

**STATE OF ALASKA**  
**ALASKA OIL AND GAS CONSERVATION COMMISSION**  
**333 West 7th Avenue, Suite 100**  
**Anchorage Alaska 99501**

Re: THE APPLICATION OF Union Oil ) Docket No. SIO 11-01  
Company of California for an order ) Storage Injection Order No. 11  
authorizing underground natural gas )  
storage, in well IRU 44-36 of the Ivan ) Ivan River Unit  
River Unit, Matanuska-Susitna Borough, ) Undefined Gas Pool  
in conformance with 20 AAC 25.252 and ) Matanuska-Susitna Borough  
20 AAC 25.412. ) Alaska  
)  
) June 20, 2011

**IT APPEARING THAT:**

1. By application dated March 30, 2011 Union Oil Company of California (Union), operator of the Ivan River Unit (IRU), requested an order from the Alaska Oil and Gas Conservation Commission (Commission), authorizing injection for underground storage of natural gas into the No. 44-36 well (IRU 44-36) in the Undefined Gas Pool of the Ivan River Unit.
2. On April 20, 2011, pursuant to 20 AAC 25.540, the Commission published in the Peninsula Clarion, on the State of Alaska's Online Public Notice Web site, and on the Commission's Internet website, notice of opportunity for a public hearing on May 26, 2011.
3. The Commission held the public hearing on May 26, 2011 at 333 West 7<sup>th</sup> Avenue, Suite 100, Anchorage, Alaska 99501. Only testimony from Union was offered. No protests or written comments were received in response to the public notice.

**FINDINGS:**

1. Operator: Union operates the IRU and IRU 44-36, the well proposed for gas storage operations. Both are located in the Matanuska-Susitna Borough, Alaska.
2. Injection Strata: Union proposes natural gas storage injection into the Beluga 71-3 Sand, which is depleted from regular gas production from the IRU 44-36 well. This sand has not been completed in, or produced from, any other well within the IRU. The sand appears to transition to overbank siltstone and silty mudstone to the south in the IRU 41-01 well, indicating that channel sands within the interval that contains the 71-3 at the north end of the unit are isolated from the channel sands within the same interval at the south end of the unit.

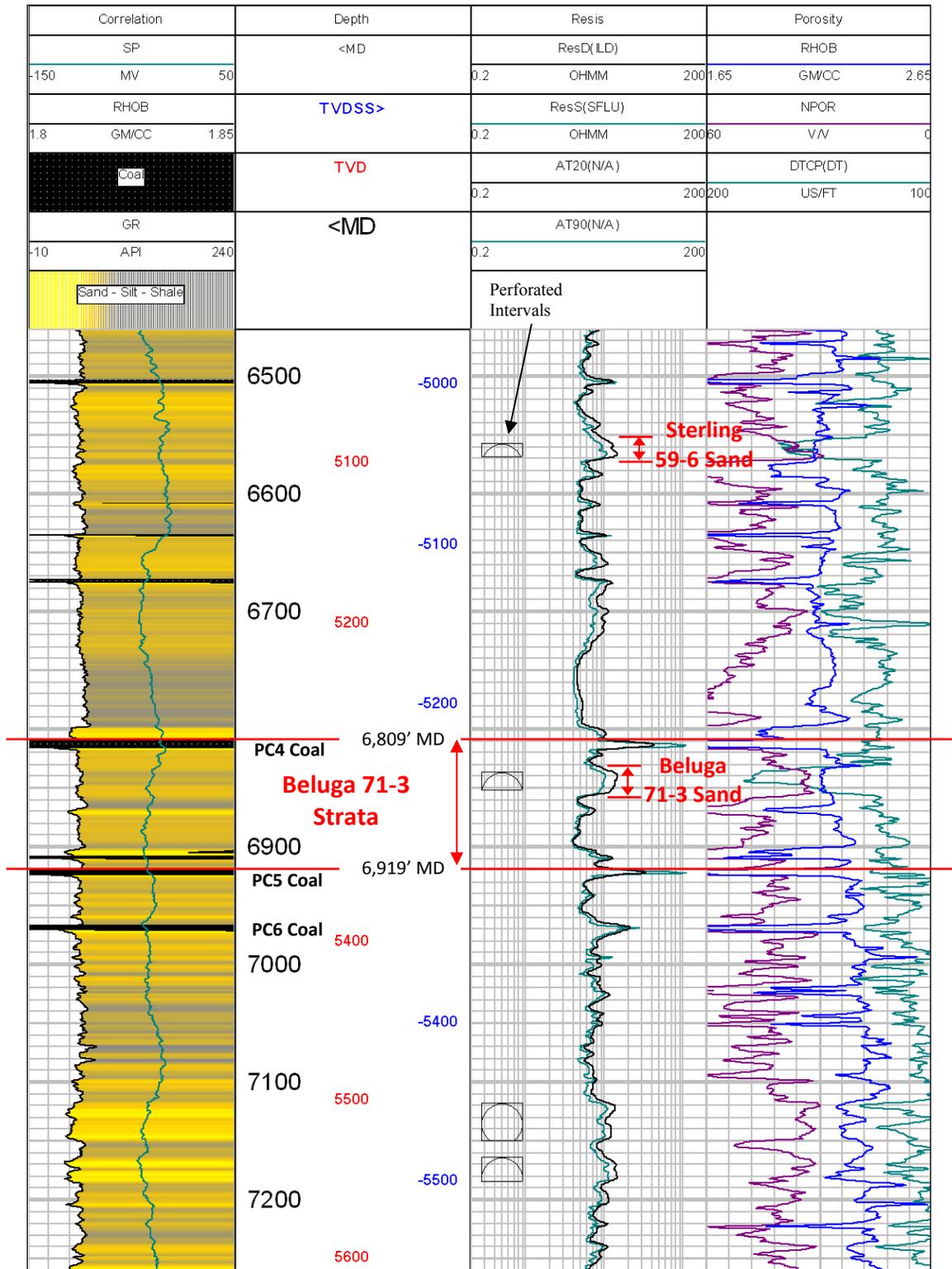


Figure 1. Well Log Recorded in Ivan River Unit No. 44-36

From 6829' to 6856' measured depth (MD), the Beluga 71-3 Sand is topped by a section of interbedded siltstone, clay-rich siltstone and mudstone, which is overlain by a 5-foot thick<sup>1</sup> coal bed, the PC4 Coal. Above the PC4 Coal is a 50-foot thick siltstone and mudstone interval, which creates an impermeable barrier above the proposed storage interval. No permeable gas sands are identified immediately above the Beluga 71-3 Sand in any of the IRU wellbores.

The Beluga 71-3 Sand is underlain by 20' of interbedded siltstone and mudstone. Below this interbedded siltstone and mudstone are additional, laterally discontinuous sands interbedded with clay-rich siltstones and mudstones. These are underlain by 4- to 6-foot thick coal layers (the PC5 Coal and the PC6 Coal) that are laterally continuous across the IRU. The sandstone, siltstone and mudstone between the top of the PC4 Coal and the top of the PC5 Coal are collectively termed the "Beluga 71-3 Strata" (Figure 1). The siltstone, mudstone, and laterally continuous coal layers above and below the Beluga 71-3 Sand act as seals.

3. Proposed Injection Well: The IRU 44-36 well was drilled and completed in March 1993, 742' from the southern section line (FSL) and 777' from the eastern section line (FEL) of Section 1, T13N, R9W, Seward Meridian (SM). The top of the proposed storage interval is at 4,382' FSL, 817' FEL, Section 1, T13N, R9W, SM. Three sands were originally perforated: the Sterling 58-4 Sand, the Sterling 59-6 Sand, and the Beluga 71-3 Sand. A single, 2-7/8" completion was run with a production packer set above all zones, and production was commingled.

After a September 2001 rig workover three deeper sands were opened, and the previous Sterling and Beluga intervals were reperfored. A 2-7/8" single-string completion was run with packers and sliding sleeves to enable isolated production intervals. Initial attempts at producing deeper zones were unsuccessful due to water, sand and coal production. An isolation plug was set below the Beluga 71-3 Sand and the sliding sleeve was opened. The Beluga 71-3 Sand continued to produce with very little associated water until March 2004. With a reservoir pressure of 615 psia, the well was unable to flow into the compressor at the Ivan facility. The Beluga 71-3 Sand was then isolated and unsuccessful attempts were made to produce the shallower Sterling sand intervals. These intervals brought water and sand into the well bore. The well has not been returned to production since.

4. Operators / Surface Owners Notification: Union has provided an affidavit affirming that surface owners and operators within one-quarter mile of the storage area have been notified. The surface owners and operators within the storage area of review are Union and the State of Alaska Department of Fish and Game.

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<sup>1</sup> All thicknesses are expressed in terms of true vertical feet.

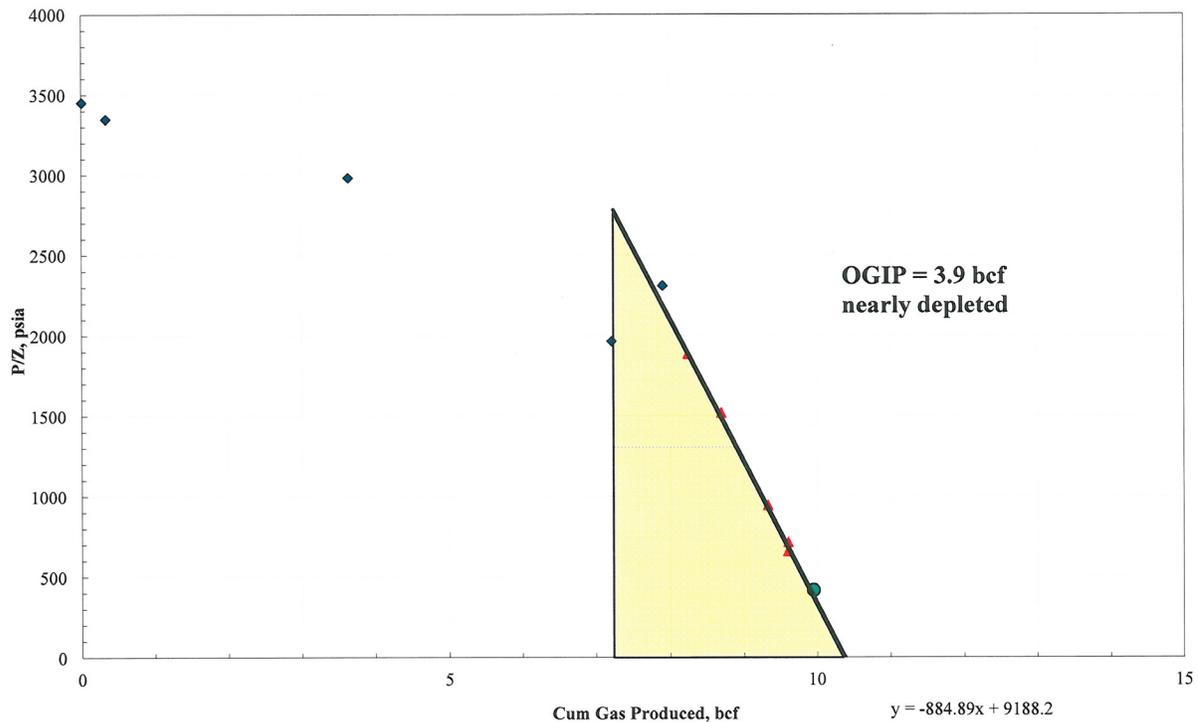
5. Description of Operation: Union proposes injecting gas into the nearly depleted Beluga 71-3 Sand for storage. The IRU 44-36 well will be the sole well for both production and injection storage operations. Gas will be injected during periods of excess supply and produced during periods of increased demand to help balance gas deliverability requirements.
6. Pool Information: Gas is regularly produced in the IRU from the Lower Sterling, Beluga and Tyonek formations. The Lower Sterling consists of interbedded layers of sandstone, siltstone, mudstone, and coal that were likely deposited in a higher-energy meandering stream to braided stream environment. The Lower Sterling contains the shallowest gas-bearing sands, which extend from about -4850' to -5,175' TVDSS, or about 320' in thickness.

The underlying Beluga Formation consists of sandstone interlayered with abundant siltstones, mudstones and coals that were deposited in thinner, lower energy meandering stream systems. Beluga sandstone deposits are likely laterally discontinuous. This low-energy Beluga section is approximately 2,750' thick at IRU. All Beluga gas production has been from the upper 350' of the formation.

The Tyonek Formation is comprised of meander belt and anastomosing stream sandstones, which are often amalgamated into thicker sandstone sections that are interbedded with siltstones, mudstones and thick coals. The Tyonek is approximately 4,850' thick at IRU; all gas production has been from the upper 200' of the formation. The IRU 44-01 and IRU 11-06 wells produce gas from the Tyonek. The IRU 44-36 wellbore did not reach the Tyonek.

Estimates of original gas in place for the Beluga 71-3 Sand were determined by analyzing the material balance plot, Figure 2, below, for the post-September 2001 period when the zone produced 1.7 billion cubic feet (BCF) in isolation from the other Beluga intervals. P/Z vs. cumulative gas produced for this time period is a straight line, indicating volumetric type depletion or a weak aquifer at most. By extrapolating this straight line back to the original reservoir pressure for the sand, a theoretical plot was generated for the zone, had it produced in isolation over the entire depletion period. This approach yields an estimate of 3.9 BCF original gas in place for this zone. Cumulative production from the IRU 44-36 well is 3.1 BCF of gas and 460 bbl water, the gas production representing about 79.5% of the original gas in place within the Beluga 71-3 Sand.

7. Well Logs: All open hole logs from wells in the IRU were sent to the Commission once the logs were completed. Figure 1 presents well log information recorded for the Beluga 71-3 Sand, the proposed injection interval.



**Figure 2: P/Z vs Cumulative Production Plot for the IRU 44-36 Well<sup>2</sup>**

8. Mechanical Integrity and Well Design: IRU 44-36 13-3/8" surface casing was set at 908' MD (-854' TVDSS) with cement returns to surface. A 12-1/4" hole was then drilled, 9-5/8" casing was set at 3,449' MD (-2,890' TVDSS) and cemented to surface. A leakoff test was run to 19.5 ppg equivalent mud weight (EMW). Seven-inch casing was set at 8,308' MD (-6,382' TVDSS) and cemented in place. A cement bond log found the top of cement at 4,400' MD (-3,540' TVDSS).

Union indicates a variance will be requested to allow more than 200' MD between the packer and perforations. The variance, if approved, will allow a second packer above the gas storage zone to ensure long-term isolation of the Sterling 58-4 and 59-6 Sands, in addition to the squeeze cementing that will be performed on those intervals. If this packer is not run, pressure cycling during future MITs may break down the squeeze perforations, creating a mechanical condition that would not allow use of the well until a workover could be performed. Considering the challenging logistics of its location, IRU 44-36 could be unavailable for several months until a workover could be performed.

<sup>2</sup> Plot provided by Union in support of the Application for Injection Order for Gas Storage, Ivan River Gas Storage Facility, received by the Commission March 30, 2011.

9. Fluid Type and Source: Proposed injection fluid is dry natural gas, which is predominantly methane. The Ivan River Storage Facility is intended for injection of Union's excess gas. The estimated maximum daily injected gas volume is 20 million cubic feet per day (MMCFD).
10. Fluid Compatibility: Since all expected sources of storage gas are predominantly methane and are very similar in composition to the original gas in the reservoir, no fluid compatibility problems are expected.
11. Injection Rates and Pressures, Fracture Information: Original reservoir pressure for the Beluga 71-3 Sand in IRU 44-36 is estimated at 2,894 psi based on the pressure gradient in offset west side wells. Proposed maximum gas injection pressure is 3,050 psig, equivalent to an average reservoir pressure of 3,183 psia or about 10% greater than original reservoir pressure. Wellhead injection pressure will be maintained so that 0.60 psi/ft pressure gradient at the target midpoint of perforations (-5,250' TVDSS in the Beluga 71-3 Sand) is not exceeded. This corresponds to wellhead pressures of approximately 2,800 psig with the well shut in.

Injecting gas to original reservoir pressure for gas storage will not initiate fractures in confining strata. Maximum injection pressure for IRU 44-36 in the Beluga 71-3 Sand will not exceed 0.60 psi/ft pressure gradient at the sand face. Leak off tests conducted while drilling IRU 44-36 show the fracture gradient at -867' TVDSS and -2,900' TVDSS to be 1.35 psi/ft and 1.014 psi/ft, respectively. A formation integrity test (not taken to leak off) in IRU 11-06 at -4,880' TVDSS achieved 0.71 psi/ft pressure gradient.

12. Underground Sources of Drinking Water: Proposed gas injection will be at depths of approximately 6,836' to 6,852' MD (-5,243' to -5,254' TVDSS). An aquifer exemption is found at Aquifer Exemption Order No. 14.
13. Mechanical Condition of Pool Wells: The proposed IRU gas storage area encompasses six wells besides IRU 44-36: IRU 14-31, IRU 13-31, IRU 11-06, IRU 41-01, IRU 44-01, and IRU 23-12. These wells are cased and cemented so there are no conduits for injected gas to escape the injection zone. No corrective action is required.
14. Monitoring: Well IRU 44-36 will be tested for mechanical integrity per 20 AAC 25.412(c). To confirm continued mechanical integrity, Union will monitor daily injection rates and pressure and notify the Commission the next working day if the rates and pressure indicate pressure communication or leakage in any casing, tubing or packer. The rate and pressure data will also be reported to the Commission on a monthly basis.

Mechanical integrity will also be monitored by observing the material balance plot (P/Z vs. cumulative gas produced or injected) during gas storage operations. Gas storage reservoir pressure and volume monitoring is a secondary check upon mechanical integrity. Data from the original depletion can be compared with subsequent injection and production cycles.

15. Public Comment: The Commission received no protest nor written comments in response to the public notice.

### **CONCLUSIONS:**

1. This proposed Ivan River Unit gas storage project meets the requirements of 20 AAC 25.252.
2. There are no compatibility concerns between injected gas and native gas in the IRU Undefined Gas Pool.
3. Construction records, casing and cementing records, a cement bond log and a witnessed mechanical integrity test on April 29, 2005 demonstrate the mechanical integrity of IRU 44-36 and demonstrate that fluids will not move behind casing beyond the gas storage zone.
4. The proposed injection and storage operations will be conducted in the permeable Beluga 71-3 Sand, which can reasonably be expected to accept injected fluids at pressures less than the fracture pressure of the confining strata.
5. The Beluga 71-3 Sand is overlain and underlain by laterally extensive intervals of siltstone, mudstone and coal that provide the primary seals to confine injected fluids in the approved interval and arrest any fractures caused by injection operations.
6. The proposed injection of natural gas into IRU 44-36 for the purpose of storage will not propagate fractures through the confining zones.
7. Surveillance of operating parameters for storage and offset wells will provide continued assurance that stored gas remains confined to the Beluga 71-3 Sand of the IRU Undefined Gas Pool.
8. Limiting the reservoir pressure to the original 2,894 psi for natural gas storage in the IRU Undefined Gas Pool eliminates the need for additional pressure monitoring beyond commitments made by Union.
9. The proposed injection of natural gas into the IRU Undefined Gas Pool for the purpose of storage will not cause waste, jeopardize correlative rights, endanger freshwater, or impair ultimate recovery.

**NOW THEREFORE IT IS ORDERED** that the following rules, in addition to statewide requirements under 20 AAC 25, apply to the underground storage of

hydrocarbons by injection operations in the Beluga 71-3 Sand within the Undefined Gas Pool into well IRU 44-36. The area described as follows is affected by this order:

T13N, R8W, S6: NW  $\frac{1}{4}$ , NW  $\frac{1}{4}$  SW  $\frac{1}{4}$ , Seward Meridian (SM);

T13N, R9W, S1: E  $\frac{1}{2}$ , SM;

T14N, R8W, S31: S  $\frac{1}{2}$  SW  $\frac{1}{4}$ , NW  $\frac{1}{4}$  SW  $\frac{1}{4}$ , SW  $\frac{1}{4}$  NW  $\frac{1}{4}$ , SM; and

T14N, R9W, S36: SE  $\frac{1}{4}$  and SE  $\frac{1}{4}$  NE  $\frac{1}{4}$ , SM.

### **RULE 1: STORAGE INJECTION**

The Commission approves injection for storage of natural gas in well IRU 44-36 within in the Beluga 71-3 Sand of the Undefined Gas Pool between 6,829' and 6,856' MD.

### **RULE 2: DEMONSTRATION OF MECHANICAL INTEGRITY**

The mechanical integrity of well IRU 44-36 must be demonstrated before injection begins, and before returning the well to service following a workover affecting mechanical integrity. A Commission-witnessed mechanical integrity test must be performed after injection is commenced for the first time in the well, to be scheduled when injection conditions (temperature, pressure, rate, etc.) have stabilized. Tests must be performed at least once every four years thereafter. The Commission shall be notified at least 24 hours in advance of a test. Unless an alternate means is approved by the Commission, mechanical integrity must be demonstrated by a tubing/casing annulus pressure test using a surface pressure of 1,500 psi or 0.25 psi/ft multiplied by the vertical depth of the packer, whichever is greater. Stabilizing pressure that does not change more than 10 percent during a 30-minute period is required for a valid test. Results of all mechanical integrity tests must be provided to the Commission.

### **RULE 3: WELL INTEGRITY FAILURE AND CONFINEMENT**

The operator shall maintain a continuous data acquisition system to record flow rates and pressures on all active wells in the field. Field personnel must perform daily visual inspections and maintenance of all active wells and production equipment. Whenever any pressure communication, leakage or lack of injection zone isolation is indicated by injection rates, operating pressure observations, tests, surveys, logs, or other evidence, the operator shall notify the Commission by the next business day and submit a plan of corrective action on a Form 10-403 for Commission approval. The operator shall immediately shut in the well if continued operation would be unsafe or would threaten contamination of freshwater, or if so directed by the Commission.

**RULE 4: MAXIMUM RESERVOIR PRESSURE**

The maximum reservoir pressure for this project shall be limited to 2,894 psi.

**RULE 5: PERFORMANCE REPORTING**

The Operator shall report disposition of production and injection as required by 20 AAC 25.228, 20 AAC 25.230, and 20 AAC 25.235.

An annual report evaluating the performance of the storage injection operation must be provided to the Commission no later than March 15. The report shall include material balance calculations of the gas production and injection volumes and a summary of well performance data to provide assurance of continued reservoir confinement of the gas storage volumes. Additional data collection and analysis will be based on a review of the operating performance and could include temperature surveys, pressure surveys, and production logs.

**RULE 6: OTHER CONDITIONS**

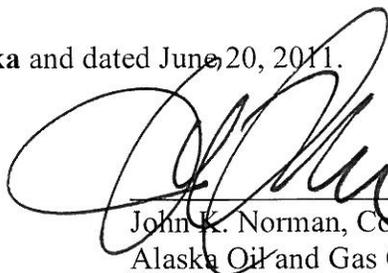
- a. Unless otherwise modified by order of the Commission, compliance with all applicable Commission regulations and statutes is required.
- b. The Commission may suspend, revoke, or modify this authorization if injected fluids fail to be confined within the designated injection strata.
- c. As provided in 20 AAC 25.252 (j), if storage operations are not begun within 24 months after the date of this Order, the injection approval shall expire unless an application for extension has been approved by the Commission.

**RULE 7: ADMINISTRATIVE ACTIONS**

Unless notice and public hearing are otherwise required, the Commission may administratively waive or amend any rule stated above as long as the change does not promote waste or jeopardize correlative rights, is based on sound engineering and geosciences principles, and will not result in fluid movement outside of the authorized injection zone.

**DONE at Anchorage, Alaska** and dated June 20, 2011.



  
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John K. Norman, Commissioner  
Alaska Oil and Gas Conservation Commission

  
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Cathy P. Foerster, Commissioner  
Alaska Oil and Gas Conservation Commission

**RECONSIDERATION AND APPEAL NOTICE**

As provided in AS 31.05.080(a), within **20** days after written notice of the entry of this order or decision, or such further time as the Commission grants for good cause shown, a person affected by it may file with the Commission an application for reconsideration of the matter determined by it. If the notice was mailed, then the period of time shall be **23** days. An application for reconsideration must set out the respect in which the order or decision is believed to be erroneous.

The Commission shall grant or refuse the application for reconsideration in whole or in part within 10 days after it is filed. Failure to act on it within 10-days is a denial of reconsideration. If the Commission denies reconsideration, upon denial, this order or decision and the denial of reconsideration are **FINAL** and may be appealed to superior court. The appeal **MUST** be filed within **33** days after the date on which the Commission mails, **OR 30** days if the Commission otherwise distributes, the order or decision denying reconsideration, **UNLESS** the denial is by inaction, in which case the appeal **MUST** be filed within **40** days after the date on which the application for reconsideration was filed.

If the Commission grants an application for reconsideration, this order or decision does not become final. Rather, the order or decision on reconsideration will be the **FINAL** order or decision of the Commission, and it may be appealed to superior court. That appeal **MUST** be filed within **33** days after the date on which the Commission mails, **OR 30** days if the Commission otherwise distributes, the order or decision on reconsideration. As provided in AS 31.05.080(b), "[t]he questions reviewed on appeal are limited to the questions presented to the Commission by the application for reconsideration."

In computing a period of time above, the date of the event or default after which the designated period begins to run is not included in the period; the last day of the period is included, unless it falls on a weekend or state holiday, in which event the period runs until 5:00 p.m. on the next day that does not fall on a weekend or state holiday.