



RAILROAD COMMISSION OF TEXAS

HEARINGS DIVISION

OIL & GAS DOCKET NO. 02-0300474, et al.

THE APPLICATIONS OF HILCORP ENERGY COMPANY PURSUANT TO 16 TEX. ADMIN. CODE §3.46 FOR PERMITS TO INJECT FLUID INTO A RESERVOIR PRODUCTIVE OF OIL OR GAS, WEST RANCH -A- LEASE, WELL NUMBERS 1042, 1043, 1044, 1045, 1046, 1066, 1067, 1075, 1110, & 1113 WEST RANCH (41-A & 98-A CONS.) FIELD, JACKSON COUNTY, TEXAS

PROPOSAL FOR DECISION

HEARD BY: Brian Fancher, P.G. – Technical Examiner
Dana A. Lewis – Administrative Law Judge

APPEARANCES:

APPLICANT:

Brian Sullivan
Bill Hayenga
Adam Friedman
Jay King
Abel Salazar
Jill Fisk
Logan Harrell
James Beach

REPRESENTING:

Hilcorp Energy Company

PROTESTANTS:

Jim Allison
Phillip Ledbetter
Venkatesh Uddameri
Tim Andruss
Michael Skalicky

REPRESENTING:

Texana Groundwater Conservation District

PROCEDURAL HISTORY

Application Published: March 23, 2016
Application Filed: April 7, 2016

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|-------------------------------|----------------------------------|
| Protest Received: | April 4, 2016 |
| Request for Hearing: | April 29, 2016 |
| Notice of Hearing: | June 22 & 23, 2016 |
| Hearing Held: | July 27, 28 & September 19, 2016 |
| Transcript Received: | October 4, 2016 |
| Record Closed: | November 14, 2016 |
| Proposal for Decision Issued: | January 17, 2017 |

STATEMENT OF THE CASE

The Technical Examiner and Administrative Law Judge's (collectively Examiners) Proposal For Decision is made of the following oil and gas docket numbers: 02-0300474, 02-0300475, 02-0300476, 02-0300477, 02-0300478, 02-0300479, 02-0300480, 02-0300481, 02-0300482, and 02-0300483. The Examiners chose to consolidate the above-named dockets into Oil & Gas Docket No. 02-0300474 due to the common facts and parties of the cases.

Hilcorp Energy Company (Hilcorp) seeks authority to inject produced water and carbon-dioxide (CO₂) into its West Ranch -A- Lease (Lease), Well Nos. 1042, 1043, 1044, 1045, 1046, 1066, 1067, 1075, 1110 and 1113 (Subject Wells), pursuant to Statewide Rule 46 [16 Tex. Admin. Code §3.46]. The Subject Lease is composed of roughly 11,582-acres. Collectively, Hilcorp proposes to inject 20,000 barrels of water per day per well and 25,000 MCF of CO₂ per day per well into two sand-members of the Frio Formation from 5,700 to 6,300 feet (collectively, Subject Application).

The Subject Application was protested by Texana Groundwater Conservation District (Texana). The boundaries of Texana are coterminous with Jackson County, Texas. Texana asserts that the Subject Application is contrary to the policy of the state, the requirements of the Injection Well Act, and the requirements of Statewide Rule 46. As a result, use of the Subject Wells, as proposed by Hilcorp, will result in harm to groundwater resources. Therefore, Texana argues that the Subject Application should not be approved without special permit conditions.¹

DISCUSSION OF THE EVIDENCE

Statewide Rule 46 ("SWR 46")

Generally, SWR 46 requires that a permit be approved prior to conducting fluid injection operations in a reservoir productive of oil, gas, or geothermal resources. An applicant is required to file its injection application with the Railroad Commission of Texas' ("Commission") Austin office, as well as supply a copy to affected persons who include: (1) the owner of record of the surface tract on which the well is located; (2) each commission-designated operator of any well located within one-half mile of the proposed injection well; (3) the county clerk of the county in which the well is located; and (4) the city clerk or other appropriate city official of any city where the well is located within the corporate city limits of the city.² In addition, notice of each injection

¹ Texana's Closing Argument; Recommended Findings of Fact Nos. 3.28 – 30; Proposed Special Permit Conditions 5.1 – 5.14

² 16 Tex. Admin. Code §3.46(c) ("Notice and opportunity for hearing").

application is required to be published once by the applicant in a newspaper of general circulation for the county where the injection well will be located.

Official Notice

At the hearing, Hilcorp requested that the Examiners take official notice of four cases that were previously heard at the Commission. At the Examiners' request, Hilcorp later submitted a list of those documents that include as follows:³

1. O&G Docket No. 10-0259183 – Application of Crest Resources, Inc. to Consider Assignment of Acreage for Allowable Purposes on its Davis Lease, Well No. 361; and to Consider Amendment of the Allocation Formula for the Stiles Ranch, South (Morrow, Lo) field, Wheeler County, Texas;
2. Rule 37 Case No. 0223786 – Application of Andrew Alan Exploration For an Exception to Statewide Rule 37 to Drill Well No. 1, C.M.E. Dunaway Lease, Multiple Fields, Panola County;
3. O&G Docket No. 02-0297674, et al. – Applications of Hilcorp Energy Company Pursuant to 16 Tex. Admin. Code §3.46 for Permits to Inject Fluid into a Reservoir Productive of Oil or Gas, West Ranch -A- Lease, Well Nos. 1002, 1003, 1005, 1006, 1008 & 1009, West Ranch (41-A/98-A Cons.) Field, Jackson County, Texas;
4. Oil & Gas Docket No. 02-0297905, et al. – Applications of Hilcorp Energy Company Pursuant to 16 Tex. Admin. Code §3.46 for Permits to Inject Fluid into a Reservoir Productive of Oil or Gas, West Ranch -A- Lease, Well Nos. 1061, 1013, 1037, 1038, 1062, 1010, 1036, 1060, 1007, 1035 & 1004, West Ranch (41-A/98-A Cons.) Field, Jackson County, Texas.

Near the end of its direct case, Texana requested that the Examiners take official notice of the complete transcript for O&G Docket No. 02-0295336, et al. – Applications of Hilcorp Energy Company Pursuant to Rule 46 for a Permit to Inject Fluid into a Reservoir Productive of Oil or Gas, West Ranch -A- Lease, Well Nos. 1129, 1144, 1133, 1139, 1089, 1136, 1131, 1104, 1149, 1126, 1115 & 1127, West Ranch (41-A & 98-A Cons.) Field, Jackson County, Texas. Instead, however, it was later admitted as evidence in the Subject Application as Texana's Exh. No. 9.⁴

Applicant's Direct Evidence (Hilcorp)

King's Supporting Testimony

Mr. Jay King, a Staff Geologist employed at Hilcorp, testified as an expert geologist on behalf of Hilcorp.⁵

³ See Examiners' Exh. No. 1 with Tr., Vol. I, Pg. 36, L. 1 – 5 ; Vol. III, Pg. 212, L. 1 – 9.

⁴ Tr., Vol. III, Pg. 177 – 178.

⁵ Tr., Vol. I, Pg. 54, L. 9 – 11.

Hilcorp provided a map of the Lease that identified several features regarding the Subject Application.⁶ That map indicates, in part, the surface locations for the Subject Wells, as well as roughly 57 other injection wells on the Lease that are permitted for injection of CO₂ and/or produced water. Based on that map, Mr. King testified that the Subject Wells appear to be nothing more than an extension of the existing injection well pattern.⁷

Hilcorp received authority from the Commission to unitize portions of the Field for secondary/tertiary recovery purposes in 2016. Hilcorp evidenced that it will recover up to 60 million barrels of oil as a result of that secondary/tertiary recovery operation on the Lease.⁸

Mr. King testified that approval of the Subject Application is integral for Hilcorp to successfully exercise its proposed enhanced recovery operations on the Subject Lease. The Subject Lease will be connected by pipeline to the W.A. Parish Power Plant located in Fort Bend County. That power plant will supply Hilcorp with CO₂ for injection into the Subject Wells.

Geology

Hilcorp submitted a “type log” to demonstrate the petrophysical nature of the subsurface geology that makes up the Field.⁹ He testified, “[i]t shows all the Frio-aged sands and, in particular our target sands down near the 4. It says the 41-A and the 98-A sands...[s]o this is a modern log that basically shows all of the formations in question and the two that we’re dealing with today are injection into the 41-A and 98-A sands.”¹⁰ He testified that there is nothing substantially different from a geologic perspective about the Subject Wells compared to the other roughly 57 injection well locations on the Lease.¹¹

Hilcorp submitted a second type log that is based on a separate well than the West Ranch -A- Lease, Well No. 600 (*i.e.* the first type log). The purpose of the second type log is to demonstrate, in part, that the Anahuac Formation lies above the Field. Mr. King testified, “[t]he Anahuac is about a 500-foot thick shale that seals – it’s above the Frio section [Field], and it’s a 500-foot shale that seals the field from hydrocarbons.”¹² In other words, he testified that the Anahuac was the original trapping mechanism for the Field, and it acts as a seal to prevent the upward migration of injection fluids. He also testified the second type log demonstrates that numerous smaller shale zones exist within the geologic layers that makeup the Field. Those smaller shale zones also act as seals to prevent upward migration of fluids.¹³

⁶ Hilcorp Exh. No. 1.

⁷ Tr., Vol. I., Pg. 57, L. 8 – 13.

⁸ Tr., Vol. I., Pg. 55, L. 8 – 14.

⁹ Hilcorp Exh. No. 4. The type log is based on a well log made for the West Ranch -A- Lease, Well No. 600. It was drilled in 2012. That well is located nearest the center of the Lease, immediately east of Well No. 1035 (*See* Hilcorp Exh. No. 1).

¹⁰ Tr., Vol. I., Pg. 60, L. 19 – Pg. 61, L. 10.

¹¹ Tr., Vol. I., Pg. 57, L. 14 – 17.

¹² Tr., Vol. I., Pg. 62, L. 14 – 16.

¹³ Tr., Vol. I., Pg. 62, L. 21 – Pg. 63, L. 4.

Fisk's Supporting Testimony

Ms. Jill Fisk, the Asset Team Leader for Hilcorp's Central Texas Assets, testified on behalf of Hilcorp as an expert engineer as to the following: (1) drilling and completing wells; (2) injection wells; (3) deploying of wells; (4) enhanced recovery operations; and (5) groundwater monitoring.¹⁴

Chronology of Related Hilcorp Applications

Through Ms Fisk's testimony, Hilcorp established a timeline of events at the Commission that lead to the Subject Application. She testified that she participated in nearly each Commission-held hearing involving Hilcorp's overall secondary/tertiary recovery project on the Lease in the Field. She indicated that the Subject Application makes for the fifth protested hearing held by the Commission to consider applications filed by Hilcorp regarding that project.¹⁵

Hilcorp submitted a series of documents related to Oil & Gas Docket No. 02-0295336, et al. that includes as follows: (1) Final Order Nunc Pro Tunc dated July 15, 2015; (2) Order Denying Motion for Rehearing of Final Order Nunc Pro Tunc dated August 25, 2015; Examiner's Letter No. 2 dated March 13, 2015 – Ruling on Motions for Continuance; and (3) Transcript excerpt from the March 18, 2015 hearing held for that case.¹⁶

The hearing held to consider Round 1 included Hilcorp's applications for authority to inject produced water in Well Nos. 1129, 1144, 1133, 1139, 1089, 1136, 1134, 1104, 1149, 1126, 1115, 1127.¹⁷ Ms. Fisk testified, "[t]his is a series of documents related to the Final Order and PFD for the first round of wells that we permitted, which are the – were the water injection wells at West Ranch."¹⁸ Those wells are described on Hilcorp's Exh. No. 1. as the blue diamonds.

Hilcorp submitted several documents related to Well Nos. 1011, 1012, 1014, 1015, 1017 and 1018 on the Lease that include as follows: (1) a copy of the injection well permit for those wells dated either December 14 or 15, 2015; (2) a copy of the Notice of Hearing dated November 9, 2015, that was created for Well No. 1015 (O&G Docket No. 02-0298352); (3) and a copy of Texana's letter of protest dated August 7, 2015 filed in opposition of Well No. 15.¹⁹ Ms. Fisk testified, "[t]hese were – these are six permits that were granted in December for CO₂ and water injection wells as part of this West Ranch project... they were the first CO₂ and water permits approved."²⁰ A hearing was held to consider Hilcorp's applications for injection authority in Well Nos. 1011 through 1018 on December 7, 2015.²¹ Ms. Fisk stated, however, that no protestant appeared at that hearing. Therefore, those wells were administratively granted authority to inject CO₂ and produced water at the Lease in the Field.²²

¹⁴ Tr., Vol. I., Pg. 115, L. 11 – Pg. 116, L. 7..

¹⁵ Tr., Vol. I., Pg. 114, L. 13 – 23.

¹⁶ Hilcorp Exh. No. 21.

¹⁷ *Id.*

¹⁸ Tr., Vol. I., Pg. 119, L. 6 – 10.

¹⁹ Hilcorp Exh. No. 22.

²⁰ Tr., Vol., I., Pg. 123, L. 19 – 25.

²¹ Hilcorp Exh. No. 22. The record reflects that Hilcorp has historically filed injection well applications on the Lease in batches that include roughly 6 to 12 applications at a time.

²² Tr., Vol. I., Pg. 124, L. 12 – 21.

Like its Exh. No. 22, Hilcorp submitted several documents related to Well Nos. 1016, 1019, 1020, 1039, 1040, and 1063 on the Lease.²³ In short, Ms. Fisk testified that a hearing was scheduled on February 3, 2016, to consider Hilcorp's applications for injection authority as to those wells. She stated that Texana filed a letter of protest opposing those applications. However, no protestant appeared when the hearing was called to order to consider them. Therefore, those wells were also administratively granted authority to inject salt water or a combination of saltwater and CO₂.²⁴

In line with Hilcorp Exh. Nos. 22 and 23, Hilcorp submitted copies of similar documents related to Well Nos. 1022, 1021, 1065, 1064, 1041, 1024, 1023, 1074, 1073, 1072, 1071, 1070, 1069, & 1059.²⁵ Those wells were also approved administratively, due to the lack of a protestant appearing at the hearing to consider their related injection well permit applications.²⁶ The injection permits for those wells provide authority for injection of saltwater and CO₂.

Hilcorp submitted copies of the Proposal for Decision and Final Order related to O&G Docket No. 02-0297674, et al. – Applications of Hilcorp Energy Company Pursuant to 16 Tex. Admin. Code §3.46 for Permits to Inject Fluid into a Reservoir Productive of Oil or Gas, West Ranch -a-Lease, Well Nos. 1002, 1003, 1005, 1006, 1008, 1009, West Ranch (41-A & 98-A Cons.) Field, Jackson County, Texas; and O&G Docket No. 02-0297905, et al. - Applications of Hilcorp Energy Company Pursuant to 16 Tex. Admin. Code §3.46 for Permits to Inject Fluid into a , Reservoir Productive of Oil or Gas, West Ranch -A- Lease, Well Nos. 1061, 1013, 1037, 1038, 1062, 1010, 1036, 1060, 1007, 1035 & 1004, West Ranch (41-A & 98-A Cons.) Field, Jackson County, Texas.²⁷ Ms. Fisk testified that Texana appeared in protest of those applications and argued that a monitoring program sought by Texana was not imposed on Hilcorp by the Commission.²⁸

Subject Wells

For each of the Subject Wells, Ms. Fisk provided the following:

- Proposed completion data and schematic for the Subject Well;
- The injection permit application for the Subject Well;
- Maps showing the quarter-mile radius for the Subject Well showing all wells in that area;
- A summary of the wells within a quarter-mile radius for each Subject Well;
- Commission records concerning the plugging of each plugged well within the quarter-mile radius of the Subject Well that penetrates the proposed injection interval;
- A determination from the Commission Groundwater Advisory Unit designating the base of usable-quality of water at the proposed location for the Subject Well;
- A half-mile radius plat showing there are no other offset operators within a half-mile of the Subject well;

²³ Hilcorp Exh. No. 23.

²⁴ Tr., Vol. I., Pg. 128, L. 7 – 14.

²⁵ Hilcorp Exh. Nos. 26 and 27.

²⁶ Tr., Vol. I., Pg. 133, L. 9 -10.; Pg. 134, L. 17 – 19.

²⁷ Hilcorp Exh. Nos. 24 and 25, respectively.

²⁸ Tr., Vol. I., Pg. 131, L. 12 – 19.

Proposal for Decision

- A Certificate of Notice that the application for the Subject Well was provided to the Chief Clerk in Jackson County, Texas;
- A Certificate of Notice that the application for the Subject Well was provided to the surface owner;
- A copy of the newspaper publication made in the *Jackson County Herald*;
- A Publisher's Affidavit from the newspaper that published notice of permit application and a copy of the notice;
- A United States Geological Survey earthquake survey of the area showing no earthquake activity;
- The Commission permit to drill the Subject Well;
- The letter from the Commission Oil and Gas Division with a determination that the application for the Subject Well is administratively complete but it cannot be approved due to protests received; and
- The Notice of Hearing for the hearing in this case.²⁹

Notice of Application

Sol West is the surface owner at the proposed locations for the Subject Wells. Hilcorp provided a copy of the Subject Application to him and the Jackson County Clerk by letters dated March 14, 2016. A copy of the Subject Application was published in *The Jackson County Herald-Tribune*, a newspaper of general circulation in Jackson County, on Wednesday, March 23, 2016.³⁰

Usable Quality Water

The Commission's Groundwater Advisory Unit determined that the current base of usable quality water ("BUQW") occurs at 1,450 feet below the surface location of the Subject Wells, and that the base of Underground Sources of Drinking Water (USDW) occur at 1,600 feet below the ground surface.

The Wells (Casing, Cementing and Completion)

The Subject Wells are planned to be drilled in the near future. Hilcorp evidenced that each well's design includes 10 ¾" surface casing set at a depth of 2,600 feet and cemented to surface with ~1,400 sacks of cement. Each well will have 7" production casing set at 6,500 feet and cemented to surface with ~1,600 sacks of cement. Injection of fluids into the Subject Wells will be at a maximum surface injection pressure of 2,850 psig.

Areas of Review (AORs)

Hilcorp performed a review of each Commission-regulated well (*e.g.* production wells) located within the ¼-mile and ½-mile radii of each Subject Well's proposed location. Hilcorp is the only operator of wells inside ½-mile of the Subject Wells' proposed locations.

²⁹ Hilcorp Exh. Nos. 29 – 38.

³⁰ *Id.*

Again, well tabulations for each Commission-regulated well located within a ¼-mile radius of the Subject Wells were provided by Hilcorp. Compiling the well tabulations provided show the following:

| | <u>Existing Wells</u> ³¹ | <u>P&A Wells</u> ³² | <u>Penetrates Inj. Int.</u> |
|-----------------------------|-------------------------------------|------------------------------------|-----------------------------|
| Well No. 1042 ³³ | 17 | 6 | 19 |
| Well No. 1113 ³⁴ | 16 | 4 | 15 |
| Well No. 1110 ³⁵ | 16 | 6 | 19 |
| Well No. 1075 ³⁶ | 9 | 3 | 11 |
| Well No. 1067 ³⁷ | 9 | 6 | 12 |
| Well No. 1066 ³⁸ | 14 | 5 | 17 |
| Well No. 1046 ³⁹ | 16 | 8 | 22 |
| Well No. 1045 ⁴⁰ | 15 | 5 | 18 |
| Well No. 1044 ⁴¹ | 17 | 6 | 19 |
| Well No. 1043 ⁴² | 15 | 5 | 16 |

For example, Well No. 1042 is surrounded by 17 existing wellbores and 6 plugged and abandoned wellbores (“P&A Wells” or “P&A’d Wells”). 19 of those 23 total wellbores located within ¼-mile of Well No. 1042 were drilled deep enough to penetrate the Subject Application’s proposed injection interval (*i.e.*, 5,700 to 6,300 feet).

In addition, Hilcorp provided a spreadsheet that summarizes several aspects of the 14 total P&A wells located inside the Subject Wells’ ¼-mile AOR that penetrate the proposed injection interval.⁴³ Of those 14 P&A wells, many are located inside two or more Subject Wells’ ¼-mile AOR. For instance, P&A Well Nos. 380 and 432 are located within six Subject Wells’ ¼-mile AOR. That spreadsheet includes well identification data, spud date, total depth, casing depths,

³¹ “Existing Wells” refers to wellbores that have not been plugged and abandoned.

³² “P&A Wells” refers to plugged and abandoned wellbores.

³³ See Hilcorp Exh. No. 29.

³⁴ See Hilcorp Exh. No. 30.

³⁵ See Hilcorp Exh. No. 31.

³⁶ See Hilcorp Exh. No. 32.

³⁷ See Hilcorp Exh. No. 33.

³⁸ See Hilcorp Exh. No. 34.

³⁹ See Hilcorp Exh. No. 35.

⁴⁰ See Hilcorp Exh. No. 36.

⁴¹ See Hilcorp Exh. No. 37.

⁴² See Hilcorp Exh. No. 38.

⁴³ Hilcorp Exh. No. 39.

plugging data, and general comments related those P&A wells. The spreadsheet shows that P&A Well Nos. 7ST, 8, 126, 154, 160, 176, 192, 204, 224, 241, 261, 298, 380 and 432 all have surface casing set above the current BUQW, which is at 1,450 feet. Ms. Fisk stated that P&A Well Nos. 192, 204, 224, 398, and 432 are within ¼-mile AORs for injection wells on the Lease that previously received a permit for injection authority from the Commission. She testified that none of the P&A'd Wells located within a ¼-mile AOR of the Subject Wells will be a conduit for the migration of injected fluids because the deepest plug in those wells is below the BUQW.⁴⁴ She asserted that approval of Hilcorp's consolidated application is necessary to recover hydrocarbons in the Subject Field to prevent waste.⁴⁵

Re-Entry of Existing P&A'd Wells

Ms. Fisk testified regarding an exhibit consisting of a three point summarization entitled, "Risks with Re-entering P&A'd Wells."⁴⁶ The three main points of that exhibit include; (1) Re-entering P&A'd Wells could damage the surface casing that is protecting usable quality groundwater; (2) If the previous operator was unable to set deeper plugs during the original P&A operation, then it is very unlikely that subsequent operations would be successful; and, (3) In many of the P&D'd wells at West Ranch (*i.e.*, Subject Lease), the production casing has been cut and salvaged near the bottom of the surface casing, which makes it very difficult to re-enter a well.

In summary, based on that exhibit, Ms. Fisk testified that "...[b]ut when we have wells that we – that have been P&A'd properly, the Railroad commission has determined that they're P&A'd properly, we don't see any reward to – any benefit to re-entering those wells. It would only present these risks where a problem doesn't currently exist."⁴⁷

Wellbore Evaluation & Monitoring Program ("WEMP")

Ms. Fisk indicated that she is in charge of the WEMP at the Subject Lease. She testified regarding an exhibit that summarizes the implementation and development of Hilcorp's WEMP at the Subject Lease.⁴⁸ With regard to the wellbore evaluation efforts, Hilcorp will review the mechanical integrity of all, roughly 700, existing wells on the Subject Lease and rate them through a priority system created by Hilcorp. After review, those wellbores will either be used as part of the CO₂ flood as production wells, used as a monitoring well, or P&A'd.

With regard to the monitoring program, Hilcorp will install tubing and casing pressure gauges on roughly 400 wells.⁴⁹ She testified, "...[s]o that extensive monitoring of these 400 wells... spread across the field aerially and vertically is, again, a very early warning system if – if a problem were to occur."⁵⁰ Ms. Fisk later stated that Hilcorp will continue that pressure monitoring program for the life of the overall secondary/tertiary recovery project.⁵¹

⁴⁴ Tr., Vol. I., Pg. 249, L. 16 – 19.

⁴⁵ Tr., Vol. I., Pg. 244, L. 4 – 14.

⁴⁶ Hilcorp Exh. No. 40.

⁴⁷ Tr., Vol. I., Pg. 176, L. 10 – 15.

⁴⁸ Hilcorp Exh. No. 41.

⁴⁹ See also Hilcorp Exh. No. 44 – Inactive Well Monitoring Program.

⁵⁰ Tr., Vol. I., Pg. 179, L. 21 – 25.

⁵¹ Tr., Vol. II., Pg. 32, L. 16 – 20.

Ms Fisk also indicated that Hilcorp will monitor certain wells by running Reservoir Saturation Logs (RST) in them to determine the movement of fluid in the subsurface. She testified, "...[y]ou run a baseline log to see where oil, gas and water are currently at in the well, and then you can run those logs through time to look for any changes in the reservoir. So again, if CO₂ were to migrate out of our injection interval into another zone, we would see that change on that log, and that would be [sic] very early identification that we may have a problem long before it gets anywhere near the groundwater interval."⁵²

Orphaned Wells

As to orphaned wells, Ms. Fisk began by stating, "[a]lso... within these unit boundaries there are no orphaned wells and no wells that we've identified so far that would cause any problems to allow fluid migration."⁵³ She indicated that Hilcorp recently acquired new leases from the Texas General Land Office (GLO) along the Lavaca River on the eastern boundary of the Field. She testified, "we did identify that down on the near -right on the border of our lease, on the opposite side of the Lavaca River from Hilcorp, two wells, the Lavaca River No. 3 and the Lavaca River No. 4, which is just off of our lease are - were orphaned... they're under contract to be plugged, but the Railroad Commission is waiting on permits from the Corps of Engineers because there will be wetland disturbance... those will be plugged as soon as they receive their Corps permits. But they are well outside of our injection interval at this point, one just on our lease [Lavaca River No. 3]⁵⁴, one just off."⁵⁵ She stated that the orphaned well within Hilcorp's unit boundary does not penetrate the injection interval.⁵⁶

Groundwater Monitoring Plan ("GMP")

Ms. Fisk testified regarding an exhibit entitled, "Groundwater Monitoring Plan," as well as an aerial map that indicates the locations of groundwater monitoring wells.⁵⁷ Hilcorp demonstrated that it will incorporate 12 total groundwater monitoring wells on the Lease. Eight groundwater monitoring wells are completed in the Chicot Aquifer; four wells will be completed in the Evangeline Aquifer.⁵⁸ The Chico Aquifer, which is the shallower aquifer that is commonly used in the area, occurs around 150 to 200 feet below ground surface. The Evangeline Aquifer, which is the deeper, higher water quality aquifer, occurs around 1,150 to 1,250 feet below the ground surface.

She testified that program is active, and that Hilcorp began performing baseline sampling in October 2015. That sampling will continue until roughly October 2016, which is the time that Hilcorp will initiate injection of CO₂ in the Field. After that, Hilcorp will sample quarterly during CO₂ injection operations for at least three years and intermittently as needed thereafter.⁵⁹

⁵² Tr., Vol. I., Pg. 180, L. 4 - 11.

⁵³ Tr., Vol. I., Pg. 181, L. 6 - 10.

⁵⁴ Tr., Vol. II., Pg. 30, L. 1 - 3.

⁵⁵ Tr., Vol. I., Pg. 181, L. 19 - Pg. 182, L. 15.

⁵⁶ Tr., Vol. I., Pg. 181, L. 16 - 20.

⁵⁷ Hilcorp Exh. Nos. 44, 45, and 46; *see also* Hilcorp Exh. No. 61.

⁵⁸ Tr., Vol. I., Pg. 207, L. 23 - Pg. 208.

⁵⁹ Tr., Vol. I., Pg. 199.

Groundwater sampling will be performed by Timberwolf Environmental, a third-party environmental consulting company.⁶⁰ Those samples will be analyzed by TestAmerica, an environmental laboratory that's accredited by the State of Texas and follows applicable EPA guidelines. Samples will be analyzed for dissolved gasses (CO₂, ethane, and methane), dissolved metals (Arsenic, Barium Cadmium, Chromium, Lead, Mercury, Selenium, and Silver), and additional water quality parameters (*e.g.*, iron, manganese, pH, etc.). The groundwater analytical results will be provided to landowners upon request.⁶¹

Salazar's Supporting Testimony

Mr. Abel Salazar, a Staff Reservoir Engineer at Hilcorp, testified as an expert reservoir engineer on behalf of Hilcorp.⁶²

Development Plan

Hilcorp plans to successively incorporate a total of about 114 CO₂ injection patterns, or injection wells, on the Subject Lease through the year 2020.⁶³ The Subject Wells are planned for Hilcorp's 2018 phase on the Lease. Mr. Salazar testified that Hilcorp plans to begin drilling roughly 48 wells per year through the year 2020. In other words, Hilcorp's development plan for the Subject Lease will include roughly 158 injection wells and 164 production wells. Each of those wells will be newly drilled.⁶⁴

Hilcorp presented a "pressure profile" of the Subject Field based on downhole pressure measurements taken from a single well, the WRA No. 600.⁶⁵ That profile eclipses 30 zones that span from roughly 3,050 to 6,400 feet in that well. Mr. Salazar testified that he used a methodology called repeat formation tester (RFT) to construct the profile. Based on that exhibit, the reservoir pressures generally increase with depth and that no fluid movement was observed between those 30 zones. Therefore, those 30 zones are not in pressure communication.⁶⁶ For example, the zone immediately overlying the proposed injection interval measured 783 pounds per square inch gauge psig. The 41-A Sand (*i.e.*, the top of the proposed injection interval) recorded a reservoir pressure of 2,162 psig. In comparison, those two zones show a pressure differential of roughly 1,379 psig, which indicates that the zone immediately overlying the 41-A Sand is isolated from the proposed injection interval. Thus, the Subject Application's proposed injection interval contains adequate confinement immediately above it.⁶⁷

Mr. Salazar further elaborated as to that pressure profile. He testified, "... these low pressure zones would see the fluids from injection interval way before any groundwater sand. So there's so many numerous low pressure sands that if there was some kind of leak, it would show up here first. And we've confirmed this. We've done –we've performed this procedure on a few other wells in the past six months where we drill the wells and the profile is the same. I mean, you

⁶⁰ *Id.*

⁶¹ Hilcorp Exh. No. 45.

⁶² Tr., Vol. II., Pg. 52, L. 11 – 16.

⁶³ See also Hilcorp Exh. Nos. 50-A & 50-B with Tr., Vol. II., Pg. 53, L. 19 – Pg. 54, L. 1..

⁶⁴ See Hilcorp Exh. No. 24; Examiners' PFD; Pg. 5; ¶1.

⁶⁵ Hilcorp Exh. No. 52.

⁶⁶ Tr., Vol. I., Pg. 83, L. 4 – 25.

⁶⁷ Tr., Vol. I., Pg. 88 , L. 25 – Pg. 89, L. 10; see also Hilcorp Exh. No. 14, Pgs. 1-2.

Proposal for Decision

got low pressure zones alternating with high pressure zones because these zones are pretty continuous...[s]o any leakage, it would have – if there was a path, it would have to go through these low pressure zones first...[y]ou would see them in the low pressure zones long before it would travel another 3,000-plus feet to hit the groundwater.”⁶⁸

Beach’s Supporting Testimony

Mr. James Beach, a consulting hydrogeologist, testified as an expert in hydrogeology on behalf of Hilcorp.⁶⁹ Mr. Beach was hired by Hilcorp to specifically look at potential fluid migration beyond the proposed injection interval, and to evaluate the sufficiency of Hilcorp’s proposed monitoring system.⁷⁰

To demonstrate his position, Hilcorp submitted a copy of a well log made for Hilcorp’s West Ranch -A- Lease, Well No. 600, complete with Mr. Beach’s annotations.⁷¹ In summary, that exhibit includes brackets on the log to distinguish shallow groundwater (*i.e.* fresh water) from deeper, brackish water. The total number of pressure monitoring wells to be completed in various reservoirs that makeup the Field are demonstrated as Tier 1 through Tier 4. For instance, it depicts that a total of 278 pressure monitoring wells will be completed in the 41-A and 98-A sands (Tiers 1 and 2). It also indicates that 12 total groundwater monitoring wells will be completed in the Chico and Evangeline Aquifers.

Based on his review of the Subject Application as to the migration of injection fluids escaping the proposed injection interval, Mr. Beach opined, “based on the fact that there’s so much confining geology, both with the – the clays and shales above the injection/production zone and then the thick, 500-foot Anahuac... it’s been concluded by several different professionals and experts in the Bureau of Economic Geology (BEG) that there’s no faulting in the area, and it’s been testified to that there’s no short circuits through abandoned wells, et cetera, there will be no migration above the fluids.”⁷²

As to whether or not Hilcorp’s proposed monitoring programs (*i.e.* pressure and groundwater monitoring) are appropriate compared to the subsurface geology beneath the Lease, Mr. Beach testified, “[i]t’s very adequate, more than adequate. It’s not required at all, but the multitiered monitoring that’s being done will – you know, basically entails what the research indicates is the best way to go about monitoring, and that’s pressure monitoring right above the injection and production zone. And then the multitiers above that just add extra layers of protection.”⁷³

Protestant’s Argument (Texana)

Texana argued the Subject Application is contrary to the policy of the state, the requirements of the Injection Well Act, and the requirements of Statewide Rule 46. As a result,

⁶⁸ Tr., Vol. II., Pg. 75, L. 21 – Pg. 76, L. 15.

⁶⁹ Tr., Vol. II., Pg. 106 – 108.

⁷⁰ Tr., Vol. II., Pg. 109, L. 11 – 15.

⁷¹ Hilcorp Exh. No. 55 – Entitled, “Schematic of West Ranch Geology and Aquifers.”

⁷² Tr., Vol. II., Pg. 135, L. 17 – Pg. 136, L. 7.

⁷³ Tr., Vol. II., Pg. 136, L. 8 – 23.

Proposal for Decision

use of the Subject Wells, as proposed by Hilcorp, will result in harm to groundwater resources. Therefore, Texana argues that the Subject Application should not be approved without special permit conditions.⁷⁴

Andruss' Supporting Testimony

Tim Andruss, general manager of Texana, testified on behalf of Texana. Mr. Andruss stated that his general duties as general manager of Texana are to oversee its operations and activities.

Texana is concerned that execution of the project on the Subject Lease by Hilcorp will put groundwater resources at risk due to the amount of development by wells in the Field. He testified that leaking oil and gas wells were discovered in 2012 that indicate deeper brine can be brought to the surface or shallow subsurface water under increased pressures.⁷⁵ Consequently, that occurrence would lead to fresh water contamination.⁷⁶

Mr. Andruss testified that Texana's approximate total annual revenue is \$190,000. Out of that annual revenue, Texana could allocate roughly \$70,000 to \$80,000 to maintain a groundwater monitoring and groundwater protection program.⁷⁷ He stated that although Texana has made an application for grant funding that would incorporate aquifer monitoring in the region, no such funding is presently available. Therefore, Texana's ability to engage in groundwater monitoring and supervision is limited.⁷⁸

Mr. Andruss testified that Texana's standing policy towards injection well applications for wells located within its boundaries is to review such applications filed by an applicant and assess its risk to groundwater. He testified that Texana commonly identifies applications for injection well permits through observation in the newspaper. Subsequently, Texana immediately protests those applications to preserve the opportunity to review and assess them. He stated that Texana exercises that practice because a notice of application for an injection well permit requires that a protest be submitted to the Commission within 10 days from the notice date. He believes that 10 days is inadequate because at the time Texana observes such notice in the newspaper it does not have a copy of the application, or it may not be available on the Commission's website. Mr. Andruss testified that there have been occasions in the past where Texana has withdrawn its protest against an application for a injection well permit after an applicant and Texana entered agreements as to groundwater monitoring around that particular project.⁷⁹ He stated that has been Texana's standard practice and process for many years. He also asserted that Texana typically deals with injection well projects that include one or two injection wells, and that it has never faced a project involving the number of injection wells Hilcorp seeks to permit for injection on the Subject Lease.

Mr. Andruss testified that Texana protested the initial injection well application filed by Hilcorp on the Subject Lease after it observed a notice of application for that well. Subsequently, Texana contacted Hilcorp and entered mutual discussions as to that injection well. As a result of those discussions, Texana later withdrew its protest to that injection well application based on an agreement that Hilcorp register water wells on their property and collect water quality data from

⁷⁴ Texana's Closing Argument; Recommended Findings of Fact Nos. 3.28 – 30; Proposed Special Permit Conditions 5.1 – 5.14.

⁷⁵ Tr., Vol. II., Pgs 166 – 167.

⁷⁶ Tr., Vol. II., Pg. 169, L. 3 – 4.

⁷⁷ Tr., Vol. II., Pgs. 151 – 152.

⁷⁸ Tr., Vol. II., Pg. 152, L. 7 – 21.

⁷⁹ Tr., Vol. II., Pgs. 154 – 156.

those water wells.⁸⁰ As Hilcorp's project continued forward on the Subject Lease, notice for additional injection wells appeared in the newspaper. Texana protested those injection well applications. He stated that Texana later continually attempted to offer conditions that could be used to negotiate a mutual agreement. However, Hilcorp did not respond to those communications. Nonetheless, Texana remains ready, willing and able to engage in discussions with Hilcorp about a joint agreement concerning its project. He further stated that Texana made efforts to initiate discussions with Hilcorp about the project through county commissioners, a judge, State Representative Stephenson and Senator Kolkhorst.

In support of its position, Texana submitted copies of letters from Jackson County residents to county and state public officials asking them to support Texana's efforts to have Hilcorp implement, "a more stringent monitoring program that is scientifically based, funded by the project partners, and carried out by an independent third party."⁸¹ Texana's exhibit number two also includes a copy of a resolution of support for its position of groundwater monitoring on the Subject Lease from presumably numerous residents of Jackson County. In addition, Texana submitted a copy of a resolution of support from the Commissioners Court of Jackson County as to Texana's position for groundwater monitoring on the Subject Lease.⁸²

In response to Hilcorp's Exh. No. 49 (Lavaca River & Adjacent Property to the East of West Ranch), Texana submitted three photographs in color that capture an area east of the Subject Lease within a half-mile of the lease boundary.⁸³ Those photographs were captured by Mr. Andruss.⁸⁴ Texana's counsel represented that the purpose of Texana Exh. No. 6 was to show the condition of that area when those orphaned wells were discovered.⁸⁵ As to Texana's Exh. No. 6, Mr. Andruss testified, "I wouldn't describe what I observed in that water beside that culvert as simply rusty water...I took a photo of a pipe in what looks to be the location of where a leak was occurring, and then what appeared to be the area that was being sprayed by whatever fluid, in particular in an attempt to capture the discoloration and apparent dying of those – that vegetation, or at least discoloration."⁸⁶ He later testified, however, he was unsure of that fluid's ultimate source.⁸⁷

Hilcorp's Existing Groundwater Monitoring Program

Mr. Andruss testified that despite ongoing activity with regard to the groundwater monitoring program on the Subject Lease, he has not had an opportunity to review that activity. He stated that although Texana may have knowledge of water well locations on the Subject Lease, he is uncertain which of those wells are sampled for groundwater quality.⁸⁸ He opined that ten water monitoring wells is insufficient to meet Texana's concerns on a 6,000-acre project (*i.e.* the Subject Lease) due to the following:⁸⁹

⁸⁰ Tr., Vol. II, Pgs 158 and 161.

⁸¹ See Texana Exh. No. 2. ¶ 3 of letters to Commissioner Niermann, Senator Kolkhorst, Representative Stephenson, and Judge Simons and Commissioners Hunt, Bubela, Bilicek and Karl of the Jackson County Commissioner's Court.

⁸² Texana Exh. No. 3.

⁸³ Texana Exh. No. 6. Mr. Andruss testified that the locations reflected on Hilcorp's Exh. No. 49 and Texana's Exh. No. 6 are within a half-mile of the Subject Lease's boundary (Tr., Vol. III, Pg. 196, L. 8 – 10.)

⁸⁴ Tr., Vol. II, Pg. 187, L. 25.

⁸⁵ Tr., Vol. II, Pg. 191, L. 1 – 3.

⁸⁶ Tr., Vol. II, Pg. 193, L. 12-24.

⁸⁷ Tr., Vol. II, Pg. 194, L. 21 – 24.

⁸⁸ Tr., Vol. II, Pg. 196.

⁸⁹ Tr., Vol. II, Pg. 197, L. 15 – 19.

Proposal for Decision

1. Hilcorp's groundwater monitoring program could cease at any moment regardless of findings and activities on the Subject Lease because it is voluntary;
2. Texana is concerned that the groundwater monitoring program is not designed for monitoring to occur at appropriate locations, depths, and frequencies;
3. Texana is concerned injected fluids may migrate off the Subject Lease and travel upwards as Hilcorp increases reservoir pressure in the Field. In addition, Texana is also concerned with Hilcorp's use of saltwater in the subsurface as a barrier to CO₂ migration off the Subject Lease because that saltwater barrier could move onto adjacent properties;
4. Texana is concerned that Hilcorp's planned cessation of its existing monitoring plan is premature.

Given the issues indicated above, Mr. Andruss identified key elements that he believes would alleviate Texana's concerns as to Hilcorp's voluntary monitoring program, which include as follows:⁹⁰

1. A groundwater monitoring program designed for early and immediate detection of CO₂ and saltwater pollution that is independently and objectively operated; and
2. Inclusion of some form of tracer to aid in any contaminant source identification.

Uddameri's Supporting Testimony

Dr. Venkatesh Uddameri testified on behalf of Texana as an expert in hydrology, environmental engineering, groundwater modeling, groundwater management and groundwater monitoring.⁹¹ Dr. Uddameri is a professor at Texas Tech University, where he teaches courses in groundwater modeling, groundwater resources, and groundwater hydrology. He is the director of the Texas Tech Water Resources Center.⁹² He is also registered as a Professional Engineer in Texas through the Texas Board of Professional Engineers.⁹³

Texana asserts that Hilcorp's pressure monitoring program on the Lease alone is insufficient to determine if pollution in the aquifers beneath the Lease occur as a result of Hilcorp's tertiary recovery operations. In addition, Texana contends that Hilcorp's proposed groundwater monitoring plan on the Lease is insufficient for the previously mentioned reasons.⁹⁴ In support of its position, Texana submitted a copy of a report entitled, "Development of Framework for a Groundwater Monitoring Program at a Geological Carbon Sequestration/Enhanced Oil Recovery Site" (Texana's GWM Report).⁹⁵ Dr. Uddameri testified that report details the study that he conducted for Texana as to "developing a framework for a groundwater monitoring program at carbon sequestration/enhanced oil recovery sites."⁹⁶

⁹⁰ Tr., Vol. II., Pg. 233, L. 21 – Pg. 234.

⁹¹ Tr., Vol. III., Pg. 15, L. 3 – 10.

⁹² Tr., Vol. III., Pg. 9.

⁹³ Texana Exh. No. 7 – A copy of Dr. Uddameri's curriculum vitae.

⁹⁴ Tr., Vol. III., Pg. 160.

⁹⁵ Texana Exh. No. 8. That report spans 55 pages in length and is authored by Dr. Venkatesh Uddameri and Tim Andruss.

⁹⁶ Tr., Vol. III., Pg. 36, L. 8 – 14.

Dr. Uddameri testified that based on his efforts regarding Texana's GWM Report, a groundwater monitoring program should be structured and designed for Hilcorp's project in the Field using a two-fold fashion as follows: (1) if a leak occurs, then it is quickly detected and contained; and (2) long-term changes in the aquifers must be properly characterized to adequately identify, or conversely eliminate, potential contaminant sources.⁹⁷ He stated that those two components were the guiding principles for developing Texana's report because the aquifer system beneath the Lease is structured in a manner that includes the Chico, Evangeline, Jasper and Burkeville Formations.⁹⁸ He asserted that Texana wants to monitor the water quality in those formations because they overlie Hilcorp's proposed injection interval in the subsurface beneath the Lease.⁹⁹ He testified, therefore, that the groundwater monitoring program described in Texana's GWM Report was comprehensively designed to evaluate geology, potentially adulterated material (*e.g.* water), and flow of contaminants from a pollution source to its surrounding environment.

Baseline and Continuous Water Quality Sampling

Dr. Uddameri generally asserted that it is important to collect baseline water quality samples prior to commencement of injection operations to later understand how water quality changes compare overtime. With regard to Hilcorp's Exh. No. 45 (Water Supply Sampling in Jackson County), Texana argued that Hilcorp's proposed water sampling analysis process would not provide adequate water quality information because it lacks several constituents. He testified, "... if you look at the water quality parameters [listed in Hilcorp's Exh. No. 45], there's a greater propensity to look at cations than anions. So they don't measure bicarbonate, you know, carbonates. So performing an ion balance to make sure that they sample is indeed correct becomes difficult. ..."¹⁰⁰ As a result of those inadequacies, he stated, "[s]o I would add, at the very least [sic], bicarbonate and carbonate, nitrate, fuel anions, total dissolved solids, EC [electrical conductivity], and pH."¹⁰¹ He stated that continuous monitoring or near continuous monitoring of total dissolved solids (TDS), EC, and pH are now relatively cheap. Consequently, monitoring of TDS, EC, and pH should be done because they are good indicators as to the aquifer's relative health.¹⁰²

Groundwater Monitoring Well Placement

Dr. Uddameri testified that the appropriate monitoring area for Hilcorp's project should include the Lease, as well as a five mile area beyond the Lease boundaries (Monitoring Area of Interest, or MAI). He stated, "...primarily because we want to make sure that the geochemical changes – there are some natural geochemical changes that do happen in the aquifer and they are not related to whatever the CO₂ operations are."¹⁰³ He emphasized that striking a balance in the number of monitoring wells is important because if there are too few wells, then the monitoring network has greater error variance. Conversely, if there are too many wells, then the monitoring

⁹⁷ Tr., Vol. III., Pg. 37.

⁹⁸ *Id.*

⁹⁹ Tr., Vol III., Pg. 38.

¹⁰⁰ Tr., Vol. III., Pg. 49, L. 23 – Pg. 50, L. 1 – 2.

¹⁰¹ Tr., Vol. III., Pg. 50, L. 5; Pg. 51, L. 7.

¹⁰² Tr., Vol. III., Pg. 51, L. 7 – 11.

¹⁰³ Tr., Vol. III., Pg. 39, L. 19 – Pg. 40, L. 1.

network is too redundant. He testified, “...clearly the plume is going to move a certain distance if there is a leak, and we want to make sure that we are capturing the plume correctly. We also want to make sure that any changes in geochemistry to the water quality that we see at the site are not because of natural causes. ...”¹⁰⁴

With regard to Hilcorp’s Exh. No. 46 (Hilcorp’s Groundwater Monitoring Plan), Dr. Uddameri testified that in his professional opinion the groundwater monitoring well locations selected by Hilcorp are not spatially balanced. He testified, “...[y]ou can see large areas where there is absolutely no monitoring happening. Especially in the – on the northeast or the southwest directions.”¹⁰⁵ For reference, that exhibit indicates Hilcorp’s groundwater monitoring plan includes eight wells in the Chicot Formation and four wells in the Evangeline Formation.

Based on Texana’s GWM Report, Dr. Uddameri testified that between 20 and 30 groundwater monitoring wells should be completed in the Chico and Evangeline Formations independently (*i.e.*, the shallowest aquifers beneath the Lease). Furthermore, he would prefer to have groundwater monitoring wells completed in the Jasper and Burkeville Formations in the long run because, “those are also being actively looked into, if not currently being used.”¹⁰⁶ He further stated, “I would place about 20 wells or so within – if I were to place 30 wells in Chico and 30 wells in Evangeline, then about 20 would be within the study area [Lease] and then another 10 more around the study area.”¹⁰⁷ He asserted that the Burkeville and Jasper Formations are deeper [compared to the Chico and Evangeline Formations] and contain brackish waters. He testified, “... [t]he state is mapping those brackish waters, so I do believe that there should be at least three wells eventually when – because those aquifer resources will also be used, even though the –what we currently define as the usable drinking water limit – I know they may be below that, but brackish water desalinization is becoming, you know, an important issue in this state. ... It’s a resource for our state, so the state is finally looking at it. So I think it makes sense to put wells in those aquifers as well and monitor them over time.”¹⁰⁸

With regard to selecting surface locations for those aforementioned groundwater monitoring wells, Dr. Uddameri stated, “... if you place two wells too closely to each other, you may collect two different piece [sic] of data, but you only have one piece of information because they are essentially tapping into the same geologic strata. ... [s]o we have two aquifers in that area ... the Chico and Evangeline, so I don’t see that spatial resolution spelled out on this map [Hilcorp Exh. No. 46]. I would ask for spatial resolution.”¹⁰⁹

¹⁰⁴ Tr., Vol. III., Pg. 157, L. 18 – 24.

¹⁰⁵ Tr., Vol. III., Pg. 47, L. 5 – 8.

¹⁰⁶ Tr., Vol. III., Pg. 40.

¹⁰⁷ Tr., Vol. III., Pg. 41, L. 3 – 6.

¹⁰⁸ Tr., Vol. III., Pg. 43, L. 23 – Pg. 44, L. 1 – 10.

¹⁰⁹ Tr., Vol. III., Pg. 40, L. 13 – 17; Pg. 53, L. 23 – Pg. 54, L. 2.

Kriging Variance

Dr. Uddameri utilized a geostatistical method known as kriging to analyze whether the monitoring well network proposed by Hilcorp sufficiently evaluates water quality changes within the MAI.¹¹⁰ Dr. Uddameri testified as follows:¹¹¹

So kriging is a technique to create a surface ... almost like ... a two dimensional regression with the data that's available. Kriging is based on the idea that if you have two wells that are close to each other, they have the same information, but – they may have two data points, but they are essentially collecting the same information. As the wells move spatially further apart, then they are collecting independent information from that region.

[...]

Kriging can also be used is to say [sic] if you have an existing monitoring network and this is how the network looks, this has got some data...it captures all of this using what's called a variogram, which tells you how the variance changes in space. And then at some point, you know, you are very close. You have a little variance and, as you move further away, you have a lot of variance. And then...we adjust that model and we can back out how a new configuration would reduce the amount of variance associated with that particular configuration.

In order to perform his kriging analysis, Dr. Uddameri stated that he incorporated data collected at the Lease by Daniel B. Stephens. Then he evaluated monitoring well designs of 20, 30, and 50-well networks to determine the reductions in variance, respectively. He testified that variance, “is a measure of how much uncertainty is associated with that network.”¹¹² Through that analysis, he concluded that a 30-well monitoring network is the appropriate number of monitoring wells in the MAI. He stated, “my recommendation was to keep the D.B. Stephens’ wells and add wells to it. So if you add those 20 wells plus these wells, we have a better start than D.B. Stephens.”¹¹³

On cross-examination, Dr. Uddameri provided the following testimony:

(Q) Friedman: And

(A) Uddameri: But I also say that you need wells in Jasper and Burkeville and I’ve not identified any wells there. So those would be wells that have to be drilled if you want to monitor in those formations.¹¹⁴

¹¹⁰ Texana Exh. No. 8; Pg. 38, ¶3. The 20 monitoring well network is based off of a report created by Danial B. Stephens and Associates at Hilcorp’s request. It is not based off of Hilcorp’s Proposed Groundwater Monitoring Plan (Exh. No.46) (Tr. Vol. III, Pg 134, l. 15 – 21.)

¹¹¹ Tr., Vol. III., Pg. 153, L. 25 – Pg. 155.

¹¹² Tr., Vol. III., Pg. 155, L. 20 – 25.

¹¹³ Compare Tr, Vol. III, Pg.149, L. 4 – 6; Pg. 152, L. 18 – 21 with Texana Exh. No. 8, Pg. 44, ¶2.

¹¹⁴ Tr., Vol. III., Pg. 78, L. 2 – 6.

(Q) Friedman: Does it matter if you can get access to the private property wells?

(A) Uddameri: The monitoring network requires a certain number of wells. And you've asked me that question before and I've answered and said if the access is not there, we have to drill wells.¹¹⁵

In other words, Dr. Uddameri opined that groundwater monitoring wells are needed in the Jasper and Burkeville Formations, but he has not identified any existing wells in the area that are completed in those formations. As a result, he concluded that if groundwater monitoring were to occur in those two formations, then new wells would likely need to be drilled.

The record indicates that the remainder of Dr. Uddameri's direct testimony does not demonstrate substantial evidence to determine what, or where, the appropriate spatial resolution of groundwater monitoring wells within the MAI should be from Texana's perspective. For example, the "bright spots" located on Figure 17 of Texana's GWM Report indicate the least amount of variance for TDS based on Texana's proposed 30-well monitoring network.¹¹⁶ When asked by the Examiners, do you know whether or not any of those stars [bright spots] land on existing surface locations for one of the 700 wells on the Lease, Dr. Uddameri testified, "[a]nd if they give us the lat lines [latitude], it's a matter of seconds to see if they will – or how close they are."¹¹⁷ On cross examination, Dr. Uddameri provided a general distance of three or four miles separating two bright spots on the top left map of Figure 17.¹¹⁸ However, no specific locations were submitted for the bright spots located in that figure.

Finally, Texana asked Dr. Uddameri his concluding opinion regarding it's proposed groundwater monitoring program.

(Q) Ledbetter: ... [I]n your opinion, would it be reasonable to – if there was a condition on implementing [sic] groundwater monitoring program that you have designed for the project Hilcorp is proposing,"

(A) Uddameri: Absolutely. I think that there is enough evidence in the literature, that there's been plenty of studies done. We document several of those in my report that talk about the potential for groundwater contamination. So adding that as a requirement, I don't see it being off the track from what the Railroad Commission wants to do or what any good – wants to do to be good stewards of the land.¹¹⁹

Applicant's Rebuttal Evidence (Hilcorp)

Hilcorp submitted additional argument and evidence in response to Texana's direct case that largely addressed several components of Texana's recommended groundwater monitoring network.

¹¹⁵ Tr., Vol. III., Pg. 92, L. 10 – 15.

¹¹⁶ Texana Exh. No. 8, Pg. 42.

¹¹⁷ Tr., Vol. III., Pg. 156, L. 16 – Pg. 157, L. 1 – 3.

¹¹⁸ Tr., Vol. III., Pg. 170, L. 3 – 24.

¹¹⁹ Tr., Vol. III., Pg. 165, L. 1 – 13.

Beach's Supporting Testimony

Private Property Access

In short, Mr. Beach was asked a series of questions by Hilcorp's counsel about how private property water wells compare to Texana's previously mentioned position. When asked, "[c]an Hilcorp utilize existing water wells on private property as part of a groundwater monitoring network if permission is not granted by the owners of those wells," Mr. Beach testified, "[a]gain I'm not a lawyer, but I would assume that they would not be able to do so."¹²⁰ He also stated that in his experience with groundwater districts, it is very difficult for a district to gain access to water wells located on private property.¹²¹

Groundwater Flow Speed

During Texana's direct evidence, Dr. Uddameri was asked a series of questions during cross-examination as to the groundwater flow speed in the Chico Aquifer. In summary, Dr. Uddameri's testimony indicated that if groundwater pollution occurred in the Chico Aquifer, then pollutants would travel at an average rate of roughly 500 feet per year in the aquifer through advection alone. However, if dispersion occurs, then it will increase the travel time of those pollutants. He indicated that opinion was not based on any research literature.¹²²

Mr. Beach was asked a series of questions by Hilcorp's counsel in response to Dr. Uddameri's previously mentioned testimony. Mr. Beach testified that he reviewed a Texas Water Development Board report that focuses on the Chico Aquifer's historical groundwater flow, which is roughly 20 feet per year. He indicated in general that if dispersion occurred, then its effects would vary on a case to case basis. Nonetheless, it would not increase the average groundwater velocity by more than twice its speed. As a result, he stated that if pollutants traveled from the injection interval to the Chico Aquifer, then it would take approximately 130 years for those pollutants to travel one mile in that aquifer.¹²³

Groundwater Monitoring Well Placement

Again, Texana argued that Hilcorp should implement a groundwater monitoring network across the MAI that consists of the following: (1) 30 groundwater wells in the Chico Aquifer; (2) 30 groundwater wells in the Evangeline Aquifer; (3) three groundwater wells in the Burkeville Aquifer; and (4) three groundwater wells in the Jasper Aquifer.

When asked by Hilcorp's counsel as to the approximate distance between each groundwater monitoring well proposed by Texana, Mr. Beach testified, [i]t would probably be about a mile and a half on average. It's going to vary from well to well because I don't know the final network, but it's going to be about a mile and half apart."¹²⁴ Based on his previous testimony regarding groundwater travel time, he indicated that it would take roughly 100 years for a pollutant

¹²⁰ Tr., Vol. III., Pg. 181, L. 25 – 182, L. 5.

¹²¹ Tr., Vol. III., Pg. 180, L. 14 – 24.

¹²² Tr., Vol. II., Pg. 94, L. 12 – Pg. 102.

¹²³ Tr., Vol. III., Pg. 182, L. 12 – Pg. 184, L. 16.

¹²⁴ Tr., Vol. III., Pg. 185.

Proposal for Decision

to travel from the center of the Lease to the nearest groundwater monitoring well proposed by Texana.¹²⁵

EXAMINERS' RECOMMENDATION

The Subject Application parallels previous Hilcorp cases for injection authority on the Subject Lease that were approved by the Commission on July 14, 2015 (Oil & Gas Final Order No. 02-0295336, et al.), June 7, 2016 (Oil & Gas Final Order No. 02-0297905, et al.), and March 29, 2016 (Oil and Gas Final Order No. 02-0297674, et al.) (collectively, Prior Applications). Based on the record evidence, Hilcorp has met its burden of proof for approval of the Subject Application. Accordingly, the Examiners recommend that it be granted.

Proposed Completion of the Subject Wells

Hilcorp established that each of the Subject Wells will be completed in manner as follows: (1) 10 ¾" surface casing set at a depth of 2,600 feet and cemented to surface with ~1,400 sacks of cement; and (2) 7" production casing set at 6,500 feet and cemented to surface with ~1,600 sacks of cement. The proposed injection will be at a maximum injection pressure of 2,850 psig. Hilcorp evidenced that its proposed completion program will meet the minimum casing and cement requirements of Statewide Rule 46.

Confinement to the Injection Interval

The Subject Wells' proposed injection interval is from 5,700 to 6,300 feet. Hilcorp seeks to inject up to 20,000 bpd of produced water and 25,000 MCFD of CO₂ in the Subject Wells. In other words, the Subject Application consists of a slightly larger (*i.e.* 50 feet) injection interval compared to the injection interval already granted to Hilcorp for injection of produced water and CO₂ on the Subject Lease in 17 injection wells through Oil and Gas Final Order Nos. 02-0295336, et al., and Oil & Gas Final Order No. 02-0297905, et al.

Hilcorp provided evidence in the Subject Application that the Subject Wells are essentially an extension of the existing, permitted injection wells on the Lease. Nonetheless, Hilcorp demonstrated that the proposed injection interval is adequately capped by the Anahuac Formation, that acts as a seal to prevent the upward migration of injection fluids. Hilcorp also demonstrated that numerous smaller shale zones exist within the geologic layers that makeup the Field. Those smaller shale zones also act as seals to prevent upward migration of fluids.

In line with its position in similar cases, Texana raised concerns that existing P&A'd Wells on the Lease, as well as one orphaned well, may provide conduits for injection fluids to escape the injection interval and enter usable quality groundwater.¹²⁶ With regard to those P&A'd Wells, Texana argued that older P&A'd Wells may be improperly plugged or have corroded casing and cement due to their age (*e.g.* 54 and 77 years old), despite the fact that the Commission approved

¹²⁵ *Id.*

¹²⁶ See Texana's Reply to Hilcorp's Closing Arguments; Pg. 4; ¶2.6; Texana's Closing Arguments; Pg. 12; ¶3.25.

Proposal for Decision

plugging reports for those wells.¹²⁷ Texana concluded, therefore, that injection fluids placed in the Subject Wells' injection interval may potentially pollute groundwater.

The Examiners find, however, that Texana did not provide substantial evidence regarding those P&A'd Wells in the Subject Application to support that claim which was not previously considered in the Prior Applications. With regard to the orphaned well on the Lease, Texana alleged that it is improperly plugged.¹²⁸ Thus, it may be a conduit for pollution to usable quality groundwater.¹²⁹ However, Hilcorp refuted that claim with evidence that the orphaned well did not penetrate the Subject Application's proposed injection interval.¹³⁰ As a result, it does not pose as a potential conduit for injection fluids to escape the injection interval because it does not penetrate the injection interval.

Discussion of Protection of Water

The record evidence demonstrates that Hilcorp represents it will employ a voluntary groundwater monitoring program in relation to the secondary/tertiary recovery operations on the Lease. In line with Hilcorp's representation, Dr. Uddameri was asked a series of questions on cross-examination as to Texana's proposed groundwater monitoring program.

(Q) Friedman: Well, Hilcorp is doing groundwater monitoring – they're proposing to do groundwater monitoring. Right?

(A) Uddameri: And I'm saying that can be improved.¹³¹

(Q) Friedman: Are you familiar with the Railroad Commission rules on injection well pursuant to Rule 46, which is the proceeding we're here [sic]?

(A) Uddameri: Yes, but I'm not a lawyer, so I don't want to get –

(Q) Friedman: Sure. But you're familiar that the rule doesn't call for any groundwater monitoring wells associated with these types of injection wells?

(A) Uddameri: I think Hilcorp has started a groundwater monitoring program and – which implies that they have recognized the importance of groundwater monitoring. And I believe that if they're monitoring, they might as well do a good job at it and do it right.¹³²

(Q) Friedman: Are you aware that the 12 [water monitoring] wells that are proposed by Hilcorp, which they have reconfigured their location, after the D.B. Stephens' report that you reviewed, is above and beyond what the Railroad Commission rule asks of Hilcorp? ...

¹²⁷ See Texana's Reply to Hilcorp's Closing Argument; Pg. 4; ¶2.7.

¹²⁸ See Texana's Closing Argument; Pg. 12; ¶3.25 and 3.26.

¹²⁹ *Id.* ¶3.26.

¹³⁰ Tr., Vol. I., Pg. 181, L. 16 – 20.

¹³¹ Tr., Vol. III., Pg. 111, L. 6 – 9.

¹³² Tr., Vol. III., Pg. 152, L. 1 – 13.

(A) Uddameri: I don't know the answer to the question.¹³³

Much of Texana's argument in this case centered on whether or not Hilcorp's proposed groundwater monitoring plan is sufficient to determine pollution of groundwater in four aquifers beneath the Lease for several reasons. The record demonstrates that Hilcorp's groundwater monitoring program in and around the Lease is voluntary from the sense of participants that own water wells in that area, and Hilcorp's willingness to implement a groundwater monitoring plan. The primary purpose of Texana's GWM Report, coupled with Dr. Uddameri's expert testimony, was aimed at pointing out deficiencies and consequential improvements to Hilcorp's proposed groundwater monitoring program from Texana's perspective. Despite the parties' differences as to Hilcorp's proposed groundwater monitoring plan on the Lease and its surrounding area (*i.e.* the MAI), the Examiners find no provision in Statewide Rule 46 that requires an applicant to implement such a program.

Furthermore, the record evidence does not include substantial evidence to determine whether the Commission compelled an operator of a secondary/tertiary recovery unit in Texas to simultaneously employ a groundwater monitoring program during the operation of that unit. To the Examiners' knowledge, as well as Mr. Andruss's testimony, if the Commission were to require Hilcorp to incorporate a simultaneous groundwater monitoring program as part of its secondary/tertiary recovery operations on the Lease (*i.e.*, the Subject Application), it would be precedential.¹³⁴ For those reasons, the Examiners are not persuaded by Texana's position that Hilcorp should be required, through special permit conditions, to implement a groundwater monitoring program on the Lease, as proposed by Texana.

The current BUQW occurs at 1,450 feet below the surface locations of the Subject Wells. Hilcorp's proposed injection interval is from 5,700 to 6,300 feet in the Subject Wells. Again, that injection interval is part of the same injection interval authorized for use in numerous injection wells on the Lease. Hilcorp demonstrated that the proposed injection interval will be confined to prevent the upward migration of disposal fluids from escaping it. Additionally, the Subject Wells will be completed in a manner that meets the requirements Statewide Rule 46. Therefore, Hilcorp has demonstrated that the manner in which the Subject Wells are proposed to be completed will protect fresh water from harm.

Discussion of Protection of Oil and Gas

Because the injected material will be confined to the injection interval, oil and gas production will also be protected. Moreover, Hilcorp is the only operator in the Subject Wells' AORs. Hilcorp has unitized portions of the Field. The purpose of that unit is to employ enhanced recovery operations in the Frio Formation to liberate residual hydrocarbons that were not recovered by previous operators in the Field. Not only will the Subject Application protect oil and gas, it will prevent waste by recovering hydrocarbons that have thus far been unrecoverable.

¹³³ Tr., Vol. III., Pg. 152, L. 23 – Pg. 153, L. 4.

¹³⁴ Tr., Vol. II., Pg. 224, L. 21 – 25. The Examiners find no other mention in the record beyond Mr. Andruss's testimony as to whether or not the Commission historically required groundwater monitoring as a permit condition in conjunction with injection operations pursuant to Statewide Rule 46.

Proposal for Decision

For those reasons, in reviewing the record in this case, and remaining consistent with the Commissions' decision made in the Prior Applications, the Examiners recommend that the Subject Application and that the Commission adopt the following Findings of Fact and Conclusions of Law.

FINDINGS OF FACT

1. Hilcorp Energy Company ("Hilcorp" or "Applicant") submitted an application to the Commission seeking authority to inject produced water and carbon-dioxide ("CO₂") into its West Ranch -A- Lease ("Lease"), Well Nos. 1042, 1043, 1044, 1045, 1046, 1066, 1067, 1075, 1110 and 1113 ("Subject Wells"), pursuant to Statewide Rule 46 [16 Tex. Admin. Code §3.46] ("Subject Application").
2. Notice of the Subject Application was published March 23, 2016, in the *Jackson County Herald Tribune*, a newspaper of general circulation in Jackson County, Texas.
3. Hilcorp provided a copy of the Subject Application to the Jackson County Clerk by letter dated March 14, 2016.
4. Hilcorp provided a copy of the Subject Application to the owner of the surface tract where the Subject Wells are located by letter dated March 14, 2016.
5. Hilcorp is the only active operator in the Subject Field.
6. Texana Groundwater Conservation District ("Texana") protests the Subject Application. There were no other submissions expressing an interest in the Subject Application.
7. On June 22, 2016, notice of the hearing in this matter was sent to all persons who expressed an interest, in writing, in the Subject Application. The hearing was held on July 27, 28 and September 19, 2016.
8. The Subject Wells will be used to inject produced water and CO₂ for the purposes of a secondary and tertiary recovery project on the Lease.
9. The proposed Subject Wells will inject a maximum volume of 20,000 barrels of produced water per day ("bpd") and 25,000,000 cubic feet of CO₂ per day ("25,000 MCFD"), per well, at a maximum surface injection pressure of 2,850 pounds per square inch gauge ("psig") per well.
10. The Subject Wells will be cased and cemented to confine the injected fluid to the proposed injection zone. Each of the Subject Wells will be completed as follows:
 - a. 10 ¾" surface casing set at a depth of 2,600 feet and cemented to surface with ~1,400 sacks of cement; and
 - b. 7" production casing set at 6,500 feet and cemented to surface with ~1,600 sacks of cement.

Proposal for Decision

11. The use or installation of the Subject Wells in the applied-for permit will not cause the pollution of ground and surface fresh water as indicated by the following:
 - a. The requested injection interval is between 5,700 feet and 6,300 feet.
 - b. Stratigraphically above the top of the proposed injection interval is a geologic shale that seals the injection interval to prevent migration of injected fluids outside the injection interval.
 - c. The Base of Usable Quality Water (“BUQW”) occurs below the surface location of the Subject Wells from the ground surface to a depth of 1,450 feet.
 - d. The Subject Wells will be cased and cemented to confine the injected fluid to the proposed injection interval.
12. The use or installation of the Subject Wells will not endanger or injure oil, gas, or other mineral formations as indicated by the following:
 - a. The purpose of the Subject Application is to implement waterflood and miscible displacement operations through the injection of produced water and CO₂ into the injection interval beneath the Lease.
 - b. Because the injection is part of a larger enhanced recovery project, the result of the injection into the Subject Wells will increase the ultimate recovery from the Subject Field by recovering hydrocarbons that have thus far not been able to be recovered.
 - c. Injection through the Subject Wells will remain confined to the Subject Application’s injection interval and protect other mineral resources outside the injection interval.
13. Hilcorp received authority for injection operations in numerous wells on the Lease prior to the hearing held for the Subject Application through Railroad Commission Final Orders that include the following: (1) Oil & Gas Final Order No. 02-0295336, et al. – approved on July 14, 2015; Oil & Gas Final Order No. 02-0297905, et al. – approved on June 7, 2016; and, Oil and Gas Final Order No. 02-0297674, et al. – approved on March 29, 2016 (collectively, Previous Cases).
14. The Subject Application is consistent with the Railroad Commission’s determinations made in the Previous Cases.
15. Texana did not submit substantial evidence in the Subject Application to support departing from the precedent established by the Previous Cases.

CONCLUSIONS OF LAW

1. Proper notice was issued in accordance with all applicable statutes and regulatory codes. *See* Tex. Water Code § 27.034; 16 Tex. Admin. Code § 3.46(c).

Proposal for Decision

2. All things have occurred and been accomplished to give the Commission jurisdiction in this matter pursuant to Tex. Nat. Res. Code Ch. 81 and Tex. Water Code Ch. 27. *See, e.g.*, Tex. Nat. Res. Code § 81.051; Tex. Water Code §§ 27.031 and 27.034.
3. Hilcorp's Subject Application pursuant to Statewide Rule 46 ("SWR 46") for permits to inject produced water and CO₂ into the proposed injection interval complies with the applicable provisions of SWR 46.
4. Approval of Hilcorp's Subject Application will not endanger or injure oil, gas, or other mineral formations. Tex. Water Code § 27.051(b).
5. Hilcorp's Subject Application will adequately protect ground and surface fresh water from pollution or harm. Tex. Water Code § 27.051(b).
6. Statewide Rule 46 does not require an applicant to plan, install, or implement a simultaneous groundwater monitoring program in relation to the operations of a secondary/tertiary recovery project. 16 Tex. Admin. Code § 3.46
7. Hilcorp has met its burden of proof and satisfied the requirements of Statewide Rule 46. 16 Tex. Admin. Code § 3.46.

EXAMINERS' RECOMMENDATION

Based on the record evidence, the Examiners recommend that the Commission approve Hilcorp's Subject Application.

Respectfully,



Brian Fancher, P.G.
Technical Examiner



Dana Lewis
Administrative Law Judge