

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

**Re: THE APPLICATION OF BP ) Area Injection Order No. 25**  
**EXPLORATION (ALASKA) INC. for )**  
**an order authorizing underground ) Prudhoe Bay Field**  
**injection of fluids for enhanced oil ) Polaris Oil Pool**  
**recovery in Polaris Oil Pool, )**  
**Prudhoe Bay Field, North Slope, )**  
**Alaska ) February 4, 2003**

**IT APPEARING THAT:**

1. By letter and application dated September 12, 2002, BP Exploration (Alaska) Inc. ("BPXA") in its capacity as Polaris Operator and Unit Operator of the Prudhoe Bay Unit ("PBU") requested an order from the Alaska Oil and Gas Conservation Commission ("Commission") authorizing the injection of fluids for enhanced oil recovery in the Polaris Oil Pool within the PBU.
2. By letter dated October 31, 2002, BPXA amended its Polaris Pool Rules and Area Injection Order ("AIO") Application and withdrew its request for approval of injection of miscible injectant ("MI") as part of the current Enhanced Oil Recovery project.
3. Notice of a public hearing was published in the Anchorage Daily News on November 8, 2002.
4. The Commission held a public hearing December 9, 2002 at 9:00 AM at the Alaska Oil and Gas Conservation Commission at 333 West 7<sup>th</sup> Avenue, Suite 100, Anchorage, Alaska 99501.
5. On December 18, 2002 and January 22, 2003, BPXA submitted for the public record exhibits containing information previously submitted within confidential exhibits.
6. The Commission may issue an order permitting underground injection of fluids on an area basis for wells within the same reservoir and operated by a single operator.

**FINDINGS:**

1. Operator:

BPXA is operator of the Polaris Oil Pool in the Prudhoe Bay Field, North Slope, Alaska.

2. Project Area Pool and Formations Authorized for Enhanced Recovery:

Strata proposed for enhanced recovery injection are a subset of the Polaris Oil Pool defined in Conservation Order 484. The target injection zones are correlative to Prudhoe Bay Unit well S-200PB1 between the measured depths (“MD”) of 5,603 feet and 6,012 feet (Schrader Bluff Formation). Development plans for the upper portion of the Polaris Oil Pool (Ugnu Formation) have not been determined and BPXA has not requested authorization to inject fluids into the Ugnu Formation.

3. Proposed Injection Area:

BPXA requested authorization to inject fluids for the purpose of enhanced recovery operations on lands within Umiat Meridian T11N-R12E, T11N-R13E, T12N-R12E, and T12N-R13E in the Prudhoe Bay Unit. The application for an Area Injection Order provides information surrounding five discrete, widely spaced injection wells. These proposed injectors are wells S-104i, proposed redrill S-200Ai, S-215Ai, W-207i, and W-212i.

4. Operators/Surface Owners Notification:

BPXA provided operators and surface owners within one-quarter mile of the proposed area with a copy of the application for injection. The only affected operator is BPXA, operator of Prudhoe Bay Unit. The State of Alaska, Department of Natural Resources is the only affected surface owner.

5. Existing Orders:

- a. Aquifer Exemption: Aquifer Exemption Order No. 1, dated July 11, 1986, exempts freshwater aquifers lying directly below the Western Operating and K-Pad Areas of the Prudhoe Bay Unit.
- b. Area Injection Order: AIO No. 3, dated July 11, 1986, authorizes underground injection of fluids within specified strata lying directly below the Western Operating Area and K-Pad Area of the Prudhoe Bay Unit for the purposes of enhanced recovery and the disposal of non-hazardous oil field waste fluids. AIO No. 3, Rule 2 authorizes injection for disposal purposes in strata that correlates with the strata found in PBU Well C-11 between 3,990 feet and 6,293 feet MD.

6. Description of Operation:

The Polaris Oil Pool will be developed in phases, beginning at the crests of the accumulations near the S-, M-, and W- Pads, and progressively working towards the outer margins of the pool. Peak production rates are expected to be between 12,000 and 15,000 barrels of oil per day (“BOPD”). Waterflood injection rates are estimated to peak between 20,000 and 25,000 barrels of water per day (“BWPD”).

7. Hydrocarbon Recovery:

The Polaris Oil Pool is estimated to contain 350 to 750 million barrels of original oil in place ("OOIP") based on exploratory drilling and seismic mapping. Computer simulation results indicate primary recovery within the target sands of the development area is expected to be 5 to 10% of the OOIP, and implementing a waterflood will recover an additional 10 to 20% of the OOIP.

8. Geologic Information:

- a. Stratigraphy: The Polaris Oil Pool encompasses reservoirs assigned to the Late Cretaceous-aged Schrader Bluff Formation ("Schrader Bluff") and the Early Tertiary-aged Ugnu Formation ("Ugnu"). The Schrader Bluff is divided into two stratigraphic intervals that are designated, from deepest to shallowest, the "O-sands" and the "N-Sands." The overlying Ugnu reservoir intervals of the Polaris Oil Pool are informally termed the "M-Sands." The O- and N-Sand intervals were deposited in marine shoreface and shallow shelf environments. The M-Sands were deposited in deltaic and fluvial environments.
- b. The Schrader Bluff O-Sands are divided into seven separate reservoir intervals that are named, from deepest to shallowest, O<sub>Bf</sub>, O<sub>Be</sub>, O<sub>Bd</sub>, O<sub>Bc</sub>, O<sub>Bb</sub>, O<sub>Ba</sub>, and O<sub>A</sub>. Each of these intervals coarsens upward from non-reservoir, laminated muddy siltstone at the base to reservoir-quality, thinly bedded sandstone at the top.
- c. The lower portion of the Schrader Bluff N-Sands is dominated by mudstone and siltstone. However, the sediments coarsen upward, and fine- to medium-grained sandstone is prevalent in the upper part of the N-Sands. Three reservoir intervals are recognized within the N-Sands. They are, from oldest to youngest, N<sub>C</sub>, N<sub>B</sub>, and N<sub>A</sub>.
- d. The Ugnu M-Sands are divided into four reservoir intervals named, from deepest to shallowest, M<sub>C</sub>, M<sub>B2</sub>, M<sub>B1</sub>, and M<sub>A</sub>. These intervals consist of unconsolidated, clean sands that are separated by thin, but extensive, intervals of non-reservoir silty mudstone.
- e. Structure Overview: The Polaris Oil Pool structure lies between approximately 4,800 feet and 5,300 feet true vertical depth subsea ("TVDss") within the affected area. The structural dip ranges up to 4 degrees to the east and northeast, and it is broken by three sets of faults: one trending northwest, the second trending north, and the third trending west. These faults are normal, and they divide the structure into a series of reservoir compartments. Northwest- and north-trending faults are the primary controls for oil distribution in the W-Pad, S-Pad and M-Pad areas. The west-trending faults occur most commonly in the down-dip portions of the pool to the east and northeast. They trap oil in the center of the pool: near the Term Well C, near N-Pad, and along the southern margin of the pool.

- f. Confining Intervals: Lower confinement for the Polaris Oil Pool is provided by the non-reservoir, laminated muddy siltstone that constitutes the base of the OBf interval and 1,100 feet of mudstone and silty mudstone assigned to the upper Colville Group.
- g. The basal portion of the Schrader Bluff N-Sands interval consists of non-reservoir mudstone and siltstone that forms a regionally extensive hydraulic barrier. This barrier separates lighter, higher quality oil in the O-Sands from the heavier oil accumulations in the overlying N- and M-Sand intervals. The MC Sand is separated from the underlying N-Sands by a silty mudstone that ranges in thickness from 15 to 25 feet.
- h. Upper confinement is provided by a 14- to 25-foot thick mudstone that lies at the base of the MB2 interval and forms a regionally continuous hydraulic barrier. This mudstone layer separates oil-bearing MC Sand from overlying, water-bearing MB2 Sand within the pool. A 9- to 15-foot thick silty mudstone overlies the uppermost MA sand and provides a regionally extensive barrier.

9. Well Logs:

The logs of existing injection wells are on file with the Commission.

10. Mechanical Integrity and Well Design of Injection Wells:

BPXA is requesting approval to inject water simultaneously into the Aurora (Kuparuk Formation) and Polaris Oil Pools within well S-104i. Water is currently being injected into the Aurora Oil Pool within this well. This well is designed to allow dual injection with packers installed for zonal isolation. Injection valves will be sized for water injection rate control and will be run within mandrels between the packers. Spinner logs will be run to verify injection rates to the separate formations.

11. Type of Fluid / Source:

Water for injection will be supplied from Gathering Center 2 and from the Seawater Treatment Plant. In addition, tracer survey fluids and well stimulation fluids will be injected periodically to ensure efficient operation of the water flood. Non-hazardous filtered water collected from Polaris Oil Pool well house cellars and well pads may also be injected.

12. Water Composition and Compatibility with Formation:

BPXA provided laboratory analysis of the injection and produced waters. No significant compatibility problems are evident from these analyses. Disposal of PBU produced water within the Ugnu sands has successfully occurred in other parts of the field.

13. Area of Injection Influence:

The area of injection influence lies within ¼ mile radial distance of the point of injection, assuming radial flow of the injected water. Reservoir simulation suggests that within 1,000 feet to 1,500 feet of the injector, the reservoir pressure dissipates to near reservoir pressure.

14. Injection Rates and Pressures, Fracture Information:

The requested maximum water injection rate is 25,000 barrels of water per day (“bwpd”) in the project area. The individual well injection rates will range from 1000 to 5000 bwpd.

BPXA requested a maximum surface injection pressure of 2800 psi with an average surface operating pressure of 2300 psi. Step rate tests indicate fractures initiate at about 1000 psi surface injection pressure while injecting at 1½ to 2 barrels per minute. A stress test performed in well S-213 indicates a fracture gradient of 0.66 psi/ft for the basal mudstone of the OBa interval. This is a typical silty mudstone within the Polaris Oil Pool. Minimum stress values for the sandstones show an average fracture gradient of 0.61 psi/ft, indicating a stress contrast of approximately 255 psi between reservoir sandstone and confining mudstone. This agrees with the stress contrast of 300 psi estimated using the dipole sonic log from well W-200.

15. Mechanical Condition of Adjacent Wells:

Wells recently drilled into the Polaris Oil Pool have been constructed in conformance with Commission regulations. Many pre-existing exploratory and development wells in this area were drilled to deeper targets. The mechanical isolation of some wells in the Polaris Oil Pool has not been demonstrated. Ivishak producing well W-17 is within 255 feet of proposed injector W-212i at the level of MB2 mudstone. Information supplied does not demonstrate cement confinement across the Polaris Oil Pool in well W-17. BPXA’s proposed surveillance program includes a pre-injection baseline temperature survey within well W-17 and additional temperature surveys at 2, 5, and 8 months after initiating water injection.

**CONCLUSIONS:**

1. The application requirements of 20 AAC 25.402 have been met.
2. Water injection will significantly improve recovery.
3. Dual injection within well S-104i is appropriate so long as mechanical isolation of the pools within the wellbore is assured and water injection is allocated between the pools.
4. Sufficient information has been provided to authorize five (5) wells to inject water into the Polaris Oil Pool for the purposes of pressure maintenance and enhanced oil recovery.
5. The proposed injection operations will be conducted in permeable strata, which can

reasonably be expected to accept injected fluids at pressures less than the fracture pressure of the confining strata.

6. Injected fluids will be confined within the appropriate receiving intervals by impermeable lithology, cement isolation of the wellbore and appropriate operating conditions.
7. Reservoir and well surveillance, coupled with regularly scheduled mechanical integrity tests will demonstrate appropriate performance of the enhanced oil recovery project or disclose possible abnormalities.
8. Disposal injection in hydrocarbon bearing strata may harm resource development.

**NOW, THEREFORE, IT IS ORDERED** that:

1. Within the affected area, this order supersedes Rule 2 of Area Injection Order No. 3, dated July 11, 1986 and Administrative Approval No. 3.1, dated August 15, 1986.
2. The underground injection of fluids for enhanced oil recovery is authorized, subject to the following rules and the statewide requirements under 20 AAC 25 (to the extent not superseded by these rules) in the following affected area.

**Umiat Meridian**

<b>Township / Range</b>	<b>Lease</b>	<b>Sections</b>
T12N-R12E	ADL 28256	Sec 22 S/2 S/2 and NE/4 SE/4
	ADL 47448	Sec 23 S/2 NW/4 and SW/4
	ADL 28257	Sec 25 SW/4 NW/4 and SW/4 and SW/4 SE/4, 26, 35, 36
	ADL 28258	Sec 27, 33 SE/4 SE/4, 34 E/2 W/2 and SW/4 SW/4 and E/2
T12N-R13E	ADL 28279	Sec 31 SW/4 NW/4 and SW/4
T11N-R13E	ADL 28282	Sec 6 W/2 and SE/4 and S/2 NE/4 and NW/4 NE/4, Sec 7 N/2 and N/2 SW/4 and SE/4 SW/4 and SE/4, Sec 8 W/2 SW/4
T11N-R12E	ADL 28260	Sec 1, 2, 11 W/2 and NW/4 NE/4, 12 N/2 N/2 and SE/4 NE/4
	ADL 28261	Sec 3, 4 E/2 E/2, 9 NE/4 NE/4 and S/2 NE/4 and SE/4, 10
	ADL 28263-1	Sec 15, 16 E/2
	ADL 28263-2	Sec 21 NE/4 NW/4 and NE/4 SE/4 and NE/4, 22 N/2 and N/2 SW/4 and SE/4 SW/4 and SE/4
	ADL 47451	Sec 14 W/2 and W/2 SE/4, 23 W/2 and W/2 E/2 and SE/4 SE/4 and SE/4 NE/4
	ADL 28264	Sec 26 N/2 N/2
	ADL 47452	Sec 27 NE/4 NE/4

**Rule 1 Authorized Injection Strata for Enhanced Recovery**

Authorized fluids may be injected for purposes of pressure maintenance and enhanced oil recovery into strata that are common to, and correlate with the N and O-Sand interval between 5,603 feet and 6,012 feet MD in Prudhoe Bay Unit well S-200PB1.

**Rule 2 Fluid Injection Wells**

The underground injection of fluids for enhanced oil recovery is authorized in the following wells:

Injection Well	Permit to Drill	Physical Location of Injection Interval
S-104i	200-196	Sec 26 and 27, T12N, R12E
S-200Ai	197-239	Sec 27, T12N, R12E (proposed)
S-215i	202-154	Sec 34, T12N, R12E
W-207i	Proposed well	Sec 23, T11N, R12E (proposed)
W-212i	202-066	Sec 22, T11N, R12E

Upon proper application, the Commission may administratively approve additional wells for injection of fluids in the Polaris Oil Pool.

The underground injection of fluids must be through a well that is 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 and 20 AAC 25.412.

The application to drill or convert a well for injection must also include a report on the mechanical condition of each well that has penetrated the injection zone within a one-quarter mile radius of the proposed injection well. The information must include cementing records, cement quality log or formation integrity test records.

**Rule 3 Authorized Fluids for Enhanced Recovery**

Fluids authorized for injection include:

- a. Produced water from the Polaris Oil Pool or Prudhoe Bay Unit production facilities for the purposes of pressure maintenance and enhanced recovery;
- b. tracer survey fluid to monitor reservoir performance;
- c. source water from a sea water treatment plant; and
- d. non-hazardous filtered water collected from Polaris Oil Pool well house cellars and well pads.

**Rule 4 Authorized Injection Pressure for Enhanced Recovery**

- a. Normal injection pressures must be maintained below the parting pressure of the confining mudstone (approximately 0.67 psi/ft).
- b. Operating pressure within well W-212i must be maintained below parting pressure of the reservoir sandstone, until offset well W-17 is proven to provide sufficient mechanical isolation to prevent migration of water out of the approved injection stratum.

**Rule 5 Monitoring Tubing-Casing Annulus Pressure**

Tubing-casing annulus pressures within each injection well must be checked and recorded weekly to ensure there is no pressure communication or leakage in any casing, tubing or packer.

**Rule 6 Demonstration of Tubing/Casing Annulus Mechanical Integrity**

A schedule must be developed and coordinated with the Commission that ensures that the tubing-casing annulus for each injection well is pressure tested prior to initiating injection, following well workovers affecting mechanical integrity, and at least once every four years thereafter.

**Rule 7 Multiple Completion of Water Injection Wells**

- a. Water injectors may be completed to allow for injection in multiple pools within the same wellbore so long as mechanical isolation between pools is demonstrated and approved by the Commission.
- b. Prior to initiation of co-mingled injection, the Commission must approve methods for allocation of injection to the separate pools.
- c. Results of logs or surveys used for determining the allocation of water injection between pools, if applicable, must be supplied in the annual reservoir surveillance report.
- d. An approved injection order is required prior to commencement of injection in each pool.

**Rule 8 Well Integrity Failure**

Whenever operating pressure or pressure tests indicate communication or leakage of any casing, tubing or packer, the operator must notify the Commission on the first working day following the observation and obtain Commission approval to continue injection. Commission approval of an Application for Sundry Approval (Form 10-403) is required before initiating corrective action.

**Rule 9 Notification of Improper Class II Injection**

Injection of fluids other than those listed in Rule 2 without prior authorization is considered improper Class II injection. Upon discovery of such an event, the operator must immediately notify the Commission, provide details of the operation, and propose actions to prevent recurrence. Additionally, notification requirements of any other State or Federal agency remain the operator's responsibility.

**Rule 10 W-17 Surveillance**

Prior initiating injection within well W-212i, a baseline temperature survey within W-17 is required. Additional temperature surveys within well W-17 are required at 2, 5, and 8 months after initiating water injection to verify the W-17 wellbore is not serving as a fluid migration path. Results and interpretation of these surveys shall be supplied to the Commission within 30 days of completing the survey.

Injection must be terminated in well W-212i if there is any indication of pressure communication or leakage within well W-17 attributed to injection in well W-212i.

**Rule 11 Plugging and Abandonment of Fluid 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.

**Rule 12 Other conditions**

- a. It is a condition of this authorization that the operator complies with all applicable Commission regulations.
- b. The Commission may suspend, revoke, or modify this authorization if injected fluids fail to be confined within the designated injection strata.

**Rule 13 Administrative Actions**

Unless notice and public hearing is otherwise required, the Commission may administratively waive the requirements of any rule stated above or administratively amend any rule as long as the change does not promote waste or jeopardize correlative rights, is based on sound engineering and geoscience principles, and will not result in an increased risk of fluid movement into freshwater.

**DONE** at Anchorage, Alaska and dated February 4, 2003.

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Cammy Oechsli Taylor, Chair  
Alaska Oil and Gas Conservation Commission

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Daniel T. Seamount, Jr., Commissioner  
Alaska Oil and Gas Conservation Commission

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Michael L. Bill, P.E., Commissioner  
Alaska Oil and Gas Conservation Commission

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 must file with the Commission an application for rehearing. A request for rehearing must be received by 4:30 PM on the 23<sup>rd</sup> 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 non-action 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., 10<sup>th</sup> day after the application for rehearing was filed).