

St. Johns Gas Unit (Stimulated Carbon Dioxide Wells)

Aquifer Protection Permit 511308

Place ID #144301, LTF #57695

The Arizona Department of Environmental Quality (ADEQ) proposes to issue an Aquifer Protection Permit for the closure of the subject facility unless suspended or revoked pursuant to A.A.C. R18-9-A213. This document gives pertinent information concerning the issuance of the permit. The requirements contained in this permit will allow the permittee to comply with the two key requirements of the Aquifer Protection Program: 1) meet Aquifer Water Quality Standards at the Point of Compliance; and 2) demonstrate Best Available Demonstrated Control Technology (BADCT). The purpose of BADCT is to employ engineering controls, processes, operating methods or other alternatives, including site-specific characteristics (i.e., local subsurface geology) to reduce discharge of pollutants to the greatest degree achievable before they reach the aquifer, or to keep pollutants from reaching the aquifer.

I. FACILITY INFORMATION

Name and Location

Name of Permittee:	Kinder Morgan CO ² Company, L.P.
Mailing Address:	1001 Louisiana, Suite 1000 Houston, Texas 77002
Facility Name and Location:	St. Johns Gas Unit (Stimulated Carbon Dioxide Wells) 830 East Main Street, Suite 220 Springerville Arizona, 85938 Apache County

Regulatory Status

This is an existing unpermitted facility. Kinder Morgan submitted an Individual APP application on October 28, 2014 to clean close the ten previously stimulated CO₂ wells and permit a lined impoundment and two brine disposal wells. Kinder Morgan withdrew the operational portion of the application (two brine disposal wells and a lined impoundment). This APP shall be for the clean closure the ten previously stimulated CO₂ wells. At the time of permit issuance, there are no active Notices of Violation (NOVs).

Facility Description

The St. Johns Field was originally discovered in 1994 by the Ridgeway Petroleum Corporation following the identification of carbon dioxide (CO₂) while drilling the Plateau

Land and Cattle #1 well. The Ridgeway Petroleum Corp drilled approximately 52 wells following the discovery of the CO₂ field and conducted stimulation operations on seven (7) of these wells (09-21-31, 10-22-30, 11-18-30, 11-21-30, 11-23-30, 11-24-29x, and 12-22-29x). The St. Johns Unit was established by the Ridgeway Arizona Oil Corporation in 2009. The St. Johns Unit encompasses approximately 260 square miles or 170,323 acres of mostly State land. Some of the land is privately held, with the largest private land owned by Tucson Electric Power (TEP) Generating Station. Kinder Morgan obtained oil and gas leases for the majority of the State and private areas within the Unit, as well as a sublease on the Prize leasehold. The entire CO₂ field extends into New Mexico; however, this application focuses only on the project area within Arizona.

January of 2012, Kinder Morgan acquired the St. Johns Unit from the Ridgeway Arizona Oil Corporation. Since acquiring the St. Johns Unit, Kinder Morgan installed one (1) CO₂ well(11-03-30) and stimulated a total of four (4) wells (11-03-29x, 11-06-30, 11-03-30, and 11-23-30), including one (1) well previously stimulated by the Ridgeway Petroleum Corporation (11-23-30). This brings the total number of previously stimulated wells covered by this permit to ten (10).

The site includes the following closed facilities:

Stimulated Well	Township/Range/Section (T/R/Section #)	Latitude	Longitude
11-03-29x	T11N/R29E/3	34° 22' 43" North	109° 15' 6" West
11-06-30	T11N/R30E/6	34° 22' 45.20" North	109° 12' 32.17" West
11-03-30	T11N/R30E/3	34° 22' 45.35" North	109° 9' 6.49" West
11-23-30	T11N/R30E/23	34° 20' 27" North	109° 8' 3" West
09-21-31	T9N/R31E/21	34° 9' 50" North	109° 4' 2" West
22-1x (12-22-29x)	T12N/R29E/22	34° 25' 53.76" North	109° 15' 58" West
10-22-30	T10N/R30E/22	34° 14' 36" North	109° 9' 42" West
11-21-30	T11N/R30E/21	34° 20' 6" North	109° 10' 30" West
11-24-29x	T11N/R29E/24	34° 20' 20" North	109° 13' 19" West
11-18-30	T11N/R30E/30	34° 20' 54" North	109° 12' 38" West

II. BEST AVAILABLE DEMONSTRATED CONTROL TECHNOLOGY (BADCT)

Closure Design

Kinder Morgan abandoned the ten previously stimulated CO₂ wells from May 20 to June 18, 2015 per the Arizona Oil and Gas Commission (AOGC) protocols. In general, each of the previously stimulated wells was abandoned by first setting a Cast Iron Bridge Plug (CIBP) approximately 50 feet above the shallowest perforation interval. A cement plug with a minimum of 50 linear feet was placed on top of the CIBP and once the cement set, a pressure test to 500 pounds per square inch (psi) was conducted for 30 minutes. The top 100 feet of the casing was perforated with deep penetration charges. A surface cement plug was installed in the top 100 feet of the casing where the casing was perforated. Cement was also circulated to the surface through the annulus, with the top

of the cement inside the casing at the surface. The casing strings were cut and the wellhead recovered. Lastly a well marker was installed to mark the location of the abandoned well.

Kinder Morgan evaluated geophysical Cement Bond Logs (CBLs) that were conducted on nine of the ten previously stimulated wells and indicated that the CBLs show good cement seals between the casing and formation. Kinder Morgan also used drilling reports for each well and cited how cement was circulated to the surface as additional evidence of good cement bonds. This line of evidence was used to indicate that the one previously stimulated well without a CBL also had a good cement seal between the casing and formation.

Site-specific Characteristics

Kinder Morgan used CBLs from the nine previously stimulated wells to determine the minimum thickness of good quality cement bond between the top of the shallowest stimulated zone and the base of the Coconino Aquifer to show that stimulation fluids would not impact the Coconino Aquifer. The following table indicates the evaluated minimum cement bond thickness:

Stimulated Wells	Minimum Thickness of Good Quality Cement Bond between the Top of the Shallowest Stimulated Zone and the Base of the Coconino Aquifer (feet)
11-03-29x	562
11-06-30	512
11-03-30	260
11-23-30	676
09-21-31	615
22-1x (12-22-29x)	810
10-22-30	1,314
11-21-30	721
11-18-30	196

III. HYDROGEOLOGIC SETTING

Hydrogeologic information was summarized from the *Hydrogeologic Study in Support of Individual Aquifer Protection Permit Application, St. Johns Gas Unit, Apache County, Arizona*, Montgomery & Associates dated October 22, 2014.

The previously stimulated wells are located on the St. Johns Dome, a regional structure that lies within the Colorado Plateau physiographic province. The St. Johns Dome is a broad, asymmetrical anticlinal structure with the axis of the fold plunging northwest-southeast. In general the following geologic units from youngest to oldest are found at each of the previously stimulated wells: 1) Kaibab Limestone with an average thickness of 300 feet; 2) Coconino Sandstone with an average thickness of 200 feet and the location

of the regional aquifer; 3) the Supai Formation with the following members (Corduoy Member with an average thickness of 700 feet, Fort Apache Member with an average thickness of 90 feet, Big A Butte Member with an average thickness of 280 feet and the Amos Wash Member with an average thickness of 425 feet) for an average Supai thickness of 1,495 feet. The Supai Formation unconformably overlies the highly-fractured, deeply weathered Precambrian Granite.

The southwestern side of the St. Johns Dome is bounded by the Coyote Wash Fault. The Coyote Wash Fault extends through the younger sedimentary rocks into the granitic basement and has vertical offsets ranging from a few to several hundred feet. The Coyote Wash Fault acts as a hydraulic barrier to groundwater flow across the fault, with hydraulic conductivities being lower east of the fault, in the area of the previously stimulated wells.

The ten previously stimulated wells are located over groundwater of the Little Colorado River Plateau Basin in northeastern Arizona. Groundwater occurs locally in shallow Quaternary alluvial deposits along the Little Colorado River and Coyote Creek; however, the regional aquifer is in the Kaibab Limestone and Coconino Sandstone, collectively called the Coconino Aquifer. The Kaibab Limestone is dry on the east side of the Coyote Wash fault in the vicinity of the previously stimulated wells. Groundwater flow in the Coconino Aquifer is generally in a west-northwest direction.

The depth to groundwater in January 2014 for the Coconino Aquifer in the area around the ten previously stimulated wells ranged from 564 feet below land surface (ft bls) to 679 ft bls. Kinder Morgan collected samples from two locations the Coconino Aquifer in the vicinity of the previously stimulated wells. Total dissolved solids (TDS) concentrations ranged from about 3,000 to about 5,000 milligrams per liter (mg/l).

Groundwater is observed beneath the Coconino Aquifer in the Supai Formation. Kinder Morgan collected three groundwater samples from the Supai Formation: one from the Fort Apache Member, one from the Big A Butte Member and the third from the Amos Wash Member. All three contained TDS concentrations greater than 11,000 mg/l.

Groundwater observed in the fractured Precambrian Granite was also collected from three CO₂ production wells. TDS concentrations from the three samples ranged from about 15,000 to over 34,000 mg/l.

Pollutant Management Area (PMA)/Discharge Impact Area (DIA)

The PMA and DIA for each of the ten previously stimulated wells was calculated by using a mathematical approach to predict the length of fractures that would be generated during hydraulic fracturing and injection of stimulation fluids by Kinder Morgan. The same approach was used to evaluate historic treatments from the previous operator. This radial distance was calculated using hydraulic fracture design and analysis software which included MFrac, MinFrac, and MView. The following table describes the PMA/DIA areas in square feet (ft²):

Stimulated Well	PMA/DIA area
11-03-29x	607,107
11-06-30	613,837
11-03-30	219,122
11-23-30	235,084
09-21-31	584,940
22-1x (12-22-29x)	249,212
10-22-30	281,237
11-21-30	374,155
11-24-29x	370,058
11-18-30	108,832

Each of the calculated PMA/DIA areas were compared to a 0.5 mile radius circle (calculated area of 21,900,000 ft²) from the well. Each of the calculated PMA/DIAs were significantly smaller than the 0.5 mile radius circle.

IV. STORM WATER/SURFACE WATER CONSIDERATIONS

Stormwater/surface water considerations included whether each of the previously stimulated wells is located within the 100-year flood plain and whether the discharge had the potential to impact surface water drainages located down-stream of each previously stimulated well.

None of the previously stimulated wells appear to be within the 100-year flood plain and should not be affected by flooding.

V. COMPLIANCE WITH AQUIFER WATER QUALITY STANDARDS

Point of Compliance (POC)

Ten conceptual POC locations were proposed to be located on the northwestern edge of the PMAs of each previously stimulated well. The locations are as follows:

POC Well Related to Stimulated Well	Latitude	Longitude
11-03-29x	34° 22' 47.9712" North	109° 15' 6.2892" West
11-06-30	34° 22' 47.9496" North	109° 12' 32.6196" West
11-03-30	34° 22' 45.6404" North	109° 9' 5.67" West
11-23-30	34° 20' 23.4096" North	109° 8' 7.7604" West
09-21-31	34° 9' 44.0496" North	109° 4' 3.8784" West
22-1x (12-22-29x)	34° 25' 49.4688" North	109° 15' 45.2988" West
10-22-30	34° 14' 35.5596" North	109° 9' 44.8488" West
11-21-30	34° 20' 11.8716" North	109° 10' 25.2516" West
11-24-29x	34° 20' 22.5708" North	109° 13' 19.0488" West
11-18-30	34° 24' 54.4812" North	109° 12' 38.4696" West

VI. COMPLIANCE SCHEDULE

Not Required

VII. OTHER REQUIREMENTS FOR ISSUING THIS PERMIT

Technical Capability

Not Required

Financial Capability

Not Required

Zoning Requirements

Not Required

VIII. ADMINISTRATIVE INFORMATION

Public Notice (A.A.C. R18-9-108(A))

The public notice is the vehicle for informing all interested parties and members of the general public of the contents of a draft permit or other significant action with respect to a permit or application. The aquifer protection program rules require that permits be public noticed in a newspaper of general circulation within the area affected by the facility or activity and provide a minimum of 30 calendar days for interested parties to respond in writing to ADEQ. The basic intent of this requirement is to ensure that all interested parties have an opportunity to comment on significant actions of the permitting agency with respect to a permit application or permit.

Public Comment Period (A.A.C. R18-9-109(A))

The Department shall accept written comments from the public before a permit is issued. The written public comment period begins on the publication date of the public notice and extends for 30 calendar days. After the closing of the public comment period, ADEQ is required to respond to all significant comments at the time a final permit decision is reached or at the same time a final permit is actually issued.

Public Hearing (A.A.C. R18-9-109(B))

A public hearing may be requested in writing by any interested party. The request should state the nature of the issues proposed to be raised during the hearing. A public hearing will be held if the Director determines there is a significant amount of interest expressed

during the 30-day public comment period, or if significant new issues arise that were not considered during the permitting process.

IX. ADDITIONAL INFORMATION

Additional information relating to this permit may be obtained from:

Arizona Department of Environmental Quality
Water Quality Division – Water Permits Section – APP Unit
Attn: Monica Phillips
1110 West Washington Street, Mail Code 5500E-3
Phoenix, Arizona 85007
Phone: (602) 771-2253

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