# STATE OF ALASKA
# OIL AND GAS CONSERVATION COMMISSION

3001 Porcupine Drive
Anchorage, Alaska 99501-3192

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| Re: | **The request of STEWART PETROLEUM COMPANY** to conduct underground fluid injection operations for the purpose of enhancing oil recovery from the West McArthur River Oil Pool. | ) Area Injection Order No. 15<br>)<br>) West McArthur River Unit<br>) West McArthur River Oil Pool<br>) |

July 24, 1996

**IT APPEARING THAT:**

1. STEWART PETROLEUM COMPANY ("SPC"), by correspondence dated May 3, 1996, made application to the Commission for authorization to conduct Class II injection into the West McArthur River Oil Pool (WMROP). The application was compliant with the requirements of 20 AAC 25.402

2. On January 2, 1996, SPC submitted to the Commission an engineering analysis related to enhanced oil recovery operations in the West McArthur River Unit. The report entitled "West McArthur River Unit Pressure Maintenance and Enhanced Recovery Plan" is intended to support SPC's application for Class II injection.

3. Notice of an opportunity for public hearing was published in the Anchorage Daily News on May 17, 1996.

4. No protest was filed.

**FINDINGS:**

1. Commission regulation 20 AAC 25.460 provides authority to issue an order governing underground injection of fluids on an area basis for all wells within the same field, facility site, reservoir, project or similar area.

2. SPC is operator of the area proposed for enhanced oil recovery operations in the subject application and is the sole operator of all wells within one-quarter mile of the proposed injection operation.

3. The area proposed for enhanced oil recovery operations includes the WMROP Pool Rules Area.

4. Three development wells are currently producing from the WMROP, the West McArthur River Unit 1A, 2A and 3. Additional production wells are not planned at this time.

5. SPC intends to redrill the abandoned Pan-Am West Foreland Unit No. 2 well to a location adjacent to the oil-water contact on the southern margin of the West McArthur River Structure, and convert the well to a Hemlock Fm. injector. The well will be renamed the West McArthur River Unit I-1 (WMRU I-1) well.

6. The WMRU I-1 well as proposed will be located external to the boundaries of the WMROP, as currently defined.

7. Production from the WMROP began with the completion of the West McArthur River No. 1 well in December, 1991. Cumulative volumes of produced fluids from the pool include, approximately 2.5 million barrels of oil, 1.6 million barrels of water, and 610 million cubic feet of associated natural gas.

8. Initial and current reservoir pressure in the WMROP, normalized to a 9400' subsea datum, are approximately 4300 psi (11/91) and 3550 psi (1/96), respectively.

9. Compositional analysis of crude from the WMROP indicates 28.8 degree API gravity, a gas-oil ratio between 140 and 350 scf/stb and a bubble point of 1048 psig.

10. The pressure decline history of the WMROP indicates that fluid expansion is the most probable source of reservoir energy, however a significant component of aquifer support may be present

11. Conservation Order No. 332 defines the WMROP in the West McArthur River Field. The WMROP is within the upper portion of the Hemlock Formation, and is defined as strata common to the 13,174 to 13,660 measured depth foot interval in the West McArthur River Unit No. 1 well.

12. The Hemlock Formation is an Oligocene aged sequence of braided stream deposits consisting of interbedded conglomerates and sandstones, separated by thin interbeds of impermeable claystones and siltstones. The Hemlock Formation ranges from four to five hundred feet thick through the project area.

13. Within the West McArthur River Unit, the Hemlock Formation is comformably overlain by the Oligocene through Lower Miocene aged Tyonek Formation. The Tyonek Formation is a very thick (thousands of feet) sequence of fluvial deposits consisting of a subordinate proportion of sandstone with minor conglomerate interbedded with impermeable claystones, siltstones and coals.

14. All data required by 20 AAC 25.071 or its precursor regulation has been submitted for all wells drilled in the project area.

15. The proposed casing and testing program for the WMRU I-1 well was included in the subject application for authorization to conduct Class II injection operations.

16. Initially, WMROP produced water will be used as the primary source of injectant. If the WMRU I-1 well has injection capacity in excess of produced water volumes, produced water from Unocal's Trading Bay Facility may supplement injection

17. A step rate test must be conducted in the WMRU I-1 to quantify optimal operational parameters including injection capacity and operating pressures.

18. WMROP produced water volumes cannot replace total reservoir voidage, and will only mitigate pressure decline.

19. Produced water from the WMROP will be chemically compatible with WMROP formation fluids.

20. Produced water from Unocal's Trading Bay Facility may require chemical treatment in order to control scale precipitation, however its chemical composition is largely comparable to WMROP produced water.

21. SPC estimates the fracture gradient of Hemlock Formation reservoir lithologies of the WMROP to be .75 psi/ft.

22. Depending on the magnitude of tubing friction pressure loss and a .75 psi/ft gradient, the maximum surface pressure for the WMRU I-1 well will range from 3000 to approximately 4000 psi.

23. Average surface pressure for the WMRU I-1 well is dependent on characteristics of the Hemlock Formation, the degree of formation damage and other factors related to the well's completion which cannot be estimated at this time.

24. Information from other Cook Inlet basin injection projects show that shales within the Hemlock Formation and the overlying Tyonek Formation have higher fracture gradients than Hemlock Formation reservoir lithologies.

25. The 200 foot thick interval of the Tyonek Formation which directly overlies the Hemlock Formation in the West McArthur River Unit is approximately 30% shale.

26. Injection pressures proposed for the Hemlock Formation will not be sufficient to propagate fractures through the Tyonek Formation shales which directly overlies the WMROP.

27. The subject application for authorization to conduct Class II injection operations contained a standard laboratory water analysis of WMROP formation water.

28. Openhole wireline log analysis and EPA-approved laboratory analysis of formation water samples from the West McArthur River Unit D-1 well indicate underground sources of drinking water are present to a depth of 4000 feet subsea in the WMRU I-1 vicinity.

29. Specific approvals to convert the Pan Am West Foreland Unit No. 2 to the WMRU I-1 well will be obtained pursuant to 20 AAC 25.005 or 20 AAC 25.507.

30. The mechanical integrity of the WMRU I-1 well must be demonstrated as specified in 20 AAC 25.412 prior to initiation of injection operations.

31. The operator is required by 20 AAC 25.402 (d) & (e) to monitor tubing-casing annulus pressures of the WMRU I-1 well periodically during injection operations to ensure there is no leakage and that casing pressure remains less than 70% of minimum yield strength of the casing.

32. All existing wells drilled within the proposed project area have been constructed in accordance with 20 AAC 25.030. All wells abandoned in the proposed project area have been abandoned in accordance with 20 AAC 25.105 or an equivalent precursor regulation.

33. Waterflooding the currently developed portion of the West McArthur River Structure is expected to result in an oil recovery of approximately 50% of the original oil in place or an incremental 4.4 million barrels beyond primary depletion.

**CONCLUSIONS:**

1. An Area Injection Order is appropriate for the project area in accordance with 20 AAC 25.402 and 20 AAC 25.460.

2. An Area Injection Order covering the project area will not cause waste nor jeopardize correlative rights.

3. Freshwater is present within the project area based on analyses of water samples and open hole wireline log salinity calculations to a subsea depth of approximately 4000'.

4. Due to the presence of underground sources of drinking water, the less stringent requirements for a underground injection project stipulated in 20 AAC 25.450 are not applicable in the West McArthur River Unit.

5. The location of the WMRU I-injection well within the project area has not been finalized, and specific approvals to drill the well will be required.

6. Shales within the conformably overlying Tyonek Formation will confine injectant to the WMROP.

7. The proposed injection operations will be conducted in permeable strata which reasonably can be expected to accept injected fluids at pressures less than the fracture pressure of the confining strata.

8. Enhanced recovery fluids will consist of produced water from the WMROP, possibly augmented by produced water from the adjacent McArthur River Unit.

9. Chemical treatment of proposed injectant can significantly mitigate scale precipitation.

10. Well mechanical integrity must be demonstrated in accordance with 20 AAC 25.412 prior to initiation of injection operations.

11. A schedule must be developed which ensures that mechanical integrity of each injection well is tested at least every four years after an initial test.

12. Tubing-casing annulus pressures and injection rates must be monitored at least weekly for disclosure of possible abnormalities in operational conditions.

13. The cumulative effects of drilling and operating proposed injection wells in the project area are consistent with proven engineering practice and are acceptable to the Commission.

**NOW, THEREFORE, IT IS ORDERED THAT** Area Injection Order No. 15 is issued with the following rules to govern Class II injection operations in the following affected area:

SEWARD MERIDIAN

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| T8N | R14W | Section 10 All<br>Section 15: N 1/2 |

Rule 1 Authorized Injection Strata for Enhanced Recovery

Within the affected area, Class II fluids may be injected for purposes of pressure maintenance and enhanced recovery into strata defined as those which correlate with and are common to those found in the 13,174 to 13,660 measured depth foot interval in the West McArthur River Unit No. 1 well.

Rule 2 Fluid Injection Wells

The underground injection of fluids must be through a well permitted for drilling as a service well for injection in conformance with 20 AAC 25.005 or through a well approved for conversion to a service well for injection in conformance with 20 AAC 25.280.

Rule 3 Monitoring the Tubing-Casing Annulus Pressure Variations

The tubing-casing annulus pressure and injection rate of each injection well must be checked at least weekly to ensure there is no leakage and that it does not exceed a pressure that will subject the casing to a hoop stress greater than 70% of the casing's minimum yield strength.

Rule 4 Reporting the Tubing-Casing Annulus Pressure Variations

Tubing-casing annulus pressure variations between consecutive observations need not be reported to the Commission unless accompanied by a greater than 10% increase in injection rate indicating possible tubing and casing leaks.

Rule 5 Demonstration of Tubing-Casing Annulus Mechanical Integrity

A schedule must be developed and coordinated with the Commission which ensures that the tubing-casing annulus for each injection well is pressure tested prior to initiating injection, and at least once every four years thereafter. A test surface pressure of 1500 psi or 0.25 psi/ft. multiplied by the vertical depth of the packer, whichever is greater, but not to exceed a hoop stress greater than 70% of the casing's minimum yield strength of the casing will be used. The test pressure must show a decline of less than 10% in a thirty minute period following thermal stabilization. The Commission must be notified at least twenty-four (24) hours in advance to enable a representative to witness pressure tests.

Rule 6 Well Integrity Failure

Whenever operating pressure observations or pressure tests indicate pressure communication or leakage of any casing, tubing or packer, the operator must notify the Commission on the first working day following the observation, obtain Commission approval of a plan for corrective action, and obtain Commission approval to continue injection.

Rule 7 Plugging and Abandonment of Injection Wells

An injection well located within the affected area must not be plugged or abandoned unless approved by the Commission in accordance with 20 AAC 25.105.

Rule 9 Administrative Action

Upon request, the Commission may administratively amend any rule stated above as long as the operator demonstrates to the Commission's satisfaction that sound engineering practices are maintained and the amendment will not result in an increased risk of fluid movement into a USDW freshwater aquifer.

Rule 10 West McArthur River Oil Pool Annual Reservoir Report

An annual West McArthur River Oil Pool surveillance report will be required by April 1 of each year subsequent to commencement of enhanced oil recovery operations. The report shall include but is not limited to the following:

a. Progress of the enhanced recovery project and reservoir management summary including engineering and geological parameters.

b. Voidage balance by month of produced fluids and injected fluids.

c. Analysis of reservoir pressure surveys within the pool.

d. Results and where appropriate, analysis of production logging surveys, tracer surveys and observation well surveys.

e. Results of any special monitoring.

f. Future development plans.

g. Review of Annual Plan of Operations and Development.

**DONE** at Anchorage, Alaska and dated July 24, 1996.

ALASKA OIL AND GAS CONSERVATION COMMISSION

David W. Johnston, Chairman

Tuckerman Babcock, Commissioner

AS 31.05.080 provides that within 20 days after receipt of written notice of the entry of an order, a person affected by it may file with the Commission an application for rehearing. A request for rehearing must be received by 4:30 PM on the 23rd day following the date of the order, or next working day if a holiday or weekend, to be timely filed. The Commission shall grant or refuse the application in whole or in part within 10 days. The Commission can refuse an application by not acting on it within the 10-day period. An affected person has 30 days from the date the Commission refuses the application or mails (or otherwise distributes) an order upon rehearing, both being the final order of the Commission, to appeal the decision to Superior Court. Where a request for rehearing is denied by nonaction of the Commission, the 30-day period for appeal to Superior Court runs from the date on which the request is deemed denied (i.e., 10th day after the application for rehearing was filed).