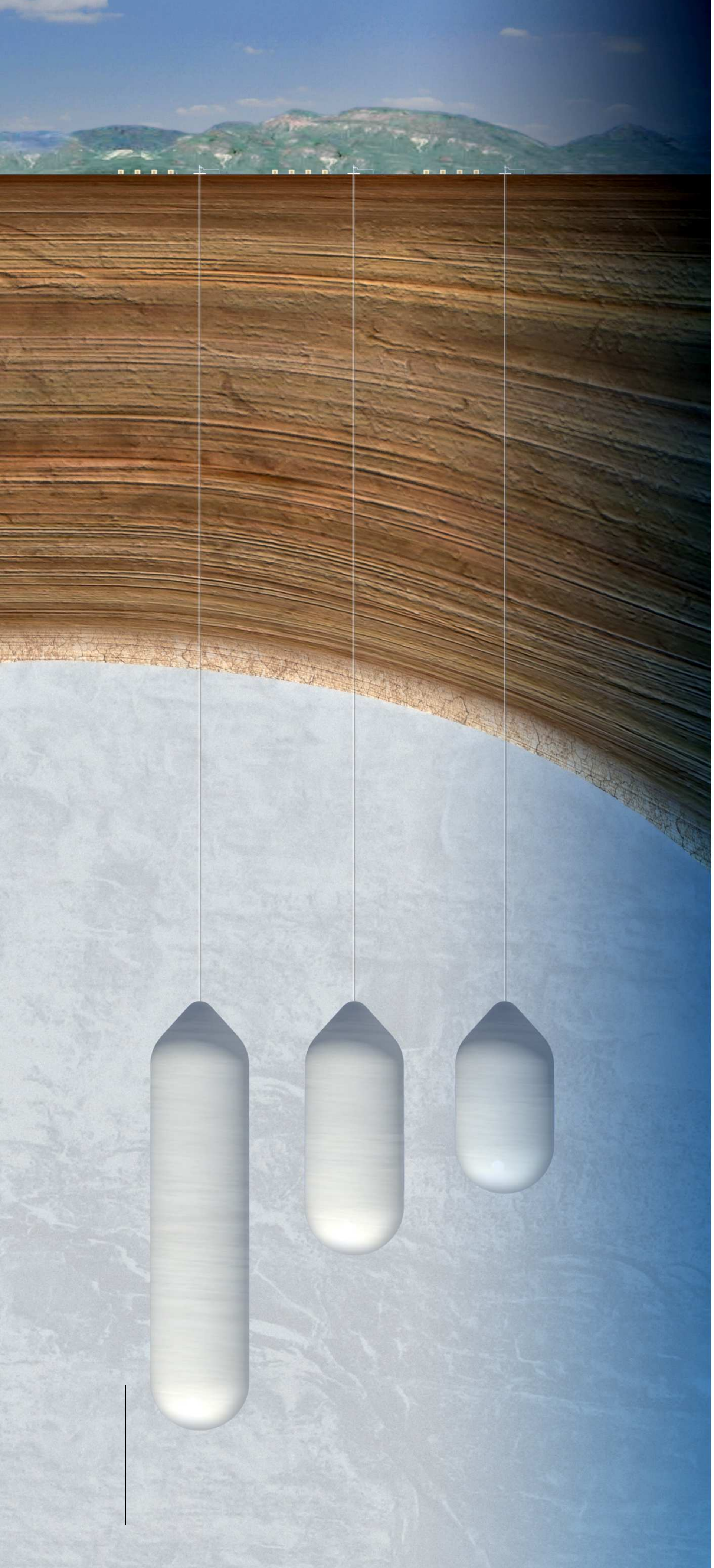
Attachment E

Monitoring, Recording, and Reporting Plan



Cavern Monitoring, Recording and Reporting Plan

Underground Injection Control Permit
UTU 27-AP-9232389

SAWTOOTH NGL CAVERNS

CAVERN MONITORING, RECORDING AND REPORTING PLAN UNDERGROUND INJECTION CONTROL PERMIT UTU 27-AP-9232389

SAWTOOTH NGL CAVERNS, LLC
DELTA, UTAH

July 2017

Table of Contents

Section 1
Introduction

1.1 Purpose of the Plan

This Plan has been developed to outline clear processes and procedures for the monitoring, reporting, and recording activities associated with the development (solution mining) of storage caverns at Sawtooth NGLs storage facility. The Plan is intended to accompany the Cavern Construction and Development Plan.

The construction (drilling) of storage caverns at the facility is under the jurisdiction of both the Utah Department of Environmental Quality (DEQ), the Division of Water Quality (DWQ), and the Utah Department of Natural Resources (DNR), the Division of Oil, Gas and Mining (DOGM). The development of storage caverns is under the sole jurisdiction of the DWQ. In addition to the UIC Permit, Sawtooth has also obtained the appropriate permits and authorizations from the necessary federal, state and local agencies.

Sawtooth has created this Plan, to meet the requirements for the solution mining of salt caverns under DWQ Underground Injection Control (UIC) Permit UTU-27-AP-9232389. This Plan has been reviewed and approved by the DWQ. Any future modifications to this Plan requested by Sawtooth are subject to approval by DWQ. DWQ may also modify the Plan after it receives new, previously unavailable information or after a review of the Plan. A copy of the Plan will be kept at the facility.

1.2 Facility Location

The Sawtooth NGLs storage facility is located approximately eight miles north of Delta in Millard County and on lands leased from the Utah School and Institutional Trust Lands Administration (SITLA). The facility address is 9650 North 540 East Delta, Utah 84624. As shown on Figure 1, the facility is situated west of Highway 6 near the intersection of Jones Road and Brush Wellman Road/SR-174.

1.3 Facility Description

The Sawtooth NGLs storage facility is located on School and Institutional Trust Lands Administration (SITLA) lands over a salt dome that is approximately one mile thick, two miles in diameter and 3,000 feet below the ground surface. Sawtooth will be solution mining storage caverns within the salt dome for the purpose of storing NGLs such as butane and propane. Figure 1 is a map depicting the storage facility layout as currently constructed and proposed. As shown, the facility consists of three main components that are connected by utilities contained within a central utility corridor. The main components are a Storage Cavern Field, a 152-acre brine evaporation pond, and a truck and rail loading and transfer facility. The utilities between the main components include brine, water, power, and product transfer lines. As currently designed, the facility will be capable of storing 16 million barrels (MMbbls) of NGLs in eight storage caverns with an individual capacity of 2 MMbbls each. The timing of cavern construction is dependent upon market demand.

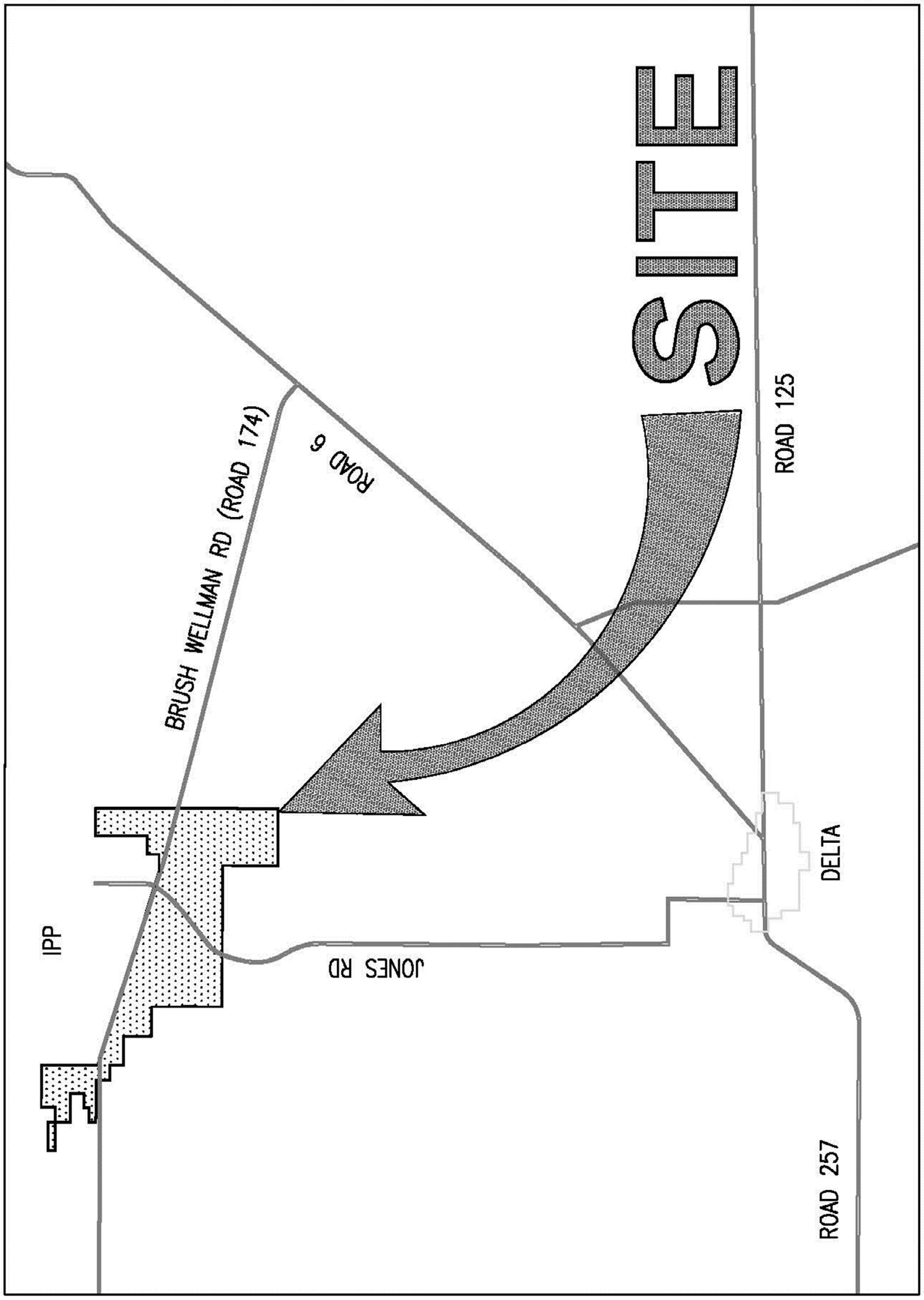
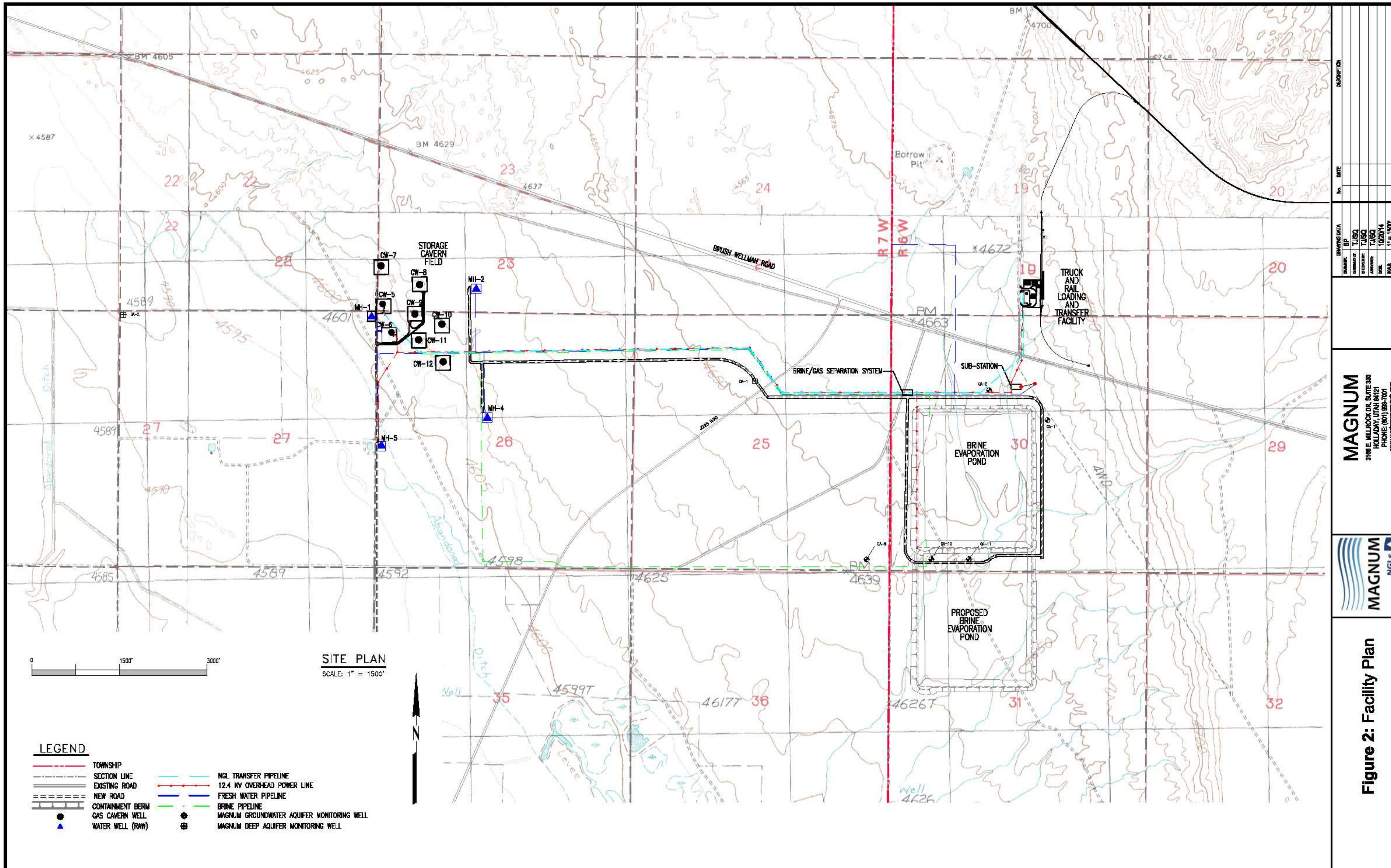


Figure 1: Vicinity Map


STORAGE CAVERN FIELD
CW-7
CW-8
CW-5
CW-9
CW-10
CW-6
CW-11
CW-12
MH-1
MH-2
MH-4
MH-5
BRUSH WELLMAN ROAD
BRINE/GAS SEPARATION SYSTEM
SUB-STATION
TRUCK AND RAIL LOADING AND TRANSFER FACILITY
BRINE EVAPORATION POND
PROPOSED BRINE EVAPORATION POND
R 7 W
R 6 W
Borrow Pit
SITE PLAN
SCALE: 1" = 1500'
0
1500'
3000'
N
LEGEND
TOWNSHIP
SECTION LINE
EXISTING ROAD
NEW ROAD
CONTAINMENT BERM
GAS CAVERN WELL
WATER WELL (RAW)
NGL TRANSFER PIPELINE
12.4 KV OVERHEAD POWER LINE
FRESH WATER PIPELINE
BRINE PIPELINE
MAGNUM GROUNDWATER AQUIFER MONITORING WELL
MAGNUM DEEP AQUIFER MONITORING WELL
MAGNUM
MAGNUM NGLs
Figure 2: Facility Plan

Section 2
Monitoring and Recording Procedures

2.1 Monitoring Methods and Equipment

2.1.1 Cavern Volume

The cavern volume will be monitored during development so that it does not exceed the permitted capacity of 2 mmbbls. Cavern volume will be monitored on a daily basis and periodically using two methods as a means of independent verification. The daily monitoring method will be completed by recording and calculating the amount of salt mined using the flowmeter data and taking daily measurements of the produced brine specific gravity. The measured data will be used to determine the gross amount of salt mined, the net open cavern space and the ratio of injected water to produced brine. The salinity and temperature of the injected fluid will be monitored on a daily basis as stipulated in the UIC Permit. This monitoring will be completed as follows:

- Specific gravity and temperature will be measured using calibrated hydrometers and thermometers.
- Hydrometers will be calibrated and maintained in accordance with American Society for Testing and Materials (ASTM) standard A126-05a.
- Thermometers will be calibrated and maintained in accordance with ASTM E77-07.

The periodic method for monitoring will be to conduct a sonar survey. This method verifies both the cavern volume and the accuracy of the instrumentation used in the daily monitoring method. The sonar surveys may be made through the mining strings if a signal is obtainable. If needed, a workover will be performed to remove the inner string to allow a sonar survey to be conducted. At the end of solution mining, a workover will be performed to remove both hanging strings, thus allowing a complete survey of the cavern, cavern floor, and cavern roof to be conducted. Sonar surveys of the cavern, cavern floor and cavern roof shall also be conducted after each solution mining phase and before commencement and / or recommencement of product storage in accordance with Part III(D)(12) of the UIC Permit.

2.1.2 Nitrogen Blanket Control

The nitrogen blanket will also be monitored by conducting periodic interface surveys and a daily review of the recorded surface nitrogen pressure. Pressure monitoring of the nitrogen blanket is important. Possible changes in nitrogen pressure due to nitrogen dissolution are small on a daily basis. If relatively large changes in the nitrogen pressure are observed these will generally be related to a major change in the mining activities (rate of mining, direction of mining, depth to the blanket) unless there is a catastrophic loss of blanket. The nitrogen pressure should trend to increasing pressures as the gravity of the produced brine increases.

There are reasons for slight variations in the nitrogen pressure due to changes in the:

- Specific gravity of the brine,

- Chemistry and temperature of the mining water,
- Depth of the nitrogen blanket as it is adjusted for roof development, and
- Rate of mining.

To ensure that nitrogen remains at the desired level, sufficient nitrogen shall be added to the blanket to replace expected losses due to dissolution into the brine and to replenish the thickness of the blanket as it thins due to covering the expanding roof. The required quantity of nitrogen is estimated to be about 500 SCF per week for the initial six weeks of mining.

Once a roof has developed at the desired depth, after about four weeks of mining, and is verified with a log, a large quantity of nitrogen should be injected into the well to establish a reservoir to account for dissolution and thinning. The needed quantity of nitrogen is on the order of 50,000 SCF. Additional injection of nitrogen may be made after about one month or 150,000 barrels of development, depending upon the specific roof development program for the cavern.

Interface logs should be run in the cavern after each 100,000 barrels of mining, until a distinct cavern roof has been developed at the desired depth. After a clear roof has been developed, interface logging should be done after each 250,000 barrels or two months (whichever is more frequent) of development

2.1.3 Cavern Operating Pressures

Cavern operating pressures will be monitored with pressure gauges and sensors installed on both the product and brine sides of the cavern well wellhead:

- Sensors will be linked to the system programmable logic controller (PLC), which provides the capability of continuous pressure recording.
- Each of the pressure sensors will record the maximum and minimum operating pressures during a 24-hour period.
- Each pressure sensor will record operating pressures at an interval of one (1) hour.

Table 1 provides the typical wellhead pressures during cavern development.

Table 1 - Typical Wellhead Pressures During Cavern Development

Mining Direction	Nitrogen Pressure (psig)	Water Pressure (psig)	Brine Pressure (psig)
Direct – Mining	1800	750	50
Direct – Static	1700	280	30
Reverse – Mining	1850	750	50
Reverse – Static	1700	405	30

Sawtooth will also monitor the wellheads for leakage with a handheld gas detection meter at least once every eight (8) hours.

2.1.4 Solution Mining Injectate

Monitoring of the injected fluid will be completed on a periodic basis to determine if the composition of the fluid is consistent with the initial characterization analysis. The mining fluid will be analyzed on a monthly basis. The analysis will include, as a minimum, sodium, calcium, potassium, magnesium, chlorides and sulfates.

2.1.5 Produced Brine

Monitoring of the produced brine composition will be completed on a weekly basis to identify zones of highly soluble salts. The monitoring will include an analysis of the brine for high levels of magnesium and potassium content that may indicate an adjustment in the development process is necessary. The produced brine will be analyzed on a monthly basis. The analysis will include, as a minimum, sodium, calcium, potassium, magnesium, chlorides and sulfates.

Section 3

Mechanical Integrity Testing

As required by the UIC Permit, mechanical integrity tests (MIT) will be completed on all storage caverns in the Storage Cavern Field during cavern well drilling, after the cavern well installation is complete (prior to the start of cavern development), and when cavern development is complete (prior to product storage). MITs will be completed at the maximum allowable testing pressure and all test procedures will use certified gauges and pressure transducers that have been calibrated annually. No storage cavern will be used for product storage if the MIT is determined unsuccessful. Several testing methods will be employed to demonstrate mechanical integrity of both the cavern well and storage cavern. These methods vary depending upon the stage of development of the well or cavern as described below.

3.1 MIT During Cavern Well Drilling/Construction

During construction, the mechanical integrity of each casing string will be demonstrated by a hydraulic pressure test which will be completed after the installation and cementing of each casing string. The pressure tests of the casing strings including the final cemented 16" casing will be completed in accordance with state rules R649-3-13 and R649-3-7.4 to ensure that the casing have no leaks. The tests will be conducted after cementing the strings and before drilling out the cement shoe. Sawtooth will perform the hydrostatic pressure tests before drilling out any casing string to the lesser of:

(1) the maximum anticipated pressure to be contained at the surface,
(2) one psi/ft of the last casing string depth, or
(3) 80% of the minimum internal yield pressure of any casing subject to the hydrostatic pressure test.

After drilling out the cement plug and drilling about 20 feet of salt below the casing shoe, a hydraulic pressure test of casing seat and cement in 16-inch production casing will be run. The surface test pressure will be 80% of the lithostatic pressure as calculated at the casing seat minus the hydrostatic pressure of the test fluid, or about 1,000 psi. The tests will last at least 60 minutes. The tests will be considered good if the pressure loss is less than 5%.

3.2 MIT of Completed Cavern Well and Storage Cavern

Prior to initiating solution mining and again at the completion of any cavern development and / or solution mining before the commencement and / or recommencement of product storage, the cavern will be tested using the nitrogen/brine interface mechanical integrity technique in accordance with Part III(H) and (D)(12) of the UIC Permit. Sawtooth can also request approval from the DWQ to use an alternate method for demonstrating mechanical integrity. The test pressure at the shoe of the 16-inch cemented casing will be about 0.75 psi per foot of depth, or about 0.23 psi per foot greater that the normal operating pressure (0.52 psi per foot of depth) to ensure that the casing and cement are not leaking.

The nitrogen/brine interface mechanical integrity test technique essentially involves pressuring the well, and cavern after mining, to the desired test pressure, and injecting nitrogen in the outer annulus of the well (the space between the cemented 16-inch casing and the hanging 13-3/8-inch tubing) to a depth of about 50 to 100 feet below the casing shoe.

The well will then be shut-in for 24 to 48 hours to allow the nitrogen temperature to equalize with the in-situ temperature. The initial depth of the nitrogen/brine interface below the casing shoe and the temperature of the wellbore will then be measured with a wireline tool. After a period of time, not less than 24 hours, determined by the size of the borehole below the casing shoe, a second interface and temperature survey will be run. The pressure at the wellhead will be monitored and recorded continuously during testing.

The change in the calculated volume of the nitrogen between the two interface measurements will be determined from the surface nitrogen pressure, the well temperature logs and the change in the level of the nitrogen/brine interface. The change in the nitrogen volume will then be converted to an equivalent fluid loss.

The temperature stabilization period, the duration of the test and the desired depth of the initial nitrogen/brine interface level will be determined from logs run during and after well construction. The selection of these features will be made so as to ensure that the test has a minimum detectable leak rate (test sensitivity) of no more than 1,000 barrels per year of nitrogen. An acceptable test will be a demonstration that the calculated leak rate is less than the minimum detectable leak rate.

The calculated leak rate and minimum detectable leak rate will be determined by the method specified by DWQ Guidance UIC-3-14 or an equivalent industry utilized method that sums and integrates temperature and pressure changes that impact nitrogen volumes over short vertical intervals to determine total quantity of nitrogen in the well at the beginning and end of each test. The nitrogen volume is determined by:

$$V_{N_2} = N_{scf} \times \sum_{i}^{N} \frac{\left[\left(P_{WB} \right)_i \times 144 \times \left(V_{WB} \right)_i \right]}{\left[\left(Z_{AVE} \right)_i \times R \times \left(T_{AVE} \right)_i \right]} \qquad \text{(0-1)}$$

where:

V_{N_2} = volume of nitrogen measured in the wellbore over a specific depth interval "i" (scf)

$\left(P_{WB} \right)_i$ = average calculated wellbore pressure over a specific depth interval "i" (psia)

$(V_{WB})_i$ = volume of wellbore of a specific depth interval "i" (ft^3)[1]

$(Z_{AVE})_i$ = gas compressibility factor at a specific depth interval[2] "i" (dimensionless)

R = specific gas constant $\left[55.16\left(\left(ft \times lb_f\right)/\left(lb\ mol \times {}^{\circ}R\right)\right)\right]$

$(T_{AVE})_i$ = average wellbore temperature over a specific depth interval "i" (°R)

N_{scf} = gas conversion for mass to volume at standard pressure and temperature conditions (13.8 scf_{N2} = 1 lb_{N2})

$i = 1, 2, \ldots N$, N = total number of depth intervals.

The calculated leak rate is the slope of the nitrogen volume versus time data.

The Minimum Detectable Leak Rate is estimated as:

$$\text{MDLR} = 3 \times \left[\frac{V_{N_2}\left(P + \sigma_P, T - \sigma_T, D + \Delta D\right) - V_{N_2}\left(P - \sigma_P, T + \sigma_T, D - \Delta D\right)}{\Delta t} \right] \quad (0\text{-}2)$$

where:

σ_P = standard deviation in pressure measurement bias

σ_T = standard deviation in temperature measurement bias

ΔD = accuracy of interface measurement

Δt = test duration.

All pressure monitoring instruments will be calibrated in accordance with manufacturer's recommendations. Testing will be performed under the supervision of a degreed engineer experienced in salt cavern testing.

3.3 Storage Operations

Following the post-completion mechanical integrity test, the individual storage caverns will be tested periodically using methods and procedures in accordance with requirements set forth by the Division of Oil, Gas and Mining.

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1 NOTE: Determined by wellbore geometry.

2 Compressibility Factor (*Z*) research developed in NOWSCO Technical Manual, NOWSCO Services, 1980.

Section 4

Agency Reporting

4.1 Reporting Requirement

All reports required by the UIC Permit for compliance or noncompliance with, or any progress reports on, interim and final requirements must be submitted no later than 30 days following each schedule date. The following section details the required reporting.

4.2 Well Completion Report

After completion of construction of a storage well, Sawtooth will prepare a report describing the well construction and testing prior to initiating solution mining activities. The report will describe the casing and cementing program for the well, including:

- Size and grade of all casing strings,
- Results of internal pressure tests of the cemented casing strings,
- Casing seat test of the final cemented casing in the salt,
- Reports from the cementing contractor showing the type and quantity of cement used for each string of casing.

The report will include copies of the geophysical logs run during drilling of the well with a description of the results. These logs will include a cement evaluation log (where available tools allow) and casing inspection log for the final cemented casing. The results of the initial nitrogen-brine interface test on the completed well will be included in this report.

4.3 Quarterly Monitoring Reporting

Quarterly monitoring reports will be submitted during the solution mining of a storage cavern. The schedule for submittals will be:

Quarter		Report Due On:
1st Quarter	Jan 1 – Mar 31	Apr 15
2nd Quarter	Apr 1 – Jun 30	July 15
3rd Quarter	Jul 1 – Sep 30	Oct 15
4th Quarter	Oct 1 – Dec 31	Jan 15

The reports will include the following data per the UIC Permit:

- Periodic Injectate Characterization
- Daily cavern development monitoring data

- Weekly Brine Analysis
- Wireline logs for all blanket/brine interface confirmations
- Sonar surveys for all cavern shape and configuration verification
- Noncompliance Not Previously Reported – Such reports shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.
- Other Required Monitoring

4.4 Mechanical Integrity Reporting

Tests determining the mechanical integrity of the well will be conducted during drilling, after completion of drilling, after completion of solution mining, and as required by DOGM during storage operations. In the event solution mining is suspended or prolonged, a mechanical integrity test will be conducted five years after completion of drilling.

These tests will be described in a report detailing the well fluids, pressures, temperatures (where appropriate) and the results of the testing.

4.5 Planned Changes

Sawtooth will give written notice to the DWQ Director of any planned physical alterations or additions to the UIC-permitted facility. This includes significant changes in the depths of casing strings while drilling, changes in the solution mining plan, or changes in the injectate while mining the cavern.

4.6 Anticipated Noncompliance

Sawtooth will give advance notice to the DWQ Director of any planned physical changes in the permitted facility or activity that may result in noncompliance with permit requirements. With the notification of anticipated noncompliance, Sawtooth understands that all permit conditions remain applicable.

4.7 Endangering/Noncompliance Reporting

Sawtooth will report to the DWQ Director any noncompliance that may endanger health or the environment, as follows:

a) Twenty-four Hour Reporting
Endangering noncompliance information shall be provided orally within 24 hours from the time Sawtooth becomes aware of the circumstances. Such reports shall include, but not be limited to, the following information:

(1) Any monitoring or other information that indicates any contaminant may cause an endangerment to a USDW, or

(2) Any noncompliance with a permit condition, or malfunction of the injection system, which may cause fluid migration into or between USDWs.

b) Five-day Reporting
   A written submission shall be provided within five days of the time the permittee becomes aware of the circumstances of the endangering noncompliance. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.

4.8 Closure and Abandonment Reporting

Should a well need to be closed and abandoned, the procedures used are described in Section 6, Plugging and Abandonment Plan. The results of the closure activities will be described in a report that details condition of the well and cavern at the time of closure and the location and composition of each plug

4.9 Permit Transfers

This permit is not transferable to a new owner or operator except in accordance with Part II (D)(6)(d) of the UIC Permit No. UTU-27-AP-9232389. Sawtooth shall notify the DWQ Director at least 30 days in advance of the proposed transfer date. Notification shall comply with the requirements in Part II(D)(6)(d) of the UIC permit.

4.10 Financial Assurance

Sawtooth has posted the required reclamation bonds with SITLA and DOGM for the drilling, operation, and abandonment of storage caverns at the Sawtooth NGLs storage facility. These bonds are on file with the respective agencies.

Section 5

Revision History

Type of Review	Reviewed By	Date
Plan Finalized & Released		12/22/14
Review of Document to Reflect Ownership Change	Glen Hogendoorn	July 2017

Appendix A

Typical Mechanical Integrity Test Procedure

Appendix A

Typical Mechanical Integrity Test Procedure

1. INTRODUCTION

The purpose of the Mechanical Integrity Test (MIT) procedure is to test the mechanical integrity of the production casing and cement and to ensure that the wellbore below the casing shoe has integrity before beginning mining. In summary, the test procedure consists of the following basic steps.

- 1.1 Bleeding brine from the well to maintain the pressure at approximately 750 psi.
- 1.2 Monitoring and recording the cavern pressure for a period of time, minimum 24 hours, until the pressure is decreasing less than 10 psi per day.
- 1.3 Inject nitrogen to place the interface at about 3460 feet depth.
- 1.4 Measuring the position of the nitrogen/brine interface and temperature of the nitrogen column at the beginning and end of the test period,
- 1.5 Recording the brine and nitrogen wellhead pressures throughout the test period, a minimum of 24 hours,
- 1.6 Determining the calculated leak rate and the minimum detectable leak rate.

2. PREPARATION

- 2.1 Provide blind flanges and/or double valves to isolate the well during the test. Test flanges with connections that are required for wellhead valves.
- 2.2 Install pressure-monitoring equipment on both tubing strings and the cemented annulus connections to allow continuous monitoring of wellhead pressures.
  - 2.2.1 NOTE: Digital pressure recorders and temperature recorders (including logging tools) utilized for the mechanical integrity test shall be calibrated in accordance with manufacturer specifications.
  - 2.2.2 Calibration papers are to be on location, available for DWQ review.
- 2.3 Provide a connection to permit injecting brine into or withdrawing brine from the well.

3. BRINE INJECTION AND MONITORING (Only applicable for pre-storage MIT)

- 3.1 Pressurize the cavern by injecting saturated (or as strong as possible) brine into the hanging string of the subject well. See the MIT Well Data Sheet for the approximate brine wellhead pressure and estimated volume of brine required. *Use of unsaturated brine will result in: 1) increase in time required to stabilize cavern pressures as the unsaturated brine dissolves salt and 2) the need to repressure the cavern multiple times*.
- 3.2 Measure and record, at approximately fifteen-minute intervals, the volume of fluid injected and the wellhead brine pressure. The rate of pressurization should not exceed 1.5 psi per minute.

3.3 Monitor the final brine wellhead pressures for a minimum of 24 hours or longer until the pressures stabilize at an acceptable level and rate of change. Pressure decline rates shall be less than 10 psi/day before starting the test.

3.4 If the pressure falls below 1000 psi during the period of monitoring, inject additional brine and monitor as in steps 3.1 through 3.3.

4. NITROGEN INJECTION

4.1 Rig up wireline logging unit and install a lubricator on wellhead. Run base interface log (Gamma-Gamma Ray or other suitable log for detecting nitrogen/brine interface) and temperature log. Temperature log should be completed from surface to approximately the end of the 13-3/8” tubing. The base interface log should be completed from the end of the 13-3/8” tubing to 300 feet above the cemented casing shoe.

4.2 Rig up nitrogen pumping unit to inject into the product annulus. Start injecting nitrogen at a slow rate. Control the nitrogen injection temperature as close as possible to the average wellbore temperature measured by the base temperature log.

4.3 Monitor and record nitrogen and brine pressures and flow conditions during injection. The MIT Well Data Sheet lists the appropriate wellhead test pressures. Monitor the differential nitrogen-brine pressure to insure the brine string is not subjected to collapse pressure condition.

4.4 While injecting nitrogen, it may be necessary to bleed off brine to avoid overpressuring the well. After the interface reaches 2,500 feet, regulate the brine flow to maintain the brine pressure specified in Step 2.0 of the Well Data Sheet.

4.5 Find the nitrogen/brine interface with the density tool and track the interface movement down the well by moving the tool down in 100 to 150 feet increments after the nitrogen is at 3,000 feet. Continue tracking the interface until it reaches the desired depth. Record the nitrogen quantity injected for each interval.

4.6 When the interface is at about 3,400 feet, stop nitrogen injection to run a casing test.

4.6.1 An initial log is recorded of the interface in the cemented casing. Nitrogen and brine pressures are recorded. The wellhead and associated piping and connections are checked for leaks and any leaks are repaired.

4.6.2 After a time interval determined by the test conditions, but not less than sixty minutes, a second interface log is recorded of the interface in the cemented casing. Nitrogen and brine pressure are recorded.

4.6.3 If the nitrogen pressure has remained constant and the interface in the cemented casing has not moved, the cemented casing string is considered tight and nitrogen injection resumed.

4.6.4 If the interface in the cemented casing moves up hole and the nitrogen pressure decreases the well head is again checked for leaks and the casing test is extended. This procedure is repeated until the casing is considered tight or a leak is identified.

4.7 Resume nitrogen injection and record the nitrogen volume, pressure and interface depth at each station. Continue tracking the interface until it reaches approximately the planned interface depth about 50 feet below the 16" casing.

4.8 Run a density log to verify the position of the nitrogen/brine interface relative to the 16” casing shoe. Determine total volume of nitrogen injected from original interface location to interface location for the MIT. See MIT Well Data Sheet for planned interface depth and estimated volumes.

4.9 Remove the logging tool from the well and close the logging valve.

4.10 Shut-in well for nitrogen temperature stabilization of at least 18 hours. During the temperature stabilization period, record nitrogen and brine wellhead pressures. Check all wellhead fittings and flanges with liquid soap or equivalent to insure there are no nitrogen leaks.

4.11 Determine the duration of the test using the appropriate test data and following calculation:

$$T = \frac{V \times R \times 365\, days/year \times 24\, hours/day}{100\, bbls/year}$$

Where:

T = Duration of test, 13 hours, with a minimum of 24 hours

V = Unit annular volume of casing, bbls/ft - 0.2964 bbls per linear foot estimated. Actual volume will be determined during nitrogen injection below the casing by injecting known quantity of nitrogen over a measured length of the borehole.

R = Resolution of the interface tool, ft, 0.5 feet

There is an over-riding minimum test period of 24 hours.

5. TEST INITIALIZATION

5.1. After a minimum wait of at least 18 hours rig up wireline logging unit and install lubricator on wellhead. Run initial density and temperature logs. Temperature log should be completed from surface to approximately 100 feet below interface depth. The density log should be completed from 100 feet below to 200 feet above the interface location below the 16” casing.

5.2. Record nitrogen and brine wellhead pressures at least every five minutes during the test.

6. TEST FINALIZATION

6.1. After the planned test duration, a minimum of 24 hours, run the final density and temperature logs. Temperature log should be completed from surface to approximately 100 feet below proposed interface depth. The base density log should be completed from 100 feet below to 200 feet above the proposed interface location below the 16” casing.

6.2. Record nitrogen and brine wellhead pressures.

6.3. If results indicate the test period must be extended, repeat steps 6.1 and 6.2 as required.

6.4. If results indicate the MIT is successful, end test

6.5. If the test indicates the well is leaking, shut-in the well and continue to monitor nitrogen pressures and interface levels to more closely isolate leak location.

7. REPORT ON TEST RESULTS

7.1. Prepare a written report presenting test procedures, results and conclusions, along with a chronology of test activity, wellhead pressure records, and supporting calculations.

7.2. The Minimum Detectable Leak Rate (MDLR) will be calculated with the following formula also described in Section 3.2:

$$\text{MDLR} = 3 \times \left[\frac{V_{N_2}\left(P + \sigma_P, T - \sigma_T, D + \Delta D\right) - V_{N_2}\left(P - \sigma_P, T + \sigma_T, D - \Delta D\right)}{\Delta t} \right]$$

where:

σ_P = standard deviation in pressure measurement bias

σ_T = standard deviation in temperature measurement bias

ΔD = accuracy of interface measurement

Δt = test duration.

7.3 The Calculated Nitrogen Leak Rate will be determined using the following methodology, also described in Section 3.2. In addition to measured quantities, knowledge of the well casing and tubular sizes and previous knowledge of the diameter of the wellbore from the casing shoe to the interface allows the nitrogen volume in the annulus to be calculated. The following *P-V-T* gas equation (which is an approximation to an integral over the axis of the annulus) is used to calculate the volume of nitrogen (at Standard temperature and pressure conditions) in the wellbore at any time during the test:

$$V_{N_2} = N_{scf} \times \sum_{i}^{N} \frac{\left[(P_{WB})_i \times 144 \times (V_{WB})_i \right]}{\left[(Z_{AVE})_i \times R \times (T_{AVE})_i \right]}$$

where:

V_{N_2} = volume of nitrogen measured in the wellbore over a specific depth interval "*i*" (scf)

$(P_{WB})_i$ = average calculated wellbore pressure over a specific depth interval "*i*" (psia)

$(V_{WB})_i$ = volume of wellbore of a specific depth interval "*i*" (ft^3)[3]

$(Z_{AVE})_i$ = gas compressibility factor at a specific depth interval "*i*" (dimensionless)

R = specific gas constant $\left[55.16 \left((\text{ft} \times \text{lb}_\text{f}) / (\text{lb mol} \times {}^\circ\text{R}) \right) \right]$

[3] NOTE: Determined by wellbore geometry.

$\left(T_{AVE}\right)_i$ = average wellbore temperature over a specific depth interval "*i*" (°R)

N_{scf} = gas conversion for mass to volume at standard pressure and temperature conditions (13.8 scf_{N2} = 1 lb_{N2})

$i = 1, 2, \ldots N$, N = total number of depth intervals.

The calculated leak rate is the slope of the nitrogen volume versus time data between the start and end of the nitrogen/brine interface test.

M.I.T. TEST WELL DATA SHEET (TYPICAL)

WELL DESCRIPTION

Name: Sawtooth Typical

Operator: Sawtooth NGL Solution Mining

Location Field: Delta

Cemented Casing Size O.D.: 16 inches

Size I.D.: 14.868 inches

Depth: 2,396 feet, measured depth

Weight: 97 lbs/ft

Size I.D.: 14.688 inches

Depth: 2,396 – 3,410 feet, measured depth

Weight: 109 lbs/ft

Hanging String: Size 13-3/8 inches

Depth: 4,100 feet

Total Depth: 4,950 feet (estimated)

TEST PRESSURES

Brine Specific Gravity in 8-5/8”: 1.2 (estimated)

Desired Interface level at Start: 3,460 feet

Test Gradient: 0.75 psi/ft

Casing Shoe Pressure: 2,558 psig

Surface Brine Pressure: 784 psig

ANNULUS VOLUME ESTIMATE

Total Volume to Casing Shoe: 150 bbls (2,396 feet*0.404 bbls/ft + 1,014 feet*0.0375 bbls/ft)

Volume from Casing Shoe to Interface Depth: 15 bbls (50 feet*0.2964 bbls/ft)

NITROGEN VOLUME

Nitrogen Volume to Casing Shoe: 92,000 SCF

Nitrogen Volume Below Casing Shoe: 36,000 SCF

Total Nitrogen Volume Required: 128,000 SCF

CAVERN COMPRESSIBILITY RESPONSE

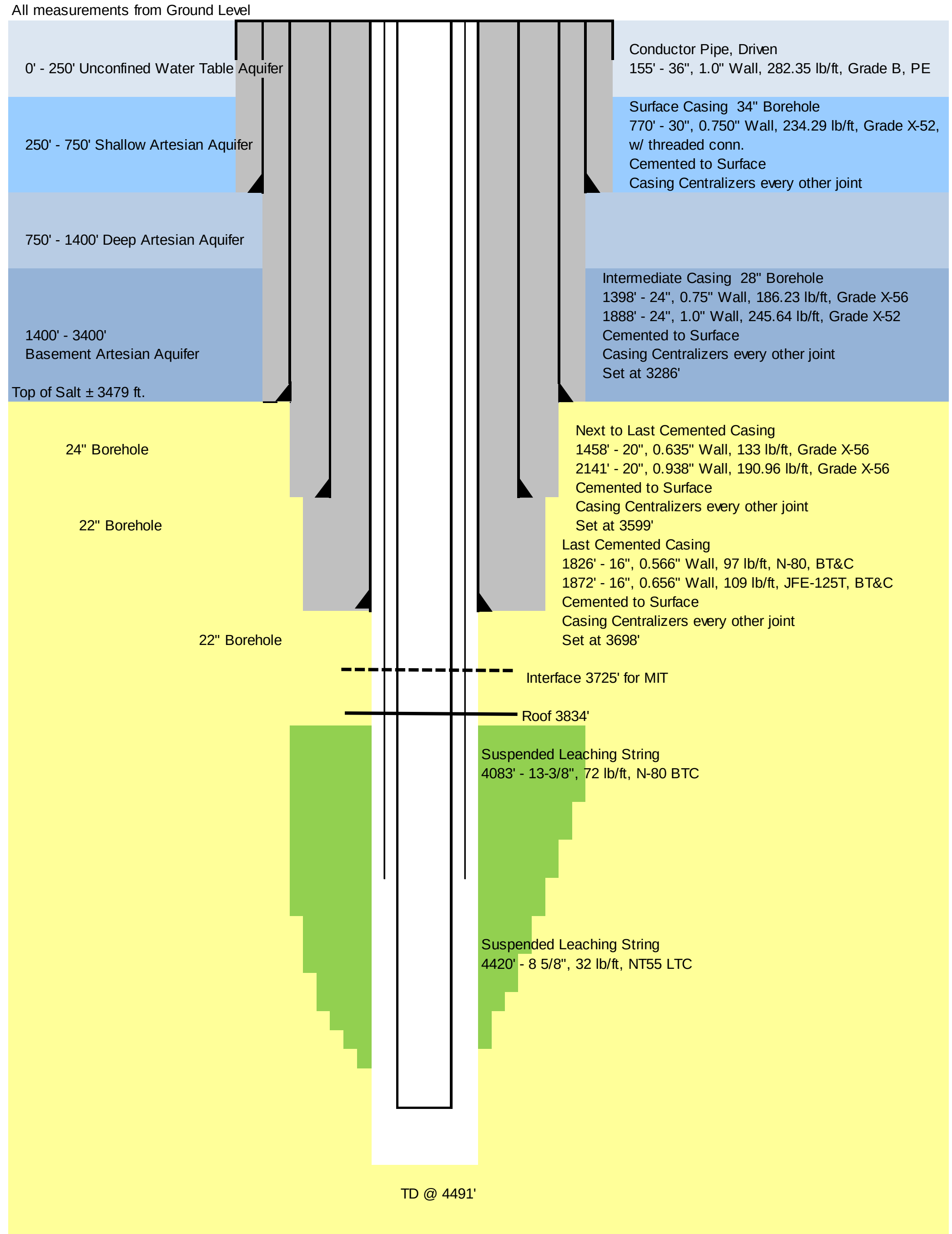
Well Volume: 744 bbls (estimated)

Well Compressibility, estimated: 0.000801 bbls/psi

Wellhead Pressure with Brine, before test: 0 psi

Pressure Increase due to nitrogen injection: over 260000 psi

Brine requirement: -210 bbls (260,000 psi*0 000801 bbls/psi)



Natural Gas Liquids	Magnum

Typical Well Configuration for MIT

DRAWN: T. Eyermann	DATE: 11/5/14	SCALE: NONE	

Appendix B
Reporting

Nitrogen / Brine Interface Mechanical Integrity Test (MIT) Part I: Casing (Internal) MIT Part II: Cavern (External) MIT	Guideline #: UIC-3-14 (February 2014)

Introduction

Operators of all Class III injection wells are required to demonstrate periodically both internal and external mechanical integrity (MI) of the wells. The nitrogen / brine interface test is the industry standard for making this demonstration for solution mined caverns and associated wells for underground hydrocarbon storage. This nitrogen / brine interface test procedure is taken, with permission, from the Kansas Underground Hydrocarbon Storage Unit.

Narrative

The nitrogen/brine interface test is designed to evaluate the internal (well) mechanical integrity and/or the external (cavern) mechanical integrity. The MIT procedure consists of filling the cavern with brine and then injecting nitrogen into the well and establishing an interface at a depth appropriate for either a well or cavern test. The nitrogen test pressure should be equal to the maximum allowable operating pressure (MAOP) gradient based on the casing seat. The interface, temperature and pressure data are used to calculate the pre-test and post-test nitrogen volumes. Comparison of the pre-test and post-test nitrogen volumes and movement of the nitrogen/brine interface are used to evaluate the well/cavern integrity.

Test Procedure Summary

All nitrogen/brine mechanical integrity tests must be conducted by a party that has experience in conducting this type of test due to the complexity of the test and associated safety requirements. The test contractor must have knowledge of: 1) the pressure rating of the well and wellhead components; 2) the use of dead-weight tests or calibrated data loggers to verify brine and nitrogen pressure; 3) methods to track the volume of nitrogen injected before and during the test; 4) differential pressure monitoring to prevent collapse of the tubing; and 5) a working knowledge of other procedural tasks that ensure a viable and safe test.

The permittee is responsible for verifying that the party/company contracted to conduct the mechanical integrity test has experience and is qualified to conduct the test in a safe manner. Failure to follow test procedure and failure to submit supporting data may result in the test being considered invalid by the Utah Division of Water Quality (DWQ). An invalid test will not meet the regulatory requirement.

Submit a test plan as specified in form UIC-3-15 to DWQ for review and approval at least 30 days prior to test commencement. Do not commence test operations until approval for the plan is received from the DWQ.

Test Preparation

- Certify that pressure ratings of the wellhead and the tubulars are adequate for the test pressures.
- Visually inspect the wellhead.
- Ensure fittings are adequate to facilitate wireline equipment, nitrogen injection, and pressure instrumentation. Install an accurate electronic pressure recording system on the well's annulus and brine tubing.
- Remove all product (to the extent feasible) from the cavern prior to conducting the test.
- Note the presence of any product in the annulus.

- Coordinate the test time with DWQ so that DWQ may have the opportunity to witness the test.

Pre-Pressurization (typically for cavern test)

Pre-pressure the cavern with brine prior to nitrogen injection, if necessary. The compressibility of the cavern and the volume of nitrogen to be injected must be considered (estimated) in calculating the pressure required prior to nitrogen injection.

1. Record the volume of fluid injected and the rate of pressurization. The fluid used for pre-pressuring should be saturated brine. The rate of pressurization typically should not exceed 2.5 psi/min. The casing seat pressure is not to exceed the permitted MAOP. The well should be tested at the MAOP.
2. Record the tubing and annulus pressures.
3. Monitor the cavern pressure until the rate of pressure change is 10 psi/day or less. Stabilization period must be a minimum of 24 hours.

Pre-Nitrogen Injection

4. Check with nitrogen supplier for the nitrogen volume required for equipment "cool down".
5. Nitrogen must be measured with a meter. Connect pressure and flow recording equipment to the wellhead so that accurate nitrogen pressure and volume data can be obtained for the test analysis.
6. Prior to nitrogen injection, conduct a temperature survey (base log) from the surface to 50 ft below the expected nitrogen interface for the casing or cavern MIT.
7. Conduct a density survey from 50 feet below the lowest expected nitrogen interface to 50 feet above the uppermost expected nitrogen interface. Note the location of any product present in the annulus. Optimal logging speed for the density log is approximately 15 – 20 ft/min. Subsequent logging runs with the density tool should be at approximately the same speed as the initial logging run for accuracy and correlation purposes.

PART I: CASING (INTERNAL) MECHANICAL INTEGRITY TEST

Nitrogen Injection

8. Inject nitrogen into the annulus between the cemented casing and the hanging string at a constant rate and at (approximately) the same temperature indicated by the temperature log. Measure nitrogen with a nitrogen meter.
9. Position the logging tools at regular depth intervals and record the annulus, brine pressure, nitrogen temperature and time as the nitrogen interface passes.
10. Terminate nitrogen injection when the interface depth is just above the casing seat (if this is the only interval being tested). If multiple intervals are to be tested, test shallow intervals before testing the deep intervals.
11. If a single test interval is used to test the casing, use the following formula to calculate the time required to achieve a minimum detectable leak rate (MDLR), or test sensitivity, of less than 100 barrels of nitrogen per year.

$$T = \frac{V \times R \times 365\ days/year \times 24\ hours/day}{100\ bbls/year}$$

where

T = Duration of test, hours

V = Unit annular volume of casing, bbls/ft

R = Resolution of the interface tool, ft

Note: reference programs or tables and show calculations for converting weight or volume (standard cubic feet - scf) of nitrogen to barrels (bbls) of nitrogen.

The test duration may be shortened if a leak is identified.

A one-hour casing test may be conducted if it is followed by a cavern nitrogen/brine interface test. The minimum test duration for the cavern test is 24 hours.

12. Record the time, nitrogen pressure, tubing pressure and the interface depth. Initialize the test for the calculated test duration.
13. At the end of the test, log the interface depth with the density tool and record the surface pressures. Down-hole movement of the interface may indicate that the test length should be extended.
14. If the nitrogen interface test is being run on the casing only, run a final temperature log.
15. Any up-hole movement of the interface accompanied by a loss in nitrogen pressure indicates nitrogen is being lost from that portion of the casing in contact with the nitrogen. Any interface movement greater than the resolution of the tool should be explained. If a leak is located in the casing above the interface depth, the interface may move up hole to the location of the leak. If multiple leaks are present in the casing, the interface may rise to the location of the greatest leak, however, conclusive determination of the leak location may not be possible.

If the casing test is not followed by a cavern test, calculate the MDLR and the CNLR.

16. Calculate the minimum detectable leak rate (MDLR):

$$MDLR\ (bbls/yr) = \frac{V \times R \times 365\ days/year}{T}$$

where

V = Unit volume of borehole, bbls/ft

R = Resolution of the interface tool, ft

T = Duration of test, days

17. Calculate the nitrogen leak rate (CNLR). Submit supporting data for determination of nitrogen volume (charts, conversion tables, weight measurements, mass-balance calculations accounting for temperature and pressure, source for values used in equation, data from software packages, etc.)

$$CNLR\ (bbls/day) = \frac{1}{T}\left[(VS) - \frac{(PF) \times (VF)}{(PS)}\right]$$

where

$CNLR$ = Calculated nitrogen leak rate, bbls/day

T = Duration of test, days

$VS =$ nitrogen volume at test start (bbls)

$VF =$ nitrogen volume at test finish (bbls)

$PS =$ nitrogen pressure at the test start (psia)

$PF =$ nitrogen pressure at the test finish (psia)

$CNLR\ (bbls/yr) =$ CNLR (bbls/day) X 365 days/year

Pass/fail criteria: The MDLR must be less than 100 barrels of nitrogen per year. The CNLR must be less than the MDLR to demonstrate integrity.

PART II: CAVERN (EXTERNAL) MECHANICAL INTEGRITY TEST

1. Resume the nitrogen injection and monitor the interface location with the logging tools. Record the time and surface pressures as the interface crosses the casing seat.

2. Spot the nitrogen below the casing seat and terminate the nitrogen injection.

3. Calculate the initial nitrogen volume at the start of the test. Submit formulas (PVT) and calculations used to determine nitrogen volume. The unit volume of the borehole can be determined from casing and tubing sizes. The open-hole volume below the casing seat may be determined with a sonar survey. Another method for determining the annular or borehole unit volume is as follows:

   Pump a finite volume of nitrogen into the annulus and log the interface.

   Calculate unit volume:

   $$\left[\frac{nitrogen\ (bbls)}{depth(ft)}\right]$$ Nitrogen pumped / change in interface depth

4. Run the post-nitrogen injection density survey to log the nitrogen interface.

5. Record the nitrogen and brine wellhead pressures.

6. Conduct a temperature survey over the test interval.

7. The test length is typically not less than 24 hours. Monitor the brine and nitrogen wellhead pressures during the test period. The test duration should ensure that the leak rate can be resolved with the accuracy of the instrumentation used.

8. At the end of the test, record the final brine and nitrogen wellhead pressures.

9. Run a density survey to determine if the nitrogen interface has moved. Down-hole movement of the interface may indicate that the test length should be extended.

10. Run a final temperature log over the test interval.

11. Calculate the final nitrogen volume. Submit formulas (PVT) and calculations used to determine nitrogen volume. Accurate nitrogen volume is necessary to determine if pressure changes were affected by temperature, salt leaching, salt creep or from volume loss in the cavern system.

12. Calculate the minimum detectable leak rate (MDLR).

$$MDLR\ (bbls/yr) = \frac{V \times R \times 365\ days/year}{T}$$

where

V = Unit volume of borehole, bbls/ft

R = Resolution of the interface tool, ft

T = Duration of test, days

Pass/fail criteria: The MDLR must be less than 1000 barrels of nitrogen per year. The CNLR must be less than the MDLR to demonstrate integrity.

13. Calculate the nitrogen leak rate (CNLR):

$$CNLR\ (bbls/day) = \frac{1}{T}\left[(VS) - \frac{(PF) \times (VF)}{(PS)}\right]$$

where

$CNLR$ = Calculated nitrogen leak rate, bbls/day

T = Duration of test, days

$VS =$ nitrogen volume at test start (bbls)

$VF =$ nitrogen volume at test finish (bbls)

$PS =$ nitrogen pressure at the test start (psia)

$PF =$ nitrogen pressure at the test finish (psia)

$CNLR\ (bbls/yr) =$ CNLR (bbls/day) X 365 days/year

References

Kansas Department of Health and Environment, Bureau of Water, Geology Section, Underground Hydrocarbon Storage Unit http://www.kdheks.gov/uhs/

Mechanical Integrity Test-Nitrogen Interface Method; SMRI Short Course; Spring 1998 Meeting

Goin, Kennith L., 1983, A Plan For Certification and Related Activities For The Department of Energy Strategic Petroleum Reserve Oil Storage Caverns: SPR Geotechnical Division 6257, Sandia National Laboratories, Albuquerque, New Mexico

McDonald, Larry K., Nitrogen Leak-Rate Testing; Subsurface Technology, Inc.: 2003 KDHE/KCC Underground Liquid Hydrocarbon and Natural Gas Cavern Well Technology Fair

Joe Ratigan, PB Energy Storage Services, Inc., Rapid City, South Dakota

Bérest P, Brouard B, Durup G. 2001. Tightness tests in salt-cavern wells. Oil & Gas Science and Technology. 56:451-469.

	Nitrogen / Brine Interface Mechanical Integrity Test (MIT) Plan	Guideline #: UIC-3-15 (February 2014)

Introduction

Operators of all Class III injection wells are required to demonstrate periodically both internal and external mechanical integrity (MI) of the wells. The nitrogen / brine interface test is the industry standard for making this demonstration for solution mined caverns and associated wells for underground hydrocarbon storage. This nitrogen / brine interface test plan template is taken, with permission, from the Kansas Underground Hydrocarbon Storage Unit.

Plan

The nitrogen/brine interface test is designed to evaluate the internal (well) mechanical integrity and/or the external (cavern) mechanical integrity. Submit a test plan to the Utah Division of Water Quality (DWQ) for review and approval at least 30 days prior to test commencement. Use the following format.

Submit a casing schematic. Attachment #:	Depth to salt:
Single casing ☐ Double casing ☐	Depth to casing shoe:
	Depth to cavern:
	Total depth:
Describe roof configuration:	Date of last sonar survey:
Salt roof thickness:	Date of last gamma-density log:
Additional logs or test to be run:	1.
	2.
	3.
Maximum operating pressure (MAOP) and test pressures:	Formulas and calculations:
Proposed changes to field procedure described in form UIC-3-16:	

TEST DESIGN: Estimate nitrogen for cool down: Estimate compressibility: Estimate nitrogen volume for test:	MIT Type: Casing Cavern Casing and Cavern (circle)	
	Interval Depth:	Test Duration:
	1.	
	2.	
	3	
	4.	
Additional Comments:		

Submit final test report in the format specified in form UIC-3-17 to DWQ within 60 days after completion of the test.

References

Kansas Department of Health and Environment, Bureau of Water, Geology Section, Underground Hydrocarbon Storage Unit http://www.kdheks.gov/uhs/

Bérest P, Brouard B, Durup G. 2001. Tightness tests in salt-cavern wells. Oil & Gas Science and Technology. 56:451-469.

	Nitrogen / Brine Interface Test Field Procedure Report	Guideline #: UIC-3-16 (February 2014)

Narrative

The following field procedure report for the nitrogen / brine interface test must be completed and submitted with the final test report (UIC-3-17). This field procedure report template is taken, with permission, from the Kansas Underground Hydrocarbon Storage Unit.

Type of MIT:	Well Casing	Cavern	Well Casing and Cavern	(circle)
Facility:		Well:		

TEST PREPARATION	Date / Time:
Wellhead inspection results: Describe external corrosion, faulty valves, gasket leaks, verification of adequate fittings for wireline equipment and nitrogen injection, installation of accurate electronic pressure instrumentation on tubing and annulus, etc.	
Removal of product	Date / Time:

PRE-PRESSURIZATION	Date / Time:		
Annulus pressure:		Tubing pressure:	
Cavern compressibility:			
Cavern Pressure (P) Stabilization:	P change < 10 psi/day? Yes / No Record P change / day:	Duration of Stabilization Period:	

PRE-NITROGEN INJECTION		
Nitrogen 'cool down' volume		
Baseline temperature log (from surface to 50 ft below expected interface)	Date / Time:	Temperature (F):

Baseline Temperature Log logging speed:		
Baseline Density Log (a minimum of 50 ft below the expected interface level or an acceptable depth above the casing seat)	Date / Time:	Interface depth:
		Anomalies (washouts, etc.)
Baseline Density Log logging speed:		

PART I: CASING TEST

Interval Depth	**Nitrogen Pressure**	**Brine Pressure**	**Nitrogen Temperature**	**Time nitrogen interface passed**

Measure nitrogen with a meter. Terminate nitrogen injection when the interface depth is just above the casing seat. If multiple intervals are to be tested, test intervals from shallow to deep.

CASING TEST		
Interval 1		
TEST START	***Time:***	
	Interface depth:	
	Nitrogen pressure:	
	Brine pressure:	

TEST END	***Time:***		
	Length of test:		
Density Log	***Interface depth:***	***Brine pressure:***	***Nitrogen pressure:***
Temperature Log **Interval logged:**	***Time:***		
	Maximum temperature:		
	Average temperature:		
	Surface temperature:		
Comments: Note any interface movement or loss of nitrogen pressure			

CASING TEST			
Interval 2			
TEST START	***Time:***		
	Interface depth:		
	Nitrogen pressure:		
	Brine pressure:		
TEST END	***Time:***		
	Length of test:		
Density Log	***Interface depth:***	***Brine pressure:***	***Nitrogen pressure:***

Temperature Log **Interval logged:**	***Time:***	
	Maximum temperature:	
	Average temperature:	
	Surface temperature:	
Comments: Note any interface movement or loss of nitrogen pressure		

CASING TEST			
Interval 3			
TEST START	***Time:***		
	Interface depth:		
	Nitrogen pressure:		
	Brine pressure:		
TEST END	***Time:***		
	Length of test:		
Density Log	***Interface depth:***	***Brine pressure:***	***Nitrogen pressure:***
Temperature Log **Interval logged:**	***Time:***		
	Maximum temperature:		
	Average temperature:		
	Surface temperature:		

Comments: Note any interface movement or loss of nitrogen pressure

PART II: CAVERN TEST

Cavern Test			
Resume nitrogen injection	**Record surface pressures and time the interface crosses the casing seat**		
	Brine pressure:		
	Nitrogen pressure:		
	Time:		
Set interface below the casing and terminate nitrogen injection			
Log interface with density log	**Interface depth:**		
Brine pressure:	**Nitrogen pressure:**		
Temperature log over test interval	**Comments:**		
START TEST			
Calculate initial nitrogen volume at start of test:			
Test period	**Length:**		
Monitor brine and nitrogen pressures during test			
Time:	**Brine:**	**Nitrogen:**	
Time:	**Brine:**	**Nitrogen:**	
Time:	**Brine:**	**Nitrogen:**	
Time:	**Brine:**	**Nitrogen:**	
Time – Final:	**Brine:**	**Nitrogen:**	
Final Density log:	**Depth:**		
Final Temperature log:	**Comments:**		
Final nitrogen volume:			

Comments:	
Supervised by: (Print name)	
Company/Title:	
Signature:	Date:

References

Kansas Department of Health and Environment, Bureau of Water, Geology Section, Underground Hydrocarbon Storage Unit http://www.kdheks.gov/uhs/

Bérest P, Brouard B, Durup G. 2001. Tightness tests in salt-cavern wells. Oil & Gas Science and Technology. 56:451-469.

	Nitrogen / Brine Interface Test Final Report	Guideline #: UIC-3-17 (February 2014)

Narrative

Submit to the Utah Division of Water Quality the final report of the nitrogen / brine interface test following the format below. This final report template is taken, with permission, from the Kansas Underground Hydrocarbon Storage Unit.

<table>
<tr><td colspan="2">Test Results</td></tr>
<tr><td>Show formula and calculation for MDLR:</td><td rowspan="2">Compare MDLR and NLR:</td></tr>
<tr><td>Show formula and calculation for nitrogen leak rate (NLR):</td></tr>
<tr><td colspan="2">Explain any interface movement during the test:</td></tr>
<tr><td colspan="2">Discuss the relationship of pressure trends to cavern integrity:</td></tr>
<tr><td colspan="2">Discuss temperature stability and any accompanying effect on the MIT:</td></tr>
<tr><td colspan="2">Discuss pressure changes in adjacent caverns. Attach a chart or a graph.</td></tr>
</table>

Summarize test results:
Submit field procedure report (UIC-3- 16)
Submit all logs.
Submit supporting data, including graphs for stabilization, temperatures, pressures, injection, etc. Submit appropriate charts.
Submit calibration charts for gauges and meters.

References

Kansas Department of Health and Environment, Bureau of Water, Geology Section, Underground Hydrocarbon Storage Unit http://www.kdheks.gov/uhs/

Bérest P, Brouard B, Durup G. 2001. Tightness tests in salt-cavern wells. Oil & Gas Science and Technology. 56:451-469.