, but there is no surface expression of such features in the area. Given the BLM definition of karst potential, we would characterize this area as low karst potential with respect to ground instability and transport of surface fluids to the water table. This conclusion is supported by the following facts on the ground.

- The dominant rock type of beneath the BDU #6 location is non-soluble sandstone and siltstone to a depth of at least 60 feet.
- Soluble rocks of the Rustler Formation exist near the ground surface to the west of the BDU #6 location and karst features are present as a result. Hackberry Draw may be caused by a collapse feature – albeit a collapse that occurred in geologic, not historical time.
- Neither caves nor karst features are present in the area of BDU #6.

- The site-specific geology and the BLM definitions of karst potential suggest a classification of low potential is appropriate with respect to transport of fluids to groundwater

We request BLM and OCD reconsider the denial of the Corrective Action Plan based upon the site-specific evidence presented in this submission.

Archeology

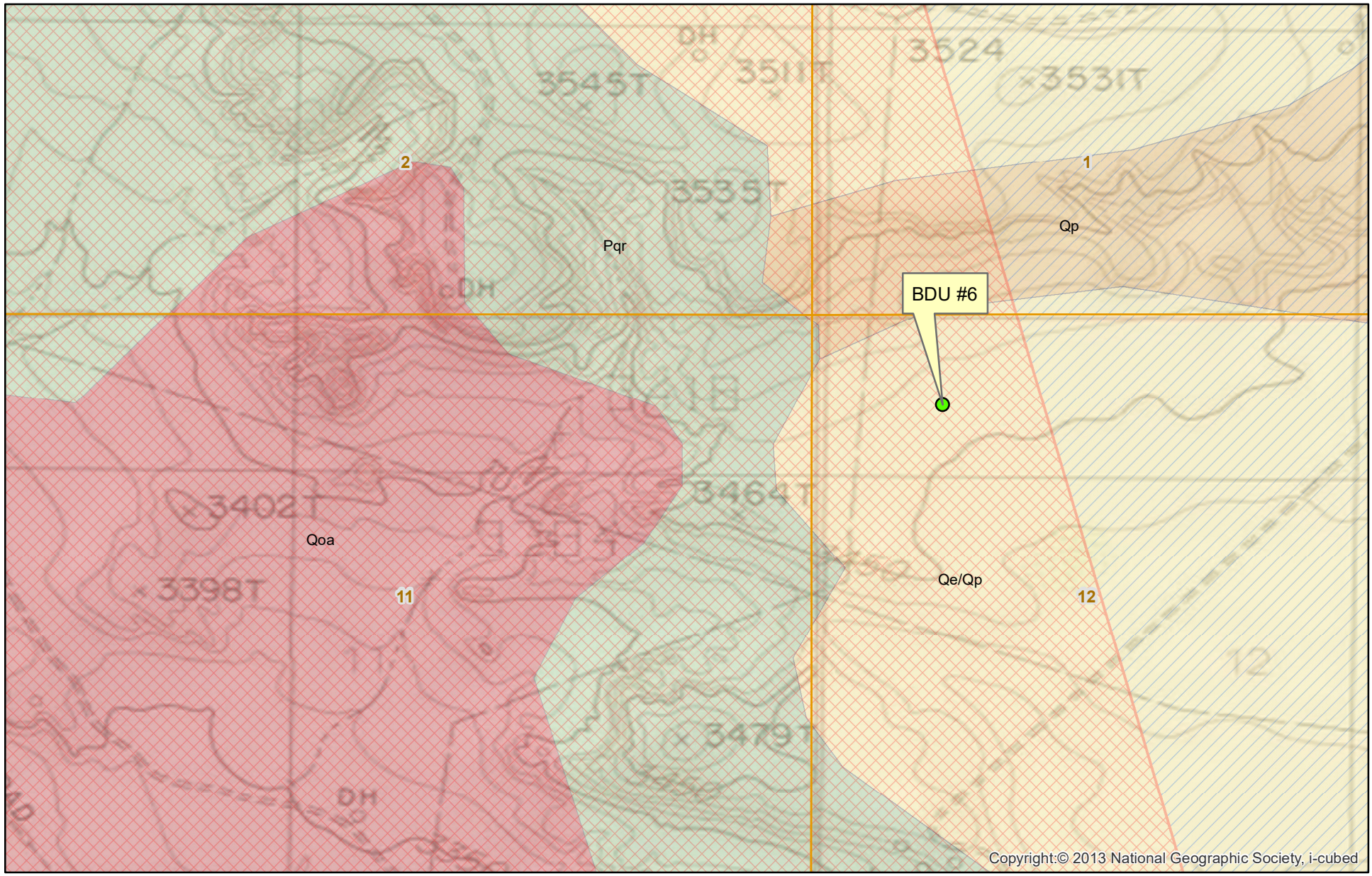
Off-road trails identified by BLM signs criss-cross the spill footprint. We would guess that an archeological survey of the area was conducted by BLM for these trails and may reside in the files. We understand that Chi Operating also caused an archeological survey of the area of the well and tank battery, which should also be in BLM files. While possible, we believe it unlikely that any historic features have been disturbed by the excavation conducted at the release.

Please contact me if you have any questions concerning this response. We would be pleased to provide a geologic field trip of the area to assuage any concerns over the area mapped as high karst.

Sincerely,
R. T. Hicks Consultants

Randall Hicks
Principal

Copy: Chi Operating
Kristin Pope, Mike Stubblefield



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Geology and Mapped Karst Potential	Plate 1
Chi Energy - BDU #6 Release	August 2017

Legend

Karst Occurence Potential

Potential

- High
- Medium

NM Geology

Map Unit, Description

- Pqr, Paleozoic-Quartermaster and Rustler Formations; Upper Permian
- Qe/Qp, Quaternary-Eolian Piedmont Deposits
- Qoa, Quaternary-Older Alluvial Deposits
- Qp, Quaternary-Piedmont Alluvial Deposits

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Geology and Mapped Karst Potential	Plate 1 LEGEND
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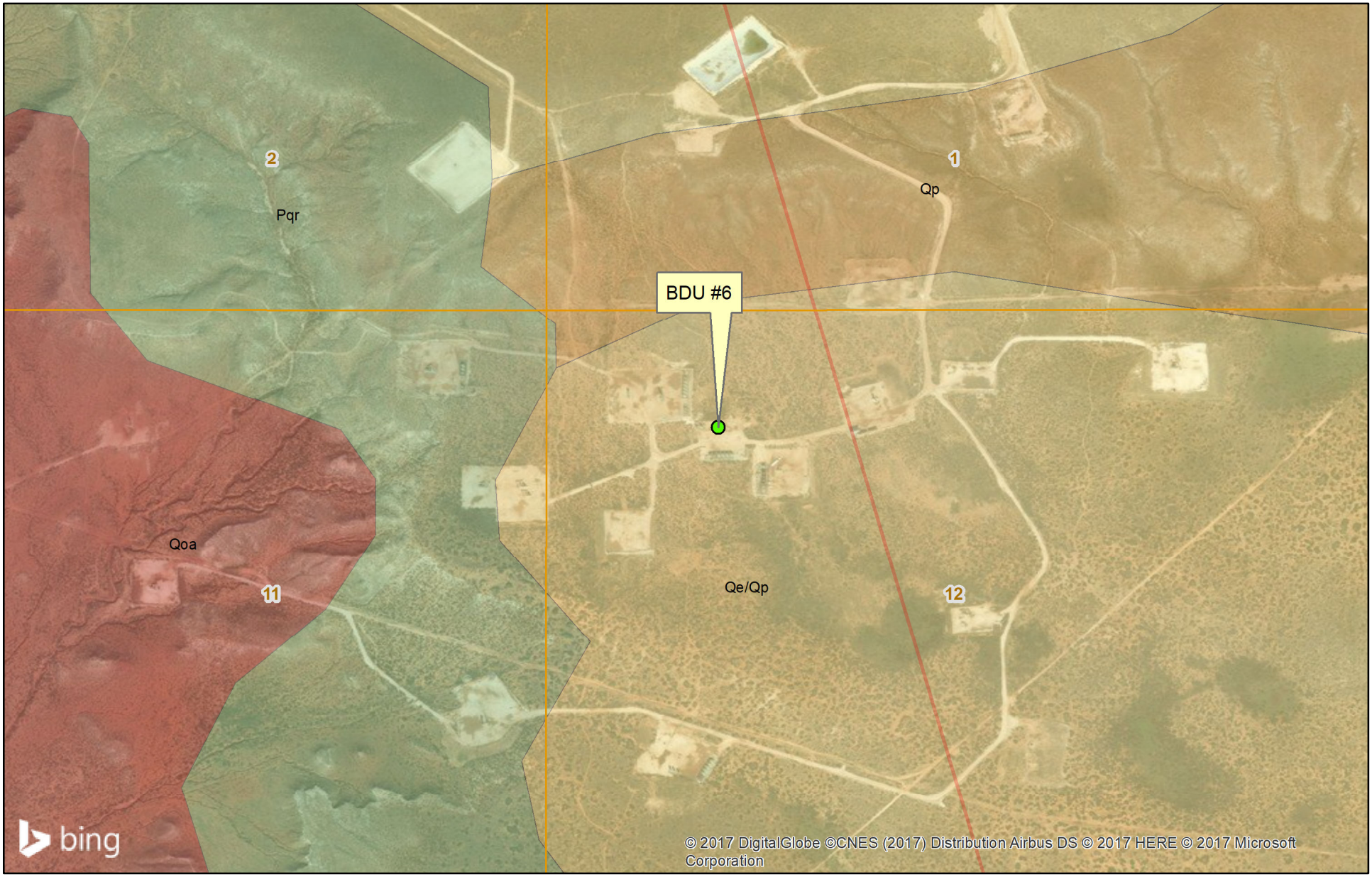

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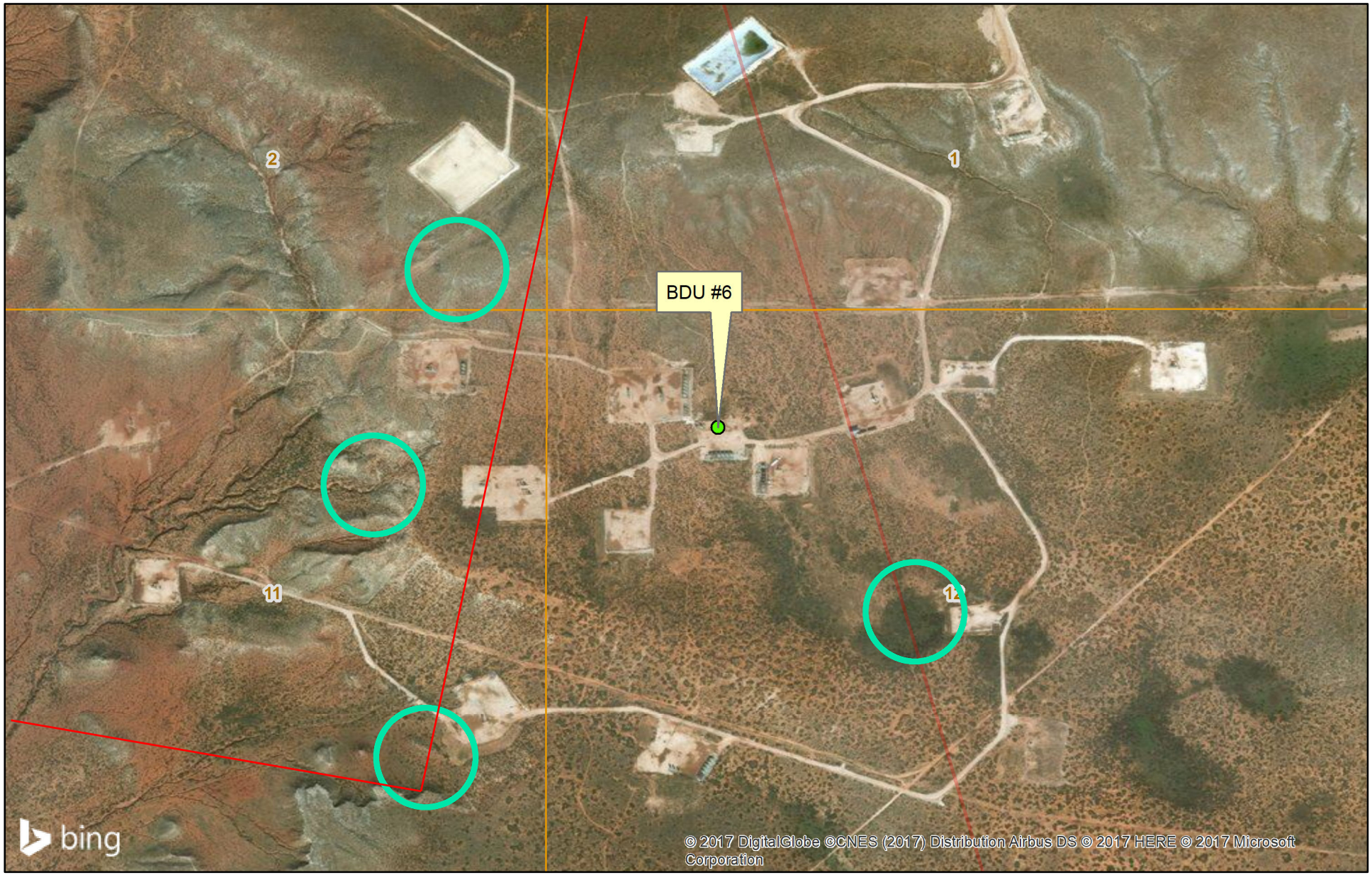
Geology and Mapped Karst Potential - Close Up	Plate 2
Chi Energy - BDU #6 Release	August 2017



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Areas of Photographs

Plate 3

Chi Energy - BDU #6 Release

August 2017