

State of New Mexico
Energy, Minerals and Natural Resources Department

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March 6, 2017

TO: David Catanach, Director, OCD
Daniel Sanchez, UIC Program Manager, OCD

Case 15753

FROM: Phillip Goetze, Engineering Bureau, OCD

RE: FINAL REPORT AND RECOMMENDATIONS REGARDING INJECTION SURVEY RESULTS FOR THE MARALO SHOLES B WELL NO. 2 (API 30-025-09806; SWD-1127); OWL SWD OPERATING LLC

This document is a summary of recent activities related to the testing for the Maralo Shoals B Well No. 2 (the "subject well") performed by the operator, OWL SWD Operating LLC (OWL or the "Operator"). The subject is located 660 feet from the South line and 660 feet from the East line (Unit letter P) of Section 25, Township 25 South, Range 36 East, NMPM. The well is approximately one mile west of the City of Jal in southeastern New Mexico (see Figure 1). The well is located on federal mineral estate under the regulatory authority of the Bureau of Land Management.

The authority to inject was approved by administrative order SWD-1127 dated June 1, 2008. The order approved an injection interval from 2938 feet to approximately 3055 feet below surface in the lower Yates and upper Seven Rivers Formations. The injection interval is open hole and the maximum surface injection pressure is limited to 588 pounds per square inch (psi).

The origins for the investigation of the subject well was due to the following initiatives:

1. The Oil Conservation Division (the "Division") received a formal correspondence from the City of Jal dated April 28, 2016;
2. The review of three applications (Administrative applications No. pMAM1530041540 [Abyss SWD No. 1]; No. pMAM1530040908 [Mojo SWD No. 1]; and No. pMAM1530039137 [Nomad SWD No. 1]) by OWL for additional commercial disposal wells in the same vicinity of the subject well with similar proposed disposal intervals; and
3. The Division's review to a formal request by the United States Environmental Protection Agency (EPA) correspondence dated August 31, 2016, to review current oil and gas injection activities within New Mexico that may potentially impact Underground Sources of Drinking Water (USDWs).

The Division submitted a request as a Notice to Operator dated July 28, 2016, to initiate an injection survey for the subject well. The deadline to complete requested survey was modified on several occasions due to equipment limitations, due to well conditions, and due to

scheduling/availability issues. Two difference injection surveys were completed; the second survey being conducted after the open-hole portions well was cleared of debris following the initial injection survey.

The three cited applications for new disposal wells in this area as the subject well were reviewed by the Division during the fourth quarter of 2015. All three applications were denied in November 2015 as not being qualified for approval through an administrative review process and would require an examiner hearing for the review.

SUBJECT WELL CONSTRUCTION AND HISTORY:

The subject well was spudded on May 25, 1947, and was completed as an oil producer in the Yates Formation on June 30, 1947. The production was form an open-hole interval beginning at the shoe of the 7-inch production casing set at 2935 feet below ground surface (BGS) to a total depth of 2950 feet BGS (see Figure 3).

Following a period of oil production, the well was recompleted in 1961 with bottom plugged back and shallow perforations added from 2871 feet BGS to 2910 feet BGS to produce from a gas sand zone in the Yates.

The well files showed three casing being used for the construction of the well. One exclusive feature of the well is the 8 $\frac{3}{8}$ -inch intermediate casing which has no cement in the annulus between the casing and borehole and was reported as having the shoe of the casing sealed only with drilling mud. This portion of the borehole was reported to penetrate the Santa Rosa Formation, a 10-foot water show in the Rustler Formation, and a single stringer of salt above the major salt interval at 1250 feet BGS.

The well was proposed for plugging on October 26, 1993, but the Notice of Intent was subsequently withdrawn. The remaining period between 1993 and 2003, when Southwest Royalties, Inc. became the new operator, are not documented in the Division's well file. In 2003, Southwest Royalties, Inc. initiated plans to convert the producing well to a disposal well, but did not complete the application process and the well was placed into a temporary abandonment status.

Notice for the conversion of the well to a disposal well was initiated on May 19, 2008, after Division received an application from the Fulfer Oil and Cattle Company, LLC (Fulfer).

INJECTION HISTORY OF SUBJECT WELL:

In 2008, a revised application was submitted to the Division to convert the well by performing remedial action to squeeze cement the perforations used in the recovery from the gas sand and deepening the open hole interval to 3055 feet BGS.

In the C-108 application provided to the Division, the applicant included the following information:

1. [Response to C-108 Section VII, Item 1] the proposed daily injection rate and sources as being "5000 bpd of produced water from Fulfer's own operation and surrounding production of the same waters."

2. [Response to C-108 Section VII, Item 4] the sources are described as “only produced water from formation in this area.”

The C-108 application also included an extensive discussion by the Division, including the Hobbs District Geologist, to determine the potential of the Capitan Reef complex being part of the proposed interval. The District Geologist provided his opinion in an e-mail dated May 16, 2008, that “the reef is not present in the area of the proposed disposal” and further states that the “Reef is probably at least a mile or more to the west.”

The Division reviewer also noted that an area of review (AOR) well, the Sholes B 25 Well No. 1 (API No. 30-025-09812; Unit letter H of Section 25, Township 25 South, Range 36 East, NMPM), should be plugged or temporarily abandoned (see Figure 2). Both this AOR well and the subject well produced from the Jalmat; Tansill-Yates-Seven Rivers (Oil) pool (pool code: 33820; referred to as the “Jalmat pool”). The application also lists another AOR well, the Humphreys Well No. 1 (API No. 30-025-09815), as being “inactive”.

With this information, the administrative order was issued and injection in the well commenced on January 6, 2009, with a reported average daily injection rate of 3,000 barrels. Injection continued until the end of November 2014 with the same operator and averaged an injection rate of 3,843 barrels of water per day (BWPD) with a peak injection rate for a single month being 6,088 BWPD (August 2010) (see Graph 1). Ownership of the subject well occurred in late 2015 and OWL commenced injection in 2016 averaging 18,427 BWPD with a peak injection for a single month being August 2016 with 34,580 BWPD.

INJECTION SURVEYS:

Prior to the commencing the first injection survey, the Division requested that the Operator install a bradenhead valve for the 8 $\frac{5}{8}$ -inch intermediate casing. This was to be monitored for any changes in pressure in this annular space during the injection surveys.

The well was initially tested in September 2016 without any modifications or maintenance of the injection interval. Results of this first survey activity were inconclusive in presenting the distribution of injection fluids for the entire permitted interval due to debris in the borehole. However, the pre-survey testing for the first survey effort did not demonstrate upward migration of fluids between the production casing and the intermediate casing or any issues with the existing tubing and packer system. A copy of the survey results is found in Attachment 3.

The Division and representatives from OWL participated in a meeting in Santa Fe on October 24, 2016. The result of the meeting was to have a new survey with an injection profile over the entire open-hole interval along with an additional effort to be conducted by OWL to demonstrate that the injection interval is not hydrologically connected with the Capitan Reef aquifer system.

Prior to the second testing of the injection interval, the Operator replaced and replumbed the valve recently installed in the 8 $\frac{5}{8}$ -inch casing for monitoring of annular pressure for this casing.

Consultant for OWL provided a Sundry NOI to the District Supervisor for the second injection survey on November 15, 2016, following discussions on possible deepening of the exiting open-

hole interval to provide additional borehole depth to accommodate survey logging tools. This proposal was withdrawn by the consultant and the final proposed plan included only a cleaning of the borehole to the original depth of 3055 feet BGS.

OWL activities for the second test at the well were initiated on November 28, 2016, and completed on December 9, 2016. Copies of the survey results are found in Attachments 5 and 6.

Mr. Chad Kronkosky, P.E., CEK Engineering LLC (CEK) of Lubbock, TX, conducted a review of the injection survey results and compiled a summary report on behalf of OWL. The report was forwarded through the Operator to the Division on January 20, 2017. This report included the efforts to address the items found in the Division's Notice to Operator. A copy of the report is included as Attachment 7.

ADDITIONAL INFORMATION SOURCES:

As part of this effort, the Division compiled and reviewed other sources of data and information available through public sources or personal communications. One of these documents was the Hydrologic Investigation Report prepared by Souder, Miller and Associates (2015) on behalf of the City of Jal. The report presented a thorough evaluation of the hydrology and ground water sources in this area including the Westfield Facility, the current municipal well field for the city. The report identified both the Santa Rosa Formation of the Dockum Group and the Capitan Reef aquifer as potential sources for assessment and possible future development to provide sustainable water sources for the city.

Another source for investigation of the hydrology for this area of Lea County was a presentation by Dr. Lewis Land of the National Cave and Karst Research Institute/New Mexico Bureau of Geology and Mineral Resources (NMBGMR) with regards to water levels in this area of the Capitan Reef aquifer. Dr. Land and the Bureau of Land Management (BLM) have attempted to assess and quantify the impacts of multiple sources (such as drought cycles, diversions of the Pecos River, agriculture uses, oil and gas industry uses, municipal area uses, etc.) on the Capitan Reef aquifer by continuing the effort to monitor the existing groundwater network in Eddy and Lea Counties.

CONCLUSIONS:

The Division reviewed all the submittals by OWL, the information provided to the Division and Division's records and offers the following conclusions:

1. The injection surveys completed by the Operator have demonstrated that injection fluids are entering the approved interval described in Administrative order SWD-1127 for the rate of injection used in the surveys. The injection survey results also indicate no vertical migration of disposal fluids to shallower formations.
2. Though the injection surveys did not demonstrate migration to shallower formations, the technical review and subsequent administrative order did not contain a condition for remedial action to be completed on the open annulus of the 8 $\frac{5}{8}$ -inch intermediate casing where two USDWs are exposed to the Salado formation with its salt intervals. The current

well construction is in violation of Rule 19.15.16.10(A) NMAC and, with continued disposal operation, increased risk for impacts to USDWs if this situation is not addressed.

3. The calculations for assessing the radius of influence (Perturbed/Displaced reservoir Volume Due to Injection (Kronkosky, 2017)) estimated an effected area of 223 acres based on the current total of injection volume. Though these calculations are viable, the model used for these calculations assumes a radial, uniform growth of the injection plume under homogeneous and isotropic conditions.

Division contends that location of the well in the backreef transition into the Capitan Reef lithosome (and inclusive aquifer) is not lithologically homogenous and is modified by structural features, such as the South Jal submarine canyon (Hiss, 1975), which impacts flow direction and transmissivity (see Figure 4C). These features result in a model with a geometry that is non-radial and very susceptible to a preferred flow direction. This model is further augmented by the higher specific gravity of the disposal fluids and its preference to migrate in the down-dip direction towards the west, in general, and possibly north due to the effects of the South Jal submarine canyon. This model would favor a migration of disposal fluids towards the lithostratigraphic boundary of the Seven Rivers Formation and the Capitan Reef, as presented in cross sections by Kronkosky (2017) and Hiss (1976), with the opportunity to impact the Capitan Reef aquifer (see Figure 4D).

4. Additionally, there is indication of impacts to correlative rights and the existing production from wells still active in the Jalmat pool. The AOR well identified in the C-108 application review, the Sholes B 25 Well No. 1 (API No. 30-025-09812), showed a significant increase in water cut from production in the same interval being used for disposal. This producing well is north of the subject well and has a continuous record of monthly production starting prior to 1993 (see Figure 2).

The well is completed with an open hole interval from 2906 feet to 2950 feet. Prior production information showed a period that well was shut-in in 1979 due to high water production. The average production at this time was reported as 10 barrels of oil per day (BOPD), six thousand cubic feet of gas (MCFPD), and 1000 BWPD. A 24-hour test conducted in 1982 showed production results of 27 barrels of oil (BO), 35 thousand cubic feet of gas (MCF), and 936 BW.

Graph 2 shows a summary of production (gas and water) for the Sholes B 25 Well No. 1 for a period beginning in 2007. Prior to the period of the graph, no significant water production was reported during a period from 2004 to 2007. However, with the increased injection rates utilized by OWL, the graphed data showed a significant increase in the water cut for this well.

For November 2016, this well reported 182 MCF produced with 50,400 BW during 19 days of operation and in the following month reported 204 MCF of gas produced along with 71,067 BW during 31 days of operation. The reported totals for the four previous months in 2016 starting with July were as follows: 5 BO, 361 MCF, 599 BW, 31 days of

operation; 296 MCF, 564 BW, 25 days of operation; 322 Mcf, 0 BW, 30 days of operation; and 355 MCF, 78 BW, 31 days of operation.

There are no other producing wells adjacent to the subject well that have continuous monthly reporting for this same period. The only active injection well, the Sholes B 25 Well No. 2 (API No. 30-025-09808), in the vicinity of the subject well shows significant lower injection volumes for the same period of review and is interpreted as having little influence on the production of the Sholes B 25 Well No. 1.

5. The operation of the subject well is not consistent with the information provided in the Form C-108 application submitted for administrative review by the Division. Sources proposed for disposal in the subject well were identified as being from the area and, primarily, for the produced water from the original applicant with primary production from the Jalmat pool. Based on volumes, the subject well is now a commercial operation and the current operator has not provided any supplemental information as to the additional sources of the produced water or its water quality.
6. The Capitan Reef aquifer in this area continues to be impacted as represented by the continued rise in the water levels as measured in the Reef. Figure 6 shows a significant decrease in the depth-to-water for the aquifer with the Southwest Jal monitoring well demonstrating a rise of over 400 feet in the water level for a 35-year period. As proposed by Land (2016), the only source with potential for such impacts would have to be associated with the disposal activities of UIC Class II wells.

If the City of Jal is going to have the opportunity for the future assessment of this portion of the Capitan Reef aquifer for municipal use, the Division should make every effort to minimize all potential sources that may impact the aquifer. This should include commercial disposal operations in shallower zones above the Capitan Reef aquifer in the vicinity.

Finally, the Operator's report provides the following statement regarding water quality:

"The WELL's equivalent (injection interval) in the Capitan Reef (Late/Upper Seven Rivers) Margin is located 3.5+ miles to the west and approximately 200-300' down dip structurally. Additionally, in our opinion, there is sufficient evidence (HISS 1975, NMOCD Case No. 8405 testimony/Water Sample Analysis, IC Potash Corp Feasibility Study) that the interstitial waters of the Capitan Reef and back reef Artesia Group members near the WELL are mineralized above 10,000 mg/L (TDS), digital copies provided on FTP site."

Division counters that the Capitan Reef is shown to have occurrences of both water quality below and above the 10,000 milligrams per liter (mg/L) total dissolved solids (TDS) threshold as defined in Rule 19.15.2.7(U)(1) NMAC. In response to the examples offered in the report:

1. Hiss (1975) provided a figure compiling water quality that showed historical dissolved chloride concentrations for this area of the Capitan Reef aquifer (CPAQ) ranging from 1,200 to 3,300 mg/L (see Figure 4B). Samples obtained from intervals in the Seven Rivers Formation (SVRV) range from 1,900 to 18,000 mg/L while the samples from the shallower Yates Formation (YTES) range from 1,500 to 69,000 mg/L.

2. The referenced sample for Case No. 8405 (offered as Exhibit 1) for Division Order R-7935 demonstrated a TDS of 12,856 mg/L for the Capitan Reef from a well located 4.2 miles to the northwest [West Jal Disposal No. 1; API 30-025-26676; last injecting at an average of 3,576 BWPD into 10 feet of perforations].
3. The IC Potash report (Crowl et al, 2011) provided an extensive discussion of the Jal Water System, a former municipal water source currently being operated by Chevron for oil and gas operations. This report included an assessment for water quality for its proposed production field ranging from 8,000 parts per million (ppm) to 13,000 ppm based on data from the Jal Water System wells.

The approach to characterize the Capitan Reef aquifer based on limited water quality information is not acceptable to support the statement that this aquifer is not protectable as a USDW, and additionally, does not satisfy the requirements for determination of an Exempted Aquifer as accepted under New Mexico State Demonstration for Class II Wells as detailed in 40 CFR 146.4.

RECOMMENDATIONS:

Based upon the findings of the testing and the reports, the Division recommends the following actions for the Director to consider:

1. **For the Operator:** Amend Administrative order SWD-1127 to include a maximum daily injection rate of 6550 BWPD which was demonstrated as an injection rate that confines disposal fluids to the approved interval.
2. **For the Operator:** Include in the amended order a requirement for the operator to install a monitoring system at the wellhead to verify and document this disposal rate for inspection of the well site and that can be compiled for later review.
3. **For the Operator:** Require the operator to submit a remedial plan that shall seal the shoe and the length of the 8 $\frac{5}{8}$ -inch intermediate casing as to isolate the following lithologies in the annulus of the borehole: the salt section, the identified occurrence of groundwater in the Rustler formation and the exposed section of the Santa Rosa Formation. This remedial plan should be submitted in a C-103 Sundry Notice of Intent to the District Supervisor for review and approval.
4. **For the Operator:** Require the operator to provide a list of produced water sources representative of current fluids being disposed in the subject well. This submittal would also provide laboratory analyses representative of the major volumes or from the tank battery/pipeline for the subject well.
5. **For the Division:** Institute a moratorium on new administrative approvals of orders for injection permits for commercial disposal in the area of the Capitan Reef bounded to the north by the outfall area (described by Hiss (1980), approximately the north boundary of Township 21 South) west of Hobbs, New Mexico and defined to the south by the New Mexico-Texas state line. This would exclude
6. **For the Division:** Continued compilation and verification of hydrologic information including current efforts by the New Mexico Office of the State Engineer, the USGS, the BLM and the NMBGMR for this area of the Capitan Reef aquifer system.

The effort to assess and manage injection of the area of Jal is necessary to provide a minimum potential to impact the Capitan Reef aquifer in this area. This allows the maintenance of the current aquifer system without additional contributions from shallow disposal at high rates of injection

and the opportunity for assessment of the USDWs in this area by the City of Jal. If the investigation of the aquifer determines that there are portions which can be excluded based on criteria in 40 CFR 146.4, then a hearing can be conducted to establish an Exempted Aquifer based on applications for future disposal in this interval.

REFERENCES:

Crowl, W. J., Hulse, D. E., and Tucker, G., 2011, Prefeasibility study for the Ochoa Project, Lea County, NM; NI 43-101 Technical Report, prepared by Gustavson Associates for IC Potash Corporation;

Harris, P. M., and Saller, A. H., 1999, Subsurface expression of the Capitan depositional system and implications for hydrocarbon reservoirs, northeastern Delaware Basin: *in* Geologic Framework of the Capitan Reef: Society for Sedimentary Geology (SEPM), Special publication No. 65, p. 37-49.

Hiss, W. L., 1973, Capitan aquifer observation-well network, Carlsbad to Jal New Mexico: New Mexico State Engineer Technical Report 38, 76 p.

Hiss, W. L., 1975, Stratigraphy and ground-water hydrology of the Capitan aquifer, southeastern New Mexico and western Texas: University of Colorado Department of Geological Sciences, Ph.D. Dissertation, 396 p.

Hiss W. L., 1976, Structure of the Permian Guadalupian Capitan aquifer, southeastern New Mexico and western Texas: U. S. Geological Survey Open-File Report 76-0053, 338 p.

Hiss W. L., 1976a, Structure of the Permian Guadalupian Capitan aquifer, southeast New Mexico and western Texas: New Mexico Bureau of Geology and Mineral Resources Resource Map 6; one page.

Hiss, W. L., 1980, Movement of ground water in the Permian Guadalupian aquifer systems, southeastern New Mexico and western Texas: *in* New Mexico Geological Society Guidebook, 31st Field Conference, Trans-Pecos Region, p. 289-294.

Land, Lewis, 2016, Using brackish water from karstic aquifers to augment freshwater resources in the semi-arid southwest, Paper No. 31-4; Geological Society of America Annual Meeting, Denver Colorado.

Souder, Miller and Associates, 2015, Hydrologic Investigation Report, City of Jal Water Rights Appropriation Project, Jal, Lea County, New Mexico; prepared for the City of Jal, p. 110.

Records of the New Mexico Oil Conservation Division: Publicly available information (well files, hearing orders, case files, production information) offered through E-permitting, Imaging and GIS databases.

FIGURES:

FIGURE 1: General Location Map of City of Jal and Related Geologic Features

FIGURE 2: Aerial Photograph Map Showing Major Features and Wells Near the Maralo Sholes B Well No. 2 Location

FIGURE 3: Maralo Sholes B No. 2 Well Diagram

FIGURE 4: Relevant Excerpts from Referenced Reports on the Capitan Reef Aquifer

FIGURE 5: Hydrographs of Capitan Reef Aquifer Monitoring Wells Near Jal, New Mexico

GRAPHS:

GRAPH 1: Daily Injection Rate vs. Time: Maralo Sholes B Well No. 2 (30-025-09806; SWD-1127)

GRAPH 2: Recent Production vs. Time: Sholes B 25 Well No. 1 (30-025-09812)

ATTACHMENTS:

Attachment 1: New Mexico Oil Conservation Division: Notice to Operator dated July 28, 2016

Attachment 2: City of Jal Correspondence dated April 28, 2016

Attachment 3: OWL SWD Operating LLC: Results of Indepth Injection Profile dated September 2, 2016

Attachment 4: OWL SWD Operating LLC: Daily Summaries for Second Injection Surveys

Attachment 5: OWL SWD Operating LLC: Results of Indepth Injection Profile dated December 2, 2016

Attachment 6: OWL SWD Operating LLC: Results of Pump-In Tracer dated December 2, 2016

Attachment 7: CEK Engineering LLC: Final UIC Geological Assessment dated January 12, 2017

**Cc: UIC Class II Program Imaging File
Administrative Order SWD-1127
Well File API 30-025-09806
Ben Stone, SOS Consulting
Robert Gallagher, Mayor, City of Jal and City Council members
Nevin Bannister, OWL SWD Operating, LLC**