MEMORANDUM
OFFICE OF THE STATE ENGINEER
Hydrology Bureau

DATE: September 14, 2023

TO: Bill Enenbach, Water Rights Division, District 5, Aztec, NM
Shawn Williams, Water Rights Division, District 5, Aztec, NM

THROUGH: Katie Zemlick, Ph.D., Hydrology Bureau Chief kz

FROM: Christopher E. Angel, PG, Senior Hydrologist, Hydrology Bureau CEA

SUBJECT: SJ-4301-POD4 Application to Repair and Deepen - Fracture Stimulation, San Juan Underground Water Basin, Sandoval County, New Mexico.

I. Summary

Enduring Resources IV, LLC (Enduring) submitted a repair and deepen application for the SJ-4301-POD4. More specifically the application is to fracture stimulate the Entrada formation (Entrada). A variance request was submitted during the application process to use non-NSF/ANSI standard 60 certified materials. As the permitted use of the SJ-4301-POD4 is for non-potable oil and gas exploration and production and the Entrada is currently being used for the disposal of oil and gas field waste, the use of non-NSF/ANSI standard 60 certified materials is acceptable.

During this review, clarifications were necessary as previous reports and information indicated that the Chinle formation (Chinle) is pourous and contributing water to the SJ-4301-POD4. During an aquifer test, Shomaker (2019) identified a potential for the Chinle to contribute water to the SJ-4301-POD4. Shomaker (2023) utilizes a MODFLOW model (unreferenced) to discuss how the Chinle is an aquiclude. Enduring submitted additional geophysical log information to aide in confirming that no porosity was likely present in the Chinle at the SJ-4301-POD4 location.

The SJ-4301-POD4 cement bond log (CBL) identified a possible micro-annulus and/or channel in the annular sealant between the Chinle and the Entrada. Based on the information and calculations provided by Enduring, it is unlikely that the fracture stimulation will migrate through the micro-annulus and/or channel.

A mechanical properties log was run in the Kimbeto Wash Unit 2309-19K WSW. Based on this log, the fracture initiation pressure for the Entrada is significantly lower than the fracture initiation pressure for the Todilto and Chinle. Therefore, the fracture stimulation will likely be contained to the Entrada.

Based on the information provided in the SJ-4301-POD4 repair and deepen application to fracture stimulate along with the additional information provided during this review, there is not a significant chance of appropriating water from another hydrogeologic unit. However, it is still recommended that groundwater samples be collected before and after the fracture stimulation according to the recommended conditions of approval.

II. Introduction

On July 20, 2022, Enduring submitted to the New Mexico Office of the State Engineer (NMOSE) District V an application to repair the SJ-4301-POD4 by means of fracture stimulation. On July 20, 2022, the NMOSE Hydrology Bureau was requested to review this application. A request was sent to the applicant for additional information on July 22, 2022. The additional data requested was submitted to the NMOSE on July 25, 2022. After reviewing the additional data, it was recommended that the well be remediated prior to any stimulation. The concerns from this preliminary review were as follows:

1) A channel was identified in the cement bond log (CBL) between 8,885 and 8,975 feet below ground level (fbgl).
2) A channel was identified on the CBL between 8,496 fbgl and 8,705 fbgl.
3) Another area of concern on the CBL is the interval between 1,100 fbg and 15 fbgl.
4) There is no information on the compressive strength of the light-weight cement.

A response email with attachments was submitted by Enduring on September 12, 2022. The Hydrology Bureau submitted a review of the SJ-4301-POD4 information on January 3, 2023 (Angel, 2023a). Some of the general concerns identified in this report are competing interpretations of groundwater being provided to the Entrada from the Chinle, containment of the fracture stimulation with a channel/micro-annulus, containment of the fracture stimulation to the Entrada.

The current review includes information provided by Enduring and John Shomaker and Associates, Inc (JSAI). This information includes:

- June 29, 2023 - Greg Olson - Rincon WSW CBL Analysis (Olson, 2023a; Attachment A1
- July 19, 2023 - Chris Angel - RE: Discussion on CBL (Attachment A2, Angel, 2023b)
- July 26, 2023 - Greg Olson - FW: Rincon Unit 2706 32F WSW with porosity from offset Stove Canyon 1 and Frac Initiation Pressures from POD2 Halliburton Mechanical Properties log 6-20-2023 pptx. (Olson, 2023b; Attachment B1)
- July 31, 2023 - Greg Olson - RE: Rincon 2706-32F WSW CBL (Olson, 2023c; Attachment A3)
- July 31, 2023 - Greg Olson - RE: RE: Rincon 2706-32F WSW CBL (Olson, 2023d; Attachment B2)
- August 14, 2023 - Greg Olson - FW: Rincon Unit WSW geologic memo - Sacerdoti (2023a) attachment (Olson 2023e; Attachment C1)

- August 15, 2023 - Greg Olson - Rincon Unit WSW Geologic Memo - Shomaker (2023) attachment (Olson 2023f; Attachment C2)
- August 15, 2023 - Greg Olson - Request for Variance - Frac Chemicals and SDS (Olson, 2023g; Attachment D1)
- August 16, 2023 - Greg Olson - Rincon POD-4 WSW Logging Issues (Olson, 2023h; Attachment C3)
- August 17, 2023 - Greg Olson - Rincon 2706-32F WSW CBL - Mechanical Properties Log (Olson, 2023i; Attachment B3)
- August 21, 2023 - Sean Owens - Enduring Resources - Rincon WSW Frac Design - Updated frac design that matches the Safety Data Sheets (SDSs) (Owens, 2023a, Attachment D2)
- August 22, 2023 - Sean Owens - - Enduring Resources - Rincon WSW Frac Design - treating pressure (Owens, 2023b, Attachment D3).

III. Chinle

The Chinle is generally considered an aquiclude by the NMOSE. As the Chinle consists of fluvial, lacustrine, eolian and palustrine deposits (Wikipedia, 2022), there is some potential to encounter porous sands and groundwater. Based on the aquifer test analysis reported in Shomaker (2019), "The actual efficiency may be somewhat less, in that there may be some contribution of water by leakage from the underlying Chinle Formation." If this leakage is significant enough so as to affect the well efficiency, then there would likely be an aquifer in the Chinle contributing significant amounts of water. According to Shomaker (2023, Attachment C2), the upper portion of the Chinle consists of claystones and mudstones that are of low permeability and "is not an aquifer." This change is not related to the aquifer test but based on a MODFLOW model (unreferenced). However additional information provided by Enduring does aide in determining if there is an aquifer present in the Chinle.

Enduring was not able to obtain open-hole geophysical logs while drilling the SJ-4301-POD4, due to wellbore stability issues (Sacerdoti, 2023b). Enduring logged the cased-hole with open-hole logs in an attempt to collect some usable data. According to Sacerdoti (2023b, Attachment C2), these logs did not provide any useable information. Therefore, the supplied porosity logs did not effectively evaluate porosity in the Chinle.

Enduring supplied correlations to the Hilcorp Stove Canyon #1 well (Olson, 2023e, and Sacerdoti, 2023a). In this write-up, the Chinle is described as being a 750-foot thick sequence of shales and tight sandstones. In addition, they indicate that the "DOE CarbonSAFE injection site is located in Township 31 North, Range 12 West". It should be noted that no reference was identified in the write-up. An internet search performed by the NMOSE found that the CarbonSAFE is still in the investigatory phase and not in production.

Based on the clarifications provided by Shomaker (2023) and Enduring's emails, it does not appear that Enduring encountered an aquifer in the Chinle confining unit. However, it is recommended that the groundwater be tested before and after the fracture stimulation. These samples will aide in evaluating the potential for groundwater being appropriated from another hydrogeologic unit.

IV. Stimulation Containment in an Annular Space with a Micro-Annulus

Enduring sent the NMOSE an email on July 31, 2023 (Attachment A3) describing the configuration of the wellbore including the number of perforations (528), perforation diameter (0.45-inches) and perforation tunnel length (43.8-inches). Utilizing these values, the perforation surface area is approximately 32,500 square inches. The estimated cross-sectional area of the micro-annulus in approximately 0.52 square inches. The micro-annulus/channel is significantly less surface area and should not take fluid during the fracture stimulation.

V. Frac Barrier

According to Enduring's email and attachments dated July 31, 2023 (Attachment, B2), there are frac barriers above and below the Entrada Sandstone. The frac gradients calculated for the Entrada from post frac data in the SJ-4301-POD1 and 1994 injection tests in the Southern Ute 17 Water Disposal Well (WDW) indicate a frac gradient of 0.58 pounds per square inch per foot (psi/ft) and 0.66 psi/ft, respectively. The frac gradients were also determined from the Halliburton AST Mechanical Properties log run the Kimbeto Wash Unit 2309-19K WSW (Attachment, B3). Based on this log the frac initiation pressure is approximately 5,600 psi for the Entrada. The frac initiation for the Toldilto and the Chinle are approximately 6,775 psi and 6,210, respectively. Therefore, the frac should initiate in the Entrada before the Todilto and the Chinle breakdown.

VI. Fracture Stimulation and Variance Request

The original frac design submitted to the NMOSE on July 20, 2022, was to use Halliburton. On August 21, 2023, Attachment D2, Enduring submitted a new fracture stimulation design utilizing Liberty (Attachment D2). This frac design was modified by email stating that the Bardac is to be replaced with Tolcide 4frac and the surfactant (SFT-NE45B) will not be used. The proposed amounts of fluids, additives and proppants are listed in Table 1. The treating pressure is to be 4,580 psi (Owens, 2023).

The use of these chemicals to fracture stimulate the SJ-4301-POD4 is acceptable, so long as the water produced from this well is only used to supply non-potable water for oil and gas exploration and production operations.

Table 1: Fracture Stimulation Chemical Additive List

Trade Name	Purpose	Quantity	% Total Volume	Comments
CSA-2400	Clay Stabilizer	218 gal	0.100	not NSF/ANSI Standard 60 Certified
Tolcide 4 frac	Biocide	55 gal	0.025	not NSF/ANSI Standard 60 Certified
FRP-48H	Friction Reducer	19 gal	0.009	not NSF/ANSI Standard 60 Certified
BLR-18	Raw AP Breaker	103 lbs by weight	0.006	not NSF/ANSI Standard 60 Certified
Safe-BFH-3	High pH Buffer	103 gal	0.047	not NSF/ANSI Standard 60 Certified
XLB-89	Crosslinker	206 gal	0.094	not NSF/ANSI Standard 60 Certified
J580	Gelling Agent	4,000 pounds	0.220	not NSF/ANSI Standard 60 Certified
7/8" BioBalls	Diverter	396 count	0.0003	not NSF/ANSI Standard 60 Certified
Water		218,000 gal		

Note: Safety Data Sheets (SDS) are attached in Attachment D.

VII. Conclusions

Based on the information provided in the SJ-4301-POD4 repair and deepen application to fracture stimulate along with the additional information provided during this review, there is not a significant chance of appropriating water from another hydrogeologic unit. However, it is still recommended that groundwater samples be collected before and after the fracture stimulation to evaluate the potential for the appropriation of groundwater from another hydrogeologic unit.

VIII. Recommended Conditions Recommendations

It is recommended that:

1) In accordance with Subsection A of 19.27.4.29 NMAC, on-site supervision of the fracture stimulation by the holder of a New Mexico Well Driller License or a NMOSE-registered Drill Rig Supervisor is required. The New Mexico licensed Well Driller shall ensure that stimulation activities are completed in accordance with 19.27.4.29, 19.27.4.30, 19.27.4.31, 19.27.4.33 NMAC, and all specific conditions of approval. While conducting the well stimulation activities, the Well Driller shall maintain a copy of the approved permit, and conditions on-site and available for inspection upon request.

2) Representative samples of groundwater diverted from the SJ-4301-POD4 shall be collected prior to the fracture stimulation.
   a. Groundwater samples shall be analyzed by a New Mexico certified laboratory.
   b. The samples are to be analyzed for concentrations of major anions and cations, alkalinity, specific conductance, and TDS utilizing EPA methods.

c. Purge and sampling protocol in general shall follow industry standards and be acceptable to OSE. Samples shall be taken as close to the wellhead as practicable, before the first branch of the discharge line and prior to any treatment or blending with other water sources. Field measurement of pH, temperature, and specific conductance shall be made at the time of sampling.
d. Laboratory reports and results shall be submitted in writing to the OSE immediately upon receipt.
e. Each analysis shall be performed by a USEPA approved methodology.
f. Groundwater samples shall be collected in accordance with ASTM and/or other suitable industry standard that are acceptable to the OSE and submitted to a New Mexico accredited analytical laboratory.

3) Representative samples of groundwater diverted from the SJ-4301-POD4 shall be collected after the recovery of the stimulation fluid and three (5) to ten (10) times the fracture stimulation volume.
   a. Groundwater samples shall be analyzed by a New Mexico certified laboratory.
   b. The samples are to be analyzed for concentrations of major anions and cations, alkalinity, specific conductance, and TDS utilizing EPA methods.
   c. Purge and sampling protocol in general shall follow industry standards and be acceptable to OSE. Samples shall be taken as close to the wellhead as practicable, before the first branch of the discharge line and prior to any treatment or blending with other water sources. Field measurement of pH, temperature, and specific conductance shall be made at the time of sampling.
   d. Laboratory reports and results shall be submitted in writing to the OSE immediately upon receipt.
   e. Each analysis shall be performed by a USEPA approved methodology.
   f. Groundwater samples shall be collected in accordance with ASTM and/or other suitable industry standard that are acceptable to the OSE and submitted to a New Mexico accredited analytical laboratory.
4) Representative groundwater samples shall be collected annually from the SJ-4301-POD4.
   a. Groundwater samples shall be analyzed by a New Mexico certified laboratory.
   b. The samples are to be analyzed for concentrations of major anions and cations, alkalinity, specific conductance, and TDS utilizing EPA methods. Purge and sampling protocol in general shall follow industry standards and be acceptable to OSE.
   c. Samples shall be taken as close to the wellhead as practicable, before the first branch of the discharge line and prior to any treatment or blending with other water sources. Field measurement of pH, temperature, and specific conductance shall be made at the time of sampling.
   d. Laboratory reports and results shall be submitted in writing to the OSE on an annual basis on or before the 10th day of January for the preceding calendar year.
   e. Each analysis shall be performed by a USEPA approved methodology.
   f. Groundwater samples shall be collected in accordance with ASTM and/or other suitable industry standard that are acceptable to the OSE and submitted to a New Mexico accredited analytical laboratory.
   g. If the water chemistry reflects a significant change in quality of water from the initial water quality information provided for this authorization, OSE may send

notification that more frequent sampling must occur, up to quarterly analysis, from that point forward.

h. If meter readings reflect no water was diverted during a calendar year, DJR shall inform the State Engineer in writing that no samples were taken for that year.

5) The District V Office of the State Engineer shall be notified 48 hours in advance of the fracture stimulation to witness the fracture stimulation.
6) At the completion of the fracture stimulation, a treatment report and chart shall be submitted to the NMOSE documenting at a minimum the treating pressure (psi), slurry rate (bpm), calculated bottom hole pressure (psi), slurry proppant concentration (lb/gal), bottom hole slurry concentration, amount and type of additives used, breakdown pressure, initial shut-in pressure, 5-, 10-, and 15-minute shut-in pressure.
7) The maximum treating pressure to be used is 4,580 psi.

IX. References

Angel, C. (2023a); Review of SJ-4301-POD4 San Juan Underground Water Basin, Sandoval County, New Mexico; New Mexico Office of the State Engineer, dated January 3, 2023.

Angel, C. (2023b); RE: CBL Discussion; to Greg Olson from Chris Angel; Emailed July 19, 2023.

Olson, G. (2023a); CBL Discussion; to Chris Angel from Greg Olson; Emailed June 29, 2023.

Olson, G. (2023b); FW: Rincon Unit 2706 32F WSW with porosity from offset Stove Canyon 1 and Frac Initiation Pressures from POD2 Halliburton Mechanical Properties log 6-20-2023 pptx.; to Chris Angel from Greg Olson, Emailed July 26, 2023.

Olson, G. (2023c); RE: Rincon 2706-32F WSW CBL; to Chris Angel from Greg Olson; Emailed July 31, 2023.

Olson, G. (2023d); RE: RE: Rincon 2706-32F WSW CBL; to Chris Angel from Greg Olson with Attachments, Emailed July 31, 2023.

Olson, G. (2023e); FW: Rincon Unit WSW geologic memo - Attachment Sacerdoti (2023a); to Chris Angel from Greg Olson; Emailed August 14, 2023.

Olson, G. (2023f); FW: Rincon Unit WSW geologic memo - Attachment Shomaker (2023); to Chris Angel from Greg Olson; Emailed August 15, 2023.

Olson, G. (2023g); Request for variance; to Chris Angel from Greg Olson; Emailed August 15, 2023.

Olson, G. (2023h); FW: Rincon POD-4 WSW Logging Issues; Sacerdoti (2023b) Forwarded to Chris Angel from Greg Olson; Emailed August 15, 2023.

Olson, G. (2023i); FW: Rincon 2706-32F WSW CBL - attachment KWU 2309-19K WSW Mechanical Properties PDF.pdf and KWU 2309-19K WSW Mechanical Properties LAS.las; Forwarded to Chris Angel from Greg Olson; Emailed August 17, 2023.

Owens, S. (2023a); Enduring Resources - Rincon WSW frac Design - Attachments; to Chris Angel from Greg Olson; Emailed August 21, 2023.

Owens, S. (2023b); Enduring Resources - Rincon WSW frac Design; to Chris Angel from Sean Owens; Emailed August 21, 2023.

Sacerdoti, R. (2023a); Rincon WSW Entrada Formation and Confining Zone Geologic Description; *in FW: Rincon Unit WSW Geologic Memo;* forwarded to Chris Angel from Sean Owens; Dated August 22, 2023.

Sacerdoti, R. (2023b); FW: Rincon POD-4 WSW Logging Issues; forwarded to Chris Angel from Greg Olson; Dated August 16, 2023.

Shoemaker, J. (2019); Results of pumping test, SJ-4301 POD4, July 12-14, 2019; John Shomaker and Associates, Inc., dated September 30, 2019.

Shoemaker, J. (2023); hydraulic relation between Entrada Sandstone and Chinle Formation; Technical Memorandum - John Shomaker and Associates, Inc., dated August 14, 2023.

Wikipedia, (2022); Chinle Formation, https://en.wikipedia.org/wiki/Chinle_Formation#Arizona_and_western_New_Mexico, accessed December 15, 2022.

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CONDITIONS

Action 300697

CONDITIONS

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CONDITIONS

Created By	Condition	Condition Date
pgoetze	None	1/7/2024