

**Northstar Unit, Beaufort Sea, Alaska**  
**Application To AOGCC For Approval Of**  
**Pool Rules And Area Injection Order**

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**BP Exploration (Alaska) Inc.**

**June 25, 2001**

**Northstar Unit, Beaufort Sea, Alaska**  
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**Northstar Unit, Beaufort Sea, Alaska**

Application To AOGCC For Approval Of  
Pool Rules And Area Injection Order

BP Exploration (Alaska) Inc. ("BPXA"), in its capacity as Northstar Unit Operator, requests that the Alaska Oil and Gas Conservation Commission (the "Commission") adopt the Area Injection Order ("AIO") set out in Section 7 of this application and the Northstar Pool Rules set out in Section 8.

For purposes of this application, the Northstar Pool is defined as the accumulation of hydrocarbons in the Ivishak, Shublik and Sag river formations common to and correlating with the interval between the measured depths of 12,418 feet and 13,044 feet in the Seal A-01 well. The boundary of the Northstar Pool is illustrated in the map attached as Exhibit 1. The boundary of the lands subject to the Northstar Area Injection Order (the "Northstar Injection Area") and the Northstar Pool Rules is shown in the map attached as Exhibit 2, and is described in Exhibit 3.

Shortly after submitting this application, BPXA will request that the United States Department of the Interior, Minerals Management Service ("MMS") approve gas reinjection pursuant to 30 CFR 250.114 and enhanced oil recovery pursuant to 30 CFR 250.1107. BPXA will coordinate its submissions to AOGCC and MMS such that both agencies receive the same information and are cross-copied on any request or application to the other agency. Where there are differences between the requirements imposed by AOGCC and MMS, BPXA will comply with the more stringent regulation or statute or, if necessary, request a waiver of mutually inconsistent regulations. BPXA is not aware at this time of any instance where complying with the regulatory requirements of one agency would violate the requirements imposed by the other.

## 1. Project Overview

The Northstar Pool is a discovery in the Ivishak formation, and is located approximately 6 miles offshore in the Beaufort Sea, north of the Prudhoe Bay Unit, as illustrated in Exhibit 1. The Northstar Pool crosses from State waters into Federal waters, and lies beyond the barrier islands. The Northstar Pool was discovered in 1983 by Shell during the drilling of the Seal A-01 well and was well appraised by Shell and Amerada Hess who drilled a total of 5 wells to the target horizon. Shell and Amerada Hess carried out extensive coring and well testing, and obtained a dense grid of two-dimensional seismic data. The exploration and appraisal wells were drilled from two gravel islands in approximately 40 feet of water. Amerada's Northstar Island was located over the northwest portion of the Northstar Pool, and Shell's Seal Island was located over the main southeast part of the Northstar Pool. Both islands were abandoned and were washed away by winter storms. In 1996, BPXA shot and processed an Ocean Bottom Cable ("OBC") 3-D seismic survey over the field.

The Northstar Pool contains a volatile, sweet crude. Oil gravities, as measured from several collected fluid samples, range from 43-45° API. Initial gas oil ratios ("GOR") were approximately 2200 scf/stb (standard cubic feet per stock tank barrel) and the viscosity was measured to be about 0.14 cp (centipoise).

The Northstar project is a stand-alone island based development on Seal Island, providing full process and export facilities for 65,000 barrels per day (bpd) oil, 600 million standard cubic feet per day (scfd) of gas injection, and 30,000 bpd of produced water handling capacity. The pipeline system consists of a 10-inch crude export line that ties in to the Trans-Alaska Pipeline System ("TAPS") at Pump Station 1, and a 10-inch gas line for providing the import of make-up gas and fuel gas from Prudhoe Bay Unit for enhanced oil recovery ("EOR") at the Northstar project. Construction of the island and installation of the pipelines were completed early in 2000.

The island includes slots for 37 wells, and the initial phase of development at the Northstar project calls for 16 production wells, 5 gas injection wells, and one Class I waste disposal well. Drilling began in December 2000. To date, BPXA has drilled the disposal well, one gas injection well, and two pre-produced gas injection wells. Development drilling will resume following the facility startup in November 2001 and will continue into 2003.

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The Northstar Pool will be developed as a tertiary recovery project using the EOR technique of miscible fluid displacement to increase recoverable oil reserves. The EOR project involves the initial injection of a large slug of miscible enriched natural gas into the oil column of the Ivishak formation. This period of miscible gas injection will last approximately four years, and will be followed by the injection of leaner chase gas through to the end of field life.

The miscible gas will be a blended mixture of reservoir gas (produced with the oil), and the gas imported from Prudhoe Bay Unit ("make-up" gas). During the miscible fluid injection phase, the gas processing plant on the island will be operated such that the associated reservoir gas is maintained as rich as possible. This will ensure that the injected gas stream is miscible with the reservoir fluids. The volume of make-up gas will be controlled such that the reservoir pressure will be maintained near to its initial value at field startup, and above the miscibility pressure determined from slim-tube experiments.

## 2. Geology

### STRATIGRAPHY

The Northstar Pool is contained within the Sag River, Shublik and Ivishak formations and was deposited during the Permian and Triassic geologic time periods. Exhibit 4 illustrates the stratigraphy of the Northstar Pool on the Seal A-01 type log. This log is scaled in true vertical depth from the rotary kelly bushing ("TVDrkb"). The top of the Northstar Pool occurs at a depth of [REDACTED] feet TVDrkb. The base of the Northstar reservoir occurs at a depth of [REDACTED] feet TVDrkb. The oil water contact exists at [REDACTED] feet true vertical depth sub-sea ("TVDss").

### Sag River

The Sag River formation lies immediately below the Kingak formation of Jurassic age and above the Shublik formation of Triassic age. The Sag River formation consists of a series of transgressive marine sands, silts, and shales and is approximately [REDACTED] feet thick in the vicinity of the Northstar pool area.

### Shublik

The Shublik formation lies immediately below the Sag River formation of Triassic age and unconformably overlies the Ivishak Formation of Permian and Triassic age. The Shublik formation consists of marine silts, shales, sands and phosphatic limestones and is approximately [REDACTED] feet thick in the vicinity of the Northstar pool area. The Shublik formation is subdivided into four lithologic units. The upper unit called the Shublik A consists of marine silts and shales and is approximately [REDACTED] feet thick. The Shublik B lies below the Shublik A and consists of phosphatic limestones and is approximately [REDACTED] feet thick. The Shublik C lies below the Shublik B and consists of limestones grading downward into interbedded shales and siltstones and is approximately [REDACTED] feet thick. The Shublik D lies below the Shublik C and unconformably overlies the Ivishak formation. The Shublik D is approximately [REDACTED] feet thick.

### Ivishak

The Ivishak formation lies unconformably below the Shublik D unit of Triassic age and conformably above the Kavik formation of Permian age. The Ivishak is approximately [REDACTED] feet thick in the vicinity of the Northstar pool area. The Ivishak consists of delta front sands and shales grading upward to fluvial sands and finally into medium to coarse grained pebbly conglomerates.

**LITHOLOGY**

**Sag River**

The sands within the Sag River represent a mineralogically mature sandstone composed of quartz with minor amounts of feldspar and authigenic clays. Calcite, silica and siderite are the primary cementing agents.

**Shublik**

The Shublik formation consists of marine silts and shales in the Shublik A unit grading downward into phosphatic limestones in the Shublik B and then into interbedded silts and shales in the Shublik C and finally into fine and very fine grained sands in the Shublik D unit. Calcite, silica, siderite and pyrite are the primary cementing agents within the Shublik formation.

**Ivishak**

The Ivishak reservoir consists of an upper conglomeratic unit and a lower sand unit. The upper conglomeratic unit is characterized by a bimodal grain size distribution consisting of mostly chert and quartz clasts with minor amounts of silt and quartz grains comprising the matrix material. The conglomeratic unit has varying amounts of microporous chert grains as part of the framework. Calcite, silica and siderite are the primary cementing agents. The lower sand unit consists of medium to coarse-grained sand with minor amounts of silt and shale. This lower unit is approximately [REDACTED] feet thick and is present below the oil / water contact throughout most of the field area. Calcite, silica and siderite are also the primary cementing agents present within the lower sand unit. The Ivishak reservoir at Northstar is more proximal, coarser grained, more deeply buried and cemented than the Ivishak reservoir in Prudhoe Bay, leading to lower average porosities and permeabilities. [REDACTED]

[REDACTED]

[REDACTED] An isopach map of the Ivishak reservoir is shown as Exhibit 5. [REDACTED]

[REDACTED].

**STRUCTURE**

The structure of the Northstar Pool consists of a faulted anticline defined by three-way dip closure on the east, west and south, with fault seal and dip closure to the north. Exhibit 6 is a structure map at the top of the Ivishak and illustrates the trapping configuration. Exhibit 7



shows two structural cross-sections. Cross-section A-A feet is a strike oriented cross-section running from the SW to the NE across the Northstar Pool. Cross-section B-B feet is a dip oriented cross-section running from the NW to the SE. These two cross-sections also serve to illustrate the trapping configuration at the Northstar Pool.

**FAULTING**

[REDACTED]

[REDACTED] A

testing and reservoir surveillance program, including pressure measurement from RFT or MDT, injection gas tracer analysis and geochemical analysis, will be implemented to address this issue more completely during development.

**CONFINING INTERVALS**

The Northstar Pool is confined below by the Kavik formation and above by the Kingak formation. The Kavik formation is continuous throughout the area. It is interpreted to be a marine shale sequence of Permian age. The Kavik rests unconformably on the carboniferous aged Lisburne group. The Kavik formation is extremely impermeable with a thickness of approximately 100 feet in this area and serves as the lower confining zone.

The Kingak formation is continuous throughout the area and conformably overlies the Sag River formation. The Kingak formation was deposited as marine shales and silts during the Jurassic period and is extremely impermeable. The Kingak formation is approximately 1,000 feet thick in the area and serves as the upper confining zone.

**FLUID CONTACTS**

[REDACTED]

### 3. Reservoir Description and Development Planning

#### ROCK AND FLUID PROPERTIES

The reservoir description of the Northstar Pool is based on core and well log data from the Seal A-01, Seal A-02A, Seal A-03 and Northstar-1 wells. A total of 1196.3 ft. of Ivishak core was acquired from these four wells. The core data were used to calibrate the porosity portion of the petrophysical log model. The type logs for the reservoir intervals in Northstar-1, Seal A-01, Seal A-02A, Seal A-03 and Seal A-04 are shown in Exhibits 8 through 12.

#### POROSITY AND PERMEABILITY

##### Sag River Formation

Routine porosity and permeability measurements are available from two wells (Seal A-02A, and Northstar-1). No significant core was obtained in what would be described as the best reservoir section of the Sag River formation with the exception of the upper part of Core 1 in the Seal A-02A well. The core plug permeability values range from [REDACTED]. The mean core porosity is [REDACTED]. The average log derived porosity was generated from the density log using an average grain density of [REDACTED]. The log porosity results average [REDACTED]. Permeability was estimated from a core poro-perm relationship. The likely permeability range is estimated to be [REDACTED]. No tests are available for comparison with the core data.

##### Shublik Formation

Core data across the Shublik formation exists on the Northstar-1 and Seal A-02A wells only. The Shublik formation is considered a source rock and not in general a reservoir rock. What core poro-perm data does exist suggest that most of the section is tight and non-reservoir with the exception of Zone D. Permeability is generally [REDACTED] and porosity [REDACTED]. However, porosity and permeability measurements can get up to [REDACTED] in a few instances in thin (< 3 inches) discontinuous intervals. These thin intervals are not observed on well log data and usually add up to less than 2 feet cumulatively in vertical extent and do not appear to correlate between wells.

**Ivishak Formation**

Extensive routine porosity and permeability measurements were available from four wells (Seal A-01, Seal A-02A, Seal A-03 and Northstar-1). Core was also obtained from Seal A-04 but was insignificant and outside the oil column. In addition, porosity and permeability data at in-situ confining pressures were available from Seal A-02A and Northstar-1. A sensitivity study of the impact of in-situ confining stress on porosity and permeability indicate [REDACTED]

The mean stress corrected core porosity for the Ivishak Formation above the oil water contact is approximately [REDACTED]. Core permeability ranges from [REDACTED] with a mean stress corrected value of approximately [REDACTED].

Permeability established from drill stem tests are higher than average permeability values from core. This may be a result of rubble sections existing in the reservoir that were not representatively sampled from the cores that were obtained. The two dominant facies, conglomerates and sandstones, have different reservoir properties and subsequently different poro-perm trend relationships. The correlation of porosity to permeability is better for the sandstones than for the conglomerates.

Two significant studies were undertaken on the Ivishak reservoir to define the percent of effective porosity and non-effective micro-porosity. Shell and Core Laboratories performed a study on these two porosity distributions. Within the Ivishak reservoir there are two dominant reservoir facies, which have been characterized as conglomerates and sandstones. The conglomerate facies as defined by Shell and Core Laboratories have an average porosity of [REDACTED] and [REDACTED], respectively, while the sandstones have an average porosity of [REDACTED] and [REDACTED], respectively. Additionally, Shell and Core Laboratories reported that within the conglomerate facies [REDACTED] and [REDACTED] respectively of the total porosity is micro-porosity. They determined that within the sandstone facies [REDACTED] and [REDACTED] respectively of the total porosity is micro-porosity. This study indicates that the volume fraction of micro-porosity increases as one moves down in the reservoir section.

**NET PAY**

**Sag River Formation**

The reservoir gross thickness ranges from [REDACTED] feet in the [REDACTED] well to a

maximum of [REDACTED] feet in the [REDACTED] well. Net pay was determined from gamma ray cutoffs and porosity cutoffs that were established from poro-perm relationships. Permeability above [REDACTED] or porosity above [REDACTED] was considered as pay. This estimate has not been verified by test. Currently, no test exists in the Sag River formation to demonstrate producibility. The net to gross for the interval was determined to range from [REDACTED] based on the above cutoffs. There is considerable uncertainty in this estimate as log coverage of the Gamma Ray and porosity is not generally complete across the Sag River section.

**Shublik Formation**

Core was obtained only on the Northstar-1 and Seal A-02A well across the Shublik formation. While mudlog shows exist, this section is in general non-reservoir. The permeability that does exist from core from the Northstar-1 and Seal A-02A wells is generally less than [REDACTED]. There are a few thin intervals of reservoir quality rock in the Shublik that have permeabilities as high as [REDACTED] but are not considered significant with the possible exception of the Shublik D unit. The gross thickness of the Shublik D is about [REDACTED].

**Ivishak Formation**

[REDACTED] Non-pay intervals include rare silty/shaley intervals recognized on the gamma ray log (V-shale) and low porosity cemented conglomerates and sandstones. Thicker and more continuous shales are only present in the very lowest portions of the reservoir and are present largely in the aquifer. Net to gross estimates were made using a combined V-shale cut off [REDACTED] porosity cutoff for sandstones and a [REDACTED] porosity cutoff for conglomerates. Porosity cutoffs were established from poro-perm relationships for the conglomerates and sandstones.

**STATIC MODEL CONSTRUCTION**

**Sag River and Shublik Formations**

Isopach maps for the Sag River and Shublik were created using the existing well control. Porosity, water saturation and net to gross ratios were determined for the Sag River from well log and core data analysis. These data were then combined to determine the OOIP for the Sag River which was estimated to be [REDACTED]. The following table summarizes the input parameters for determining the OOIP for the Sag River:





Conglomerates:

Sw = [REDACTED]

Sandstones:

Sw = [REDACTED]

Where:

Sw = Water saturation (v/v)

$\emptyset$  = Porosity (v/v)

HAOWC = Height above oil water contact (feet)

A total of 131 capillary pressure curve measurements were obtained from the Seal A-01, Seal A-02A, Seal A-03 and Northstar-1 wells. Of these, 101 were mercury injection, 24 were porous plate and 8 were centrifuge capillary pressure measurements. Of these, 26 were conglomerates, 94 were sandstones and 13 were cherts. This data was used to define the amount of effective porosity, micro-porosity, pore size distribution and oil saturation as a function of height above a free water level for both the conglomerate and sandstone facies.

A significant amount of special core analysis measurements were obtained from the Northstar cores. Electrical property measurements were conducted on 35 core samples in order to define "m" (cementation exponent) and on 24 core samples to define "n" (saturation exponent) for use in the Archie equation to calculate water saturation from log data. The average "m" and "n" value for the Northstar Pool is [REDACTED], respectively. These electrical property measurements were also broken out by conglomerates and sandstones facies. The average "m" value for the conglomerates and sandstones were [REDACTED], respectively. The average "n" value for the conglomerates and sandstones were [REDACTED], respectively.

Water resistivity was determined to be [REDACTED] based on a formation water sample of 19,340 ppm NaCl from the Seal A-01 well. The chemical composition of the formation water sample taken from Seal A-01 is shown in Exhibit 13. Comparing core porosity measurements to the wireline log curves indicates that the sonic log provides the best correlation to core porosity followed by the density log and then finally the neutron log. The average grain density of the Ivishak reservoir rock [REDACTED] g/cc.



**PRESSURE & TEMPERATURE**

The initial pressure of the Northstar Pool at [REDACTED], the oil water contact, was [REDACTED] psig (pounds per square inch gauge) based on RFT and bottom hole pressures measured in the Seal A-02 and Seal A-01 wells. For reference, this equates to [REDACTED] psig at [REDACTED] ft. TVDss, which is near the crest of the structure. Average reservoir temperature is estimated to be [REDACTED] F at the oil column centroid.

[REDACTED]

[REDACTED]

**FLUID PVT DATA**

PVT analysis was carried out on recombined surface samples from Seal A-01, Seal A-02A, Seal A-03 and the Northstar-1 wells. A compositional analysis from Seal A-01 Test #2 is included as Exhibit 30 to typify the Northstar oil and gas. One bottom hole sample was obtained from the Seal A-01 well allowing comparison to the surface samples. Analysis of the PVT fluid samples indicates [REDACTED]

[REDACTED] The ranges of fluid properties at initial reservoir conditions are listed below.

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<b>Fluid Property</b>	<b>Near Water-Oil Contact</b>	<b>Near Gas-Oil Contact</b>
Oil API Gravity (Degrees API)	■	■
Solution GOR (SCF/STB)	■	■
Oil Formation Volume Factor (RB/STF)	■	■
Oil Density at Bubble Point Pressure (gm/cc)	■	■
Oil Viscosity (cp)	■	■
Gas Viscosity Estimated (cp)	■	■
Water Viscosity Estimated (cp)	■	■

Analysis of the bubble point pressure versus depth from the Seal A-01 well indicates the reservoir may be [REDACTED]

Several feet of gas were present in the top of the reservoir in the Shublik D zone in the Northstar-1 well. The gas elevated the GOR to [REDACTED] SCF/STB in the well test in which the upper 30 feet of the well was perforated. These perforations included the Shublik D in addition to the upper Ivishak (Ivishak E). This gas appears to be isolated from other upstructure Ivishak wells in which free gas is not present. There is no evidence of a Heavy Oil Tar zone in the Northstar Ivishak reservoir.

Results from the PVT data were used to generate both a 10 and a 15 component equation of state ("EOS"). The EOS along with the oil compositional gradient were used in the reservoir simulation studies. One slim tube experiment has been run with oil from the Northstar-1 well to verify miscibility. This experiment, which achieved a [REDACTED] recovery efficiency at [REDACTED] gas injection, was used to validate the EOS by history matching the slim tube results.

PVT quality bottom hole fluid samples were taken in late May 2001 with the MDT tool from NS31. Oil samples (450 cc) were taken throughout the oil column with larger samples taken near the oil column centroid. The oil samples will be used in PVT studies to determine bubble point pressures and compositions, and for slim tube experiments to verify miscibility. [REDACTED]

[REDACTED]

**HYDROCARBONS IN PLACE**

Estimates of hydrocarbons in place for the Northstar Pool reflect well control, stratigraphic and structural interpretation, and rock and fluid properties. These data were integrated into a geologic model that provides the basis for the estimation of the original fluids in place. The results indicate an Original Oil in Place (“OOIP”) of [REDACTED] (“MMSTB”), a [REDACTED] inferred gas cap occupying [REDACTED] of the hydrocarbon pore volume, and [REDACTED] total gas including solution gas. Structural interpretation is believed to have the greatest impact on uncertainty in OOIP, although there is also large uncertainty in determining the volume of oil filled intergranular porosity versus water filled microporosity.

**DEVELOPMENT PLANS**

Reservoir models of the Northstar Pool were constructed to evaluate development options, investigate reservoir management practices, and generate rate profiles for facility design. This section of the application describes the reservoir models, recovery process selection, and the current development plans.

**Reservoir Model Description**

To evaluate the performance of the Northstar reservoir, both 3-D (three dimensional) full field models (“FFM”) and finer grid mechanistic models were constructed. The models are compositional utilizing either a 10 or 15 component equation of state. The 3-D compositional full field model covers the entire Ivishak reservoir and the surrounding aquifer. The Sag and Shublik formations were not included in the reservoir simulation.

The FFM has 400 foot (3.7 acre) grid blocks over the oil column with 2000 foot (92 acre) grid blocks over the surrounding aquifer. There are 18 vertical layers with grid block thickness averaging 15 to 30 feet. Faults are included in the model through corner point geometry and are considered to be neutral with respect to fluid flow. A capillary pressure equation (as defined earlier) relating porosity and height above the oil water contact was used to predict initial water

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saturations. Grid block values for porosity, permeability, net to gross, and isopach layer thickness were obtained by back interpolating grid block coordinates against the static model. Grid block values for top Ivishak were derived from maps of top Sag River and isopach maps of the Sag and Shublik.

Very finely gridded mechanistic 1-D (one dimensional) models were used to study miscible displacement aspects of the flood. One slim tube experiment has been run with oil from the Northstar-1 well to verify miscibility. This experiment was used to validate the EOS by history matching the slim tube results.

Mechanistic finer gridded 3-D partial field models were also developed. These ongoing model studies are being used to study water coning, horizontal versus vertical well performance, and to validate the coarser grid FFM.

The full field model is in the process of being updated to incorporate the revised geological model which is being modified to include the results of the development wells drilled to date.

**Recovery Process Selection**

A miscible gas injection project, along with waterflood, gas cycling, and primary depletion scenarios, were evaluated. All of the cases used the same number of wells and locations. Injection was controlled to maintain reservoir pressure near ██████████ for the miscible gas and waterflood cases, with pressure declining in the gas cycling and primary depletion cases. Oil and natural gas liquids ("NGL") recovery for these cases are given below with production plots shown in Exhibits 14 through 17.

	<b>Oil</b>	<b>NGL</b>	<b>Total Liquid</b>	<b>RF % OOIP (Oil)</b>
Miscible Gas Injection	██████	████	██████	████
Waterflood	██████	██	██████	████
Gas Cycling	██████	████	██████	████
Primary Depletion	████	██	████	████

Miscible gas injection was the recovery method selected due to its significantly higher recovery efficiency. Oil recovery with miscible gas injection is forecast to be ██████████ higher than

either gas cycling or waterflood. The project is being implemented concurrent with field startup to deliver maximum benefit.

Water alternating with gas ("WAG") injection was also evaluated. The model runs indicated essentially no additional recovery from WAG injection. However, if the reservoir turns out to be highly stratified, WAG injection could mitigate gas channeling through high permeability intervals.

Miscible injectant is made by blending "make-up" gas from Prudhoe Bay Unit ("PBU") with Northstar produced gas. NGLs are left in the produced gas during the miscible injection phase of the project by not running the refrigeration unit of the NGL plant. The "make-up" gas from PBU acts to maintain reservoir pressure which maintains miscibility. It is currently anticipated that NGLs will be left in the produced gas for the first four years of the project resulting in injection of up to [REDACTED] hydrocarbon pore volume of miscible enriched natural gas into the oil column. The miscible gas injection phase will be followed by leaner chase gas injection for the remainder of the oil production phase of field life.

#### **Current Development Plans**

The current Northstar development provides for drilling 21 new wells on an average well spacing of about 400 acres. Five of the wells are planned as miscible gas injectors, with sixteen oil producers. The injectors are located in the central thicker oil column portion of the reservoir to maximize miscible sweep efficiency in areas that contain the greatest OOIP. Two of the injectors will be pre-produced to help load the production facility at startup. The wells in the thicker oil column portion of the reservoir are scheduled earlier in the drilling schedule.

The current development plan calls for drilling the peripheral producers as high angle wells which allows e-line or slick-line access for routine surveillance. Water coning at Northstar is an area of uncertainty due to the apparent absence of barriers to vertical flow, and horizontal peripheral wells are currently being evaluated as a possible option. To help evaluate water coning issues, we plan to take RFT pressure data in wells drilled after field startup to determine if there are vertical cement barriers present in the reservoir that might act to reduce water

coning. Recent model runs indicate that with sufficient standoff from the OWC, water production should remain below the 30,000 BWPD facility limit.

**Future Development Plans**

Additional reserve options exist within the Northstar unit beyond the scope of the initial development described in this document. Our ability to drill extended reach wells presently limits us to wells with bottom hole locations no more than approximately 17,500 ft. from the production island. As a consequence, approximately [REDACTED] barrels of oil remain in the North West portion of the reservoir at the end of field life if no further development drilling were carried out after the initial 22 well drilling program. We expect that with the experience that the initial well schedule will gain us, and with advances in drilling technology, that additional wells that will tap this remaining [REDACTED] potential will be possible at the end of the current drilling program. The reserves in the North West portion of the reservoir will remain essentially untouched by the initial development program as a consequence of maintaining the reservoir pressure close to original pressure.

We also recognize the possibility that satellite oil accumulations may exist within expected drilling reach from the island. These targets will be the subject of additional appraisal.

**RESERVOIR MANAGEMENT STRATEGY**

The objective of the reservoir management strategy is to maximize ultimate recovery consistent with sound engineering practice. Reservoir pressure strategy and field oil production rate are addressed in the reservoir management strategy.

**Reservoir Pressure Strategy**

Reservoir pressure in the Northstar reservoir will need to be managed in order to: ensure miscibility; minimize oil loss due to shrinkage from producing below bubble point pressure; minimize oil loss due to pushing oil into the aquifer by over pressuring the reservoir; and achieve some aquifer influx to sweep the periphery and structurally low areas.

Our current reservoir management strategy during the miscible phase of the project, which is expected to last the first four years of field life, is to voidage replace 100% of total production to maintain reservoir pressure at the initial value found at field startup. However, during the first

year of the project we would like to maintain the option of exceeding 100% voidage replacement to ensure miscibility and compensate for some of the prior and anticipated pressure declines. To maintain operational flexibility during the miscible phase we plan to operate within a [REDACTED] range around the pressure found at flood start.

[REDACTED]  
[REDACTED] After the miscible phase of the project, it is yet to be determined how much reservoir pressure should be allowed to drop to stimulate water influx around the periphery of the field.

To prevent hydrocarbons from being displaced into the aquifer, the average reservoir pressure will not be increased appreciably above its initial value. Most of the reservoir is underlain by bottom water and there is also a large oil water contact periphery. Locating the injection wells in the thick oil column areas of the reservoir which have low OWC's will help to minimize oil pushed into the aquifer beneath injectors due to local pressure gradients.

After the miscible phase of the project, there may be benefit from dropping reservoir pressure below the initial value to achieve natural water influx around the periphery of the reservoir and low in the oil column. The lower portion of the reservoir is not as efficiently swept by the injected gas due to gravity segregation of the gas within the oil column. Allowing a decline in reservoir pressure allows water influx to sweep areas that are less efficiently swept by the miscible flood.

Late in field life (approximately 16 years after field start up) during blow down, reservoir pressure will be reduced to maximize recovery of the injected gas. Gas recovery volumes from blow down have not as yet been estimated.

**Impact Of Field Production Rate**

Three field production rate scenarios have been evaluated. These cases were run prior to obtaining the pressure data from new wells. Average oil off take rates of 65, 72, and 90 MSTB/D were evaluated in the full field simulation model with the results shown below and production plots shown in Exhibits 14, 18 and 19.





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[REDACTED]

[REDACTED]

[REDACTED]

## **4. Facilities**

### **INTRODUCTION**

The Northstar project consists of a self-contained production facility on Seal Island, located 6 miles offshore of the Point Storkerson area in the Alaskan Beaufort Sea. Seal Island is a gravel island of approximately 5 acres constructed over the remains of the island built by Shell Oil Company to conduct exploratory activities during the 1980's.

Two pipelines have been buried in a single trench from Seal Island to existing onshore facilities to transport hydrocarbons to and from the Northstar Unit. The pipelines include one 10-inch common carrier pipeline from Seal Island to Pump Station No. 1 to transport the sales oil to TAPS. The second 10-inch pipeline facilitates the import of up to 100 mmscfd hydrocarbon gas from the Central Compressor Plant in the Prudhoe Bay Unit to Seal Island to assist with the gas cycling process used to produce the Northstar Pool. The plant design allows the imported gas to be used for fuel.

The production facility will be capable of handling 65 mbd of oil, 30 mbd of produced water, and 600 mmscfd of total injected gas. The processing facilities consist of three primary modules. The first, a three level module, will contain the separation, gas dehydration and power generation equipment. The second module will contain the low and high pressure gas compression equipment. The third module will contain the water storage and disposal systems. These three modules are being assembled in Anchorage and will be sea-lifted to Seal Island in the summer of 2001. A simplified process flow diagram is shown in Exhibit 20. Options to allow an increase in the facility handling capacities are currently being evaluated.

A permanent camp facility for up to 74 production and drilling personnel will be installed on the island. Emergency power generation, seawater treatment and sewage facilities will be provided for the camp. Tankage for diesel fuel and water storage will also be included. Exhibit 21 shows the general layout of the island.

While drilling operations are underway, access to the island in the winter months will be by ice road. During the summer open water period, routine access will be barge or supply boat. At all other times, helicopters will be used to travel to and from the island.

**INFRASTRUCTURE**

Seal Island will be the first offshore production island in the Beaufort Sea. The critical infrastructure installed to support operating and essential maintenance of the production facility include:

1. A 74 bed permanent camp with kitchen, dining room, fitness equipment and critical medical care facility;
2. Utilities, including potable water generation, waste water treating, solids incineration, communication gear, and firewater systems;
3. Warehouse / Shop for onsite repairs and critical materials storage;
4. Helideck and dockface; and
5. Class 1 disposal well.

**Well Row Facilities**

The island layout is designed for 37 well slots. Sixteen producers, five gas injectors and one disposal well are planned for the base development. The piperack along the well row has headers for well testing, single train production, gas injection and water disposal. A hydraulic well system and individual well safety panels are included in the piperack, as are utility water, fuel gas, highline electric connections, and vacuum / fluid exchange headers to support drill rig operations.

**Main Process Module**

The main process module, which will be sealifted in two halves and reconnected onsite, will house production separators, gas coolers and dehydration facilities, a Natural Gas Liquids ("NGL") stabilization system, turbine driven generators, a waste heat recovery system for process and utility heat, gas relief collection headers / scrubbers, fuel gas letdown skid, and plant air and nitrogen systems.

The south end of the process module will house the oil custody transfer LACT unit, shipping pumps, the oil pipeline pig launcher and the gas import line pig receiver.

**Compressor Module**

The compressor module will support the flare boom, and will include a single low pressure, multi-section motor driven compressor, two turbine driven injection gas compressors, and coolers, piping and scrubbers for the three compressors.

**Pumphouse Module**

A small pump-house module will have tankage for produced water and well cleanup fluids, centrifugal produced water pumps, and a positive displacement water disposal pump.

**Production Allocation**

Production will be allocated to producing wells based on individual well tests and actual plant oil sales volume. All production wells are individually connected to the test header. Each producing well will be tested monthly to ensure accurate allocation of the produced fluids.

The Programmable Logic Control (“PLC”) system (Plantscape) and Plant Historical Database (Uniformance Historian) will continuously gather operating data from the plant, wells, and test separator. The following points will be honored as part of the production allocation procedure:

1. All wells will be tested monthly.
2. The stabilization and duration of each test will be optimized by the operator to obtain a representative test.
3. Well and field operating condition information required for the construction of a field production history will be maintained.
4. Test separator meters and major gas system meters will be installed and maintained according to industry recommended practices or standards.
5. The Operator will maintain records that permit verification of the satisfactory execution of the production allocation methodologies.

**Flaring Philosophy**

Northstar flaring will be aligned with the BPXA corporate policy to “minimize flaring.” Flaring will be governed by these principles:

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1. Gas injection will be started prior to opening production chokes. This will minimize flaring of primary stage separation off gas during plant startup.
2. Gas will be flared from low pressure separators only long enough for gas flows to stabilize at a rate sufficient for startup of the multistage LP Compressor.
3. Maintenance flaring will continue only during limited periods of problem solving or equipment / compressor testing. In no event will maintenance flaring exceed 48 hours without notification and approval from the MMS as required by 30 CFR 250.1105(a)(2)(i).
4. The control system will be configured to initiate an automatic shutdown of operator selected wells in the event of partial loss of Injection Gas Compression capacity (shutdown of one of two IG compressors). In the event of a compressor emergency shutdown, this will limit flaring to equipment depressurization volumes only.
5. Depressurized plant shutdown will be the automatic response to gas detected in environmentally controlled spaces of the process module.

The gas injection plant and the gas injection well will be commissioned prior to the initial start of oil production at Northstar in November using Prudhoe Bay Unit make up gas. This will reduce the amount of flared gas that traditionally is associated with the start up of new production facilities.

## 5. Well Operations

### DRILLING

The Northstar Pool will be accessed by wells directionally drilled from the newly constructed Seal Island. These wells have been designed in accordance with standard practices and operations across the North Slope. Current island layout results in these wells being drilled on 10 foot nominal centers. Below is a brief summary outlining the proposed drilling and completion plans for both the production and injection wells.

Well construction will be initiated on 20 inch structural casing which has already been driven to approximately 160 ft. below ground level for all of the wells. The structural casing will provide an adequate anchor for the diverter system and support any shallow unconsolidated strata. A diverter system compliant with 20 AAC 25.035(c) and 30 CFR 250.409 will be nipped up during surface hole drilling operations for the first five wells, during which the required data for a diverter waiver application will be collected. A diverter will not be rigged up for the remainder of the wells drilled at Northstar, assuming that BPXA, the Commission and MMS reach mutual agreement concerning the interpretation of the data. BPXA will request Field Drilling Rules from MMS at a later date in order to waive the MMS diverter requirements of 30 CFR 250.409.

Conductor casing requirements as outlined in 20 AAC 25.030(c)(2) have been waived for the Northstar development as per the memo entitled "Dispensation for 20 AAC 25.030(c)(2)" dated March 1, 2000. The structural casing provides an adequate anchor to allowing drilling to the surface casing point at which point the blow-out preventer ("BOP") stack will be nipped up.

Surface hole sections for all wells will be drilled to a depth of approximately 3160 ft. TVDss (150 ft. TVD below the SV6 marker). Intermediate hole sections for the gas injection wells will be directionally drilled to top set the Sag River formation at approximately 10,645 ft. TVDss, while intermediate hole sections for the production wells will be directionally drilled to top set the Miluveach formation at approximately 9264' TVDss. For production wells only, a second intermediate hole section will be required and will be directionally drilled to top set the Sag River formation at approximately 10,645 ft. TVDs. Both production and injection hole sections will be drilled through the Sag River, Shublik, and Ivishak formations to a TD in the Ivishak or the adjacent Kavik formation.

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All casing strings will be run and cemented in accordance with 20 ACC 25.030 and 30 CFR 250.404. Injection wells will have a cement evaluation log run to confirm isolation of the injection fluids to the approved injection intervals (Sag River and Ivishak Formations) as required per 20 AAC 25.030(d)(7). Such logs will also satisfy the requirements of 30 CFR 250.404(a)(5).

The casing and tubing heads will be nipped up with the BOP stack and tested according to Commission and MMS regulations.

Leak-Off-Test ("LOT") and Formation Integrity Test ("FIT") will be performed on all casing strings after drilling 20-50 feet in accordance with 20 AAC 25.030(f) and 30 CFR 250.404(a)(6) or as approved by the drilling permit.

In addition to lined, cemented, and perforated completions, it is proposed that the Pool Rules authorize the following alternative completions:

1. Horizontal or "high angle" completions with slotted or perforated liners.
2. Open hole and/or slotted / pre-perforated completions.
3. Multi-lateral completions in which more than one reservoir penetration is completed from a single well.

Tubing will be run in all wells with a packer. Injection well design will place the packer within 200 ft. of the targeted injection zones, the Sag River and Ivishak, in accordance with 20 AAC 25.412(b). Although this packer placement may result in a packer to perforation distance greater than 200 ft., it retains the option of perforating the Sag River in the future and it does not compromise zonal isolation given the depth and thickness of the overlying confining zone (Kingak formation).

The drilling schedule for Northstar should follow a drill and complete scenario based on current planning. Batch drilling of surface and/or intermediate holes may be initiated dependent on broken ice restrictions and logistical constraints.

**BLOWOUT PREVENTION EQUIPMENT**

Blowout prevention equipment ("BOPE") will be rigged up and tested in accordance with 20 AAC 25.035 and 30 CFR 250.406, .407, .515 and 516, as applicable. Any modifications to previously submitted BOPE diagrams will be updated and submitted with the appropriate Application for Permit to Drill ("APD"). A diverter waiver request will be submitted if the above referenced shallow gas hazard identification indicates that no shallow gas hazard exists at Northstar.

**DRILLING FLUIDS**

The drilling fluid program designed for Northstar will be prepared and implemented in full compliance with 20 AAC 25.033 and 30 CFR 250.410. Formation pressures for all horizons to be penetrated are known based on the Seal Island appraisal wells.

**DIRECTIONAL DRILLING**

Conventional MWD surveys will be used at Northstar.

BPXA requests that the detailed reporting and plotting for directionally drilled wells required by 20 AAC 25.050(b) be waived for the Northstar Pool. Current regulations require extensive data packages with the APD on all wells located within 200 ft. of a directionally drilled well. All drilling at Northstar will be confined to the Northstar Pool and Northstar Unit boundaries with established working and royalty ownership. Instead, the Operator requests that the following information be included in each APD:

1. Plan view;
2. Vertical section;
3. Close approach data; and
4. Directional data.

**WELL DESIGN**

Current development plans for Northstar include five gas injectors, sixteen oil producers and one Class I disposal well. Three of the gas injectors will be completed with 7-inch tubing and liners. Two of these wells will be pre-produced for a period of between 3 and 6 months, and will be completed with 13 Chrome tubing and liners. The remaining 7-inch gas injector will be



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placed on dedicated gas injection service from the start of operations and will be completed with L-80 grade tubulars. The other two gas injectors will be completed with 5½-inch L-80 tubing and liners. The sixteen production wells will be completed with 4½-inch 13 Chrome tubing and liners. Exhibits 22 through 26 show wellbore schematics for the completion designs.

The detailed casing program will be included with the APD for each well and documented with the Commission or MMS, as applicable, in the completion record. API injection casing specifications must be submitted with each APD.

All injection casing will be cemented, tested and its mechanical integrity verified in accordance with 20 AAC 25.030, 20 AAC 25.412, 30 CFR 250.404 and 30 CFR 250.405. The detailed well casing and cement program will be submitted with the APD for each injection well.

Injection well tubing / casing annulus pressures will be monitored and recorded on a regular basis. BPXA, as Operator, will be responsible for the mechanical integrity of injection wells and for ensuring compliance with monitoring and reporting requirements.

The tubing / casing annulus pressure of each injection well will be monitored weekly to ensure that there is no leakage and that the pressure does not subject the casing to a hoop stress greater than 70 percent of the casing's minimum yield strength. However, if an injection well is deemed to have anomalous annulus pressure, it will be investigated for tubing / annulus communication using a variety of diagnostic techniques and a mechanical integrity test. If a subsequent investigation proves hydraulic communication between the tubing / casing exists, then a plan for remedial action will be formulated and scheduled. In addition, a variance will be obtained from the Commission or MMS, as applicable, to continue safe operations, if technically feasible, until the remedial solution is implemented. Tubing / casing pressure variations between consecutive observations need not be reported to the Commission or MMS.

A schedule will be developed and coordinated with the Commission which ensures that the casing / annulus for each injection well is pressure tested prior to initiating injection. A pressure test will consist of subjecting the injection well to a test surface pressure of at least 1,400 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 percent of the casing's minimum yield strength. The test

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pressure must be held for 30 minutes with no more than a 10 percent decline. The Commission will be notified at least 24 hours in advance to enable a representative to witness the pressure test. Alternative EPA approved methods may also be used, with Commission approval, including, but not necessarily limited to: timed-run radioactive tracer surveys ("RTS"); oxygen activation logs ("OAL"); temperature logs ("TL") and noise logs ("NL").

An injection well located within the area subject to the AIO will not be plugged or abandoned unless approved by the Commission or MMS, as applicable, in accordance with 20 AAC 25.105 and 30 CFR 250.701.

**SURFACE AND SUBSURFACE SAFETY VALVES**

All Northstar wells, with the exception of the Class I disposal well, will be equipped with a fail safe automatic surface safety valve ("SSV") and a fail safe automatic surface controlled subsurface safety valve ("SSSV"). The SSSV's in both the producers and injectors will be wire line retrievable. The SSSV's will comply with the requirements of 30 CFR 250.801 and .806.

**RESERVOIR SURVEILLANCE PROGRAM**

Northstar reservoir data will be collected to monitor reservoir performance and to define reservoir properties. In lieu of the requirements of 20 AAC 25.071(a), BPXA requests that a complete electrical or complete radioactivity log be required from below the structural casing to TD for only one well drilled from Seal Island.

**RESERVOIR PRESSURE MEASUREMENTS**

Initial static reservoir pressure will be measured in each new well prior to long term production or injection. Additionally, a reservoir pressure will be recorded in at least half of the available active wells annually. These will consist of stabilized static pressure measurements at bottom-hole conditions, or, in the case of the gas injectors where a single phase fluid occupies the well bore, extrapolations from shut in surface pressures. The reservoir pressures will be reported at the common datum elevation of 11,100 ft. TVDss. It is the intention to run surface read out real time fiber optic temperature and pressure gauges in the producing wells at Northstar. These gauges will provide additional static and dynamic pressure information above that normally available in traditional North Slope wells.

**SURVEILLANCE LOGS**

Additional surveillance logs, which may include flowmeters, temperature logs, or other industry proven downhole diagnostic tools, will be periodically run to help determine reservoir performance.

Additionally, injected gas tracers are being evaluated as a means of further evaluating the sweep efficiency of the flood. The program as envisaged would involve a separate tracer being injected into each gas injector, followed by a program of sampling and analysis of produced gas at each producer.

## **6. Area Injection Order Application**

BPXA, as Northstar Unit Operator, hereby applies for an Area Injection Order ("AIO") to cover water and miscible fluid injection operations in the Northstar Pool as proposed herein. This section addresses the specific requirements of 20 AAC 25.402(c).

### **PLAT OF PROJECT AREA – 20 AAC 25.402(c)(1)**

Exhibit 6 is a plat showing the location of existing and proposed injection and production wells, and the original Northstar exploration and appraisal wells. Exhibit 3 contains the legal description of the lands subject to the Northstar Area Injection Order (the "Northstar Injection Area"), and these are presented on a map in Exhibit 2.

### **OPERATORS/SURFACE OWNERS – 20 AAC 25.402(c)(2) and 20 AAC 25.402(c)(3)**

The surface owners and operators within a one-quarter mile radius of the Northstar Injection Area are:

#### **Operators:**

BP Exploration (Alaska) Inc.  
P.O. Box 196612  
Anchorage, AK 99519-6612

#### **Surface Owners:**

Department of Natural Resources  
State of Alaska  
550 W. 7<sup>th</sup> Avenue, Suite 800  
Anchorage, AK 99501

Minerals Management Service  
949 East 36<sup>th</sup> Avenue, Room 308  
Anchorage, AK 99508-4363

#### **Oil & Gas Lessees:**

BP Exploration (Alaska) Inc.  
P.O. Box 196612  
Anchorage, AK 99519-6612

Murphy Exploration (Alaska) Inc.  
550 WestLake Park Blvd., Suite 1000  
Houston, TX 77079

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Phillips Alaska, Inc.  
700 G Street  
P.O. Box 100360  
Anchorage, AK 99510-0360

AVCG LLC  
225 North Market  
Wichita, KS 67202

Note: AVCG LLC has purchased Phillips Alaska, Inc.'s interest in ADLs 385198 and 385202. Assignments have been submitted to the State of Alaska, Department of Natural Resources, Division of Oil & Gas for approval.

Exhibit 28 is an affidavit showing that the Operators and Surface Owners within a one-quarter mile radius of the Northstar Injection Area have been provided a copy of this application, as required by 20 AAC 25.402(c)(3). Lessees have also been provided a copy.

**DESCRIPTION OF OPERATION – 20 AAC 25.402(c)(4)**

Development plans for the Northstar Pool are described in Section 3 of this application. Island facilities and operations are described in Sections 4 and 5.

**POOL INFORMATION – 20 AAC 25.402(c)(5)**

The proposed Northstar Injection Area encompasses the Northstar Pool. The Northstar Pool is defined as the accumulation of hydrocarbons in the Ivishak, Shublik and Sag River formations common to and correlating with the interval between the measured depths of 12,418 feet and 13,044 feet in the Seal A-01 well.

**GEOLOGIC INFORMATION – 20 AAC 25.402(c)(6)**

The geology of the Northstar Pool is described in Section 2 of this application.

**WELL LOGS – 20 AAC 25.402(c)(7)**

Copies of all open hole logs from Northstar wells are sent to the Commission as the wells are completed. Exhibit 4 is the type log for the proposed Northstar Injection Area with stratigraphic and marker horizons annotated.

**INJECTION WELL CASING INFORMATION – 20 AAC 25.402(c)(8)**

The injection well casing design and additional information is described in Section 5 of this application.

**INJECTION FLUIDS – 20 AAC 25.402(c)(9)**

A description of the recovery process and development scheme is included in Section 3 of this document. Injection fluid will comprise a blend of associated reservoir gas and imported PBU gas. The composition of the injected fluids is listed in Exhibit 27. Maximum daily injection rates are presented in Exhibit 14.

Fluid incompatibility problems, including asphaltene deposition, are not anticipated with the miscible gas flood.

**INJECTION PRESSURES – 20 AAC 25.402(c)(10)**

The maximum injection pressure at the wellhead is estimated to be 5300 psig. The average injection pressure at the wellhead is estimated to be 5000 psig.

**FRACTURE INFORMATION – 20 AAC 25.402(c)(11)**

The expected maximum injection pressure for the gas injection wells, 5300 psi, is insufficient to initiate or propagate fractures through the confining strata, and, therefore, will not allow injection or formation fluid to enter any freshwater strata.

**Fracture Gradients**

Exhibit 29 presents a summary of the fracture pressure and reservoir pressures determined from leak off testing, mud weights and drill stem testing in the discovery and appraisal wells in the Northstar Unit.

**Freshwater Strata**

EPA has determined that there are no underground sources of drinking water (“USDW”) beneath the Northstar Unit, as stated in the Public Notice dated June 24, 2000, and the Fact Sheet for the proposed issuance of UIC Area Permit AK-1002-A dated June 23, 2000.

The lack of fresh water and USDW's in the Northstar Injection Area eliminates the need for an aquifer exemption. The presence of hydrocarbons, either live or as residual, causes the Northstar sands to be unsuitable as a source of drinking water

**FORMATION WATER ANALYSIS – 20 AAC 25.402(c)(12)**

Exhibit 13 lists the composition of a Northstar area formation water sample. The source of the sample was produced water from a production test on Seal A-01. A production test was performed to confirm the presence of an apparent oil-water contact at approximately 11,110 ft. TVDss. The water analysis was conducted by Chemical & Geological Laboratories of Alaska, Inc. on June 15, 1984.

**AQUIFER EXEMPTION – 20 AAC 25.402(c)(13)**

As set forth above, the lack of fresh water and USDW's in the Northstar Injection Area eliminates the need for an aquifer exemption. The presence of hydrocarbons, either live or as residual, causes the Northstar Pool to be unsuitable as a source of drinking water.

**HYDROCARBON RECOVERY – 20 AAC 25.402(c)(14)**

The initial reservoir modeling of the Northstar Pool involving a waterflood only development scheme indicated recoverable reserves of 135 mmbbls of oil. The miscible gas recycle program currently yields 176 mmbbls oil, an increase of 41 mmbbls of ultimate oil recovery. The recoveries for the development options considered for the Northstar Pool are discussed in Section 3 of this document.

**MECHANICAL CONDITION OF ADJACENT WELLS – 20 AAC 25.402(c)(15)**

Exhibit 6 shows the location of proposed injection wells and existing wells. None of the proposed injection wells penetrate the injection zone within one-quarter mile radius of an existing well.

The information submitted herein establishes that drilling 16 producers and 5 injectors at the Northstar project through 2003 will increase ultimate recovery without increasing the probability that any individual well will suffer an integrity failure.

## 7. Proposed Area Injection Order Rules

BP, in its capacity as Northstar Operator, respectfully requests that the Commission issue an order authorizing the underground injection of Class II fluids for enhanced oil recovery in the Northstar Oil Pool and consider the following rules to govern such activity.

The boundary of the lands subject to the Northstar Area Injection Order (the "Northstar Injection Area") and the Northstar Pool Rules is shown in the map attached as Exhibit 2, and is described in Exhibit 3.

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

Within the affected area, Class II fluids may be injected for the purposes of pressure maintenance and enhanced recovery into strata defined as those which correlate with and are common to the formation found in the Seal A-01 well between measured depths of 12,418 - 13,044 feet.

### **Rule 2: Fluid Injection Wells**

The injection of fluids must be conducted through a new well that has been permitted for drilling as a service well for injection in conformance with 20 AAC 25.005, or through an existing well that has been 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 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.



**Rule 5: 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, and following well workovers affecting mechanical integrity. 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 casings minimum yield strength must be held for at least a 30 minute period with decline no more than or equal to 10% of test pressure. The Commission must be notified at least 24 hours in advance to enable a representative to witness pressure tests.

**Rule 6: Well Integrity Failure**

Whenever injection rates and/or 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 to continue injection and submit a plan of corrective action on Form 10-403 for Commission approval.

**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 8: Administrative Action**

Upon proper application, the Commission may administratively waive the requirements of any rule stated above or administratively amend this order as long as the change does not promote waste or jeopardize correlative rights, and is based on sound engineering principles.

## **8. Proposed Pool Rules**

BPXA, in its capacity as Northstar Operator, requests that the Commission adopt the following Pool Rules for the Northstar Pool:

Subject to the rules below and statewide requirements, production from the Northstar reservoir may occur in a manner that will protect freshwater, prevent waste, protect correlative rights, and provide for the maximum ultimate recovery of oil and gas that is prudent.

In addition to statewide requirements, the following pool rules are proposed to govern the proposed development and operation of the Northstar Pool.

### **Rule 1: Field and Pool Name and Classification**

The field is the Northstar Oil Field and the pool is the Northstar Pool. The Northstar Pool is classified as an Oil Pool.

### **Rule 2: Pool Definition**

The boundary of the lands subject to the Northstar Area Injection Order (the "Northstar Injection Area") and the Northstar Pool Rules is shown in the map attached as Exhibit 2, and is described in Exhibit 3. The Northstar Pool is defined as the accumulation of hydrocarbons in the Ivishak, Shublik and Sag River formations common to and correlating with the interval between measured depths of 12,418 feet and 13,044 feet in the Seal A-01 well.

### **Rule 3: Spacing**

Minimum spacing within the pool will be 40 acres. The pool shall not be opened in any well closer than 500 feet to an external unit boundary where ownership changes.

### **Rule 4: Drilling and Completion Practices**

- a) The following alternative completions are authorized:
  - 1) Horizontal or "high angle" completions with slotted or perforated liners.
  - 2) Open hole and/or slotted / pre-perforated completions.
  - 3) Multi-lateral completions in which more than one reservoir penetration is completed from a single well.

- b) At a minimum, the following information must be included in each APD:
  - 1) Plan view;
  - 2) Vertical section;
  - 3) Close approach data; and
  - 4) Directional data.
- c) A complete electrical or complete radioactivity log is required from below the structural casing to TD in only one well drilled from Seal Island.

**Rule 5: Reservoir Pressure Monitoring**

- a) Bottom hole reservoir pressure will be measured in at least half of the active wells each year.
- b) The reservoir datum will be 11,100 ft. true vertical depth subsea.
- c) Pressure surveys may consist of stabilized static pressure measurements at bottom-hole conditions or, in the case of the gas injectors where a single phase fluid occupies the well bore, extrapolation from surface shut in pressure. Initial reservoir pressure may also be determined from open-hole formation tests.
- d) Data and results from pressure surveys shall be reported annually to the AOGCC (but within 60 days to the MMS).

**Rule 6: Gas-Oil Ratio Exemption**

Wells producing from the Northstar Oil Pool are exempt from the gas-oil ratio limit set forth in 20 AAC 25.240(b).

**Rule 7: Administrative Action**

Upon proper application, the Commission may administratively waive the requirements of any rule stated above or administratively amend the order as long as the change does not promote waste, jeopardize correlative rights, and is based on sound engineering.



### Exhibit 3

#### Description of Northstar Injection Area

The Northstar Injection Area is shown on the map attached as Exhibit 2.

##### State Leases

The Northstar Injection Area encompasses State oil and gas leases ADLs 312798, 312799, 312808, 312809 and 355001 to the extent such leases are located within the lands described below:

T. 14 N., R. 13 E., Umiat Meridian, Alaska  
Sections 30–35

T. 13 N., R. 13 E., Umiat Meridian, Alaska  
Sections 2–18, and 20–24

T. 13 N., R. 14 E., Umiat Meridian, Alaska  
Sections 17–20, 29 and 30

ADL 312798 consists of Tract C30-46 (BF-46), a portion of Blocks 470 and 514 as shown on the “Leasing and Nomination Map” for the Federal/State Beaufort Sea Oil and Gas Lease Sale, dated 1/30/79.

ADL 312799 consists of Tract C30-47 (BF-47), a portion of Blocks 471 and 515 as shown on the “Leasing and Nomination Map” for the Federal/State Beaufort Sea Oil and Gas Lease Sale, dated 1/30/79.

ADL 312808 consists of Tract C30-56 (BF-56), a portion of Blocks 514, 515, 558 and 559 as shown on the “Leasing and Nomination Map” for the Federal/State Beaufort Sea Oil and Gas Lease Sale, dated 1/30/79.

ADL 312809 consists of Tract C30-57 (BF-57), a portion of Blocks 516 and 560 as shown on the “Leasing and Nomination Map” for the Federal/State Beaufort Sea Oil and Gas Lease Sale, dated 1/30/79.

ADL 355001 consists of Tract 39-01, more particularly described as:

T. 13 N., R. 13 E., Umiat Meridian, Alaska  
Section 17, Protracted, All, 640 acres;  
Section 18, Protracted, All, 631 acres;  
Section 19, Protracted, All, 633 acres;  
Section 20, Protracted, All, 640 acres;  
Section 25, Protracted, All, 640 acres;  
Section 26, Protracted, All, 640 acres;  
Section 27, Protracted, All, 640 acres;  
Section 28, Protracted, All, 640 acres;  
Section 29, Protracted, All, 640 acres.

### Exhibit 3

#### Description of Northstar Injection Area

##### Federal Leases

The Northstar Injection Area encompasses all lands within the following Federal oil and gas leases OCS-Y-1645, OCS-Y-0179 and OCS-Y-0181:

OCS-Y-1645 consists of:

That portion of Block 6510, OCS Official Protraction Diagram NR06-03, Beechey Point, approved February 1, 1996, shown as Federal 8(g) Area C on OCS Composite Block Diagram dated April 24, 1996.

OCS-Y-0179 consists of:

That area of Block 470 lying east of the line marking the western boundary of Parcel "1", and between the two lines bisecting Block 470, identified as Parcel "1", containing approximately 94.30 hectares, and Parcel "2", containing approximately 15.27 hectares, as shown on the Supplemental Official OCS Block Diagram, dated 10/4/79, based on Official Protraction Diagram NR 6-3, Beechey Point, approved 4/29/75; and

That area lying between the two lines bisecting Block 471, containing approximately 611.95 hectares, as shown on the Supplemental Official OCS Block Diagram, dated 10/4/79, based on Official Protraction Diagram NR 6-3, Beechey Point, approved 4/29/75; and

That area lying northeasterly of the line bisecting Block 515, containing approximately 189.83 hectares, as shown on the Supplemental Official OCS Block Diagram, dated 10/4/79, based on Official Protraction Diagram NR 6-3, Beechey Point, approved 4/29/75;

OCS-Y-0181 consists of:

That area lying northeasterly of the line bisecting Block 516, containing approximately 2076.98 hectares, as shown on the Supplemental Official OCS Block Diagram, dated 10/4/79, based on Official Protraction Diagram NR 6-3, Beechey Point, approved 4/29/75; and

That area lying northeasterly of the line bisecting Block 560, located in the northeast corner of Block 560, containing approximately 44.65 hectares, as shown on the Supplemental Official OCS Block Diagram, dated 12/9/79, based on Official Protraction Diagram NR 6-3, Beechey Point, approved 4/29/75.

# Exhibit 4 Northstar Type Log - Seal A-01

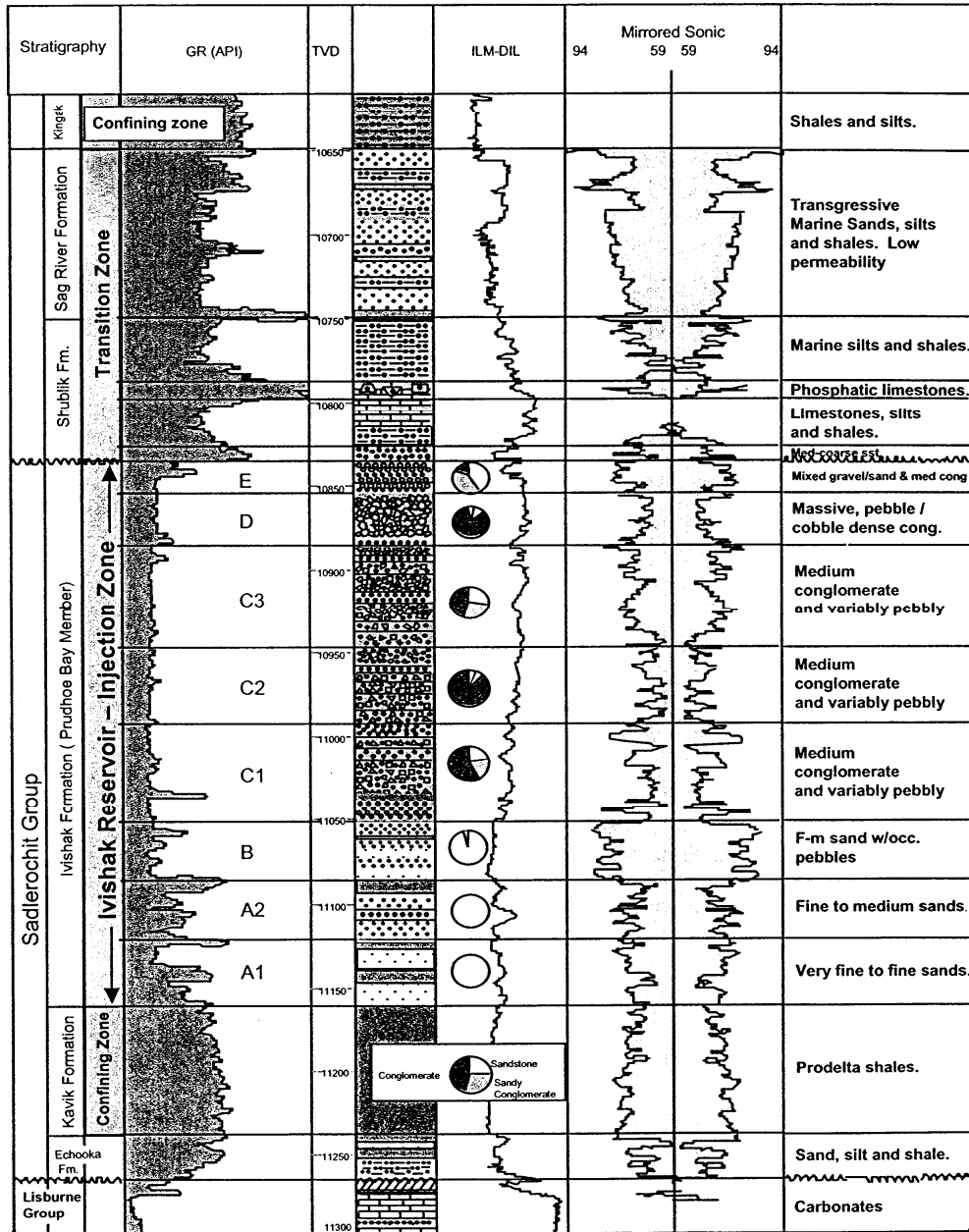


Exhibit 13

Chemical Composition of Seal #1  
Formation Water Sample

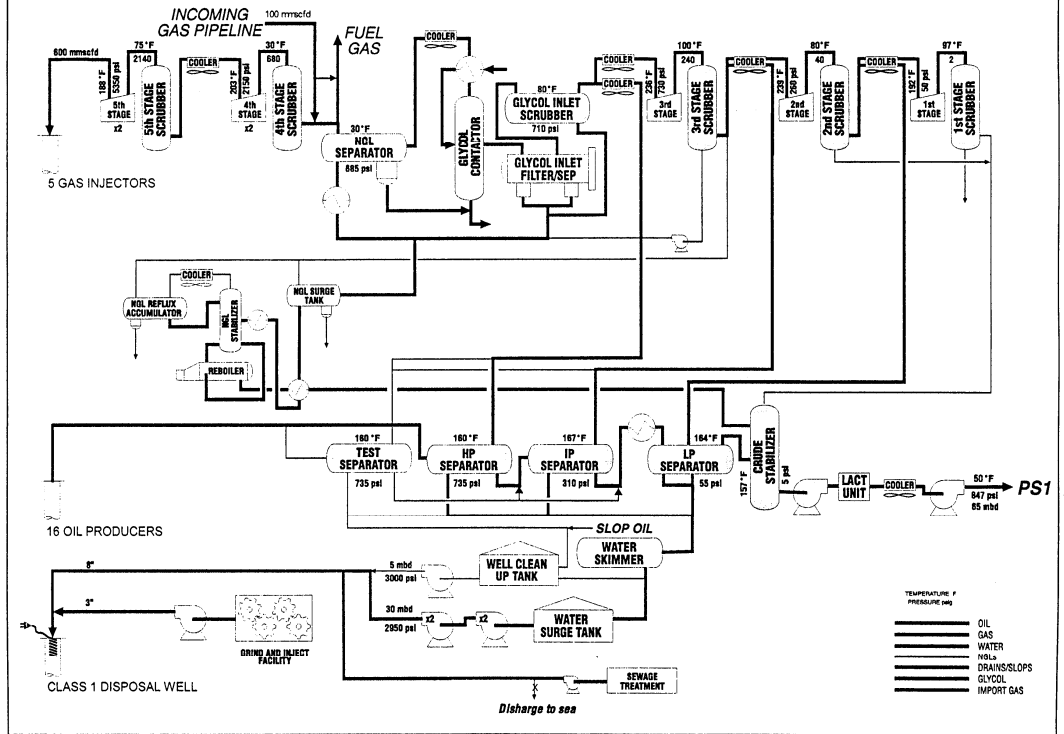
Component	Concentration (mg/l)
Ca	575
Mg	12
Na	7540
Fe	115
Ba	1
Cl	11800
HCO <sub>3</sub>	1425
SO <sub>4</sub> <sup>2-</sup>	130
K	45
Sr	20
Total dissolved solids (TDS)	20804
Measured Resistivity	0.36 @ 68 deg F
Resistivity	0.10 @ 245 deg F

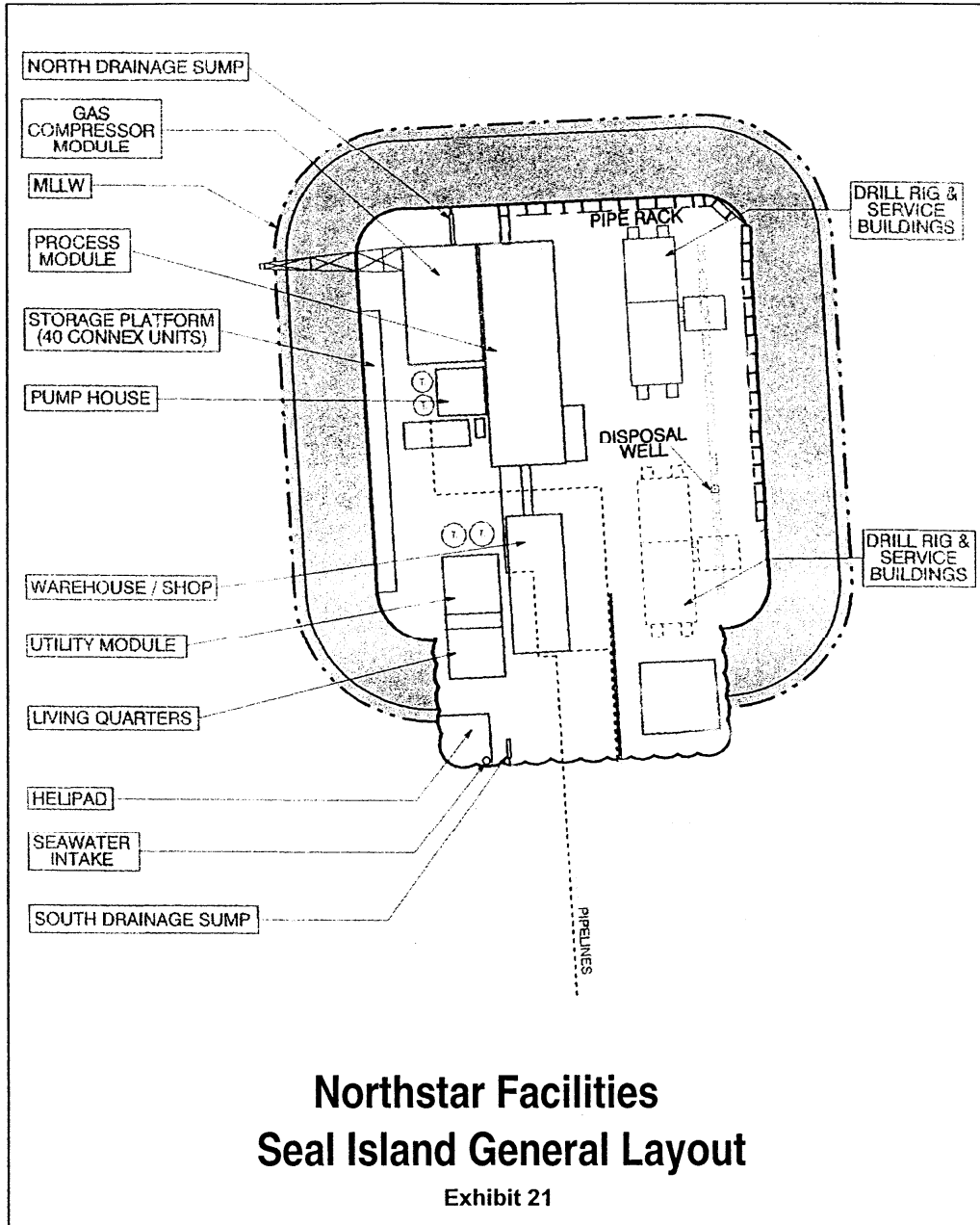
Source of sample: Produced water from Seal #1



Exhibit 20

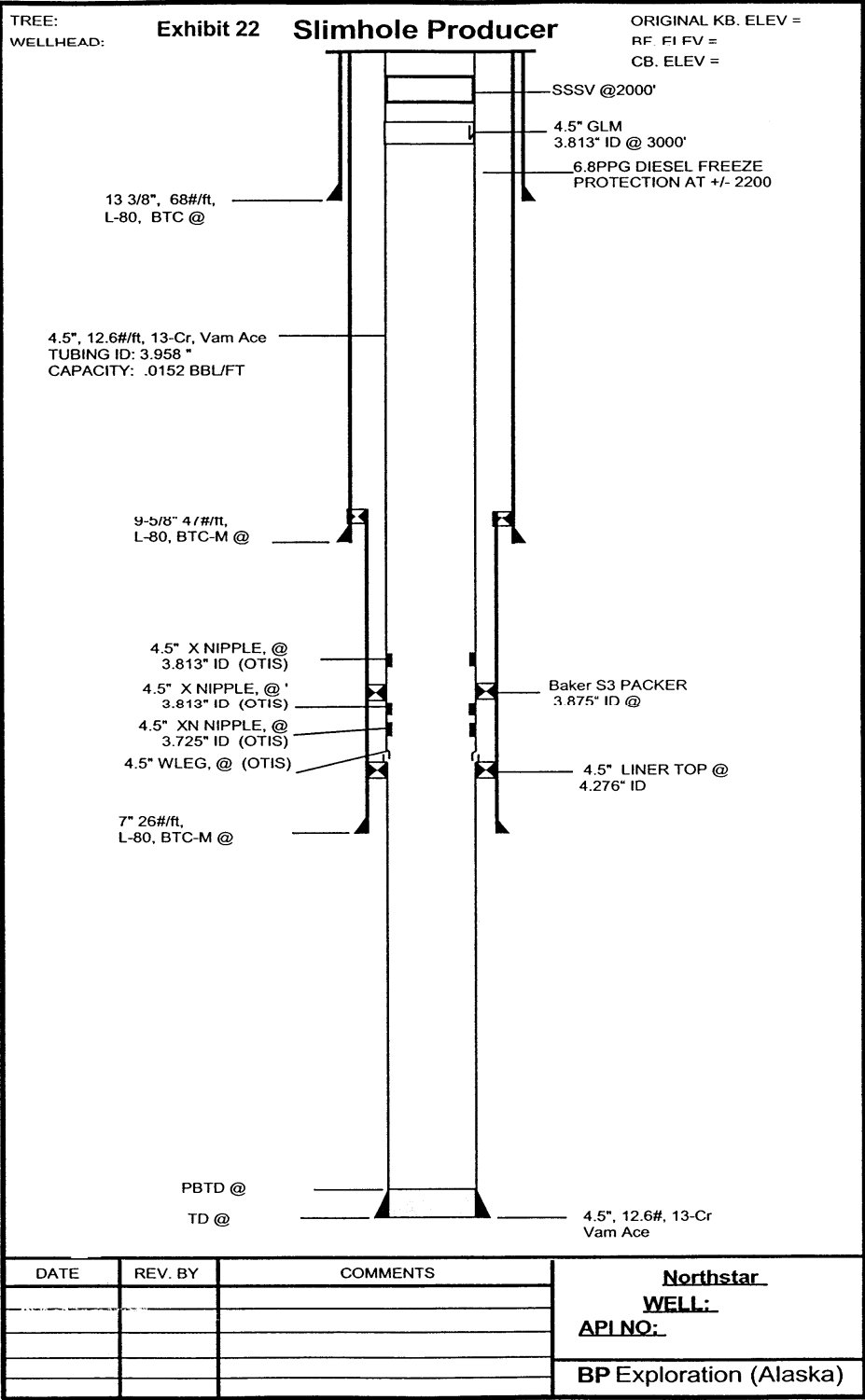
### Northstar Simplified Process Flow Diagram





## Northstar Facilities Seal Island General Layout

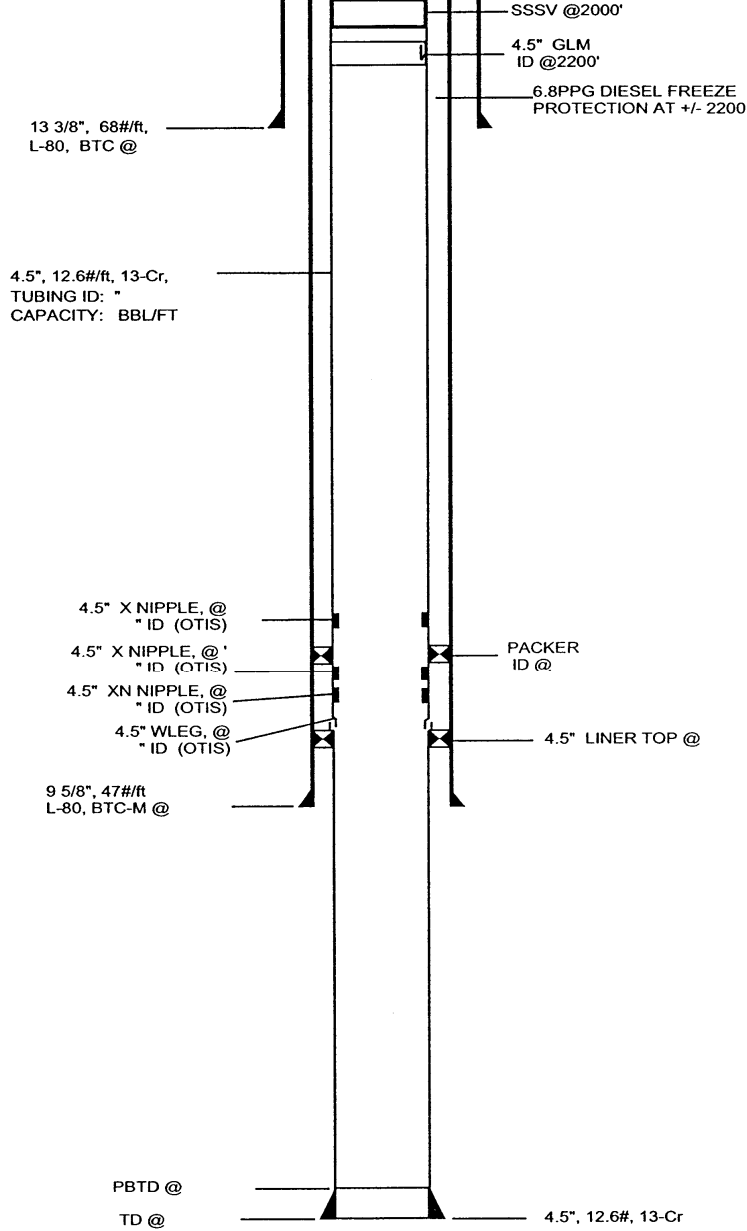
Exhibit 21



TREE:  
WELL HEAD:

### Exhibit 23 Big Bore Producer

ORIGINAL KB. ELEV =  
BF. ELEV =  
CB. ELEV =



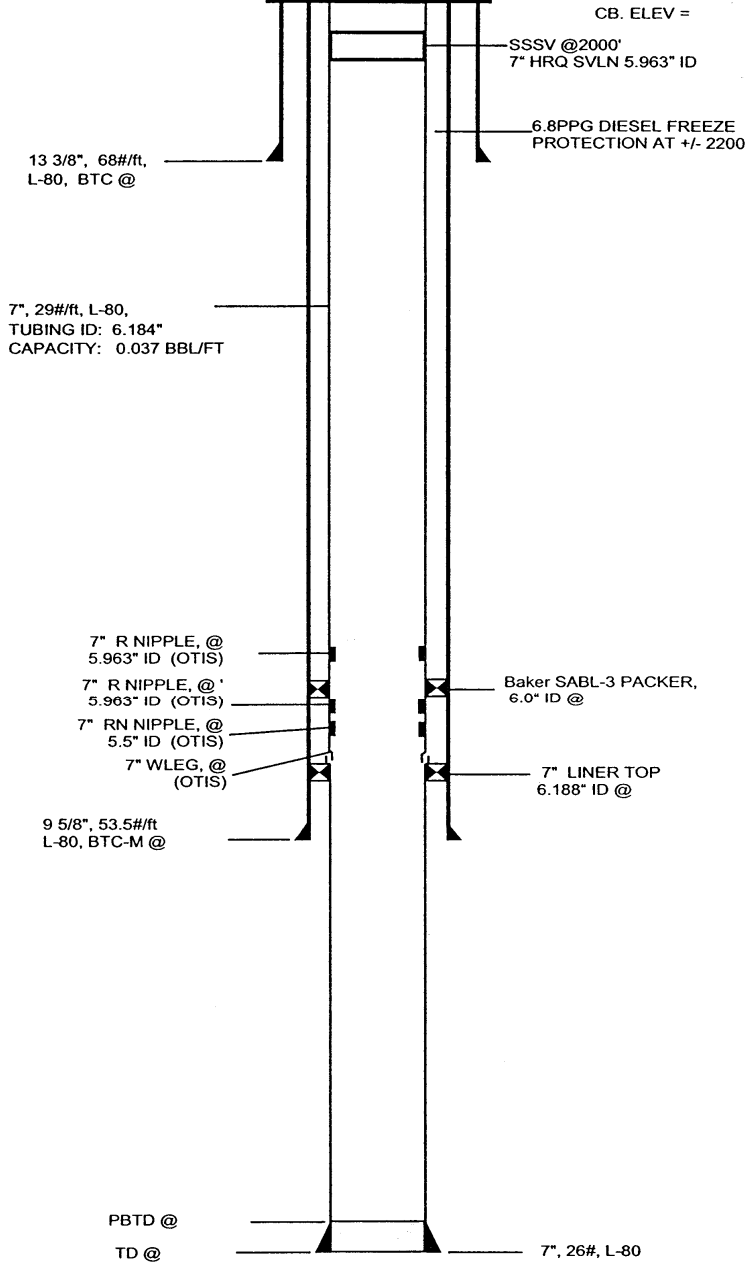
DATE	REV. BY	COMMENTS

**Northstar**  
**WELL:**  
**API NO:**  
**BP Exploration (Alaska)**

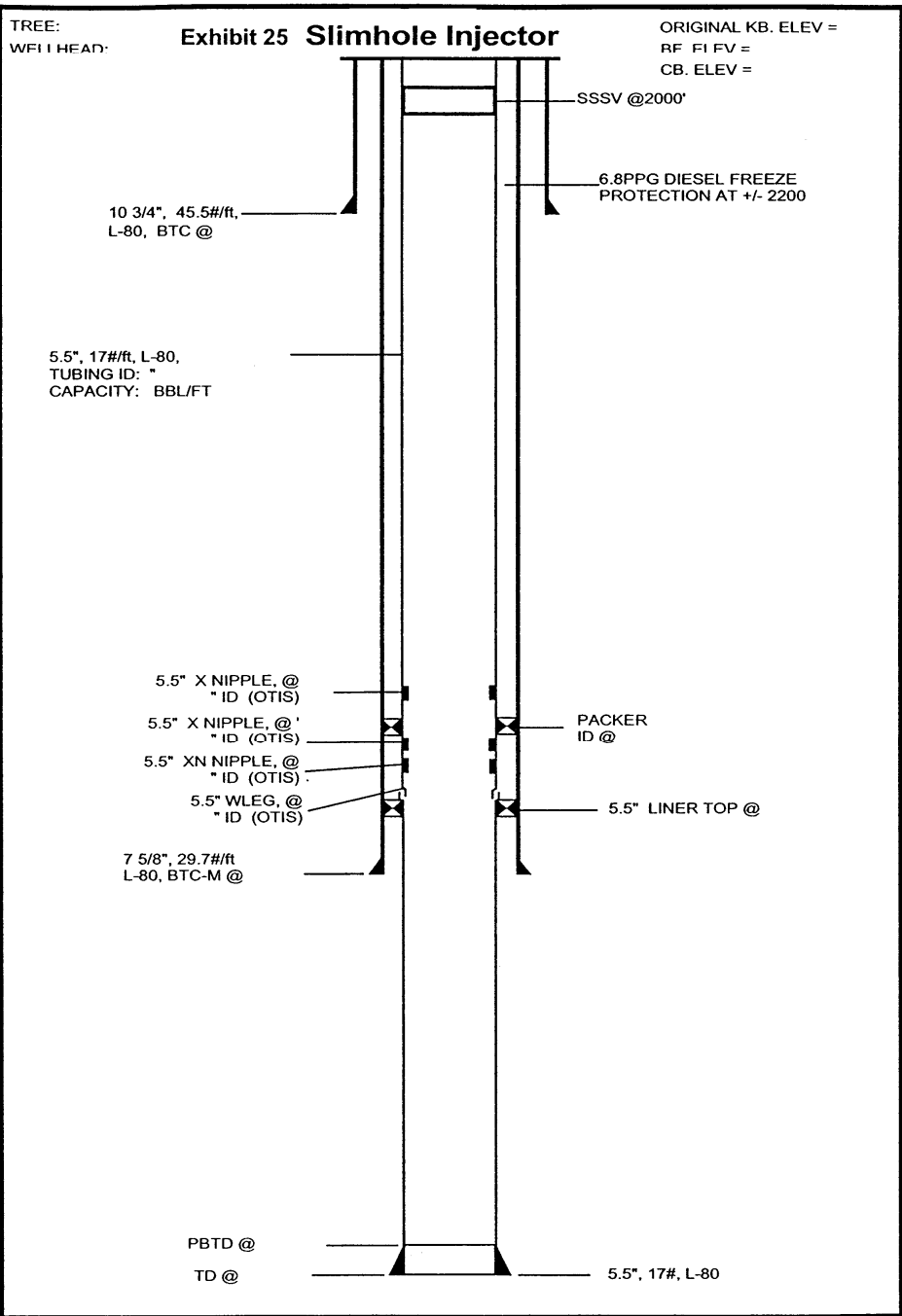
TREE:  
WELLHEAD:

### Exhibit 24 Big Bore Injector

ORIGINAL KB. ELEV =  
DF. ELEV =  
CB. ELEV =



DATE	REV. BY	COMMENTS	Northstar WELL: API NO:



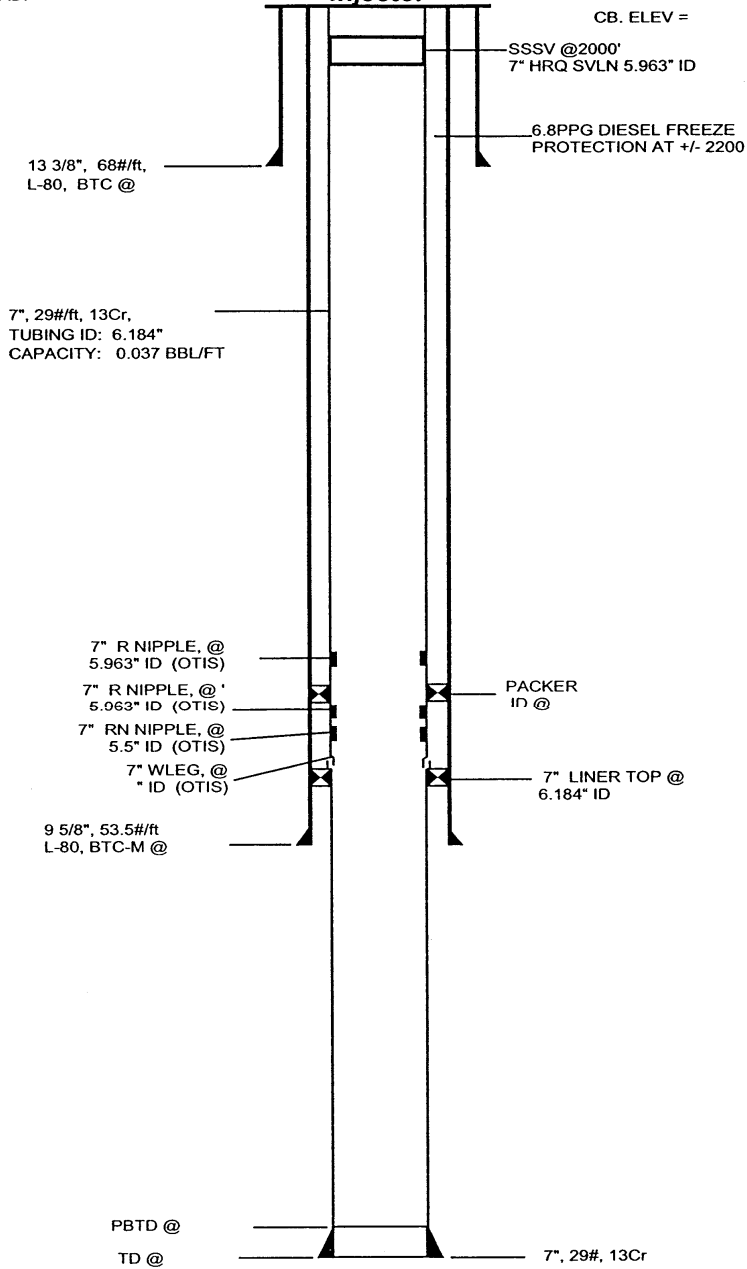
DATE	REV. BY	COMMENTS	<b>Northstar</b> <b>WELL:</b> <b>API NO:</b>
			<b>BP Exploration (Alaska)</b>

TREE:  
WELLHEAD:

**Exhibit 26**

**Pre-Produced Big Bore  
Injector**

ORIGINAL KB. ELEV =  
BF. ELEV =  
CB. ELEV =



DATE	REV. BY	COMMENTS	<p><b>Northstar</b> <b>WELL:</b> <b>API NO:</b> <b>BP Exploration (Alaska)</b></p>

Exhibit 28

**Affidavit Of Krissell Crandall Regarding  
Notice To Surface Owners In The  
Vicinity Of The Proposed Injection Wells**

KRISSELL CRANDALL, on oath, deposes and says:

1. I am employed as a Senior Landman by BP Exploration (Alaska) Inc. BP Exploration (Alaska) Inc. is the Operator of the Northstar Unit, and the applicant for the Northstar Area Injection Order.

2. On June ~~25~~<sup>25</sup>, 2001, I caused copies of the confidential version of the application for the Northstar Pool Rules and Area Injection Order to be hand-delivered to the following persons who represent surface owners and operators within one-quarter mile of the area affected by the proposed Northstar Area Injection Order:

Pat Pourchot, Commissioner  
Department of Natural Resources  
State of Alaska  
550 W. 7<sup>th</sup> Avenue, Suite 800  
Anchorage, AK 99501

Mark Meyers, Director  
Division of Oil & Gas  
Department of Natural Resources  
State of Alaska  
550 W. 7<sup>th</sup> Avenue, Suite 800  
Anchorage, AK 99501

Jeff Walker  
Regional Supervisor, Field Operations  
Minerals Management Service  
949 East 36<sup>th</sup> Avenue, Room 308  
Anchorage, AK 99508-4363

E. P. Zselezky, Land Manager  
BP Exploration (Alaska) Inc.  
900 E. Benson Blvd.  
Anchorage, AK 99508

3. On June ~~25~~<sup>25</sup>, 2001, I caused a copy of the confidential version of the application for the Northstar Pool Rules and Area Injection Order to be mailed first class to:

Buford Bates  
Murphy Exploration (Alaska) Inc.  
550 WestLake Park Blvd., Suite 1000  
Houston, TX 77079





