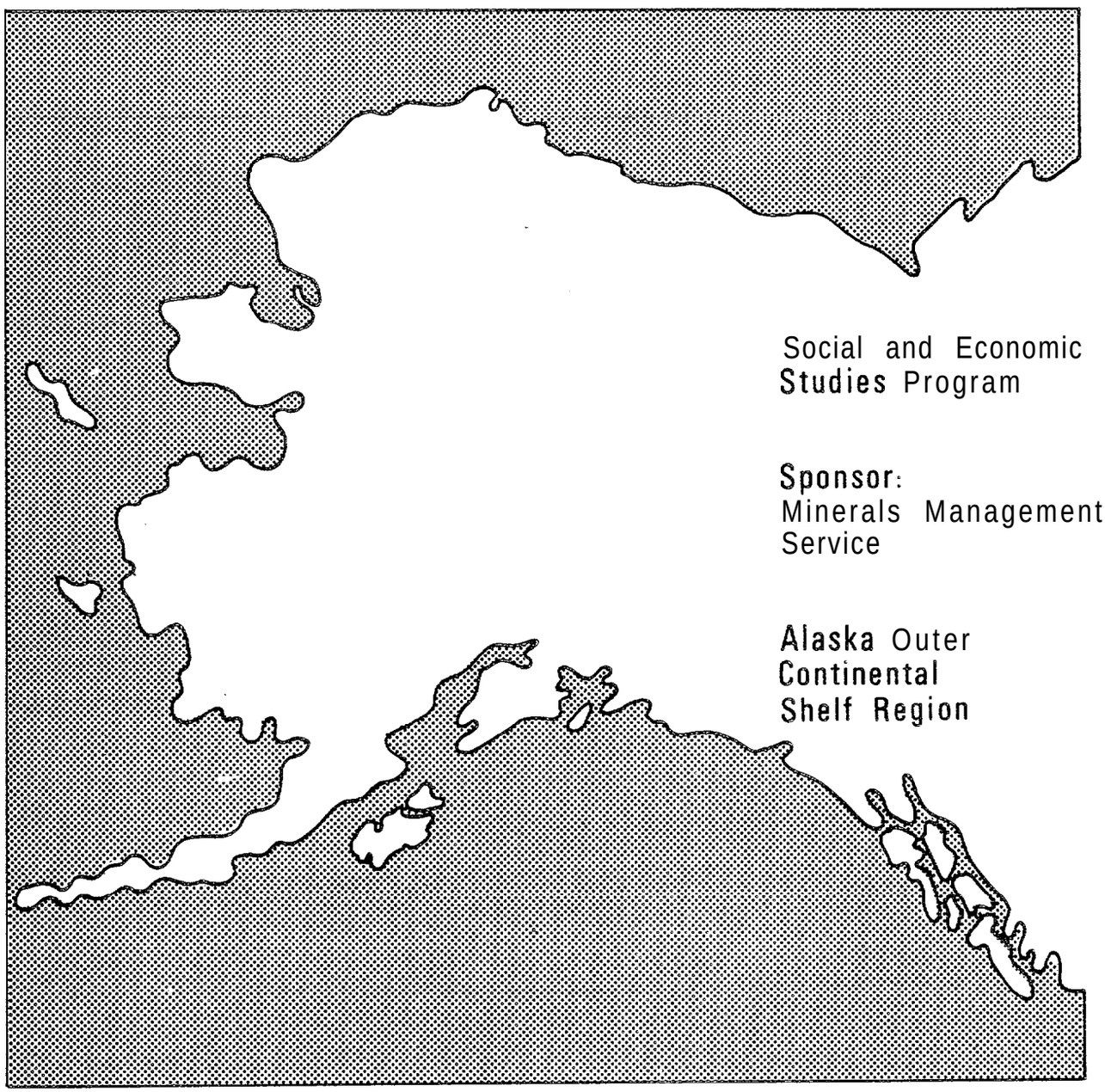
SE-AK85

OCS Study
MMS 84-0060

U.S. Department of the Interior

Technical Report
Number 107



Social and Economic Studies Program

Sponsor:
Minerals Management Service

Alaska Outer Continental Shelf Region

Monitoring Oil Exploration Activities in the Beaufort Sea

TECHNICAL REPORT NO. 107 CONTRACT NO. 14-12-0001-30030

ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM

MONITORING OIL EXPLORATION ACTIVITIES IN THE BEAUFORT SEA

prepared for

MINERALS MANAGEMENT SERVICE

ALASKA OUTER CONTINENTAL SHELF OFFICE

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January 1985

ABSTRACT

The purpose of this study is "to obtain an accurate historical accounting of events, equipment, timing, employment, wages, locations, requirements, expenditures and effects of OCS activity" through October 1983 related to the Joint Federal /State Beaufort Sea Sale (Sale BF) of December 1979 and the Diapir Field OCS Sale 71 (Sale 71) of October 1982.

The qualitative impact of Beaufort Sea exploration upon the Prudhoe Bay enclave's facilities and labor force can not simply be equated to the incremental demand for facilities and services attributable to Beaufort Sea projects. Well before the Beaufort Sea OCS sales, Prudhoe Bay/Deadhorse was a highly developed industrial enclave already possessing most of the transportation, industrial, personnel support and other infrastructure typically needed to support Beaufort Sea operations. On the other hand, Prudhoe Bay/Deadhorse did not and does not have a permanent pool of resident workers. Instead, the enclave draws from the labor pool in other areas of Alaska and beyond for its workforce as needed. Overall, the Beaufort Sea exploration programs comprised a substantial industrial undertaking. Even so, they were greatly outweighed by other Prudhoe Bay petroleum industry employment and accounted for no more than perhaps two to three percent. of average annual employment in the Prudhoe Bay area during any single year.

Up to November 1983, seventeen exploration wells were completed or committed, eleven on artificial gravel islands and six on natural barrier islands, Five exploration wells were completed in the first post-sale drilling season, nine more in the second season, one in the third season, and two committed to be spudded in November 1983.

Because of the number of gravel islands (six) built for Beaufort Sea exploration, the construction and transportation industries accounted for a large share of onsite employment. Wintertime island construction and drilling operations permitted use of ice roads to truck large volumes of gravel and drilling supplies to the exploration site. On the other hand, there was relatively minor use of marine supply systems compared to typical remote offshore exploration programs in open water regions, partly because of the overland access provided by the Dalton Highway and ice roads. Likewise, there was less use made of helicopters and crew boats for transport of personnel and supplies.

Total onsite employment for Beaufort Sea exploration programs for the 1980-83 period was estimated at about 1,532 manyears of which 1,185 manyears or 77% was provided by Alaskan residents. In absolute numbers, Anchorage (39.6%) and Fairbanks (17.3%) regions supplied most of the resident workforce, trailed by the Kenai Peninsula (6.9%), Matanuska-Susitna (6.5%) and North Slope (2.8%) Boroughs and the rest of the state (4.1%).

The North Slope Borough's indigenous economy supplied virtually no supplies and services for Beaufort Sea exploration operations. Most equipment and supplies are either delivered directly by barge to Prudhoe Bay or relayed by truck or airfreight from points of entry in southcentral Alaska (Anchorage, Seward, Whittier, Valdez). Some of these goods and supplies may be drawn from inventories stockpiled at Fairbanks, Anchorage or the Kenai area. In these respects, this economic pattern for Beaufort Sea operations resembles the relationship between North Slope petroleum industry operations in general and the indigenous economy.

Total Alaska resident wages earned during the three years of exploration amounted to about $47,426,0(90. It was presumed that resident wages were attributable to home communities in the same proportion as employment..

While Beaufort Sea exploration made a significant contribution in absolute terms to jobs and wages in Alaska's economy, this contribution did not amount to a share of overall regional economic activity sufficient to generate adverse growth impacts in any region.

The sale stipulations on seasonal driling affected the choice of logistic arrangements and island construction and drilling strategies. According to data provided by the operators, the seasonal stipulations often added to the worktime and overall cost of exploration projects. Also by report of the operators, the seasonal stipulations adversely affected the time available for well testing. Time extensions were frequently sought in order to complete well testing, but not always approved.

The intial pace of Sale BF exploration exceeded the Sale BF FEIS mean exploration scenario, with the overall level of effort about as expected. It is premature to conclude what the eventual level of Sale 71 exploration will be, although at this time the number of exploration wells appears likely to fall short of the Sale 71 FEIS mean exploration scenario.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

I. INTRODUCTION

Purpose and Scope of the Study

The purpose of this Beaufort Sea area monitoring study is to document the events, employment, expenditures? logistics, support arrangements and other economic aspects of exploratory activity following the two arctic sales: the Joint Federal/State Beaufort Sea Sale (Sale BF) of December 1979 and the Diapir Field Sale 71 (Sale 71) of October 1982. The study spans the period from December 1979, following Sale BF, to November 1, 1983. This latter date coincides with the end of annual seasonal drilling restrictions and with the start of a new annual round of exploratory drilling, and so was a convenient and logical cut-off date for the study. All gravel island construction and exploratory drilling data is current at least through to November 1, 1983 -- the last full drilling season completed in time to be covered in the study. However, in" some matters, where later data was available about significant events (e.g., exploration results, proposed exploration and development plans), the cut-off date for the study was bent in favor of including post-November 1983 data.

The study is part of the Minerals Management" Service's (MMS) ongoing Social and Economic Studies Program (SESP). MMS is responsible for preparing forecasts and assessments of the employment and other socio-economic impacts of proposed Alaskan OCS lease sales upon local, regional, and statewide jurisdictions for use in the sale Environmental Impact Statement and for any subsequent developmental EIS. MMS's fore-

casting method uses exploration scenarios to evaluate the socioeconomic impacts of alternative tract offerings for the proposed lease sale. These scenarios involve standard assumptions about such key elements of the exploration phase as: typical work crew sizes and hiring arrangements; exploration program expenditures; logistic arrangements; and the level and timing of exploration effort appropriate to different resource estimates for the proposed sale area. From these standard assumptions, detailed hypothetical scenarios and impact assessments are devised to illustrate the implications of the sale alternatives. Thus, the validity and plausibility of the exploration scenarios and the socioeconomic impact assessments ultimately depend on the realism of the scenario assumptions about offshore exploration programs.

MMS has sponsored two previous 'monitoring studies to verify post-sale exploratory impacts in comparison to scenario forecasts. These monitoring studies (Technical Report Number 17 - "Monitoring Petroleum Activities in Alaska" and Technical Report Number 55 - "Monitoring Oil Exploration Activities in the Lower Cook Inlet") documented post-sale activities in the Northern Gulf of Alaska (Sale 39) and Lower Cook Inlet (Sale CI) lease sale areas, respectively.

Ten federal OCS lease sales were held in Alaska between May 1976 and November 1, 1983. By November 1983, thirty-five exploratory wells had been drilled in four of these lease sale areas: Northern Gulf of Alaska (11 wells), Sale CI (8), Eastern Gulf of Alaska (1), and the Joint Federal/State Sale BF (15). As of that date, these thirty-five wells (plus thirteen Continental Offshore Stratigraphic Test wells) comprised

industry's and Alaska's experience with exploratory drilling in OCS lease sale tracts. . See Table 1. Twelve additional Alaskan OCS lease offerings are currently scheduled between January 1984 and the end of 1987. See Table 2 and Figure 1.

This Beaufort Sea Area monitoring study documents the post-sale exploration activities in the arctic offshore province. Specifically, the study covers the fifteen exploratory wells completed on the Sale BF tracts, plus gravel island construction and other preparations for two exploratory wells that were spudded upon the lifting of seasonal drilling restrictions on November 1, 1983.

Precisely speaking, none of the wells so far drilled on Sale BF tracts are in uncontested federal OCS jurisdiction (Table 3). Eleven Sale BF exploration wells were drilled on state tracts leased in the joint sale and so are not in federal OCS waters. The other four wells drilled by November 1, 1983 were on federally managed tracts whose ownership was disputed. Nevertheless, at MMS's direction, we have included the Sale BF state tracts in this study in order to enlarge the data base. (However, some earlier state oil and gas lease sales of submerged lands along the arctic coast are not included. Some of these offshore tracts have been explored by directional drilling from uplands or from shallow-water artificial islands.)

The lease areas examined in this study differ from the Gulf of Alaska and Cook Inlet offshore provinces covered in earlier monitoring studies in two important respects. First, the lease tracts are in arctic waters

TABLE 1

EXPLORATION SUMMARY[a]

ALASKA OCS LEASE SALES

Sale	Date	# of Tracts Leased	Exploration Wells
Lease Sale 39 - Northern Gulf of Alaska	5/13/76	76	11
Lease Sale CI	10/27/77	%7	8
Lease Sale BF - Joint Federal/State	12/11/79	86[b]	15[c]
Lease Sale 55 - Eastern Gulf of Alaska	10/21/80	35	1
Lease Sale RS-1	6/30/81	1	0
Lease Sale 60	9/29/81	13	0
Lease Sale RS-2	8/5/82	0	0
Lease Sale 71 - Diapir Field	10/13/82	121	0
Lease Sale 57 - North Basin	3/15/83	59	0
Lease Sale 70 - St. George Basin	4/12/83	96	0
Total		574	35

a As of October 31, 1983.

b Twenty-four federally managed tracts, including 19 disputed tracts, and 62 state-managed tracts, including four disputed tracts.

c Includes four wells on federally managed tracts and eleven wells on state-managed tracts.

Source: Minerals Management Service.

TABLE 2

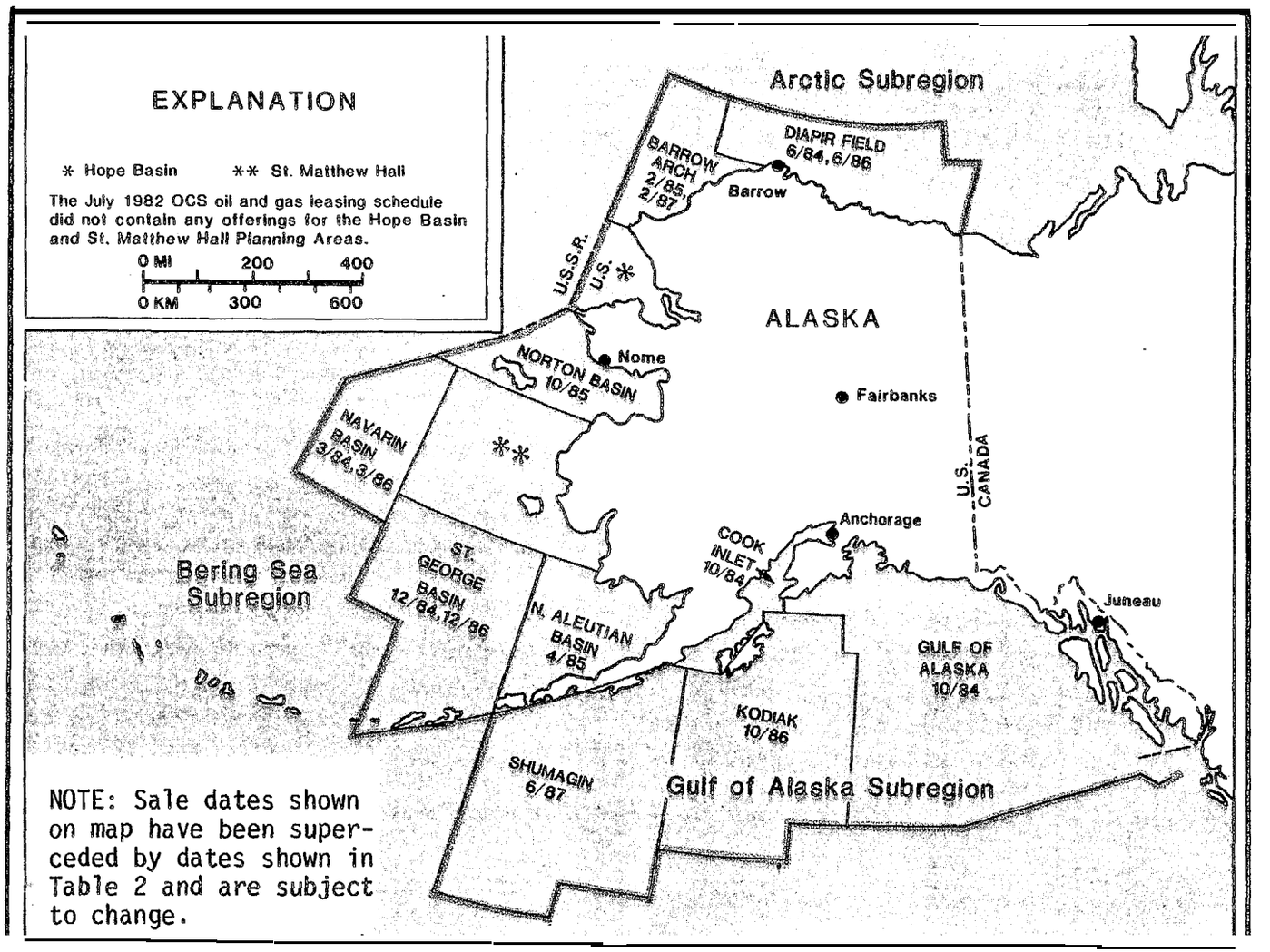
PROPOSED ALASKA OCS LEASE SALES
1984 - 1987

Sale		Proposed Sale Date
83	Navarin Basin	April 1984 (held)
87	Diapir Field	August 1984 (held)
88	Gulf of Alaska/Cook Inlet	December 1984
89	St. George Basin	September 1985
92	North Aleutian Basin	December 1985
100	Norton Basin	December 1985
107	Navarin Basin	March 1986
97	Diapir Field	December 1986
99	Kodiak	February 1987
109	Barrow Arch	February 1987
101	St. George Basin	April 1987
86	Shumagin	June 1987

Source: Minerals-Management Service, October 1984.

FIGURE 1

ALASKA OCS SUBREGIONS



Source: Rogers, Golden & Halpern. 1983b. Arctic Summary Report Update.

TABLE 3

SALE BF EXPLORATION TRACTS
MANAGEMENT/OWNERSHIP STATUS

Management/Ownership	Number of Wells
Federally-managed	
Undisputed Ownership	0
Disputed Ownership	4
State-managed	
Undisputed	11
Disputed Ownership	0
TOTAL	15

Source: Minerals Management Service.
Current through October 1983

which pose novel environmental, technical, logistic and other operational challenges to exploration. Second, the tracts are near the state's most elaborate industrial complex, comprised of the production and transportation facilities, oil field service industries, camp quarters and miscellaneous facilities established to support production from the Prudhoe Bay and Kuparuk oil fields and other North Slope petroleum operations.

To date, Sale BF has not progressed beyond the exploration phase. Production prospects are, however, being evaluated for a number of finds wholly or partly within the boundaries of Sale BF. Sohio and its partners are reportedly near a commitment to the Endicott Development Project (formerly the Duck Island/Sag Delta discovery), most of which overlies tracts acquired in an earlier State of Alaska sale, plus some state tracts leased in Sale BF. Conoco and its partners have announced production plans for the Milne Point Unit Discovery, which straddles upland and near-shore shallow-water tracts about 25 to 30 miles west of Prudhoe Bay. Finally, Shell is evaluating the commercial value of its Seal Island discovery in the Sale BF lease area.

The study approach is primarily empirical, rather than analytic or speculative. This factual approach is appropriate to document and summarize the chief economic impacts of exploratory activities as a reference point to check the accuracy of scenario assumptions. However, the study findings must be used with care as a guide or benchmark for forecasting exploration patterns for future arctic offshore lease sales.

Three caveats to an historic study of Beaufort Sea petroleum exploration are noted here. First, the industrial technology applied to arctic offshore exploration is a product of continuing innovation, drawing upon field experience and technical advances in many related engineering disciplines. The study does not examine the technical imovations now being developed that may transform how exploration is conducted in the future. Second, as exploration penetrates to deeper, more ice-endangered sectors further offshore the arctic coast, different logistic arrangements and exploratory technology will be employed. Third, the study does not analyze the complex interplay of environmental, technical, and economic factors that ultimately accounts for entrepreneurial decisions about exploration risks and strategies and technical choices about exploration equipment and operations. Finally, it is important to note that this study covers a specific time and place in a rapidly developing sector of the petroleum industry and that historic data should be used with care for forecasting future events.

Next, it is important to underline the limited topical scope of this monitoring study. The economic and environmental stakes for arctic offshore petroleum development are great. These two lease sales have prompted public controversy and litigation, as well as extensive multidisciplinary research. For the most part, these important and controversial public issues are related to environmental, jurisdictional? and other matters that are beyond the scope of the economic and other data compiled in this study.

The results of the study are presented in four chapters:

- o Chapter II: BACKGROUND AND METHODOLOGY is devoted to a brief overview of the status of North Slope petroleum development, including Sale BF and Sale 71, and an explanation of the study methodology.

- o Chapter III: EXPLORATION PROFILE deals mainly with an array of basic industrial activities and functions that support arctic offshore exploration. These include: shore-based support functions; marines air, and overland logistics; gravel island construction; and drilling operations. Chapter III recounts the industrial activities and the employment and certain other economic impacts associated with exploration of these lease sales. This chapter is introduced with an account of the existing support infrastructure at Prudhoe Bay.

- o Chapter IV: EXPLORATION BACKGROUND deals with a mix of topics related to management of OCS exploration, as well as certain indirect economic effects of exploration. Chapter topics include: permits ; seasonal drilling stipulations; mitigation measures; development proposals; resident employment; regional economic impacts and marine surveys.

- o Chapter V: SUMMARY OF FINDINGS presents the most important factual findings of the study.

At the end of the report there are seven APPENDICES: a bibliography, the exploration scenarios that MMS originally developed and published in the Final Environmental Impact Statements for Sale BF and Sale 71, a technical paper on the construction of Mukluk Island, excerpts from industry testimony on seasonal stipulations, an explanation of the method used to estimate Beaufort Sea exploration work hours and wages and a list of individuals who contributed data to the study.

Note: for brevity, we have used shortened names (e.g. , Amoco, Chevron, Exxon , Gulf, Shell, Sohio, Tenneco, Texaco) for the major oil companies active in Beaufort Sea exploration in place of their full corporate names (e.g., Amoco Production Company, Chevron USA; Exxon Company USA; Gull Oil Corporation; Shell Oil Company; Sohio Alaska Petroleum Company; Tenneco Oil Company; Texaco, Inc.)

II. BACKGROUND AND METHODOLOGY

Background

This chapter presents (1) background data on North Slope petroleum development, including Beaufort Sea sale history, and (2) an explanation of the research methods employed to compile study data.

NORTH SLOPE PETROLEUM DEVELOPMENT

Before presenting the detailed account of Beaufort Sea exploration programs, some background on historic and ongoing petroleum industry activities on the North Slope will provide a useful comparative frame of reference. For this purpose, we have compiled sore-e data about earlier lease sales and sale acreage, drilling activity, employment and payrolls and capital investments to indicate in gross terms the relative scale of existing North Slope development in comparison to Beaufort Sea exploration.

As shown in Table 4, the State of Alaska conducted eleven oil and gas lease sales on the North Slope between 1964 and May 1984. A total of 3,271,846 acres were leased at these sales. For comparison, 382,512 acres were leased in Sale BF (including 296,308 acres under State management) and about 600,000 acres in Sale 71.

The annual level of drilling activity on these State leases is a good index of the scale of the North Slope petroleum industry. According to

TABLE 4

STATE OF ALASKA
NORTH SLOPE OIL AND GAS LEASE SALES
THROUGH 1984

Sale	Date	Description	Acres Leased
13. Prudhoe West*	12/9/64	Offshore/Uplands	722,659
14. Prudhoe West to Canning River	7/14/65	Offshore/Uplands	403,000
18. Prudhoe**	1/24/67	Offshore/Uplands	42,397
23. Colville to Canning River	9/10/69	Offshore/Uplands	412,548
29A. Point Thompson	Cancelled		
30. Beaufort Sea (Joint Federal/State Sale)	12/12/79	Offshore	296,308
31. Prudhoe Uplands	9/16/80	Uplands	196,268
36. Beaufort Sea	5/16/82	Offshore/Uplands	56,862
34. Prudhoe Uplands	9/28/82	Uplands	517,954
39. Beaufort Sea	5/17/83	Offshore/Uplands	211,988
43. Beaufort Sea	5/84	Offshore/Uplands	281,783
43A. Colville Delta/Prudhoe Bay Uplands, Exempt	5/84	Offshore/Uplands	76,079
TOTAL ACRES LEASED			3,271,846

* Sale 13 included some Cook Inlet tracts at. Fire Island, West Forelands and Trinity Islands as well as West Prudhoe.

** Sale 18 included some tracts at Katalla.

Note: Proposed North Slope sales listed in the January 1984 Five-Year Oil and Gas Leasing Program include: 47. Kuparuk Uplands (5/85); 48. Kuparuk Uplands (1/86); 50. Camden Bay (5/87); 51. Prudhoe Bay Uplands (1/87); 52. Beaufort Sea (9/86]; 54. Kuparuk Uplands (1/88); and 55. Demarcation Point (5/88).

Source: Five-Year Oil and Gas Leasing Program, January 1984.

the Alaska Oil and Gas Conservation Commission, State permits were issued for a total of 1,039 exploration, development and service wells on the Arctic Slope between 1970 and 1983. See Table 5. The bulk (543) of these permits were issued in the last three years of this period, Thirty permits were for exploration wells and 513 permits were for production wells. For comparison a total of 15 exploration wells were undertaken during the first three drilling seasons after Sale BF. Thus, over this three-year period, Beaufort Sea exploration accounted for about half of all arctic exploration, but only about 3 percent of total arctic drilling activity.

In the 17 years since the 1967 Prudhoe Bay discovery well, the Prudhoe Bay vicinity has seen a number of massive petroleum development and construction projects (Figure 2). These projects include construction of the TAPS facilities, Prudhoe Bay field development, Kuparuk Field development, the waterflood project and other measures for enhanced recovery, and continuing maintenance drilling. The scale of these activities is reflected in historic employment and payroll data for the Barrow-North Slope Census Division. As shown in Table 6, between 1970 and 1982, average annual employment in the mining sector, which includes the petroleum industry, grew by 283 percent to 3,564 jobs; payrolls increased by 1127 percent. (Note: Due to changes in data reporting practices, employment may be understated in earlier years of this period.) Over the same period, construction employment grew by 440 percent to 2,414 jobs; construction payrolls increased by 1501 percent. In 1982, the payroll for the mining sector amounted to $206,576,000; for the construction sector, $191,331,000. These figures include some

TABLE 5

ARCTIC SLOPE DRILLING PERMITS*

1970 - 1982

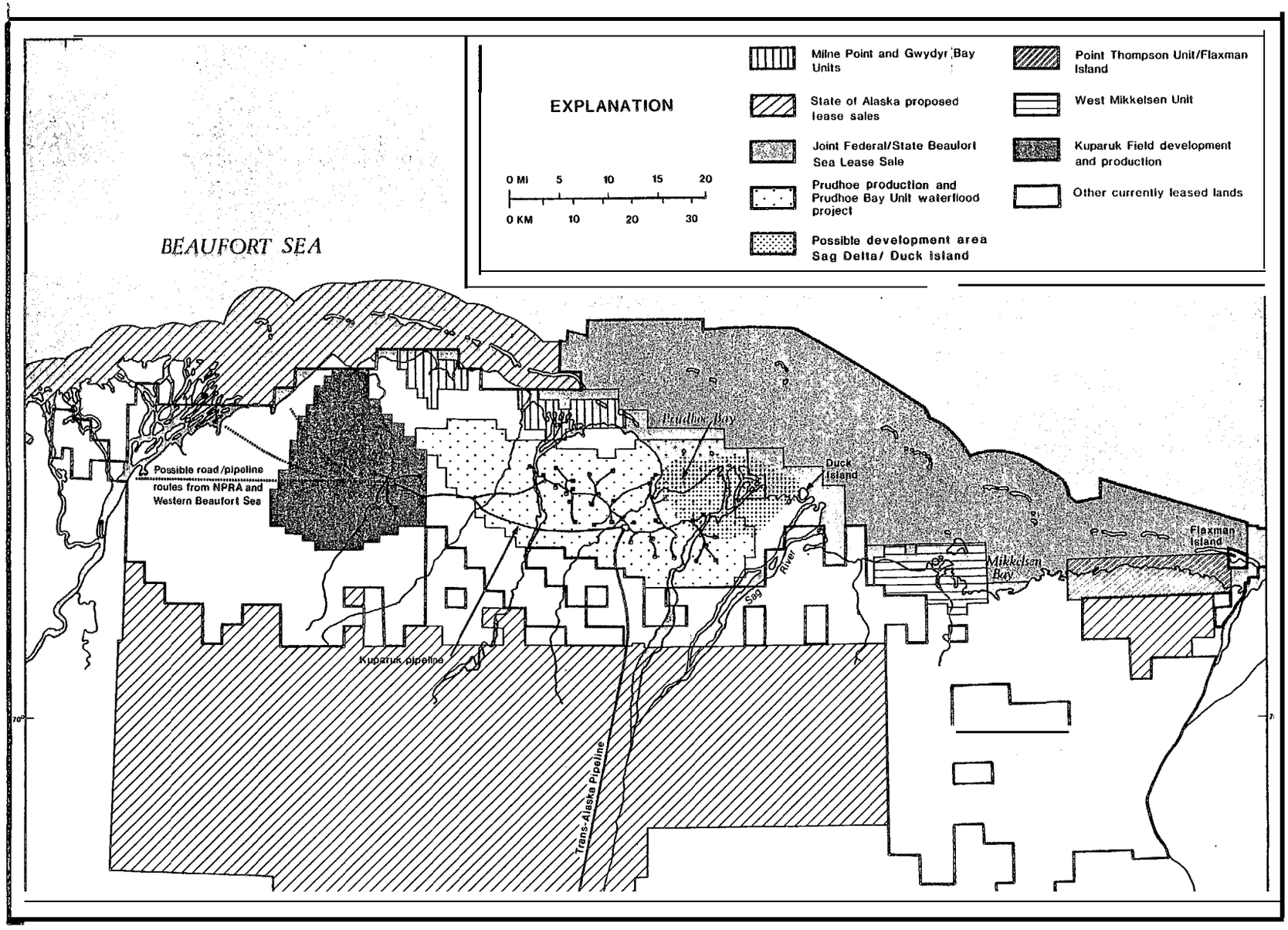
Year	Exploratory Drilling Permits	Developmental & Service Drilling Permits	Total Permits
1970	5	5	10
1971	3	23	26
1972	3	6	9
1973	2	8	10
1974	14	11	25
1975	6	29	35
1976	7	44	51
1977	9	40	49
1978	7	67	74
1979	14	68	82
1980	16	109	125
1981	12	152	164
1982	10	190	200
1983	8	171	179
TOTAL	116	923	1,039

* Does not include OCS, nor NPRA prior to 1982.

Source: Alaska Oil and Gas Conservation Commission, 1983 Statistical Report.

FIGURE 2

ARCTIC PETROLEUM DEVELOPMENT PROJECTS



Source: Rogers, Go den & Halpern. 1983b. Arctic Summary Report Update.

TABLE 6

EMPLOYMENT AND PAYROLLS, 1970 - 1982
MINING AND CONSTRUCTION INDUSTRIES
BARROW-NORTH SLOPE CENSUS DIVISION

	Mining		Construction	
Year	Average Annual Employment	Annual Payroll ($1,000)	Average Annual Employment	Annual Payroll ($1,000)
1970	930	16,837	447	11,953
1971	541	10,591	303	7,814
1972	350	6,855	180	4,691
1973	188	3,935	92	2,494
1974	290	8,899	*	*
1975	1,166	39,020	3,152	152,658
1976	1,271	46,994	3,738	231,382
1977	1,961	83,801	1,472	85,443
1978	2,420	112,918	1,283	77,272
1979	2,569	123,356	415	23,667
1980	2,763	152,524	705	46,717
1981	3,860	218,749	1,744	128,003
1982	3,564	206,576	2,414	191,331
Percent Change 1970-1982	+283%	+1127%	+440%	+1501%

Source: Alaska Department of Labor, Statistical Quarterly.

employment and payroll unrelated to North Slope petroleum activity, but they omit data for the Transportation and service sectors which also make substantial contributions to oil field employment. In all, it is likely that the North Slope petroleum industry accounted for more than a half billion dollar payroll in the Barrow-North Slope Census Division in 1982.

Real property tax assessment records illustrate another dimension of the enormous growth in petroleum industry plant and facilities on the North Slope. Table 7 presents the assessed valuation of oil and gas exploration, production and pipeline transportation property in the North Slope Borough taxable under the State's oil and gas property tax from 1974 through 1984. Since this tax was first levied in 1974, the assessed valuation of taxable oil and gas real property in North Slope Borough has grown from $226,000,000 in 1974 to $11,726,000,000 in 1984. For comparison, it can be noted that by 1983 assessed valuation of oil and gas property in the North Slope Borough ($9,450,000,000) exceeded the total real property valuation of the entire Municipality of Anchorage ($9,169,000,000).

The point that stands out in these comparisons is that the Beaufort Sea exploration programs, however substantial in their own right, comprise a relatively small part of overall petroleum industry activity in the Prudhoe Bay vicinity. This fact is' central to an appreciation of the incremental impact of Beaufort Sea activities upon the level of industrial and economic activity in the region as a whole. Another important circumstance is that Beaufort Sea exploration programs have been able to

TABLE 7

ASSESSED VALUATION
OIL & GAS EXPLORATION, PRODUCTION
AND PIPELINE TRANSPORTATION PROPERTY
NORTH SLOPE BOROUGH, 1974 - 1984

Year	Assessed Valuation ($1,000,000)
1974	226
1975	424
1976	1,520
1977	3,305
1978	4,456
1979	4,818
1980	5,451
1981	6,298
1982	7,722
1983	9,450
1984	11,726

Source: Alaska Department of Revenue,
Division of Petroleum Revenue.

draw upon the highly developed support system already serving the Prudhoe Bay area. In good part, these two factors help account for the pattern that Beaufort Sea exploration programs have followed and for the incremental impact they have had on the region.

SALE BF

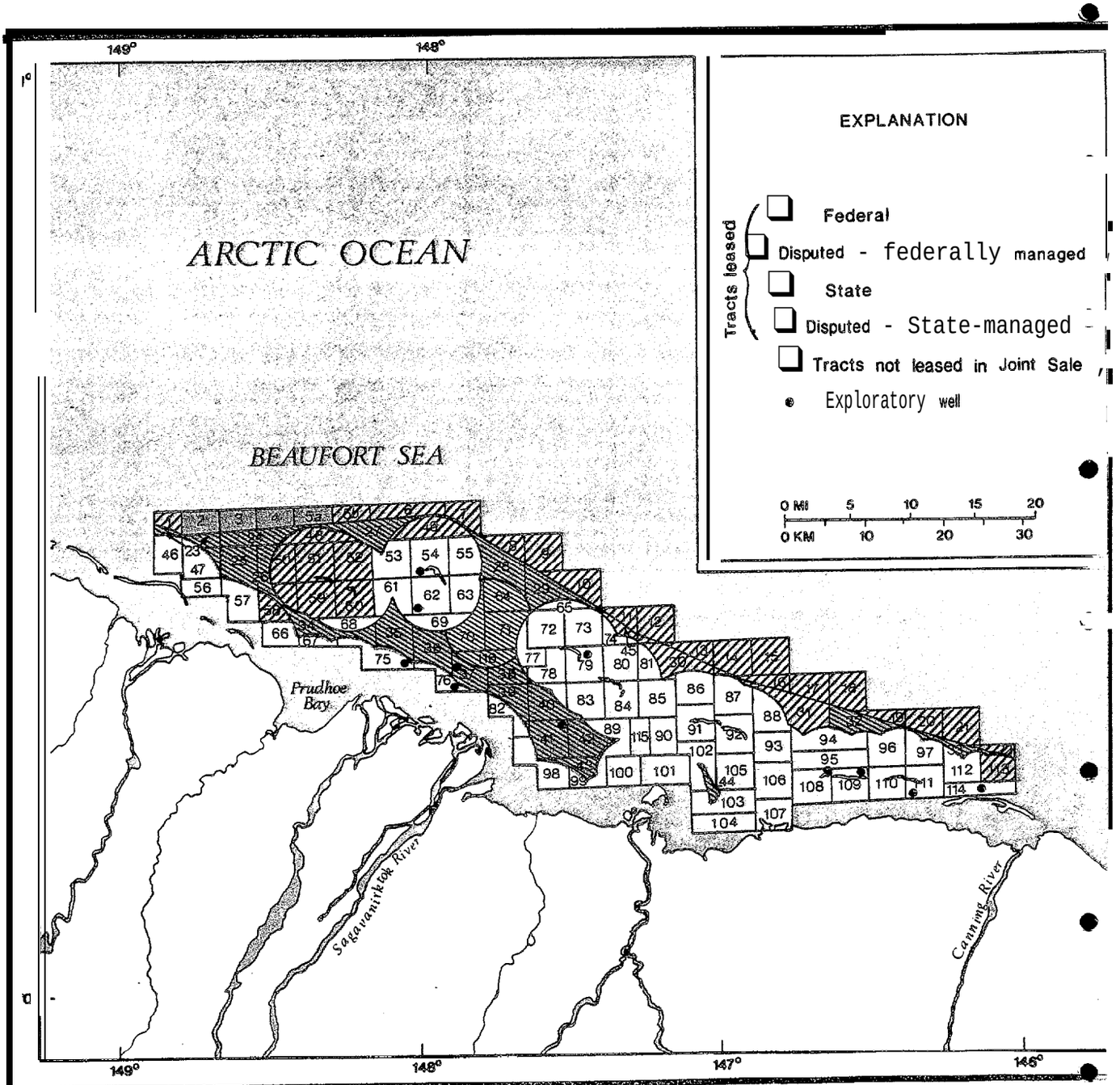
The Joint Federal/State Beaufort Lease Sale (Sale BF) was the first federal arctic offshore lease sale. Joint Sale BF comprised both federal and state offshore tracts north and east of Prudhoe Bay. See Figures 2 and 3. Ownership of some tracts in the proposed federal sale area was disputed by the State of Alaska, which was simultaneously considering sale of some submerged state tracts adjacent to the federal lease area. To facilitate the sale of contested tracts, the two governments negotiated a joint "Memorandum of Understanding." The memorandum allocated responsibilities for sale and interim management of the offered tracts while litigation to resolve the boundary disputes proceeded.

Because of the split management of the lease tracts, different bid arrangements, lease stipulations, permit requirements, etc., governed the management of federal and state tracts. Some of the important permits and stipulations affecting offshore operations are discussed in Chapter IV.

Sale BF was held in Anchorage on December 11, 1979. Bids were received for 87 of the 117 tracts offered for lease. The bid terms for the

FIGURE 3

SALE BF TRACT MAP



Source: Rogers, Golden & Halpern. 1983b. Arctic Summary Report Update.

federal tracts offered were a fixed royalty, plus a bonus bid. The state tracts were offered under three different bid methods. As a result, the amounts bid for individual tracts offered in this sale are not necessarily comparable, nor are total bid receipts directly comparable to previous OCS lease sale receipts.

In November 1979, the North Slope Borough, the village of Kaktovik and other groups filed lawsuits contesting the adequacy of the Environmental Impact Statement for the proposed sale. This resulted in a federal district court injunction on acceptance of bids for federally managed tracts. Issuance of the federal leases was delayed until July 1980. State leases were issued in January and February 1980.

Ultimately, bids for 86 tracts were accepted. See Table 8. Five leased tracts were in undisputed federal ownership and 58 tracts were in undisputed state ownership. Nineteen disputed tracts were assigned to federal management and four to state management, pending resolution of the ownership litigation. The bonus bids accepted for federal tracts amounted to $488,691,137. Because of the different bidding methods adopted for state tracts, direct comparisons between state and federal bid amounts are not meaningful.

Both the bid results and the subsequent exploration pattern indicate that the prime prospects were thought by industry to be on state tracts or on the federally managed disputed tracts. Exploration on Sale BF tracts has been more intensive than for any other Alaskan OCS sale area. As Table 1 illustrated, a higher percentage of lease tracts in Sale BF

TABLE 8

SALE BF BID RESULTS

FEDERALLY MANAGED TRACTS
(Bonus bidding, fixed sliding scale royalty, starting at 16⅔%)

Tract	Acres	High bidder, Interest	Bid	Bid per hectare
1	2,260	Shell 50, ARCO 40, Murphy 10	$ 3,037,000	$ 3,321
2	3,510	Amoco	11,090,550	7,809
3	3,434	Exxon	114,000	82
4	3,347	Shell 50, ARCO 40, Murphy 10	211,000	156
5(a)	3,207	Shell 50, ARCO 40, Murphy 10	211,000	163
23	2,252	Amoco	20,190,995	22,155
24	4,010	Amoco	15,050,900	9,272
25	5,242	Shell 90, Murphy 10	60,890,000	28,700
26	1,669	Chevron 50, Phillips 50	461,125	683
27	4,901	ARCO 80, Murphy 20	1,505,000	759
28	5,418	Hamilton Bros. Oil Co.	2,379,657	439/acre
29	4,616	ARCO	1,642,614	279
32	3,413	BP Alaska 87, Sohio 10, native groups 3*	305,258	222
33	1,328	BP Alaska 87, Sohio 10, native groups 3	151,077	281
34	3,303	Gulf group†	11,267,000	8,429
35	5,159	Exxon 50, Union of Cal. 50	53,139,000	10,716
36	4,238	ARCO ⅓, Exxon ⅓, Union ⅓	121,279,000	70,708
37	3,267	ARCO ⅓, Exxon ⅓, Union ⅓	143,089,000	108,234
38	3,813	ARCO ⅓, Exxon ⅓, Union ⅓	12,229,000	7,925
39	2,591	ARCO ⅓, Exxon ⅓, Union ⅓	12,353,000	11,779
40	5,391	ARCO	1,500,946	688
41	4,855	ARCO	8,310,101	4,230
42	4,172	Shell 85, Murphy 15	8,108,000	4,802
43	1,752	ARCO 50, Exxon 50	3,131,914	4,416
44	885	ARCO 50, Murphy 50	81,000	226

STATE MANAGED TRACTS
($875/acre, 20% royalty, net profits share bid)

Tract	Acres	High bidder	Fixed bonus	Bid (%)
46	4,393	Amerada Hess	$3,843,717	93.20000
47	4,472	Amerada Hess	3,913,323	91.20000
53	5,241	Tenneco	4,586,190	21.58000
54	5,693	Tenneco	4,981,628	59.00000
55	5,508	Tenneco	4,426,100	31.67000
56	3,433	Texas Eastern Exploration	3,003,805	8.5.25978
57	5,301	Texas Eastern Exploration	4,638,707	85.25978
66	3,601	Chevron	3,150,962	2.76002
67	1,866	Gulf group†	1,633,082	38.56650
114	4,%35	Exxon	4,318,536	52.35200

STATE MANAGED TRACTS
($1,750/acre, 20% royalty, net profits share bid)

Tract	Acres	High bidder	Fixed bonus	Bid (%)
61	5,050	Amoco	$8,837,150	71.04449
62	5,693	Amoco	9,963,257	61.04959
68	2,272	Gulf group†	3,976,052	46.12575
69	3,795	Amerada Hess	6,641,565	93.'20000
75	5,646	Marathon 50, Amerada Hess 50	9,880,867	74.83000
76	4,300	Sohio 96, native groups 4	7,524,545	7%59350
82	3,580	ARCO ⅓, Exxon ⅓, Union ⅓	6,266,120	48.87031

STATE MANAGED TRACTS
(Bonus bidding, fixed sliding scale royalty starting at 20%)

Tract	Acres	High bidder	Bid
63	5,051	Union	$16,400,387
65	1,936	ARCO	1,642,624
72	5,616	E x x o n	1,129,000
73	5,681	Exxon	1,129,000
74	2,%35	Frank L. Shogrin	25,347
77	3,056	Mobil 50, Chevron 50	1,537,500
78	4,910	Mobil 50, Chevron 50	1,025,000
79	5,693	Mobil ⅓, Phillips ⅓, Chevron ⅓	6,148,000
80	5,693	Mobil ⅓, Phillips ⅓, Chevron ⅓	2,045,000
81	2,862	Burglin group	14,312
83	5.025	Burglin group	25,127
84	5,693	Mobil 50, Chevron 50	4,100,000
85	5,693	Mobil 50, Chevron 50	6,145,000
86	5,196	Burglin group	25,982
87	5,578	Burglin group	27,892
88	4,842	Burglin group	24,212
89	5,663	Burglin group	25,500
90	4,270	Mobil ⅓, Phillips ⅓, Chevron ⅓	3,070,000
91	5,693	Mobil ⅓, Phillips ⅓, Chevron ⅓	3,075,000
92	5,693	Mobil	7,124,525
93	4,270	Mobil ⅓, Phillips ⅓, Chevron ⅓	512,500
94	5,727	BP Alaska 87, Sohio 10, native groups 3	3,000,953
95	5,693	BP Alaska 87, Sohio 10, native groups 3	47,442,185
96	5,266	Sohio 97, native groups 3	21,069,146
97	4,234	Sohio 97, native groups 3	7,176,019
98	5,487	ARCO	1,563,709
99	3,504	Shell 85, Murphy 15	1,034,000
100	5,357	Shell 85, Murphy 15	809,000
101	5,435	Murphy	272,000
102	5,212	Mobil 50, Chevron 50	1,025,000
103	5,733	Murphy	287,000
104	5,530	Burglin group	27,650
105	5,693	Mobil	5,530,500
106	5,693	Exxon	1,339,000
107	4,729	ARCO	2,390,310
108	5,732	Mobil ⅓, Phillips ⅓, Chevron ⅓	31,450,000
109	5,696	Exxon	36,279,000
110	5,648	Exxon	85,689,000
111	5,589	Exxon	55,689,000
112	4,682	Exxon	6,659,000
115	2,846	Mobil ⅓, Phillips ⅓, Chevron ⅓	1,025,000

STATE MANAGED TRACTS
(Bonus bidding, fixed sliding scale royalty starting at 16⅔%)

Tract	Acres	High bidder	Bid
64	4,728	BP Alaska 87, Sohio 10, native groups 3	$10,005,231
70	5,312	ARCO ⅓, Exxon ⅓, Union ⅓	53,900,406
71	4,835	BP Alaska 87, Sohio 10, native groups 3	18,380,457
116	2,950	ARCO ⅓, Exxon ⅓, Union ⅓	28,610,409

*NANA, Koniag, Sealaska. Cook Inlet participated in BF-76. †In Tract 34, Gulf 47, Cities Service 20, Conoco 20, Texasgulf 10, Rowan Petroleum 3. In Tracts 67 and 68, Gulf 25, Cities Service 25, Conoco 25, Placid 16, Texasgulf 6, Rowan Petroleum 3.

Reproduced from Oil & Gas Journal, December 17, 1979.

has been explored than in any other sale area. Prior to November 1, 1983, 14 wells had been completed, another started, and gravel islands built for two more wellsites, for a total of 17 wells completed or committed. This was nearly equal to the total number of wells (20) drilled for all other federal OCS sales in Alaska to that time.

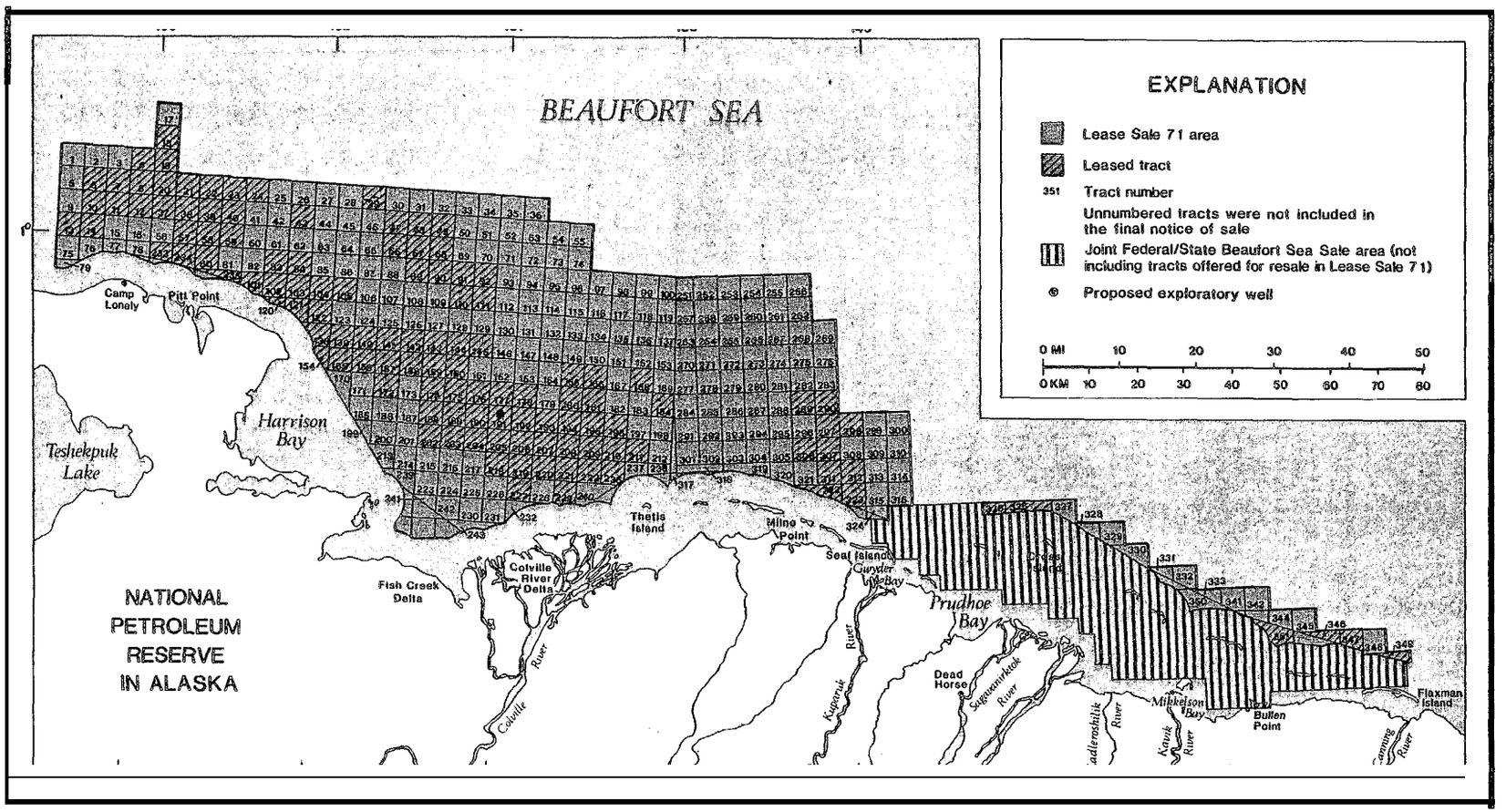
SALE 71

The Diapir Field OCS Sale 71, held in Anchorage on October 13, 1982, attracted near-record bids. The lease offering encompassed 338 tracts extending from the three-mile limit up to 45 miles offshore and along the arctic coast stretched from near Flaxman Island in the east to Smith Bay about 190 miles to the west. See Figure 4. Sale 71 was exclusively a federal sale, but west of Prudhoe Bay it abutted submerged state lands later leased under State of Alaska oil and gas lease sales Beaufort Sea #39 (May 1983) and Beaufort Sea #43 (May 1984).

At the sale, bids were received on 125 tracts and high bids totaling $2,055,632,336 were accepted for 121 tracts, giving Sale 71 the third highest OCS lease sale receipts total at that time. Tracts 191 and 206 overlying the Mukluk structure received bids of $227,171,250 and $219,117,312, respectively, at that time the second and third highest single tract bonus bids in OCS leasing history. Table 9 lists the 30 lease tracts obtaining the highest bids in Sale 71. This list includes the prime tracts most likely to be selected for exploratory drilling.

FIGURE 4

OCS LEASE SALE 71 TRACT MAP



Source: Rogers, Golden & Halpern. 1983b. Arctic Summary Report Update.

TABLE 9

Ocs SALE 71

THIRTY HIGHEST CASH BONUS BID TRACTS

Tract	Major Ownership Interest	Total Bonus Bid
191[a]	Sohio	$227,173,250
206[a]	Texaco	217,117,312
207[d]	BP	193,579,570
204	Texaco	168,118,272
190	Sohio	148,871,130
205[a]	Sohio	136,637,450
192[a]	Shell	113,456,000
58[b]	Exxon	73,250,000
189	Sohio	71,793,250
221	BP	60,753,370
220[d]	Texaco	57,116,160
219[d]	Chevron	47,542,000
208	Amoco	45,754,000
57[b]	Exxon	44,250,000
218	Chevron	35,114,624
193	Sohio	31,321,220
180	Texaco	22,118,400
203	Texaco	22,118,400
181	Texaco	18,118,656
188	Sohio	17,838,460
39	Gulf	15,876,000
194	Union	15,466,000
209	Unio	15,210,000
38[b]	Exxon	14,200,000
311	Murphy	13,006,080
322[c]	Amoco/Shell	12,721,000
157	Amoco	10,278,000
174	Amoco	10,210,000
155	Amoco	10,205,000
156	Amoco	10,205,000

a Tract included in Sohio Mukluk project exploration plan.

b Tract included in Exxon Antares Project exploration plan.

c Tract included in Shell Sandpiper project exploration plan.

d Tract included in Texaco's cancelled Fur Seal project exploration plan.

Source: Oil and Gas Journal.

Exploration of Sale 71 tracts poses great challenges. Compared to Sale BF tracts, most of the tracts leased in Sale 71 are further from support facilities established at Prudhoe Bay. Most tracts are further offshore in deeper waters and face more severe ice conditions than Sale BF tracts. In contrast to Sale BF, there are no natural islands that can beused as drilling bases.

Sohio holds a major ownership interest in tracts covering the Mukluk structure. Under the exploration plan for the Mukluk project, Sohio was exploration operator for a set of four adjacent tracts (191, 192, 205, 206) which together received high bonus bids totaling $696,387,012. During 1982-83, Sohio constructed an artificial gravel island on the common comer of these four tracts at an estimated expense of $100,000,000. The first Sale 71 exploration well was spudded on Tract 191 in November 1983 and resulted in a dry hole. Due to the cost of building Mukluk Island, this was the most costly OCS exploratory well to date.

Exxon has filed an exploration plan for the Antares prospect covering seven tracts it. leased in the western end of Sale 71. Exxon tentatively plans to employ a Concrete Island Drilling System (CIDS) for a drilling base rather than an artificial island. Unlike an artificial gravel island, this drilling platform is relocatable and, due to that feature, is expected to be more economical for the relatively deep waters in the tracts Exxon has targeted for exploration. The planned spud date for the first well is November 1, 1984.

In November 1983, Texaco filed its Fur Seal exploration plan for a gravel island exploration pad and up to five exploration wells on a set of four Sale 71 tracts near Sohio's Mukluk project. However, Texaco suspended this project after appraisal of the negative results of the Mukluk project. Finally, Shell also filed an exploration plan in November 1983 to construct a gravel island (Sandpiper) and drill up to four exploratory wells on its Harvard Prospect.

Methodology

The general methodological approach for the Beaufort Sea monitoring study derives from the study goal set out in the MMS scope of work: to compile an empirical account of "events, equipment timing, employment, wages, locations, requirements, expenditures and effects of OCS activity related to the Beaufort Sea for the period beginning December 1979 through, to the extent possible, 1983 . . ."

Given the factual orientation of the scope of work, the study approach did not present any difficult conceptual problems. Nevertheless, the procedures for data collecting analysis and synthesis did have to cope with a host of troublesome practical methodological problems. There is no single way to characterize these problems. For discussion purposes below, we have grouped them under two topical headings: entrepreneurial structure of exploration and North Slope petroleum industry infrastructure. Here, emphasis is on the methodological problems associated with these circumstances. In the next chapter, a descriptive section is devoted to existing infrastructure.

ENTREPRENEURIAL STRUCTURE OF EXPLORATION

In broad terms, the preliminary phase of offshore exploration begins with the search to identify potential hydrocarbon structures through geological and geophysical surveys of the outer continental shelf conducted by the U.S. Geological Survey or private firms. Prospective structures may be considered for inclusion in the Department, of the Interior's Five Year OCS Lease Sale Schedule. Under the Department of the Interiorgs administrative procedures, proposed sale areas receive further detailed analysis in the form of additional resource, environmental, economic, socioeconomic, transportation and other studies, NEPA EIS and other review processes, public hearings, etc., leading up to the offering of particular tracts for lease at an OCS lease sale. Where acceptable bids are received, the sale culminates in award of a lease tract to the successful bidder, usually a group of firms, but sometimes an individual company.

Formation of the Management of the Enterprise

After leases are awarded to the winning bidder or consortium of bidders, exploration plans can be made. Where a number of firms bid together, they select a single firm, usually the dominant partner, to perform as operator on behalf of the consortium which share exploration costs and findings. Sometimes, a minor partner with superior technical expertise or existing operations in the exploration region may be chosen operator. Sometimes, too, a group of tracts which overlie a single drilling prospect may be consolidated into a single exploration unit, with the

collected lessees committing to share exploration drilling costs and results in order to make optimal use of exploration efforts.

The exploration program may consist of a single exploration well or, tentatively, a series of wells. The operator becomes manager of that specific endeavor, responsible for administrative tasks, surveying drilling, and other support necessary to accomplish the program. The onsite personnel involved in the 'exploration enterprise" will consist of a few professional/managerial representatives of the lease operator and, perhaps, the other owners. The bulk of the field staff are comprised of contractors and consultants (and their employees) engaged for specific tasks in the enterprise.

The Exploration Process

The operator's management duties include obtaining needed permits; determining the timing for drilling; selection of the drill site, whether natural or manmade island location; selection of drilling contractor and the specialized support contractors; determining mode of access; e.g., air, marine, ice road; selection of transportation and construction contractors for access preparation and site work; providing or arranging for onsite materials needed for drilling, such as drill pipe, drilling mud , etc.; providing or arranging for access and site work materials such as gravel; direction of procurement activity, which may consist of direct purchase or may provide for a chain of procurement activities by various contractors and subcontractors; inspection arid audit of work; financial management; representation of all owners as the

onsite managing and contracting representative; coordination with governmental representatives on permits and continuing inspections and reports regarding the progress of exploration, as required by laws or regulations.

Post Exploration Responsibilities

After the drilling program is concluded and results evaluated, the ownership group may decide to abandon drilling or agree to further exploration of a promising structure to analyze development and production possibilities. Unless further exploration drilling is going to take place soon, the equipment and personnel are demobilized. Once again, the lease operator serves as the manager of that activity and uses the contract system to engage companies to clear the site as necessary under applicable permits and in accordance with economic decisions which have been reached. The mobilization process is reversed as the drill rig, camp, etc., are dismantled and moved to an assigned onshore location.

The foregoing account has emphasized the fragmented nature of participation in an 'Exploration enterprise." Despite the prominence of a few major international oil firms as leaseholders and operators, the industrial organization of the enterprise is not monolithic. The many specialized skills and services which contribute to the overall effort foster a decentralized structure, where the major firms maintain many smaller client enterprises in the oil services industry rather than developing full in-house capabilities.

This characteristic of the "exploration enterprise" receives a strong test in the remote frontier areas, such as the Outer ContinentalShelf, where a full range of needed services may not be quickly or locally available. Frontier conditions may force tighter operator management of the many enterprise requirements than is customary in more developed petroleum regions. These conditions include high operating costs, seasonality and brief operating "windows," long and often weatherbound lines of support, and high cost penalties for delay or unreliable performance of exploration activities. Generally, the frontier lease operators maintain a stronger hold on contracting and subcontracting arrangements to ensure accountability and performance.

Exploration Data

For good business reasons, wildcat oil and gas exploration in high potential frontier areas is secretive in some aspects. The financial stakes in OCS exploration programs are high for lease owners and operators. Petroleum intelligence is valuable. Lease owners and operators are habitually guarded about publicizing details about project plans or operations that might prematurely suggest the status of their resource appraisals or exploration findings

The entrepreneurial structure within which exploration programs are implemented is fragmented and competitive. The 1984 Anchorage Municipal telephone directory gives some sense of this entrepreneurial pluralism. Even though no oil or gas is produced in its boundaries, Anchorage has become the administrative headquarters for the major oil firms in Alaska

and for most of the oil field "service and supply firms that cater to them. The 1984 telephone directory listed only 13 producing firms, but listed over six pages of oil field supply and service firms, plus many more pages advertising air, marine and truck transportation firms, catering and camp services, construction management, etc. for the petroleum industry.

Often, the operating firm which manages the exploration program will have as few as one to three of its own employees directly assigned to supervise onsite field operations". For a single exploration project - this monitoring study covers 15 exploration wells - the operator may engage under separate contracts 20 or more independent, specialized construction and transportation contractors oil field service companies and other highly mobile support businesses to carry out specific tasks. The contractual arrangements typically require that the contractors (or their subcontractors) themselves provide all labor, supplies, equipment, etc., required by their services. Also, responsibility and recordkeeping for staffing and purchase of supplies and equipment is divided among many separate firms, not directly managed by the operator. As a result of this diffuse contracting pattern, there is no single central source of uniform data about workforce levels, wages, supplies, purchases etc., for exploration programs. It is impractical to seek this data from each of the contractors and subcontractors engaged in exploration activities.

By 1980, the North Slope had developed a mature and highly competitive oil field services industry. For most needed supplies and services,

there are usually numerous vendors. Operators are eager to maintain competition among vendors and vendors are eager to protect their competitive position. For these reasons, operators, as well as contractors and oil field service and supply firms, are reluctant to volunteer cost data or other operational data that may provide indirect clues to costs. In the case of contractors, this reticence is reinforced by contractual terms that prohibit disclosure of information about their contractual activities.

In any case, oil field contractors ordinarily have no internal reason to record or store for easy retrieval much of the data about workforce, payroll, purchasing or other operational details sought for this monitoring study. Certainly, management policies and recordkeeping practices for many types of data sought for, this study are not uniform throughout the industry. For example, provisions for shift and rotation schedules terms of compensation and overtime and leave practices vary, depending on conditions in the field and on recruitment, personnel and labor policies and agreements appropriate to different firms and oil field operations.

There are some uniform data reporting requirements set by law, for example, Alaska Department of Labor payroll data reports. However, disclosure constraints protect the confidentiality of individual firm data. Data aggregation makes it impractical to retrieve employment and payroll or other operational data for attribution to individual firms or for specific Beaufort Sea exploration projects. Even where this data is internally available firms may hesitate to volunteer certain types of

workforce data (e.g., resident, female or minority employment data) that might be used to question their personnel practices or to ascertain pricing practices.

NORTH SLOPE PETROLEUM INDUSTRY INFRASTRUCTURE

Most of the frontier regions of Alaska are remote and undeveloped, lacking ready facilities for support of early exploration program-s. In such frontier regions, specific provision must be made for all onsite support facilities and services for exploration programs. As" a result, any onshore exploration impacts tend to be visible and readily attributable to specific exploration programs.

The context for Beaufort Sea exploration programs has been very different. As noted above , the Deadhorse/Prudhoe Bay vicinity now harbors Alaska's greatest concentration of oil field services and other petroleum industry infrastructure and support. firms. This infrastructure has developed over the years to meet the support needs of earlier Prudhoe Bay petroleum operations and trans-Alaska oil pipeline construction and continues to be available and used for ongoing petroleum industry activities.

As a result, essentially all of the basic transportation and other support facilities and services that might be 'needed for Beaufort Sea exploration programs were in place before the Beaufort Sea OCS sales. Even though the start-up of Beaufort Sea exploration coincided with a slack period of North Slope activity, these exploration programs have

comprised' a relatively small part of the overall North Slope petroleum industry activity since 1980. Thus, Beaufort Sea exploration programs have had ready access to the support facilities and oil field service firms already in business in the Prudhoe Bay area. Except at the drill-site, Beaufort Sea exploration programs have not required major new support infrastructure.

Because Beaufort Sea exploration programs make common use of support facilities and suppliers that serve other North Slope petroleum development, it is virtually impossible to single out the impacts of Beaufort Sea exploration programs. These impacts are intermingled with ongoing activities in support of other North Slope petroleum operations.

RESEARCH METHODS

The project approach employed research methods specifically selected to cope with the previously described problems of fragmented data sources and commingling of Beaufort Sea exploration support with other ongoing arctic petroleum activity.

First, the project team assembled and reviewed available published sources for pertinent data. This review mainly included exploration plans and environmental reports, permit applications and similar public documents on file at public agencies; petroleum and construction industry trade publications (e.g., Oil and Gas Journal, Alaska Report, Alaska Construction and Oil, Offshore, Alaskan newspapers, company house publications) that regularly report on the status of industry plans and

projects; and available studies on OCS-related topics relevant to the present study scope.

Second, the secondary data extracted from published sources were reviewed for timeliness and adequacy for the project. Data gaps were identified to be filled in by further research and through an interview program with industry informants knowledgeable about oil exploration in the Beaufort Sea and with staff of public agencies responsible for management of OCS exploration.

Third, tentative tabular formats were designed to display how exploration data would be presented in the study report. At this stage, a significant technical decision was made: the most meaningful and coherent way to organize and tabulate most study data was by individual exploration drilling program. The main advantage of this organization was, that. it reflected the central and continuing role of the operating firm in planning for and implementing the drilling program. The operator was the only entity with an overall grasp of the history of the exploration program. This organization also made it feasible to group, summarize and compare data about exploration programs in the most meaningful terms, that is, by exploration phase, by key exploration functions and by drilling season.

Based on these tabular formats, a standard interview format was developed for use in interviews with exploration managers and other senior staff of the operating firms to fill in data gaps and to verify information obtained from other sources. Verification. of actual exploration

data with the operating' firms was important, partly because published data sources were sometimes in disagreement and partly because unforeseeable factors sometimes necessitated revisions in features of the exploration plan. This standard interview format served to assure full coverage and comparability in the quality of data collected from operators.

Fourth, after it became clear that it would not be possible to obtain all the information sought in the interview program from all firms, some improvisations were made to fill in data gaps. For example, it was not feasible to retrieve full and comparable historic labor data for all exploration programs. Therefore, we attempted a detailed reconstruction of the manpower and wages for specific phases of each exploration project. The process of reconstruction made use of available data about typical staffing patterns, occupational wage scales, rotation and shift schedules, and recruitment and hiring practices for the North Slope petroleum industry in general, plus specific information about the duration of each exploration project and any special circumstances. The information about exploration activities supplied by the operators was the first step for this exercise. Additionally, data were obtained from and cross-checked with knowledgeable sources, including exploration managers, drilling foremen, individual contractors, transportation industry specialists, union officials and dispatchers> Alaska Department of Labor staff and other public officials. Based on the information and guidelines provided by these knowledgeable informants, we are confident that this method of reconstructing employment data can yield a more complete and accurate picture than could be practicably obtained by

trying to compose the exploration history from the spotty and scattered records of many dozen individual companies.

Industry firms were willing to provide some types of information about exploration so long as it would not be directly attributed. For example, . most firms were forthcoming with observations and data about the effects of permits, regulations and sale stipulations on the pace and level of exploration efforts, but were also concerned about impairing working relationships with permitting and regulatory agencies. In other cases, firms were willing to provide proprietary cost and labor data about their exploration programs, so long as the data would be aggregated or published in a form that masked the identity of the source. In such cases, the research team acquired data on the condition it would not be used in a manner that identified the source: For purposes of the present study, it was the research team's judgment, concurred in by MMS, that the information thereby gained outweighed the lack of full documentation. Where the lack of attribution seemed a significant qualification to the data, that circumstance was noted.

111. EXPLORATION PROFILE

Introduction

This chapter provides a factual account of the main onsite industrial and transportation activities and employment entailed by sixteen Beaufort Sea exploration programs- undertaken or initiated through the 1982-83 drilling season. The first section of the chapter presents background on existing infrastructure as explanatory context for the detailed account of exploration activities that follows. The next group of sections are organized in logical order to cover the main logistic, island construction and drilling operations for each of the 16 exploratory wells covered in this monitoring study. These sections are briefly described:

- o Existing Infrastructure, which describes the base camp, industrial, commercial and transportation facilities and services available in the vicinity of Prudhoe Bay to support Beaufort Sea exploration. The advantageous access afforded Beaufort Sea operations to existing facilities and services greatly simplified logistic and support arrangements and probably hastened the pace of exploration. In this regard, as in others, the Beaufort Sea sale areas are unique among Alaska's frontier OCS regions, where exploration pioneers must make provisions for virtually all support arrangements. As arctic OCS lease offerings progress to tracts more remote from existing support facilities, it is likely that exploration will entail establishment of new

forward bases of support for offshore activities, with added expenses for facilities manpower and contingency arrangements. For these reasons, the findings about Beaufort Sea exploration activities must be applied with care in any process for fore-" casting the likely pattern of exploration in other OCS regions.

- o Marine, Air and Surface Logistics arrangements for transport of drilling equipment, material, supplies, personnel, etc. between North Slope camps and depots and the Beaufort Sea well sites.

- o Gravel Island construction, for those exploratory projects where manmade drilling platforms were required to support exploratory drilling.

- o Drilling Operations, comprising the array of onsite activities entailed by exploratory drilling.

Finally, the last section of this chapter summarizes direct employment associated with each of the above phases of Beaufort Sea exploration programs.

Existing Infrastructure

Nearly all of the support services and facilities for Beaufort Sea offshore development between 1980 and 1983 have been based at Prudhoe Bay, less than 60 miles from any of the wells included in this analysis. Typically, the Environmental Report for the Shell Seal prospect noted:

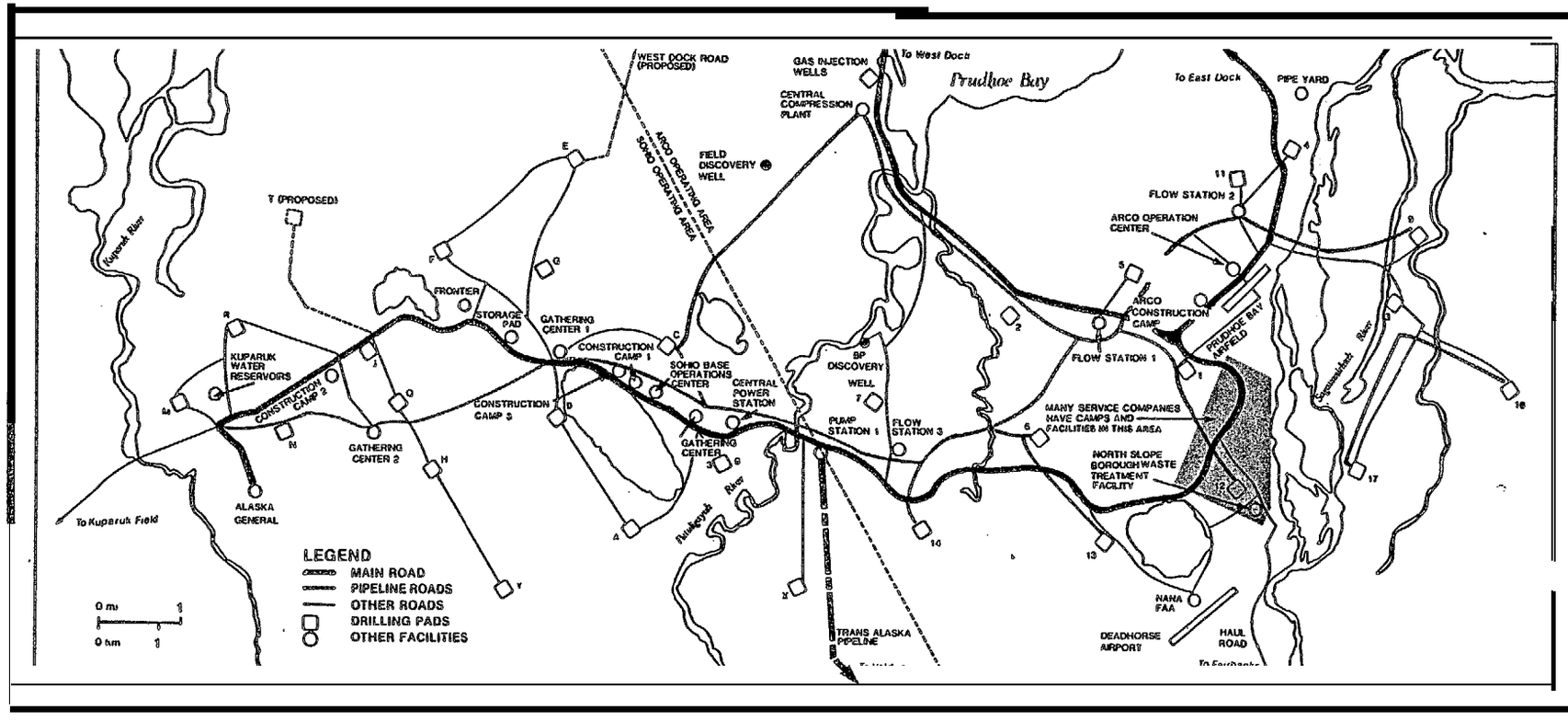
> Projected need for onshore project support facilities include a storage area, haul roads, communication center, and airport facilities. These facilities are currently available in the Prudhoe Bay complex, hence no significant project-related construction impacts will occur onshore. . .
>
> Supplies, equipment, energy and other resources will be obtained through the Prudhoe Bay complex from established contractors. (p. 4-9)

This section covers support facilities and services available at Deadhorse and Prudhoe Bay to support Beaufort Sea exploration. The next section. gives a detailed discussion of air, marine and surface logistic support for Prudhoe Bay in general and Beaufort Sea exploration activities specifically.

Figures 5 and 6 illustrate existing roads and facilities at Prudhoe Bay. Two base camps or operation areas are located in the Prudhoe Bay unit: 1) the ARCO camp on the east side of the field, just west of the Sagavanirktok River, and 2) the Sohio camp on the west side of the field near the Putuligayuk River. Deadhorse is located on the ARCO side about five miles south of Prudhoe Bay. Deadhorse encompasses the state-owned and operated airport and the facilities of contractors, oil field service companies, suppliers and other firms which provide support services to the oil and gas industry. Deadhorse is also the northern terminus of the Dalton Highway (formerly the North Slope Haul Road) which connects the Prudhoe Bay area and Fairbanks. The Kuparuk River Unit is located just west of the Sohio side of the Prudhoe Bay unit. All of these areas are linked by the Spine Road and a network of access roads to various facilities.

FIGURE 5

EXISTING ROADS AND PIPELINES, PRUDHOE BAY FIELD, 1982



Source: Rogers, Golden & Halpern. 1983. Arctic Summary Report, January 1983.

Construction contractors, oil industry support services, transportation services and other service firms are all located on the east side of the Prudhoe Bay unit. Most support facilities are located in the North Slope Subdivision on land leased from the State Division of Land and Water Management. The remaining support service firms an-d contractors are located at or near the Deadhorse Airport on a subdivided tract under leases from the Alaska Department of Transportation.

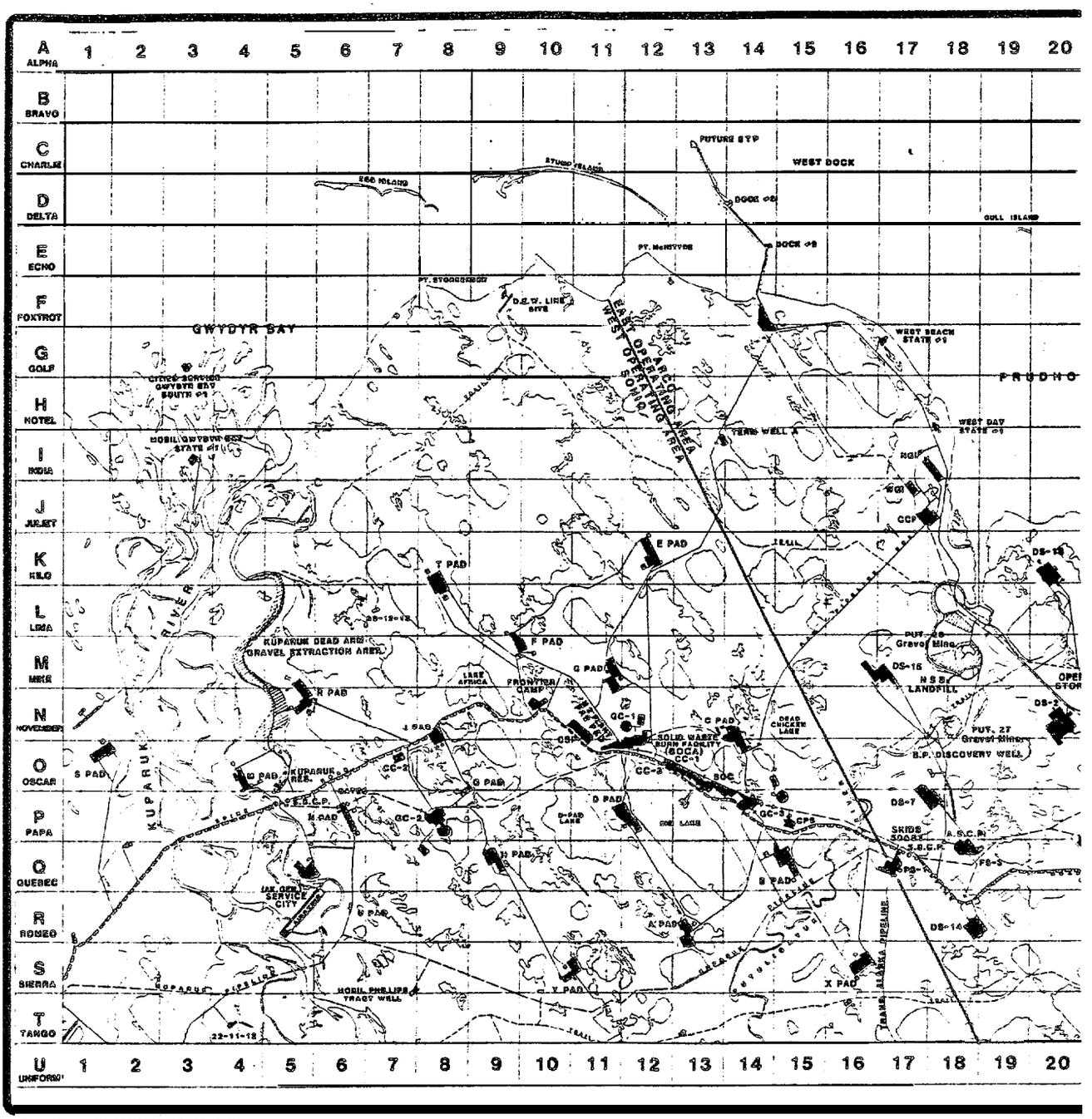
Tables 10, 11 and 12 show the diversity and depth of contractors and support services available to support petroleum development at Prudhoe Bay. Most of these firms have been in Prudhoe Bay for a number of years and predate Beaufort Sea exploration. The Beaufort Sea work performed by these-firms has been largely a supplement to their North Slope activities, rather than their sole reason for being located there.

During the 1980-83 period there was sufficient lease space available to accommodate any additional contractors or service demands generated by the Beaufort Sea activity. Some of the offshore work, particularly gravel hauling operations, required the contractors to house personnel at Prudhoe Bay. There was adequate existing space to accommodate such personnel in rental housing at Prudhoe Bay. In winter 1983 there was substantial surplus bed capacity in rental camp housing at Prudhoe Bay (Table 13) . There were 896 beds in closed facilities which could have been activated if needed. Another 446 beds became available in 1984 with opening of the Kuparuk Industrial Center,

In conclusion, the Beaufort Sea activity to date has not required expansion of Prudhoe Bay support services and facilities, nor has it over-

FIGURE 6 - PART A

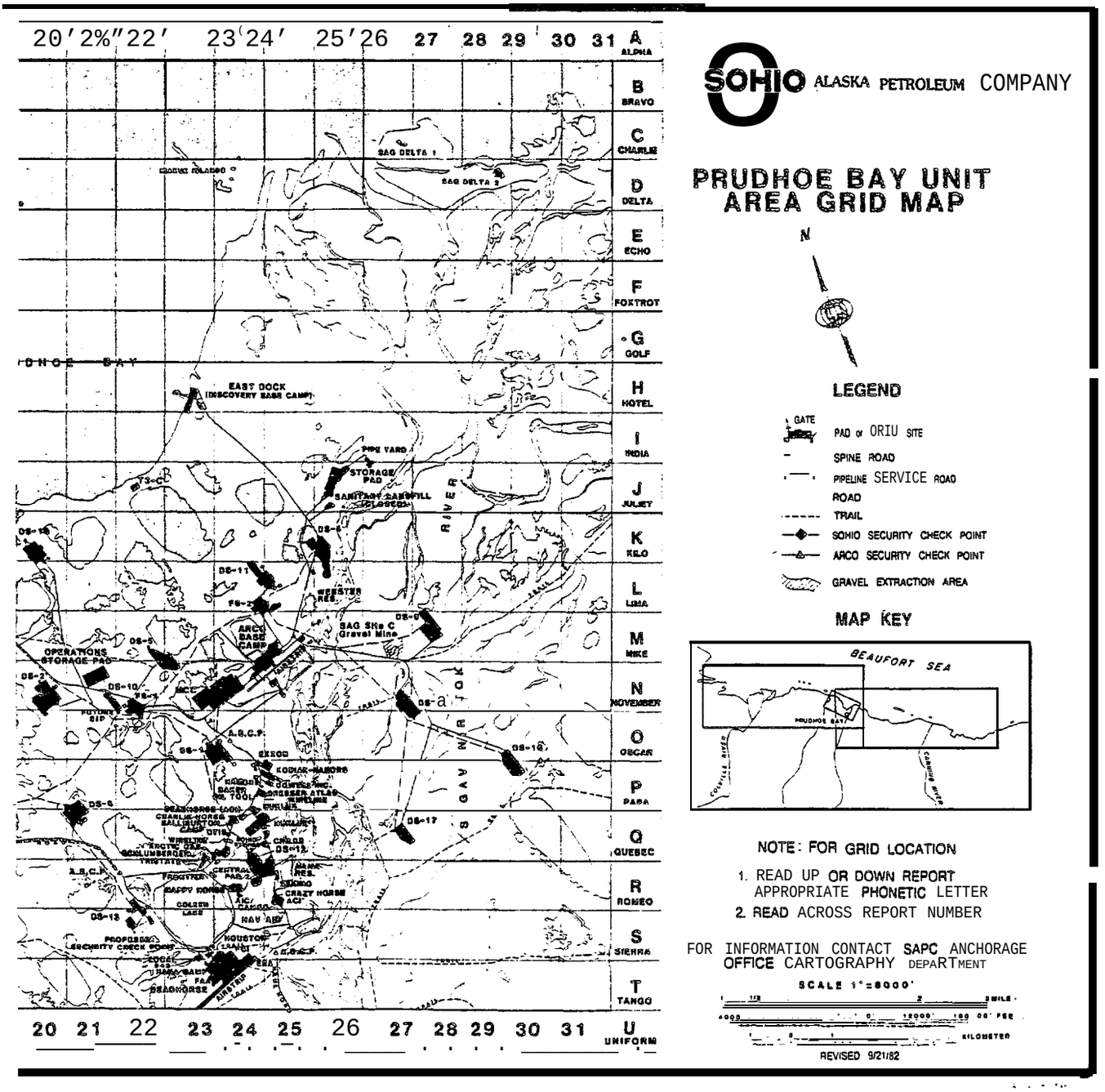
EXISTING FACILITIES, PRUDHOE BAY, 1982



Prepared by: AIR PHOTO TECH, INC.

FIGURE 6 - PART B

EXISTING FACILITIES, PRUDHOE BAY, 1982



SOHIO ALASKA PETROLEUM COMPANY

PRUDHOE BAY UNIT AREA GRID MAP

N

LEGEND

- GATE
- PAD or ORIU SITE
- SPINE ROAD
- PIPELINE SERVICE ROAD
- ROAD
- TRAIL
- SOHIO SECURITY CHECK POINT
- ARCO SECURITY CHECK POINT
- GRAVEL EXTRACTION AREA

MAP KEY

NOTE: FOR GRID LOCATION

1. READ UP OR DOWN REPORT APPROPRIATE PHONETIC LETTER
2. READ ACROSS REPORT NUMBER

FOR INFORMATION CONTACT SAPC ANCHORAGE OFFICE CARTOGRAPHY DEPARTMENT

SCALE 1"=8000'

REVISED 9/21/82

TABLE 10

CONSTRUCTION CONTRACTORS
Based or Operating at Prudhoe Bay
1983

Management Contractors

- Bechtel Corporation
- Fluor Corporation
- R. M. Parsons Comapny

Major General Contractors

- Alaska International Construction, Inc.
- Anglo Alaska Construction, Inc.
- Arctic Slope/Wright Schuchart
- Doyon Construction Company
- Fluor Corporation
- Green Construction Company
- Halvorson Construction Company
- Houston Contractors
- Peter Kiewit Sons' Company
- Morrison-Knudsen Co., Inc.
- Northwestern Construction, Inc.
- R. M. Parsons Company
- H. C. Price Construction Co.
- Wick Construction Co.

General Subcontractors

- ASAG/Gregory Cook
- Forward Alaska, Inc.
- Frontier Rock & Sand, Inc.
- Norton, Inc.
- Polar/NANA

Electrical Contractors

- Bussell Electric of Alaska
- City Electric, Inc.
- Fishback & Moore
- Kentron International, Inc.
- Southern Electric Co., Inc.

Mechanical Contractors

- C. R. Lewis Company
- National Mechanical Contractors, Inc.
- Natkin & Company
- North Slope Mechanical

Sheetmetal Contractors

- ClearWater Sheetmetal

Steel Building Contractors

- H.A.P. Enterprises, Inc.
- L & H Enterprises, Inc.
- Darrell Peterson Construction

Sources: Arctic Slope Telephone Association Co-op., Inc., ARCO Alaska, Sohio Alaska Petroleum Corporation, Veto, Inc., Doyon Drilling Co., and telephone contacts with several firms listed above.

TABLE 11

OIL INDUSTRY SUPPORT SERVICES
Based or Operating at Prudhoe Bay
1983

Geophysical Companies
- Geophysical Services, Inc.
- Harding Lawson Associates
- Mile Hi Exploration Co., Inc.
- Pearson of Alaska
- Western Geophysical Co.

Oil Field Service Companies
- Alaska Oilfield Services, Inc.
- GSL Oilfield Services Co.
- Halliburton Services
- NANA Oilfield Service, Inc.
- Oil Field Services, Inc.
- Pingo Corporation
- Udelhoven Oilfield System Services, Inc.
- Veto, Inc.

Oil Spill Clean-up
- ABSORB
- Alaska Offshore, Inc.
- Crowley Environmental Services
- Oilfield Services, Inc.

Oil Well Casing
- GBR Equipment, Inc.
- Weatherford Oil Tool Company Ltd.

Oil Well Cementing
- Dowell (Div. of DOW Chemical)
- B. J. Hughes, Inc.

Oil Well Pipe Inspection
- AMF Turboscope
- Larimer InspectionCompany

Oil Well Service Companies
- Arctic. Coiled Tubing, Inc.
- Nowsco Services

Oil Well Directional Drilling & Surveying
- Eastman Whipstock, Inc.
- Scientific Drilling Controls
- N.L. Sperry-Sun, Inc.

Oil Well Drilling
- Alaska United Drilling, Inc.
- Anglo-Nabors
- Arctic Alaska Drilling Co.
- Brinkerhoff-Signal, Inc.
- Doyon Drilling Co.
- Parker Drilling Co.
- Rowan Drilling U.S.

Oil Well Drilling Mud & Additives
- N.L. Baroid/N.L. Industries, Inc.
- Dresser/Magcobar Industries
- Milchem, Inc.

Oil Well Equipment & Supplies
- Baker Packers
- Brown Oil Tools, Inc.
- McEvoy, Div. of Smith International, Inc.
- Tri-State Oil Tool Industries, Inc.

Oil Well Logging & Perforating
- CAMCO, Inc.
- Dresser Atlas
- Gearhart Industries, Inc.
- Geo Vann
- Johnston Macco Schlumberger
- Otis Engineering Corp.

Sources: Arctic Slope Telephone Association Co-op., Inc., ARCO Alaska, Sohio Alaska Petroleum Corporation, Veto, Inc., Doyon Drilling Co., and telephone contacts with several firms listed above.

TABLE 12

TRANSPORTATION AND OTHER SERVICE FIRMS
Based or Operating at Prudhoe Bay
1983

Scheduled Air Passenger & Cargo Service
- Alaska Airlines
- Mark Air (passenger service begins 1984)
- Wien Air Alaska, Inc.

Air Charter Operators
- Air Logistics
- Audi Air
- ERA Helicopters, Inc.
- Evergreen Helicopters of Alaska, Inc.

Trucking & Heavy Hauling
- Alaska International Construction, Inc.
- Frontier Transportation Company
- Kodiak Oilfield Haulers
- Lynden Transfer Company
- Mukluk Freight Lines, Inc.

Tug & Barge & Offshore Support
- Alaska Offshore, Inc.
- Arctic Marine Freighters
- GSL Oilfield Services
- Kodiak Marine Transport., Inc.

Catering Services
- Arctic Hosts, Inc.
- Boatel Alaska, Inc.
- Greyhound Support Services, Inc.
- International Superior Services, Inc.
- NANA/Mannings
- Universal Services, Inc.

Contractors Equipment, Parts, Supplies & Service
- Airport Machinery
- Arctic Rentals
- CATCO, Inc.
- Childs Equipment Services
- Frontier Transportation Company
- McDonald Industries Alaska, Inc.
- NC Machinery Co.
- Prudhoe Bay Supply
- Sag River Hardware

Fuel Delivery
- Alaska Oilfield Service
- Kodiak Oilfield Haulers, Inc.
- Mukluk Freight Lines, Inc.
- NANA Oilfield Services, Inc.

Courier Services
- DHL Worldwide Courier Express

Security Services
- Arctic Hosts, Inc.
- NANA/Purcell
- Wackenhut/American Guard & Alert
- O'Neill Security

Surveying
- LHD/ITECH

Sources: Arctic Slope Telephone Association Co-op., Inc., ARCO Alaska, Sohio Alaska Petroleum Corporation, Veto, Inc., Doyon Drilling Co., and telephone contacts with several firms listed above.

TABLE 13

PRUDHOE BAY CAMPS AND HOTELS
1983

Rental Camps

Hotel/Camp	Owner	Number of Beds		
		Operating	Closed	Total
Crazy Horse Hotel	Crazy Horse, Inc.		380	380
Happy Horse Hotel	Alaska International Constr.	340		340
Prudhoe Bay Hotel	Simlog	230	100	330
Service City Camp	"Arctic Slope/Wright Schuchart	325		325
Frontier Main Camp	Frontier Transportation Co. .	250		250
Kuparuk Industrial Center Camp	North Slope Borough		250 (opens 1984)	250
Veto Camp	Veto, Inc.	225		225
Anglo Camp	Anglo Alaska Construction Co., Inc.	220		220
South Lake Inn	BMW Partnership	212		212
Kodiak Camp	Kodiak Oilfield Haulers, Inc.	206		206
Frontier-Delta Pad	Frontier Transportation Co.		205	205
Dalton Camp	Northern Oil Field Services	200		200
Mukluk Base Camp	Crowley Maritime Corporation	179		179
NANA Camp	NANA Oil Field Service, Inc.	165		165
Sag River Inn	Forward Alaska, Inc.	150		150
Mukluk - Camp 2	Crowley Maritime Corporation		80	80
Grizzly Bear Inn	Childs Equipment Services	70		70
Seair Camp	Seair Alaska		24	24
	Subtotal	2,772	1,039	3,811

TABLE 13

(continued)

PRUDHOE BAY CAMPS AND HOTELS

1983

Oil Company Camps

Hotel/Camp	Owner	Number of Beds		
		Operating	Closed	Total
Prudhoe Operations Center	ARCO	496		496
Prudhoe Operations Center	ARCO	1,900		1,900
Kuparuk Operations Center	ARCO	96	196 (opens 1984)	292
Kuparuk Operations Center	ARCO	650		650
Kuparuk Operations Center	ARCO	360		360
Prudhoe Operations Center	Sohio	474		474
Construction Camp 1	Sohio	480		480
Construction Camp 2	Sohio	504		504
Construction Camp 3	Sohio	612		612
	Subtotal	5,572	196	5,768

TABLE 13
(Continued)

PRUDHOE BAY CAMPS AND HOTELS
1983

Non-rental Camps

Hotel/Camp	Owner	Number of Beds		
		Operating	Closed	Total
Surfcote Camp	Bredero/Price		94	94
Slumber J	Schlumberger Offshore Services	64		64
Sleepy Bear Camp	Arctic Pipe Engineering	61		61
	North Slope Borough	60		60
Deadhorse Camp	Halliburton Services	50		50
	Dowell/Schlumberger	50		50
	Dresser Atlas	48		48
	Geophysical Services, Inc.	35		35
	Cameo, Inc.	32		32
	Western Geophysical	30		30
	Gearhart Industries, Inc.	30		30
	Wien Air Alaska, Inc.	18		18
	Alaska Airlines	17		17
	Parker Drilling Co.	14		14
	Exxon	14		14
	C. R. Lewis Co.		13	13
	Baker Packer	12		12
	Dresser/Magcobar Industries	11		11
	Prudhoe Bay Supply	9		9
	Houston Contractors	4		4
	Audi Air	2		2
	Subtotals	561	107	668
	TOTALS	8,905	1,342	10,247

Sources: Kevin Waring Associates survey of the owners listed above.

taxed the existing infrastructure. In fact, the Beaufort Sea operations have helped to take up some of the slack created by a drop in the demand for contracting and support services which has occurred at Prudhoe Bay since 1980.

Logistics

The distinctive characteristics of each of the Alaskan offshore lease areas has led to differing arrangements for logistics support. In the immediate area of Cook Inlet, exploration and development activities were located in close proximity to the Anchorage and Kenai Peninsula support centers. This circumstance led to extensive use of short-haul marine support to the offshore drilling platforms and extensive use of air support for personnel movement and some supplies.

For the more remote Gulf of Alaska exploration, it was necessary to enhance the support capabilities of port areas such as Seward, or to establish a new forward base at Yakutat. Without surface access to Yakutat, movement of major supplies and equipment into the staging area required maximum use of marine logistics support. That same mode was used for delivery of most supplies and crew transfers from shorebases to the exploratory. rigs. Air support for the movement, of personnel and some supplies was also used, but distances and weather conditions made this more difficult than it would have been in the Cook Inlet area.

For support of their Beaufort Sea exploration programs, operators have been able to use the extensive air, marine and surface transportation

facilities and services which already exist at Prudhoe Bay/Deadhorse. Although weather conditions preclude marine transportation during the winter months, the Dalton Highway provides an important year-round land transportation link. Year-round overland transportation was not available for Gulf of Alaska exploration and will not be available to support offshore operations in western Alaska OCS provinces. The following sections describe the air, marine and surface logistics used to support petroleum development in the Prudhoe Bay area in general and how these modes were used to support. Beaufort Sea exploration.

AIR LOGISTICS

Air transportation services. for the Prudhoe Bay area are based at the Deadhorse Airport, about five miles south of Prudhoe Bay, which is owned and operated by the State of Alaska. Nearly all of the traffic through the Deadhorse Airport is oil industry related. Although Fairbanks, located about 380 miles south of Deadhorse, is closer, Anchorage, located about 550 miles south of Deadhorse, serves as the primary air link. Most passengers and air cargo for Deadhorse originate at or are routed through Anchorage. Fairbanks is an intermediate stop on some Anchorage-Deadhorse flights.

The airport has a 6,500-foot by 150-foot paved, lighted runway. There is no active control tower at Deadhorse, but the Federal Aviation Administration operates a full-time flight service station from 9:00 a.m. to 10:30 p.m. Monday through Friday there are seven scheduled passenger jet flights per day between Anchorage and Deadhorse. Some of

these flights have intermediate stops in Fairbanks. In addition ARCO and Sohio have two non-stop jet charters per day each between Anchorage and Deadhorse.

In 1981 Alaska Airlines opened a new 40,000-square-foot terminal at the Deadhorse Airport. The terminal includes a ticket counter, passenger holding area, baggage handling, housing for 17 airline personnel, warehousing, refrigerated storage, shop facility, office space and leaseable space. Wien Airlines has a separate 15,800-foot terminal with a ticket counter, passenger holding area, baggage handling, housing for 18 airline personnel, warm storage and office space.

Alaska Airlines and Wien Airlines transported cargo on their passenger flights. In addition Mark Air (formerly Alaska International Air) has a base at Deadhorse and one scheduled cargo flight per day between Anchorage and Deadhorse. Mark Air was scheduled to begin passenger service between Anchorage and Deadhorse in May 1984. It should be noted that air service to Deadhorse is highly competitive and subject to frequent changes in schedules and service levels.

Nearly every exploratory well covered in this report has made some use of air logistics for the transfer of personnel and light supplies from onshore bases to the offshore exploration. sites. The use of air logistics for exploration support has increased with distance from the shorebases, particularly for the movement of personnel. Where possible, particularly during winter operations personnel are moved by bus or similar vehicle if the distance permits that to be done economically.

As the operations have moved further offshore, aircraft have become more commonly used for movement of personnel. Materials and equipment movement are generally limited to lighter goods for air movement. Aircraft are heavily relied upon for emergency requirements and for special missions during mobilization or key parts of the drilling operations.

Helicopters are the most common mode for offshore air logistics. Two principal companies providing this service for the Beaufort Sea operations have been ERA Helicopters and Evergreen Helicopters. Both companies are headquartered in Anchorage but have support operations in the Prudhoe Bay area near the Deadhorse Airport. Helicopter services have also been provided by Air Logistics, Inc., another Anchorage based company. On relatively short notice, these three operators can bring in additional aircraft from elsewhere in the state. Air Logistics has provided most of the fixed wing support for the Beaufort Sea area. The fixed wing aircraft used for this purpose has been the 16-passenger CASA STOL . This particular aircraft is uniquely suited to the short runway operations required for drill site support.

Generally, the support has been provided from the shorebases on either a scheduled or on-call basis. However, there have been instances of basing of the aircraft at the island so that they are immediately available to support around-the-clock operation as well as for emergency services that may be required. Nearly all helicopter service has used the Bell 212 IFR equipment, with some use of the Bell 206 helicopter. Except for very close-in operations where the Bell 206 has been used with a single pilot, all operations have been conducted with both a pilot and co-pilot onboard the aircraft.

The Bell 212 (IFR) helicopter used for offshore operations in the Beaufort Sea has a basic cost of about $2,000,000. Lease rates will vary to some extent. However, one rate quoted for this aircraft with pilot and co-pilot was $53,000 monthly, plus $415 per hour of flight time. The cargo capacity for the Bell 212 in an all-cargo configuration is 3,800 pounds, while the maximum non-crew passenger capacity is thirteen.

The flight crews (pilot and co-pilot) for helicopter and fixed wing operations stationed at Deadhorse typically work a 12-hour shift -- maximum 7:00 a.m. to 7:00 p.m. for a single shift. The operational day is' limited by Civil Aeronautics Board regulations. The usual personnel rotation schedule is 14 days on, 14 days off, with overlapping rotation of the pilot and co-pilot to ensure operational continuity. Most air crew members are based in the Anchorage area according to aviation company managers.

Table 14 provides data on air services contractors aircraft equipment, aircraft crews, passenger and cargo capacity and shorebase location employed for each exploratory well project.

MARINE LOGISTICS

Marine transportation is used to move large modules and other bulk items from the 'Lower 48' to Prudhoe Bay on the annual summer sea lift. These shipments are transported via ocean-going tug and barge combinations, Since 1968 Crowley Maritime has handled most of the Prudhoe Bay sea lift traffic. Four barge unloading facilities serve the Prudhoe Bay area:

one at the Prudhoe Bay East Dock, "two at the Prudhoe Bay West Dock and one at the Oliktok Point Dock. In addition to material brought. in on the sea lift, marine transport from these dock facilities is used to transport equipment and supplies in support of Beaufort Sea exploration during open water periods.

The Prudhoe Bay East Dock was built in 1969 during the original development of the Prudhoe Bay field. The East Dock is located in the southeast portion of Prudhoe Bay at the end of a 1,100-foot by 30-foot gravel causeway. During the summer lighterage barges are grounded to provide a 270-foot by 100-foot wharf. Prior to 1981 this dock was used to unload smaller barges from the MacKenzie River. Since that time the primary use of the dock during the summer has been for loading gravel into shallow-draft barges for use in construction of artificial islands. During winter months the East Dock has been used as the take-off point for hauling gravel via ice roads to build artificial islands. The East Dock is also used extensively for stockpiling gravel and other commodities to be transported to offshore operations in the Beaufort Sea.

The Prudhoe Bay West Dock, situated in the northwest part of the bay, is now the main dock at Prudhoe Bay. It handles the unloading of barges and modules in the annual sea lift and has also been used for marine operations in support of Beaufort Sea activities. Prior to 1982 the West Dock was a 10,100-foot by 40-foot gravel causeway with two unloading facilities. The first, built in 1974, is 4,500 feet from shore and has a six-foot draft. The second facility is located 10,000 feet from shore and has a 10-foot draft. This facility is used for unloading the

TABLE 14

AIR SUPPORT OPERATIONS
SALE BF & SALE 71 EXPLORATION
1980 - 1983

1980 - 1981

	Challenge Island #1	Sag Delta #7	Sag Delta #8	Sag Delta #9	Sag Delta #10
Sale and Tract Number	BF 108	BF 76	BF 75	BF 76	BF 76
Lease Operator	Sohio	Sohio	Sohio	Sohio	Sohio
Air Services Contractor	Evergreen Helicopters Air Logistics - Fixed-wing	None	None	Evergreen Helicopters Note: Used only until ice road completed.	None
Aircraft Identification	Bell 212 IFR Helicopter CASA STOL, fixed-wing twin-engine, turbo prop			Bell 212 IFR Helicopter	
Aircraft Crew	Helo: Pilot & Copilot (weekly rotation) STOL: Pilot & Copilot (weekly rotation)			Pilot & Copilot	
Passenger Capacity	Helo: 10 passengers STOL: 16 passengers			10 passengers	
Cargo Capacity	Helo: 3,000 lbs. STOL: 4,000 lbs.			3,000 lbs.	
Shorebase Location	Both aircraft stationed on island; maintenance facility at Deadhorse.			Deadhorse	
Trip Data	Helo: 1 trip/day each for passengers & freight; STOL: 3 trips/week for passengers & freight			Daily passenger & cargo flights	

TABLE 14
(Continued)

AIR SUPPORT OPERATIONS
SALS BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1981 - 1982

	Alaska Island #1	Alaska State D #1	Alaska State F #1	No Name Island #1
Sale and Tract Number	BF 109	BF 114	BF 111	BF 62
Lease Operator	Sohio	Exxon	Exxon	AMOCO
Air Services Contractor	Evergreen Helicopters Era Helicopters Air Logistics - Fixed-wing	Evergreen Helicopters	Evergreen Helicopters	Evergreen Helicopters
Aircraft Identification	Evergreen - Bell 212 ERA - Bell 212 Air Log: CASA STOL	Bell 212 IFR	Bell 212 IFR	Bell 212 IFR
Aircraft Crew	Pilot & Co-pilot Pilot & Co-pilot Pilot & Co-pilot	Pilot & Co-pilot	Pilot & Co-pilot	Pilot & Co-pilot
Passenger Capacity	10 passengers 10 passengers 16 passengers	10 passengers	10 passengers	13 passengers
Cargo Capacity	3,000 lbs. 3,000 lbs. 4,000 lbs.	3,000 lbs.	3,000 lbs.	3,800 lbs.
Shorebase Location	Evergreen Helo & Air Log STOL stationed on island; Maintenance facility at Deadhorse. ERA Helo at Deadhorse.	Deadhorse	Deadhorse	Deadhorse & Sleepy Bear Camp
Trip Data	Evergreen Helo: Daily, passenger & cargo flights; STOL: 3 passenger & cargo flights per week; ERA Helo: Casual use.	15 passenger trips/week 10 cargo flights/week	15 passenger trips/week 10 cargo flights/week	3 flights/day during drilling operations; during mobilization, round-the-clock operations with 2 flight crews.

TABLE 14
(Continued)

AIR SUPPORT OPERATIONS
SALE BF & SALE 71 EXPLORATION RAM
1980 - 1983

1981 - 1982
(Continued)

	Exploration Well Name				
	OCS-Y0191 #1	OCS-Y0191 4}2	Jeanette Island #1	Tern island #1	Tern Island #2
Sale and Tract Number	BF 37	BF 37	BF 79	BF 42	BF 43
Lease Operator	Exxon	Exxon	Chevron	Shell	Shell
Air Services Contractor	Evergreen Helicopters	Evergreen Helicopters	ERA Helicopters	ERA Helicopters Evergreen Hel i copters	ERA Helicopters Evergreen Helicopters
Aircraft Identification	Bell 212 IFR	Bell 212 IFR	Bell 212 IFR	Bell 212 IFR	Bell 212 IFR
Aircraft Crew	Pilot & Co-pilot (2 weeks on/2 weeks off)	Pilot & Co-pilot (2 weeks on/2 weeks off)	Pilot & Co-pilot (2 weeks on/2 weeks off)		
Passenger Capacity	10 passengers	10 passengers	10 passengers		
Cargo Capacity	3,000 lbs.	3,000 lbs.	3,000 lbs.		
Shorebase Location	Deadhorse	Deadhorse	Deadhorse	Deadhorse	Deadhorse
Trip Data	15 passenger flights/week 10 cargo flights /week	Minimal use because of availability of ice road.	10/81-1/82: 10 to 12 trips daily to haul fuel & supplies until ice road completed. Fuel: 500 gals. /trip. Average 1 trip daily for passengers. 2/82-3/82: Average 1 trip daily for passengers; no freight.		

TABLE 14
(Continued)

AIR SUPPORT OPERATIONS
SALE BF L SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1982 - 1983

	Exploration Well Name		
	Seal Island #1	Cross Island #1	Mukluk
Sale and Tract Number	BF 47	BF 54	71 191
Lease Operator	Shell	Gulf	Sohio
Air Services Contractor	ERA Helicopters Evergreen Helicopters	ERA Helicopters	Air Logistics
Aircraft Identification	Bell 212 IFR	Bell 212	Bell 212 IFR
Aircraft Crew		2 Pilot	Pilot & Co-pilot (double crew for 2 shift operation -- 2 weeks on/ 2 weeks off)
Passenger Capacity		12 passengers	13 passengers
Cargo Capacity		Used for light cargo only	3,800 lbs
Shorebase Location	Deadhorse	Deadhorse	Deadhorse maintenance base, but Milne Point used for support. base location because of distance; on lease from Amoco.
Trip Data		Passenger & small cargo	1 aircraft on exclusive use charter, with double crew (2 pilots & 2 co-pilots); mixed passenger & cargo carried on trips; on-call continuous use rather than fixed schedule.

Source: Operator interviews; exploration plans.

400-foot by 100-foot modules and other bulk items transported to Prudhoe on the sea lift. In 1982 the Prudhoe Bay West Dock was lengthened in conjunction with the waterflood project. A mile-long breached gravel causeway was added, an island built, and the existing causeway widened to accommodate a water intake facility for the waterflood project. The West Dock now extends 2½ miles offshore and reaches a depth of 12 feet.

During the winter of 1982 ARCO constructed a new dock at Oliktok Point about 33 miles west of Prudhoe Bay West Dock to serve the Kuparuk River Unit oil field development. ARCO built a 975-foot by 225-foot gravel causeway and a dock with a six- to eight-foot draft. In 1983 ARCO widened the causeway to 324 feet. and the dock was used to handle the off-loading of freight and modules from sea lift support of Kuparuk development. To date the Oliktok Point dock has not been used extensively in support of Beaufort Sea development. However, the gravel hauling operations for the Mukluk project used the road to the dock and the ice road to Thetis Island began near the dock.

Marine transportation has been used for the movement of gravel to build gravel islands, the transport of additional gravel to existing islands, and the initial transport of the drill rig, camp material and equipment to a site in preparation for drilling. Two principal contractors have performed the bulk of this work, namely Arctic Marine Freighters (a Crowley Maritime company) and Kodiak Marine Transport. The shorebase consistently used for support of local marine transportation is the West Dock at Prudhoe Bay. Types of barges employed have included flat deck barges used for truck or gravel transport, fuel barges and camp barges.

In some instances barges have been left on station at the drill site to serve as a camp barge or a fuel barge, or to provide extra room at a small, contained site. Table 15 summarizes data on marine transportation contractors used for each site, the shorebase location, the type and numbers of vessels utilized for that support, typical crew composition and other information on trip schedules, tonnage, etc.

As a general rule the use of marine logistics has been confined to transportation of drill rigs, camp facilities, and general equipment and bulk supplies. The only instance of significant use of marine transportation for personnel transfer was during construction of Endeavor and Resolution gravel islands, when crew boats were used to transport gravel placement crews to the worksite.

The principal innovation in use of marine logistics, which formerly was mainly confined to the long-range annual sealift, was the use of the marine mode for local support during the open-water periods of summer and early fall. Marine support proved a cost effective means of transportation during that time. However, transport of the drill rig and camp and other support equipment during the ice-free months results in considerable standby costs until drilling is permitted. Therefore, there is added cost compared to movement of the equipment and supplies by truck over an ice road directly from the Prudhoe Bay area just before commencement of drilling.

TABLE 15

MARINE LOGISTICS
SALE BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1980 - 1981

	Exploration Well Name				
	Challenge Island #1	Sag Delta #7	Sag Delta #8	Sag Delta #9	Sag Delta #10
Sale and Tract Number	BF 108	BF 76	BF 75	BF 76	BF 76
Lease Operator	Sohio	Sohio	Sohio	Sohio	Sohio
Marine Transport Contractor	Arctic Marine Freighters	None	None	Arctic Marine Freighters	None
Shorebase Location	Prudhoe Bay West Dock	N/A	N/A	Prudhoe Bay West. Dock	N/A
Vessels Utilized	2 Tugs ; 4 Barges	N/A	N/A	2 Tugs; 5 Barges (1 fuel barge remained at island for fuel storage]	N/A
Crew Number & Composition	Each Tug: Captain, Mate, Engineers Deckhand, Cook; total 5.	N/A	N/A	Each Tug: Captain, Mate, Engineer, Deckhand, Cook; total 5.	N/A
Trip Information (tonnage, scheduling, etc.)	6,000 tons, handled in 16 trips. Rig #36; 50-person camp; 875,000 gals. diesel fuel; 37,000 sacks mud & chemicals; 6,723 cu. ft. cements.	N/A	N/A	4,150 tons, handled in 16 trips. Rig #26E; 60-person camp; 500,000 gals. diesel fuel; 11,800 sacks mud & chemicals.; 6,300 cu. ft. cements.	N/A
	Note: Demobilization via ice road.	Note: Ice road used for transport.	Note: Ice road used for transport.		Note: Ice road used for transport & demobilization:

TABLE 15
(Continued)

MARINE LOGISTICS
SALE BF & SALS 71 EXPLORATION RAM
1980 - 1983

1981 - 1982

	Exploration Well Name			
	Alaska Island #1	Alaska State D #1	Alaska State F #1	No Name Island #1
Sale and Tract Number	BF 109	BF 114	BF 111	BF 62
Lease Operator	Sohio	Exxon	Exxon	Amoco
Marine Transport Contractor	Arctic Marine Freighters, Kodiak Marine	Arctic Marine Freighters	Arctic Marine Freighters	Arctic Marine Freighters
Shorebase Location	Prudhoe Bay West Dock	Prudhoe Bay West Dock	Prudhoe Bsy West Dock	Prudhoe flay West Dock
Vessels Utilized	2 Tugs; 5 Barges	2 Tugs; 4 Barges	2 Tugs; 4 Barges	2 Tugs; 4 Barges
Crew Number & Composition	Total of 5 for each tug: CapLain, Mate, Engineer, Deckhand, Cook.	Total of 5 for each tug: Captain, Mate, Engineer, Deckhand, Cook.	Total of 5 for each tug: Captain, Mate , Engineer, Deckhand, Cook.	Total of 5 for each tug: Captain, Mate, Engineer, Deckhand, Cook.
Trip Information (tonnage, scheduling, etc.)	7,000 tons, 25 trips to island for mobilization. 3,500 tons/12 trips from island to Prudhoe Bay for demobilization.	1,900 tons to island during mobilization; ice road used for support of operations. Demobilization by truck via ice road.	5,100 tons to island during mobilization, drill rig, camp supplies. Demobilization also by barge.	Movement of Parker drill rig, camp equipment. and supplies in July 1981. Gravel haul/pad construction support was via ice road. Demobilization via ice road.

TABLE 15
[Continued]

MARINE LOGISTICS
SALE BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1981 - 1982 .
(Continued)

	Exploration Well Name				
	OCS-Y0191 #1	OCS-Y0191 #2	Jeanette Island #1	Tern Island #1	Tem Island #2
Sale and Tract Number	BF 37	BF 37	BF 79	BF 42	BF 43
Lease Operator	Exxon	Exxon	Chevron	Shell	Shell
Ma rine Transport. Contractor	Arctic Marine Freighters	Arctic Marine Freighters	Arctic Marine Freighters GSI Marine	Crowley Maritime	Crowley Maritime
Shorebase Location	Prudhoe Bay, West Dock	Prudhoe Bay, West Dock	Prudhoe Bay, West Dock		
Vessels Utilized	2 Tugs; 5 Barges	2 Tugs; 4 Barges for demobil ization	3 Tugs; 3 Barges from AMF for mobilization; 1 self-propelled barge from GSI Ma rine.		
Crew Number & Composition	Total of 5 foreach tug: Captain, Mate, Engineer, Deckhand, Cook.	Totalof 5 for each tug: Captain, Mate, Engineer, Deckhand, Cook.	Total of 5 for each tug: Captain, Mate, Engineer, Deckhand, Cook.		
Trip Information [tonnage, scheduling, et-c.)	5,200 tons including drill rig, camp, supplies & equipment. No demobilization; rig moved to OCS-Y0191 #2.	Rig and camp. Demobilization by barge.	Drill rig, camp, supplies & equipment; ice deflectors: 10 days operation over 20-day period. 3 AMF barges sunk in lee of island for work and supply purposes during drilling. Major demobilization by ice road. Final demobilization of 3 barges from island with ice deflectors, heavy equipment used to renovate drilling area, and remaining equipment.		

TABLE 15

(Continued)

MARINE LOGISTICS
SALE BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1982 - 1983

	Exploration Well Name		
	Seal Island #1	Cross Island #1	Mukluk
Sale and Tract Number	BF 47	BF 54	71 191
Lease Operator	Shell	Gulf	Sohio
Marine Transport Contractor	Crowley Maritime Kodiak Marine	Arctic Marine Freighters	Arctic Marine Freighters & Kodiak Marine
Shorebase Location		Prudhoe 'Ray, West Dock	Prudhoe Bay, West Dock
Vessels Utilized		2 Tugs; 5 Barges	Arctic Marine: 8 flat deck barges to haul gravel, plus camp support barge & construction equipment barge; 9 tugs. Kodiak Marine: 2 barges & 2 tugs.
Crew Number & Composition		Total of 5 for each tug: Captain, hate, Engineer, Deckhand, Cook.	Total of 5 for each tug: Captain, Hate, Engineer, Deckhand, Cook.
Trip Information [tonnage, scheduling, etc.)		Alaska United drill rig #1; 70-man camp; equipment; drilling supplies; food supplies. 12 barge loads over a 7-day period July-August 1983.	Alaska United rig #2; 70-man camp; all supplies & equipment.

Source: Operator interviews, exploration plans.

Marine operations become more important as the distance of exploration sites from Prudhoe Bay increases to the east or the west, and as the exploratory operations move further from shore to the deeper areas of the Beaufort Sea.

SURFACE LOGISTICS

The key element in support arrangements for the Beaufort Sea exploration activities has been the availability of surface access via the Dalton Highway from Fairbanks to Prudhoe Bay. While massive modular buildings and the heavier equipment must still be moved by sea during the annual sea lift, the Dalton Highway allows year-round overland delivery of supplies and equipment into the Prudhoe Bay area for exploration and development activities.

The Dalton Highway (formerly the North Slope Haul Road) provides an important land link to Fairbanks, Anchorage and points south in support of North Slope development. The Dalton Highway is a two-lane secondary arterial. Road conditions vary considerably, but are frequently poor with numerous safety hazards. A wide variety of commodities and equipment are trucked over the highway to the North Slope. The table below summarizes North Slope truck traffic trends from 1978-1983:

TABLE 16

AVERAGE DAILY TRUCK TRAFFIC*

DALTON HIGHWAY

(at Yukon River Bridge)

1978	1979	1980	1981	1982	1983
45	42	68	108	115	90

* Counts traffic going both ways.

Source: Community Research Center, Fairbanks North Star Borough

It is not possible to determine precisely how many of these truck loads were hauled to the North Slope to support Beaufort Sea activities. However, given that peak activity for Beaufort developments occurred during the 1980-82 period, it is logical to assume that a portion of the increased traffic in the period was due to Beaufort activity.

About a dozen motor carriers move 80 to 90 percent of the North Slope bound truck traffic. Carriers often specialize in the types of cargo they transport with different firms hauling petroleum products, drilling muds, pipe, or refrigerated cargo.

Some cargo destined for Prudhoe Bay is transported via barges or ships to the Southcentral ports of Whittier or Seward, shipped by rail to Fairbanks and then trucked from Fairbanks to the North Slope. Most of the pipe and pipe fittings are brought in through Seward, while other commodities are transported via Whittier.

The extensive development of the Prudhoe Bay and Kuparuk fields have led to the development of an extensive local industrial" road system. This upland system, joined with the seasonal ice roads, provides a usable surface link from the mainland to many offshore drill sites. This road system has been used for local transport of supplies and personnel and for transport of large volumes of gravel fill for use in island construction and enhancement of drill pads on some of the barrier islands.

As shown later in Tables 18 and 19, every exploration program made use of the local surface transportation network for goods in transit to the West Dock at Prudhoe Bay for forwarding by barge or directly to drill site via an ice road and surface (truck) transportation.

The role of surface transport in Beaufort Sea exploration is reflected in employment data (see Table 22) which shows the estimated manhours and costs directly attributed to the transportation and construction efforts. It is significant to note that the relatively shorter distances involved in nearshore exploration activities have permitted more expeditious and cost effective surface transportation. The comparative cost savings are due in part to avoidance of extra handling required if both ground and marine transportation modes are used.

Based on data obtained. from operators and transportation contractors the mobilization of the drill rig, camp, and supporting equipment and supplies to a drill site typically took 5 to 5½ days when accomplished entirely by surface transportation. On the other hand, mobilization by

ground transportation to the West Dock for transshipment by barge to the drill site took approximately 7 to 7½ days.

Gravel Islands

OVER-VIEW

Of the 15 Sale BF exploration wells drilled before November 1, 1983, six were based on five natural islands within state leased tracts: Challenge Island, Alaska Island, No Name Island, Flaxman Island (two wells) and Jeanette Island. The nine remaining exploratory wells were sited on submerged tracts which required artificial drilling platforms.

The environmental and technical conditions prevailing in the Sale BF and Sale 71 submerged tracts generally preclude deployment of such standard offshore exploratory drilling platforms as jack-up rigs, semi-submersible rigs or drillships. Though suitable for open water drilling, this equipment is not well suited to conditions in this sector of the Beaufort Sea. (Union Oil is considering use of an ice-reinforced drillship for exploration of a deepwater tract acquired in Sale 87.) Likewise, manmade ice islands, built and used for drilling over a single winter, have not been used in the Beaufort Sea sale tracts, though they have proved feasible in other arctic regimes. Instead, for submerged Sale BF and Sale 71 tracts, where natural islands were not available to serve as a drilling platform, the preferred approach has been to construct an artificial gravel island at the drillsite. The manmade gravel island then served as a fixed platform upon which conventional arctic upland

drilling equipment was installed. The locations of the artificial islands built for Sale BF and Sale 71 drilling are shown in Figures 7 and 8.

Altogether, seven gravel islands have been built for Sale BF and Sale 71 exploration. All nine exploratory wells on submerged Sale BF tracts were based OKI five manmade gravel islands: Endeavor Island (three wells), Resolution Island, Unnamed Island (two), Tern Island (two) and Seal Island. See Table 17. As an interesting sidelight, it should be noted that Endeavor and Resolution Islands were actually grounded on submerged State lands outside the Sale BF area. The drilling targets in Sale BF Tracts 75 and 76 were reached by directional drilling from these islands. The single new Sale BF drilling program scheduled for the 1983/1984 drilling season was also planned for Gulf's manmade gravel island named Cross Island and immediately adjacent- to the natural barrier island of the same name.

As for Sale 71 tracts, while no exploration wells were spudded before start of the 1983/1984 drilling season, four exploration programs were pending or planned at that time. Sale 71 included only federal tracts, by definition three or more miles from surface lands. All of these proposed exploration programs will require artificial drilling bases in water depths ranging from 44 to 50 feet. These exploration programs are Sohio's Mukluk project (planned for 1983/1984) and Exxon's Antares project, Shell's Sandpiper project and Texaco's Fur Seal project (all proposed for 1984/1985).

TABLE 17

EXPLORATORY WELLS ON ARTIFICIAL ISLANDS
SALE BF AND SALE 71
THROUGH 12/83

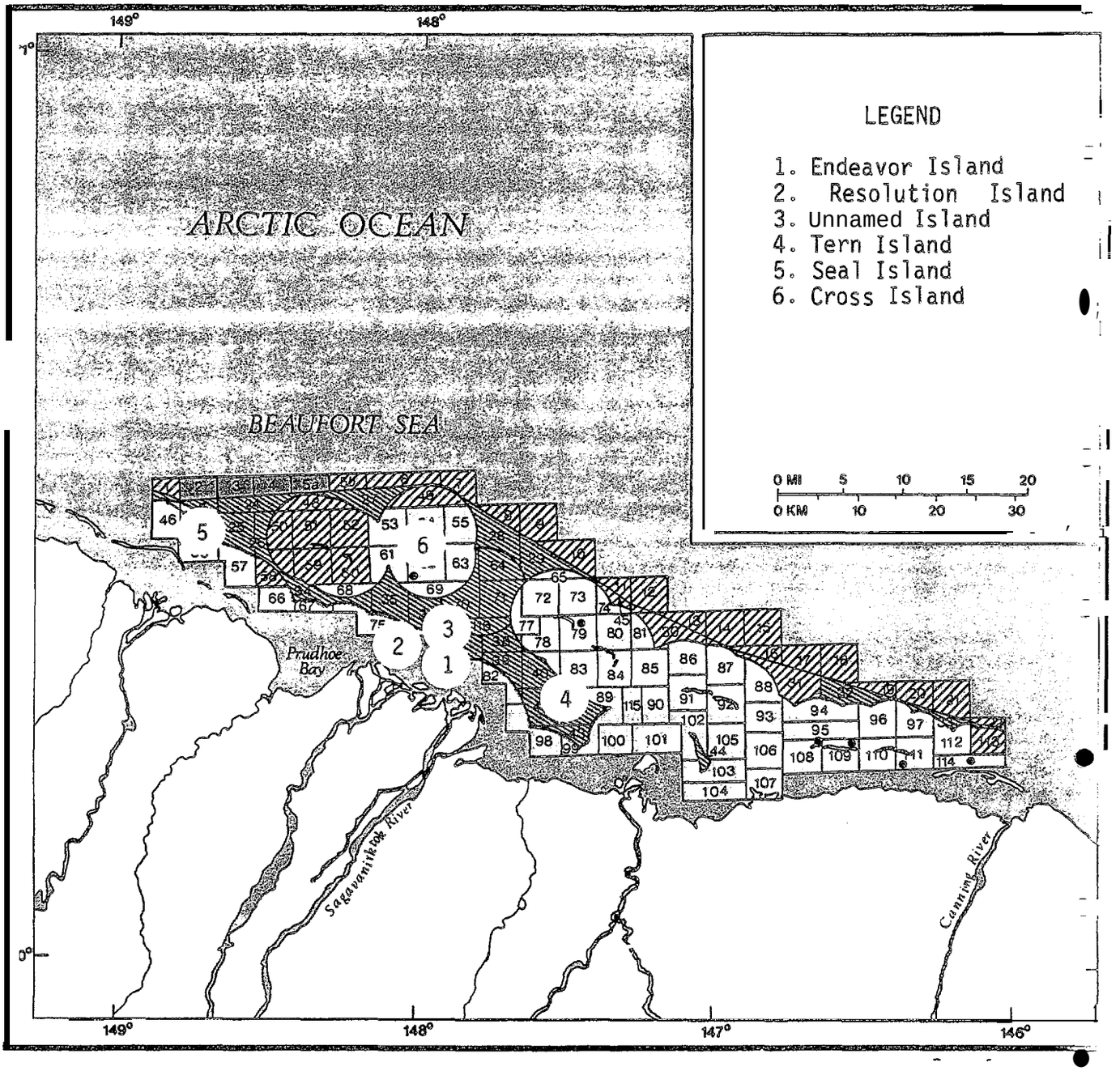
Name of Island	Number of Exploratory wells
Endeavor Island	3
Resolution Island	1
Unnamed Island	2
Cross Island	1a
Tern. Island	2
Seal Island	1
Mukluk Island	1[a]
TOTAL	12

a Cross Island and Mukluk Island were constructed during the winter of 1982-1983. The wells were not spudded until November 1983.

Source: Minerals Management Service

FIGURE 7

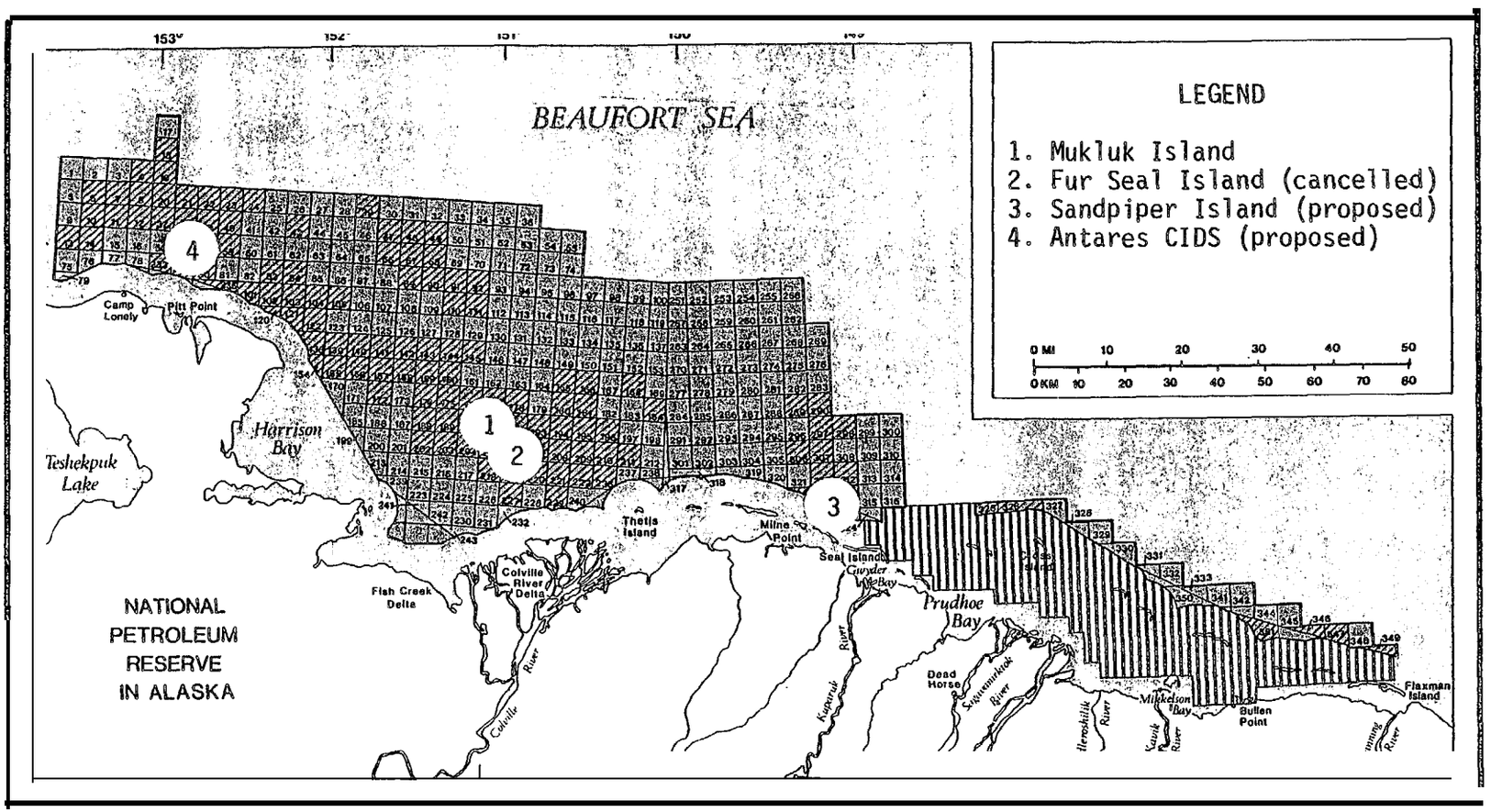
LOCATION OF ARTIFICIAL GRAVEL ISLANDS
SALE BF



NOTE: Base map adapted from Rogers, Golden & Halpern. 1983b. Arctic Summary Report Update.

FIGURE 8

LOCATION OF EXISTING AND PROPOSED
ARTIFICIAL DRILLING PLATFORMS
OCS LEASE SALE 71



NOTE: Base map adapted from Rogers, Golden & Halpern 1983b. Arctic Summary Report Update.

Mukluk Island was constructed during the winter and summer of 1983 for use at the start of the 1983/1984 drilling season. Built at a cost estimated by Sohio of about $100 million, Mukluk Island is part of the most expensive offshore exploratory drilling program to date, exclusive of lease acquisition outlays. Appendix D, Engineering and Construction of Mukluk Island (Ashford, 1984) gives an excellent account of Mukluk Island's construction history. This paper illustrates the influence of regulatory logistic and technical constraints on the design program, as well as the need for operating flexibility and improvisation in the face of adverse weather and other operating conditions.

Exxon's Antares project proposed to employ a Concrete Island Drilling Structure (CIDS), a mobile drilling platform specially designed for arctic offshore use. (See Wetmore, 1984 for an explanation of the CIDS design concept developed by Global Marine Development for arctic offshore drilling projects.) Global's first CIDS was built by the Japanese shipyard Nippon Kokan KK for use on Exxon's Antares project and delivered to the drilling location in fall 1984.

Shell's exploration plan for its Sandpiper project proposes construction of a conventional artificial gravel island as did Texaco's now cancelled exploration plan for its Fur Seal project over the Mukluk structure.

To sum up, 14 of the 15 exploratory wells completed or proposed for submerged tracts in Sale BF and Sale 71 were to be drilled on artificial gravel islands. The exception was Exxon's Antares prospect for which the CIDS system is planned. (Four artificial gravel islands were built

to support exploration of nearshore submerged state tracts leased in earlier state sales. These islands are in the vicinity of the Endicott Project and are not covered in this discussion which treats only islands built for Sales BF and 71.)

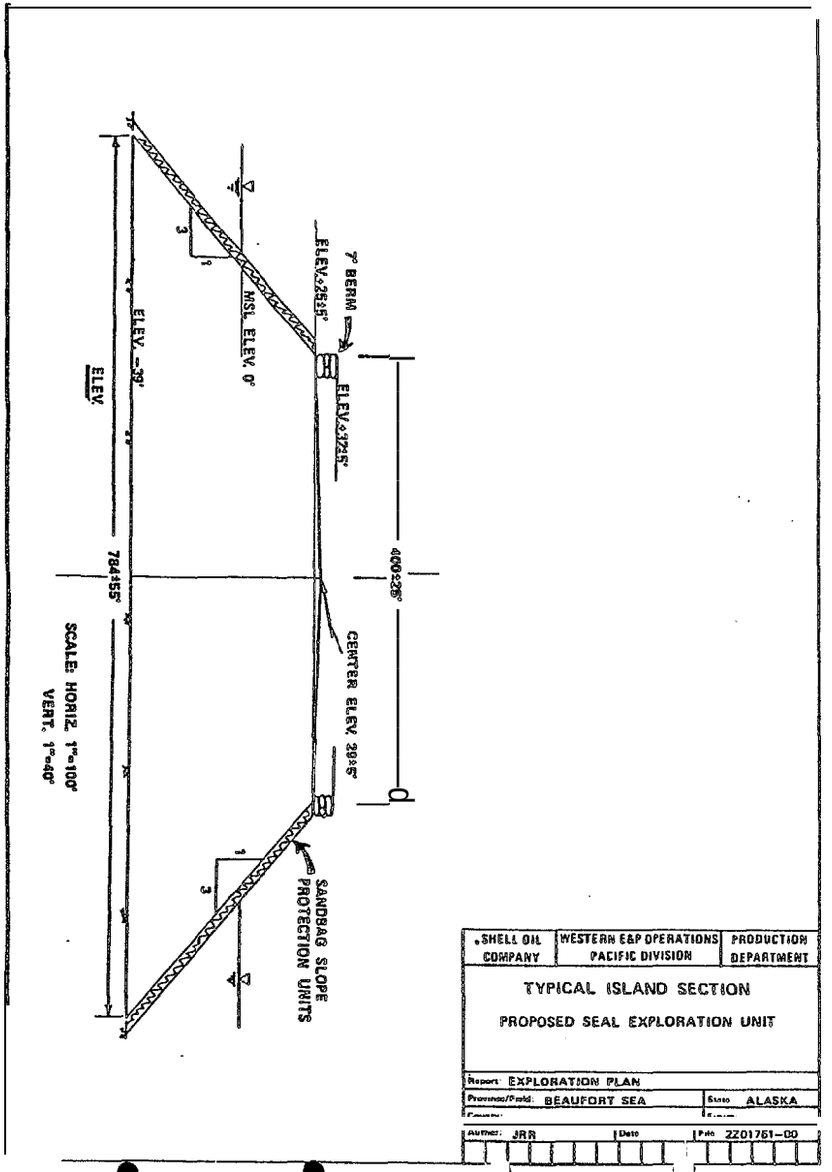
DESIGN CONCEPT

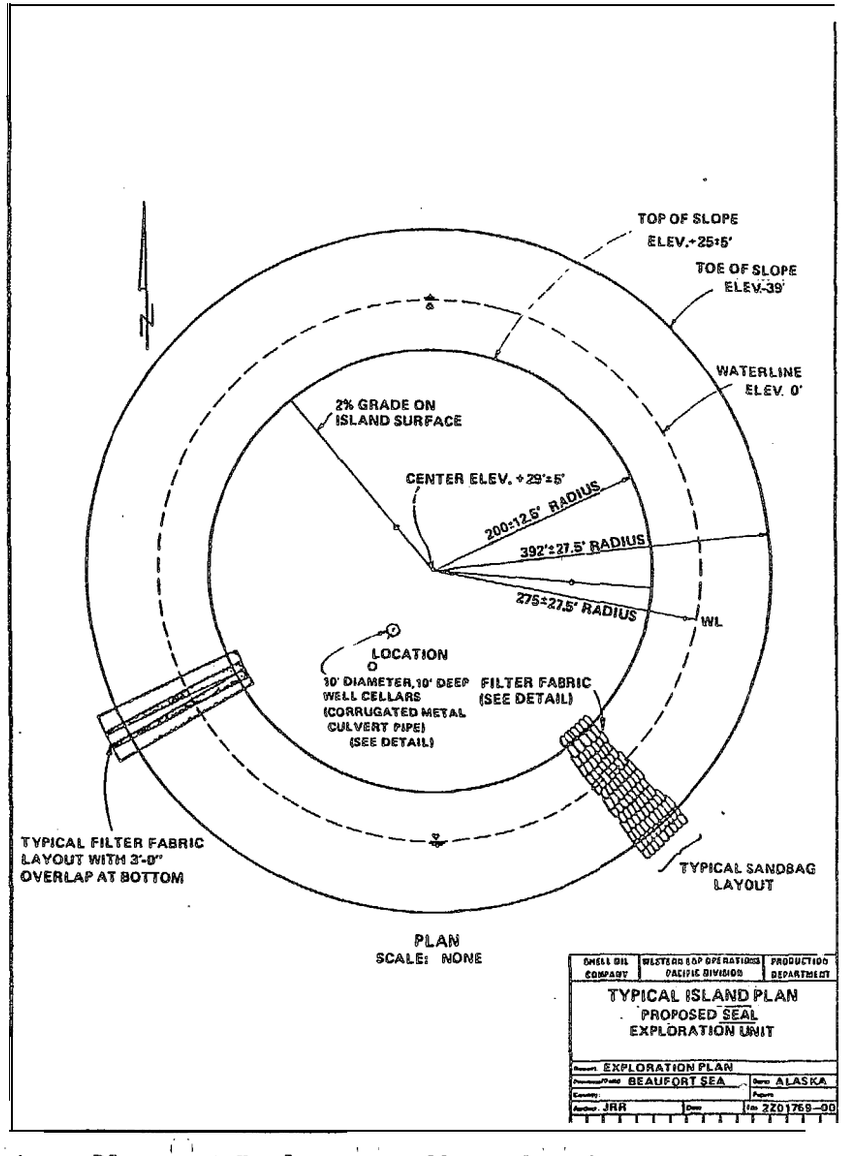
The basic design concept for an arctic offshore artificial gravel island is simple. It mainly involves construction of an artifical island of suitable materials with adequate height, bulk and slope protection to secure the island against damage by ice and water forces over the life of the drilling project. Figure 9 schematically illustrates a typical island construction plan proposed for Shell's Seal Island. While the technical and engineering considerations governing artificial gravel island design are beyond the scope of this study, a good overview of typical design problems and solutions is provided in a series of technical papers published by Exxon Production Research Company under the title Technical Seminar on Alaskan Beaufort Sea Gravel Island Design.

Offshore drill sites are usually remote from supply and service depots and established camp quarters. Due to changing surface ice conditions, access by vehicles and vessels to the island site is intermittent. Helicopters are usually the only reliable means for moving personnel and light supplies on short notice. Therefore, the island is sized to provide for self-contained operations to minimize risk of shutdowns due to resupply needs, weather or other problems. The island surface area must be sufficient to accommodate drilling activities, necessary storage and other functions essential to the drilling program.

GURE 9

TYPICAL GRAVEL ISLAND CONSTRUCTION PLAN





Source: Shell Oil Company, 1981a, Lease Operations Plan and Exploration Plan, Beaufort

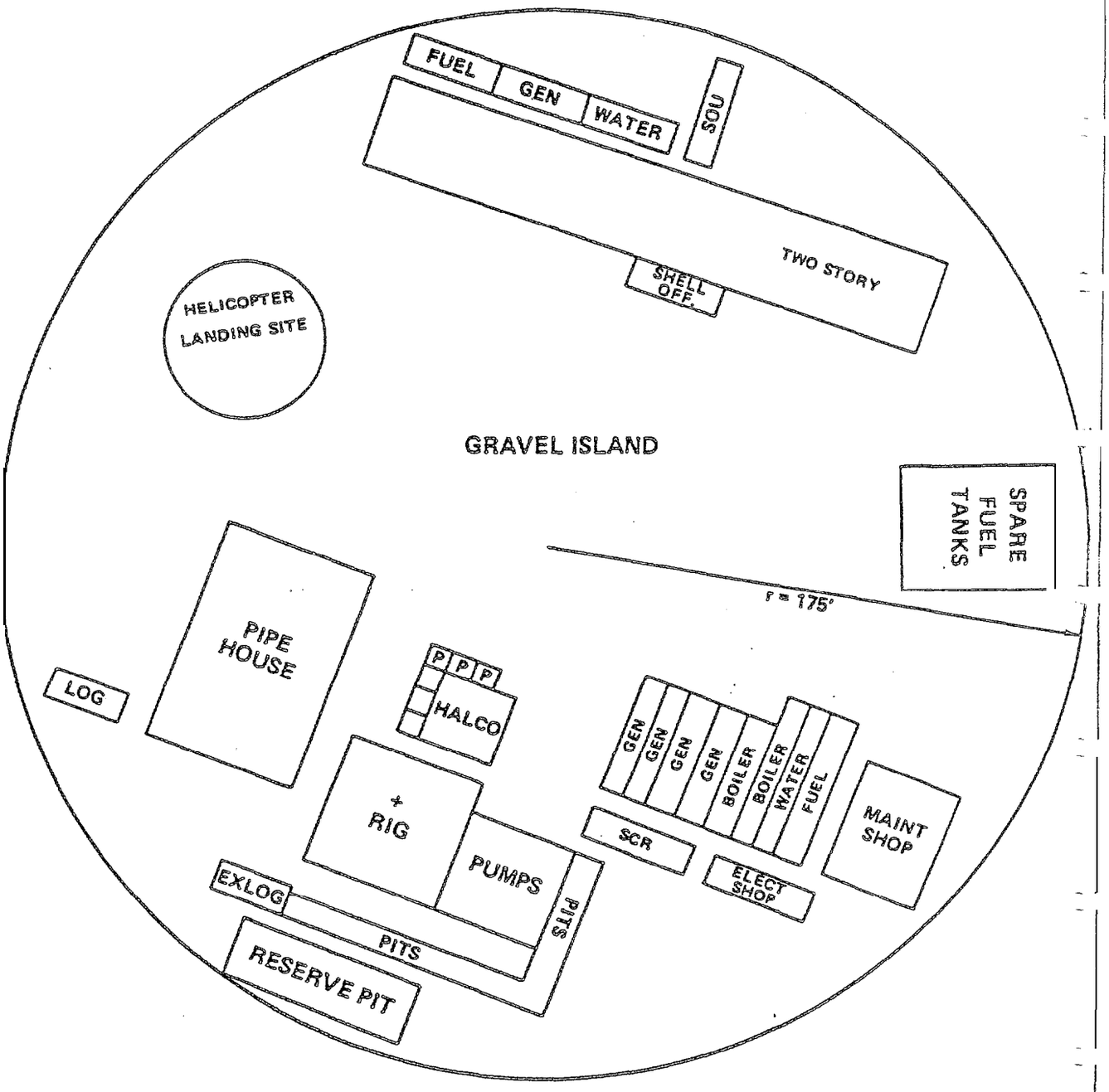
The island surface must have space for a drilling pad and equipment, warehousing and open storage to stockpile pipe, drilling muds and cements, lubricants and other consumable drilling supplies, shop facilities, power plant, water and fuel storage, onsite utilities, communications, crew quarters, helipad, barge ramp or dock, and various other functions essential to permit uninterrupted drilling. Figure 10 illustrates a typical compact configuration for facilities as proposed in Shell's Seal Island exploration plan.

CONSTRUCTION METHODS AND SCHEDULES

For the most part, gravel island construction is a straightforward process of mining, hauling and emplacing large volumes of gravelly fill materials. Depending upon the season of construction, there are two basic modes of operation. For wintertime construction, gravel is typically hauled by truck from the source over specially constructed ice roads to the island site. The island is built up by depositing the gravel on the seabed through a hole cut in the ice. The hauling/construction phase may take from one to three months, depending upon the volume of materials hauled and haul distance. Figure 11 illustrates the sequence of steps in a typical winter construction schedule followed by mobilization and execution of the drilling program the following summer or winter. Alternatively, for summer construction, gravel is barged to the island construction site, where it is deposited directly to build up the island.

FIGURE 10

TYPICAL RIG LAYOUT FOR GRAVEL ISLAND



Source: Shell Oil Company. 1981a. Lease Operations Plan and Exploration Plan, Beaufort Sea Area, Seal Prospect, Alaska.

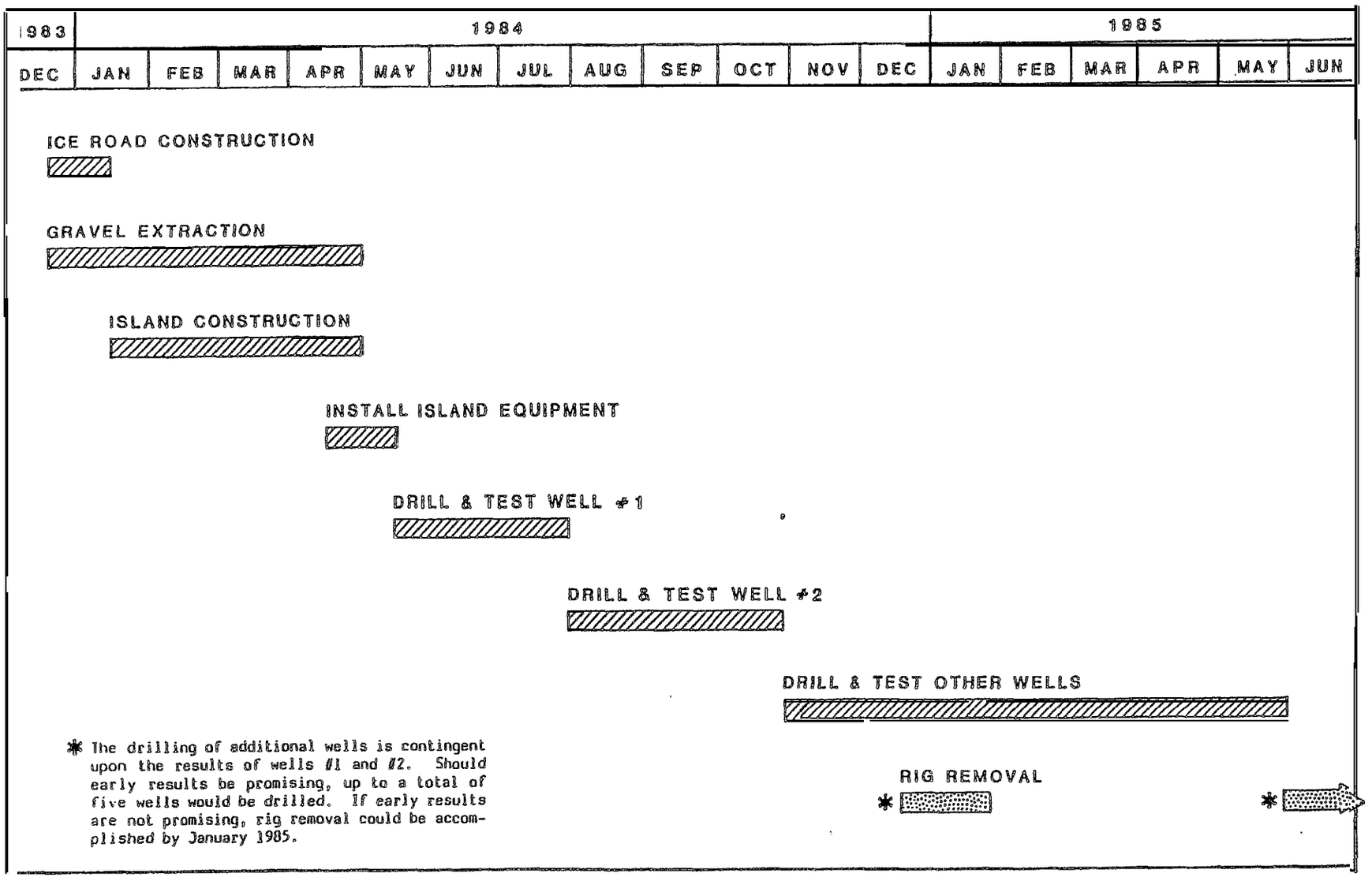
SHELL OIL COMPANY	WESTERN E&P OPERATIONS PACIFIC DIVISION	PRODUCTION DEPARTMENT
TYPICAL RIG LAYOUT PROPOSED SEAL EXPLORATION UNIT 1" = 50'		
EXPLORATION PLAN		
BEAUFORT SEA		ALASKA
KWB		2Z01760-00

Under certain circumstances, a hybrid approach employing both haul methods may be employed as illustrated in Figure 12. For instance, to construct Mukluk Island, gravel was first trucked over an ice road to Thetis Island during winter where it was stockpiled. The following summer, the gravel was transshipped to the final construction des~ination by barge. This two-step process was necessitated by the risk that rough sea ice or ice leads beyond the barrier islands might interrupt truck haulage in winter. For its Seal Island project, Shell had a similar back-up plan for temporary stockpile of gravel at a way station on Long Island, in case unsafe ice conditions prohibited direct haul to the eventual island site.

'To date, the only gravel resources employed for island construction have been situated in upland gravel pits or salvaged from other artificial islands built earlier and now abandoned. The cost of materials transport comprises a significant share of the total cost of island construction. A proposed federal sale of sand and gravel resources on submerged federal lands in Sale BF and Sale 71 lease areas would make available a plentiful and more accessible supply of materials for island construction. Use of submerged sand and gravel resources would entail a summertime dredging/barging operation as opposed to present construction methods. This proposed sand and gravel sale was first scheduled for October 1983, but has been indefinitely postponed, amid speculation that a developing preference for relocatable drilling structures for deepwater arctic offshore exploration has lessened industry's immediate interest in offshore gravel resources. Other reasons for postponement cited by industry sources include inadequate data on the location,

FIGURE 11

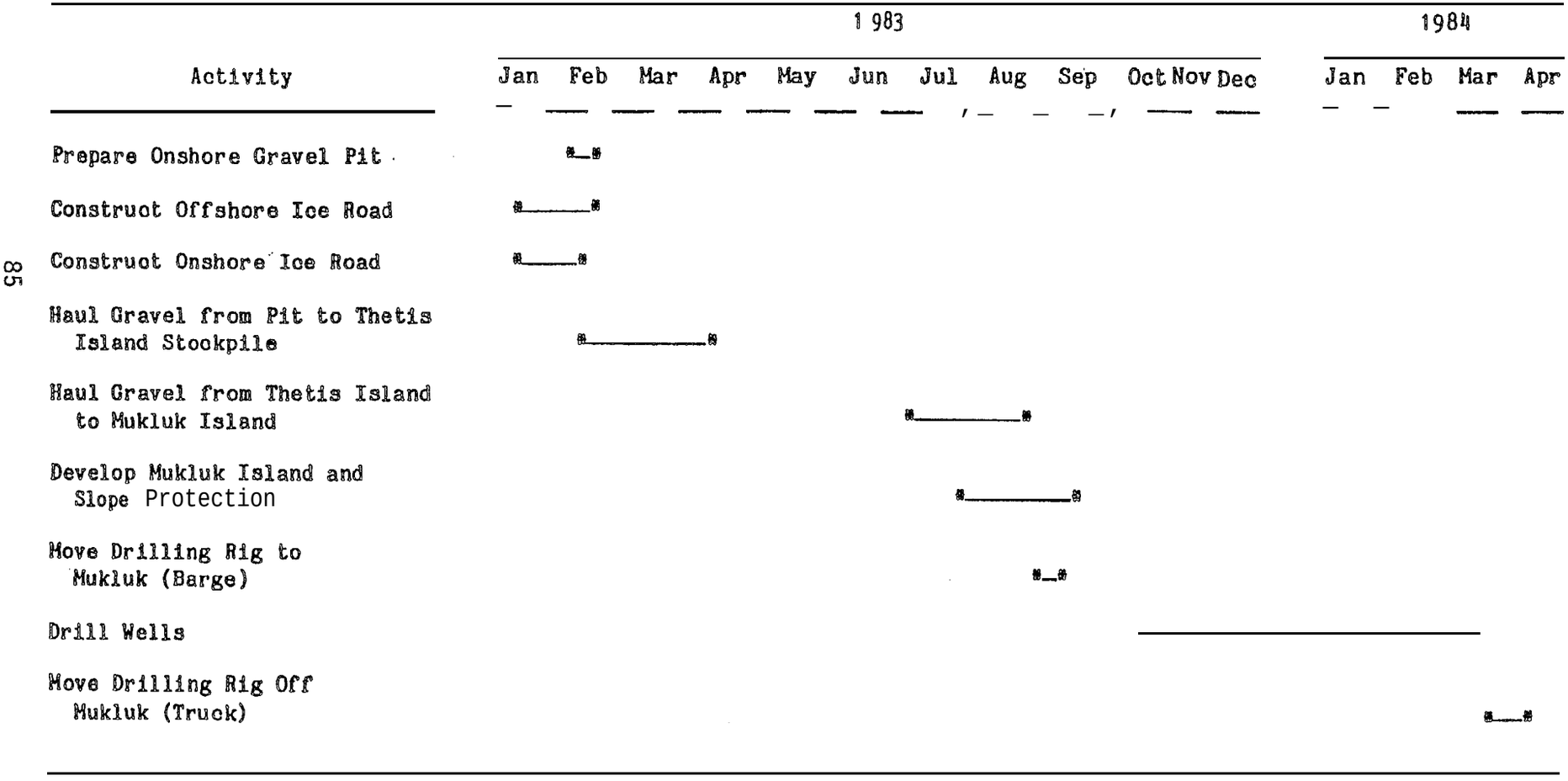
PROPOSED SCHEDULE, FUR SEAL ISLAND PROJECT



Source: Texaco, Inc. 1983. Fur Seal Exploration Plan.

FIGURE 12

MUKLUK ISLAND PROJECT SCHEDULE



Source: Sohio Alaska Petroleum Company. 1983. Mukluk Project Lease Operations Plan and Exploration Plan.

quality and quantity of offshore sand and gravel resources and difficulties with the procedures for leasing sand and gravel resources. However, if large volumes of gravel are needed for construction of semi-permanent production islands, industry interest in an OCS sand and gravel sale may quicken.

BEAUFORT SEA GRAVEL ISLAND CONSTRUCTION SUMMARY

Table 18 summarizes the key facts about Beaufort Sea artificial gravel island features and construction methods pertinent to this monitoring Study. This table shows some of the important similarities and differences among the construction projects.

Island construction has been dominated by a small group of general contractors experienced in arctic construction. Alaska International Constructors was prime contractor for the Unnamed Island, Tern Island, Seal Island and Cross Island construction projects. Green Construction Co. and Morrison/Knudsen Co. collaborated on the Endeavor and Resolution Island projects. Finally, the Arctic Slope Wright Schuchart/Frontier Companies J.V., supported by Alaska International Constructors, was prime contractor for the Mukluk Island project.

The seven island, varied widely in some critical design characteristics. For example:

- Water depths ranged from less than eight feet up to 48 feet.
- Island working surface area varied from as little as 2.2 acres to as much as 4.5 acres.

- Island freeboard ranged from 8 feet up to 21 feet.
- Distance from gravel source ranged from about 10 to 22 miles.
- Volume of gravel fill used for island construction varied from 131,000 cubic yards to 1,000,000 cubic yards.
- Four islands were built in winter by truck haul over ice roads; two were built in summer using barge transportation; the Mukluk project combined winter and summer construction techniques.
- Regardless of whether the winter or summer construction methods were used, all projects employed conventional equipment (summer: barges; winter: truck haul over ice road) for materials excavation, handling and transportation.
- Island construction cost ranged from $3.5 million (Resolution Island) to about $100 million (Mukluk Island].

The extreme variation in gravel island construction cost for Beaufort Sea exploration programs can be accounted for by the wide variation noted above in such design factors as water depth, island surface area and freeboard, all of which affect the volume of fill used, and by haul distance between gravel source and island construction site. Resolution Island required the smallest fill volume and one of the shortest haul distances and was least costly to build. Mukluk Island required the largest volume of fill and, by far, the longest haul. These factors, together with its accelerated construction schedule, help account for Mukluk Island's great cost.

The status of the various gravel islands as of November 1983 was as follows. Two islands (Resolution, Unnamed) were abandoned after unsuc-

TABLE 18

GRAVEL ISLAND SUMMARY DATA

SALE SF AND SALE 71

	Name of Island		
	Endeavor	Resolution	Unnamed
Sale and Tract Number	BF 76	BF 75	BF 37
Management/Ownership Status	State/State	State/State	Federal/Disputed
Operator	Sohio	Sohio	Exxon
Construction Contractor (s)	Green Construction Co. ; Morrison/Knudson Co.	Green Construction Co. ; Morrison/Knudson Co.	Alaska Internationa 1 Constructors
Year Constructed	1980 - Summer	1980 - Summer	1981
Island Surface Area/ Freeboard	350′ Diameter (2.2A) /13. 0′	350′ Diameter (2.2A) /13. 0′	500′ Diameter (4.5A)/13.5′ .
Water Depth/ Island Slope Below MSL	12.0′ /1:3	8.0′/ 1:3	18.0′/1 :3
Special Design Considerations/Features	Gravel island w/sandbag slope protection & gravel access ramp ." In addition to general bags for slope protection, several test panels of long ground tubes were incorporated to subdivide sandbagged areas into smaller sections to prevent progressive bag failures. Also pre-cast rig dock incorporated .	Gravel island w/sandbag slope protection & special slope protection test panels of concrete blocks	Sandbag slope protection (installed in summer) consisting of: 1 layer Geo textile filter cloth; 1 layer of 2.0 CY sandbags over entire slope from top of island to 10′ beyond the toe at the mud line; a 2nd layer of 2.0 CY sandbags over 3/4 of island slopes from +10′ to -10′ NWL. 320,000 CY gravel for island; 24,000 CY gravel, 272,000 ft² of filter cloth, & 11,900 CY sandbags for a lope protection.
Construction Material, by Volume	160,000 CY Gravel	131,000 CY Gravel	36.4.000 CY Gravel
Material Source/Distance	Put River Pit (ARCO) 3+ miles from pit to dock; 12□iles overeater from dock to site.	Put River Pit (ARCO) 3+ miles from pit to dock; 12 miles overwater from dock to site.	Exxon ′ S Duck Island Gravel Source, Sag Delta, Sec. 1, T10N, R15E, UM; approximately 15 miles by ice road.
Construction/Materials-Handling Equipment	B-70 trucks, Cats, haul trucks, flatdeck barges, 46oo draglines, tug boata, pickup trucks, front loaders, conveyors, sand bag plant.	B-70 trucks , Cats, haul trucks, flatdeck barges, 4600 draglines, tug boats, pickup trucks, front loaders. conveyors. sand bag plant.	Conventional earth moving equipment.
Method Of Gravel Transportation/Handling	Conventional land handling & transport to Prudhoe Bay West Dock; conveyored on to flat dock barges; transported to site by barge; placed by dragline.	*Convent* ionalland handling & transport to Prudhoe Bay West Dock; conveyored on to flat dock barges; transported to site by barge; placed by dragline.	30 CY belly-dump trucks over ice road.
Construction Coat	$4.3 Million	$3.5 Million	$8 Million
Exploration Wells Drilled thru 10/31/s3	Sag Delta #7. Sag Delta #9, Sag Delta #10	Sag Delta #8	OCS-Y 0191 #1 OCS-Y 0191 #2
Current Status	Suspended	Abandoned	Abandoned

NOTE: Endeavor and Resolution Islands were grounded on submerged State lands outside Sale BF tracts.

Source: Operator interviews; exploration plans.

TABLE 18 (continued)

Name of Island	Seal	Cross	Mukluk
BF 42	BF 47	BF 54	Sale 71 191
Federal/Disputed	State/State	State/State	Federal/Federal
Shell	Shell	Gulf	Sohio
Alaska International constructors; roads by CATCO & GSL Services	Alaska International Constructors; roads by GSL Services & Kodiak Oilfield Haulers	Alaska International Constructors; ice road construction by Oil Field Services & Pingo	Arctic Slope Wright Schuchart (J. V. , Incl. Frontier Construction, Frontier Rock & Sand); Alaska International Constructors
1982	1982/1983	1983	1983
400' Diameter (2.9 A)/12.5'	427' Diameter (3.3A) /19. 0'	250' X 650' (3.7 A)/8'	350' Diameter (2.5A)/21'
22'/1:3	39.0' /1:3	0.5' to 8.0' /--	48.0' /1:3
Gravel island w/2 CY gravel-filled sandbag over filter fabric for slope & berm protection; sheetpile dock.	Gravel island w/4 CY gravel-filled sandbag over filter cloth for slope & berm protection; sheetpile dock & craneway.	All gravel construction; gravel bags on perimeter on 2 sides; natural island protection on 2 sites within approximately 10'.	Gravel Island with sandbag slope protection; pre-cast rig dock; sheet pile fuel pit. Helicopter pad is integrated into the main island. Discharge lines for mud and cuttings are sandbag protected.
312,000 CY Grave 1	720,000 CY Gravel	137,000 CY Gravel	800,000 CY Gravel
Dead arm of Shaviovik River, about 10 miles by ice road.	Dead arm of Kuparuk River, about 11.4 miles by ice road.	15.2 miles from East Dock area, b miles along the coast & 11 miles of ice road.	Ugnuravik Pit, 5 miles south of Oliktok Point & 22 miles from island site.
Standard onshore equipment (loaders, dozers, graders, compactors, air drills. dump trucks) for excavation of material, haul over ice road & emplacement through "bole-in-the-ice" method,	Standard onshore equipment (loaders, dozers, graders, compactors, air drills, dump trucks) for excavation of materia 1, haul over ice road & emplacement through l!hole-in.the- ice" method .	On-site construction by "hole-in-the-ice" method Ice cut by ditchwitch, ice removed by backhoes, fill by conveyor dump.	B-70 trucks, Cats, loaders, 4600 draglines, flat deck barges, ice breakers, roligons, pickups, haul trucks, scrapers, water cannons, sandbagging plants, cranes, pile driving rigs, survey boats, tugs.
30 CT belly-dump trucks over ice road.	30 CY belly-dump trucks river ice road.	Truck haul across ice road.	Winter haul using conventional land hauling equipment to Thetis Island over ice road. Stockpiled at, Thetis Island. Transported to site in summer by barge, after conveyoringgravel to flat deck barges.
$24 Million	$32.5 Million	$7 Million	$100 Million±
Tern Island #1 Tern Island #2	Seal Island #1 (Seal Island #2 spudded after 11/1/83)	None (Cross Island #1 spudded 11 / 2/83)	None (exploratory well spudded 11/1/83)
	Active	Active	Abandoned

cessful exploration programs. The two wells drilled on Tern Island were abandoned but not the island itself.. Under Sohio's proposed development scheme for the Endicott Development Project, Endeavor Island will be used as a breakwater in the offshore production/transportation system. At the start of the 1983/84 drilling season, Seal, Cross and Mukluk Islands were in readiness for exploratory drilling. (Mukluk Island was, of course , abandoned shortly after a single unsuccessful exploratory well).

CONSTRUCTION WORK FORCE AND LABOR COSTS

Gravel island construction is relativly labor-intensive. Total labor related costs are estimated to comprise between 25 percent to 40 percent of total island construction cost. Data on the estimated work force and labor costs for each island. construction project are presented in Table 21.

Consistent with the design and cost variations noted above, the labor effort required varied widely from project to project. Most obviously, labor effort and cost vary with gravel fill volume and with distance between the materials source and island location. Also, labor effort is partly governed by the choice of construction transport modes. For example, summertime barge transport of gravel fill to the worksite requires a different work force mix and work period than truck transportation over winter ice roads. The use of barge transport rather than sole use of truck transport can increase labor costs by requiring more time and workhours. Extra transfer and handling costs entailed by

loading and offloading barges and need for a ba-rge crew also add to expenses. This same rule would apply to the delivery of drill rig and equipment camp facilities, drilling materials and other supplies to a Beaufort Sea site, for which barge transport typically might take seven days but truck transport only five days.

CONCLUSIONS

Because of the wide-ranging differences noted among the islands built to date for Sale BF and Sale 71, it is difficult to designate a representative gravel island construction project. Likewise, it is hard to arrive at meaningful averages for cost or manpower levels as guidelines for forecasting the total cost and manpower requirements for future projects in federal sale areas. For -future consideration, however, it is both important and useful to note that federal tracts, as a rule, are more distant from shore and in deeper waters compared to state tracts; Conversely, most state-owned or managed Sale BF submerged tracts are either accessible from natural islands, obviating the need for artificial islands, or in comparatively shallow nearshore waters. For these reasons , gravel island construction projects in the federally-managed sector of Sale BF and Sale 71 have tended to be more costly and more labor-intensive than in state-managed tracts. Projects such as Shell's Seal Island or Sohio's Mukluk Island are likely more representative of the scale of gravel island projects that may be undertaken for future federal arctic OCS sale areas, where that design concept is advantageous.

This conclusion must be qualified by, the observation that, after a point, water depths and haul distances make gravel islands economically disadvantageous compared to caissoned gravel islands, which require less gravel, or prefabricated, relocatable structures like Exxon's CIDS platform which is ballasted with seawater. For a fuller discussion of some of the technical and economic considerations governing choices among gravel island designs and other platform options, reference is made to Technical Report Number 79, Chukchi Sea Petroleum Technology Assessment (Dames & Moore). According to that report,

> While precise break points between technical concepts have not been delineated, gravel islands become uneconomic somewhere beyond 15 meters (50 feet) and caisson-retained gravel islands fall out beyond 37 meters (120 feet), leaving only one-piece caissons, concrete or steel monocones and ice-breaking drill ships or semi-submersibles as viable drilling concepts for waters out to 60 meters (200 feet) and beyond.

Technical Report Number 79, issued in December 1982, also describes a variety of other exploration options that might be employed in arctic offshore regions.

Finally, the industry's continuing search for innovative equipment and techniques for dealing with the novel requirements for arctic offshore exploratory drilling must qualify the future applicability of the design concepts and construction methods used to date iri Beaufort Sea exploration programs. As exploratory drilling progresses to more remote, deeper-water offshore arctic tracts remote from established support facilities it is probable that economic and engineering constraints will result in new drilling approaches.

Exploration Drilling

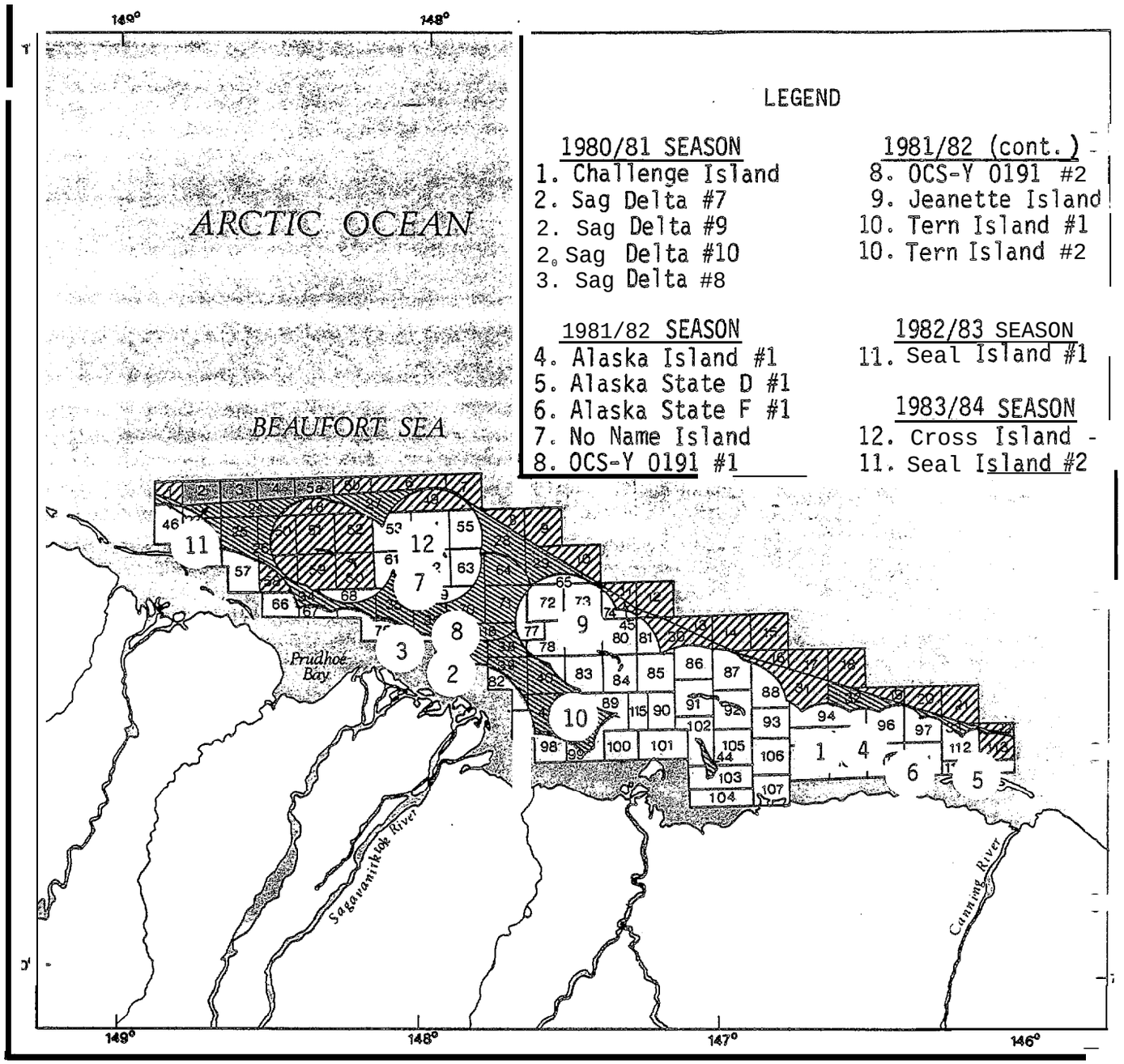
This section presents data compiled for the fifteen exploration wells (see Figure 13) drilled on Sale BF tracts through October 31, 1983. The narrative portion of this section identifies key features of those drilling operations and the companies and systems that 'were involved. The chronology reflects and explains the timeframes governing the planning and conduct of exploratory drilling programs as well as the role of permits and other regulatory mechanisms.

The exploratory drilling data shown in Table 19 have been grouped generally in a chronological order and by drilling season. Thus, the five drilling programs which occurred in the 1980-81 season are grouped, followed in turn by programs conducted in the 1981-82 season and in 1982-83. Because seasonal restrictions and permit conditions determine when drilling is allowed we have used a drilling season running from November 1 through October 31 rather than a calendar year. As can be seen by reference to the well spud dates in Table 19, most wells were spudded on or shortly after November 1. Thus, this drilling season more closely represents the actual cycle of drilling program activities.

Five different major oil firms have been involved as operators for the 15 exploration wells actually commenced prior to October 31, 1983. Sohio has been operator for six wells; Exxon for four; Shell for three; and AMOCO and Chevron for one well each. Shell, Gulf, Sohio and Exxon, respectively, are operators for the four wells committed to be drilled after October 31, 1983. Six of the wells were drilled from natural

FIGURE 13

EXPLORATORY WELL LOCATIONS
SALE BF



NOTE: Base map adapted from Rogers, Golden & Halpern. 1983b. Arctic Summary Report Update.

island locations in the Beaufort Sea, while the remaining nine were spudded from specially constructed gravel islands. Of those proposed or pending, three are planned to be located on gravel islands and the fourth from a CIDS.

The influence of the permitting requirements and seasonal drilling restrictions is evidenced by the fact that six of the exploration wells were spudded on November 1, four others in December or January, and three of the remainder during the month of October. Permitting ramifications are explored elsewhere in this report. However, it is noted here that the seasonal restrictions determined the selection of a transportation mode (for example, marine or ice road) with resulting changes in workforce composition otherwise unrelated to company preference or economic considerations.

Detailed exploration data summarized in Table 19 include:

- Exploration Well Name and Sale and Tract Number
- Management/Ownership Status
- Lease Operator
- Drilling Contractor & Drill Rig
- Drilling Pad Construction Features
- Rig Movement Mode
- Well Spud Date & Completion Date
- Well Depth
- Demobilization Mode
- Identification of Marine, Air, and Surface Transportation Contractors, Oilfield Services Contractors, Catering Contractors, and Work Camp Support Contractors

TABLE 19

EXPLORATION WELL DATA SUMMARY
SALE BF, 1980 - 1983

1980 - 1981

	Exploration Well Name				
	Challenge Island #1	Sag Delta #7	Sag Delta #8	Sag Delta H..	Sag Delta #10
Sale and Tract Number	BF 108	BF 76	BF 75	BF 76	BF 76
Management/Ownership Status	State/State	State/State	State/State	State/State	State/State
Lease Operator	Sohio	Sohio	Sohio	Sohio	Sohio
Drilling Contractor	Brinkerhoff Signal, Inc	Nabors Alaska Drilling	Alaska United Drilling	Nabors Alaska Drilling	Nabors Alaska Drilling
Drill Rig	Brinkerhof Rig #36	Nabors Rig #26E	Vanguard Rig #2	NaborsRig 026S	14.bets Rig#26E
Drilling Pad Construction	Natural barrier island. Ice deflectors on north side of island.	Manmade gravel island (Endeavor Island). Pad & pre-case rig dock incorporated in island construction.	Manmade gravel island (Resolution Island). Pad incorporated in to island construction.	Manmade gravel island (Endeavor Island).	Manmade gravel island (Endeavor island).
How Rig Moved to Site	Barge	Trucks, over ice road from Prudhoe Bay.	Trucks, over ice road from Prudhoe Bay.	Barge	N/A - Same as island
Well Spud Date/ Completion Date	11/01/80 03/17/81	01/15/81 03{30/81	01/25/81 04/15/81	10/15/81* 91/15/82	10/20/81. 03/22/82
Well Depth - 'Fetal , TVD,	13,587' 83,094'	12,537' 10,294'	13,250' 13,128'	14,100' 11,728'	83,240' 10,595'
Demobilization Mode	Rig & equipment returned to Prudhoe Bay by trucks via iceroad.	Rig & equipment returned to Prudhoe Bay by trucks via ice road.	Rig & equipment moved off island by trucks via ice road.	Rig also used for #10.	Rig & equipment moved off island by trucks via ice road.
Marine Transport Contractors	Arctic Marine Freighters		None	Arctic Marine Freighters	N/A - Same Rig from #9
Air Transport Contractors	Evergreen Helicopters Air Logistics, Inc.	None	None	Evergreen Helicopters (Until ice road available)	None
Surface (Truck) Transportation	Mukluk Freight Lines Kodiak Oilfield Haulers	Mukluk Freight Lines Kodiak OilfieldHaulers	Mukluk Freight Lines Kodiak Oilfield Haulers	Mukluk Freight Lines Kodiak Oilfield Haulers	Mukluk Freight Lines Kodiak Oilfield Haulers
0,1 FieldServices Contractors					
Catering Contractor	Drilling Contractor	Drilling Contractor	NANA-Mannings	Drilling Contractors	Drilling Contractor
Work Camp Support Contractors	Fairweather, Inc. (expediting, weather observation, medical technician)	Fairweather, Inc (expediting, weather observation, medical technician)	Fairweather, Inc. (expediting, weather observation, medical technician)	Same as #8.	Same as #8.

*Note: Conductor and surface pipe were first set in Sag Delta #9. The rig was then moved to Sag Delta #10 where conductor and surface pipe were set Same rig the. moved back over 119 to complete and back to #10 to complete.

TABLE 19
(Continued)

EXPLORATION WELL DATA SUMMARY
SALE BF, 1980 - 1983

1981 - 1982

	Exploration Well Name			
	Alaska Island #1	Alaska State D #1	Alaska State F #1	No Name Island #1
Sale and Tract Number	BF 109	BF 114	BF 111	BF 62
Management/Ownership Status	State/State	State/State	State/State	State/State
Lease Operator	Sohio	Exxon	Exxon	Amoco
Drilling Contractor	Alaska United Drilling	Pool Arctic Alaska Drilling Co. (formerly Arctic Alaska Drilling)	Pool Arctic Alaska Drilling Co. (formerly Arctic Alaska Drilling)	Parker Drilling Company
Drill Rig	Vanguard Rig #2	AADCO Rig #4	AADCO Rig #5	Parker Rig #95
Drilling Pad Construction	Natural barrier island. Ice deflectors installed on north side of island.	33,325 CY gravel; 1,576 linear feet of sheet piling on perimeter.	28,765 CY w.[illegible]; 1,746 linear feet of sheet piling . . perimeter.	Natural island approx. 5000' long, 60-400, wide, wipe. gravel surface 3.5-3, above sea level Used 25,860 CY gravel to construct drilling pad which is 250°, 600' built up to a height of 8' above mean ,,,1,,.1, 8,256 CY gravel stockpiled to replace weathered areas.
How Rig Moved to Site	Barge	Barge	Barge	Barge
Well Spud Date/ Completion Date	11/01/81 06/08/82	11/01/81 02/16/82	11/01/81 05/30/S2	11/01/81 06/10/82
Well Depth - Total, TVD:	15,222' 13,093'	13.050'	14,316'	14,350 11,345
Demobilization Mode	Barge	Trucks over ice road	Barge	Trucked to Deadhorse via ice road
Marine Transport Contractors	Arctic Marine Freighters	Arctic Marine Freighters	Arctic Marine Freighters	Arctic Marine Freighters
Air Transport Contractors	Evergreen Helicopters ERA Helicopters Air Logistics, Inc.	Evergreen Helicopters	Evergreen Helicopters	ERA Helicopters
Surface (Truck) Transportation	Mukluk Freight Lines Kodiak Oilfield Haulers	Pioneer Oilfield Services	Various	Oil Field Ser.,...., Inc
Oil Field Services Contractors		Mud - Dresser Magcobar Cement - Halliburton Mud Logging - Exlog Wireline Logging - Dresser Atlas	Mud - Dresser Magcobar Cement - Halliburton Logging - Schlumberger	
Catering Contractor	NANA - Hamm.ngs	Universal Services, Inc.	Universal Services, Inc	
Work Camp Support Contractors	Fairweather, Inc. (expediting, weather observation, medical technician)	Pioneer Oilfield Servi <., (truck transport, roustabouts) Eagle Enterprises (desalinization mbit, weather observation) Frontier Equipment Co. (loader & cat)	FGH, Inc (roustabouts) Eagle Enterprises (weather observation)	well, Inc. (surveying)

TABLE 19

(Continued)

EXPLORATION WELL DATA SUMMARY

SALE BF, 1980 - 1983

1981 - 1982

1982-1983

	Exploration Well Name					
	OCS-Y0191 #1	OCS-Y0191 #2	Jeannette Island #1	Tern Island #1	Tern Island #2	Seal Island #1
Sale and Tract Number	BF 37	BF 37	BF 79	BF 42	BF 43	BF 47
Hacla.Sumn.lowma.ship Status	Federal/Disputed	Federal/Disputed	State/State	Federal/Disputed	Federal/Disputed	State/State
Lease Operator	Exxon	Exxon	Chevron	Shell	Shell	Shell
Drilling Contractor	Nabors Alaska Drilling	Nabors Alaska Drilling	Parker Drilling Co.	Brinkerhoff Signal, Inc.	Brinkerhoff Signal, Inc.	Brinkerhoff Signal, Inc.
Drill Rig	Nabors Rig #27E	Nabors Rig #27E	Parker Rig #147	Brinkerhoff Rig #84	Brinkerhoff Rig #84	Brinkerhoff PN JV #1
Drilling Pad Construction	320,000 CY gravel island; 24,000 CY gravel for 11,902 CY sandbags for slope protection; 272,000 sq. ft. of filter cloth.	See OCS-Y0191	Bladed & leveled natural surface; built ice drilling pad & other ice pads for equipment & supplies; no external gravel fill; installed ice deflector units to create protective rubble field; restored surface to natural condition during demobilization.			
How Rig Moved to Site	Barge	See OCS-Y0191 #1	Barge	Truck over ice road.	Truck over ice road.	Truck over ice road.
Well Spud Date/ Completion Date	11/01/80 03/31/82	12/27/81 03/15/82	12/24/81 03/05/82	5/28/82 09/18/82	10/16/82 03/03/83	06/ 01/83 01/30/84
Well Depth - Total: 2?30:	13,093' 11,639'	13,442' 11,138'	12,335' 12.323"	13,376'	13,399'	12,200$
Demobilization Mode	Barge	See OCS-Y0191 #1.	Trucks over ice road w/ barge for final phase.			
Marine Transport Contractors	Arctic Marine Freighters	See OCS-Y0191 #1.	Arctic Marine Freighters GCI Marine	Crowley Maritime	Crowley Maritime	Crowley Maritime
Air Transport Contractors	ERA Helicopters	ERA Helicopters	Sss Helicopters	ERA Helicopters Evergreen Helicopters	ERA Helicopters Evergreen Helicopters	ERA Helicopters Evergreen Helicopters
Surface (Truck) Transportation	N/A	N/A	Mukluk Freight Lines Kodiak Oilfield Haulers	Kodiak Oilfield Haulers Hustlers, Inc. Mukluk Freight Lines Lynden Transport	Kodiak Oilfield Haulers Hustlers, Inc. Mukluk Freight Lines Lynden Transport	Kodiak Oilfield Haulers Hustler, Inc. Mukluk Freight Lines Lynden Transport
Oil Field Services Contractors	Mud - ML Baroid Cement - Halliburton Mud Logging - The Analyst Logging - Schlumberger H_2S - Secorp	Mud - ML Baroid Cement - Halliburton Mud Logging - The Analyst Logging - Schlumberger H_2S - Secorp	Mud - Dressor Magcobar Mud Logging - Exploration Logging Mud Cleaning - SWACO Systems	GSL Oilfield Service Alaska Oilfield Services Veco, Inc. Udelhoven, Inc. Northern Oilfield Svcs. Tri-State Oil Tool Ind. Weatherford Alaska, Inc. Childs Equipment Services Schlumberger Baroid Moralco	GSL Oilfield Service Alaska Oilfield Services Veco, Inc. Udelhoven, Inc. Northern Oilfield Svcs. Tri-State Oil Tool Ind. Weatherford Alaska, Inc. Childs Equipment Service. Schlumberger Baroid Moralco	GSL Oilfield Service Alaska Oilfield Services Vet. , Inc. Udelhoven, Inc. Northern Oilfield Services Tri-State Oil Tool Ind. Weatherford Alaska, Inc. Childs Equipment Service. Schlumberger Baroid Moralco
Catering Contractor	Universal Services, Inc.	Universal Services, Inc.	Universal Servic e., Inc. (including medic.1)	International Superior Services, hat.	International Superior Services, Inc.	International Superior Services, Inc.
Work Camp Support Contractors	FGH, Inc. (roustabouts)	FGH, Inc. (roustabouts)	Alaska Offshore, Inc. (expeditors, logistics, fuel handling) Fairweather (weather observation)	Fairweather Eagle Enterprises	Fairweather Eagle Enterprises	Fairweather Eagle Enterprises

Source: Operator interviews.

DRILLING OPERATIONS

Beaufort Sea exploration ventures have involved most of the major drilling contractors active in Alaska. Following standard procedures, the contractors providing basic oil field control services report directly to representatives of the lease operator. These include specialty oil field service contractors for drilling mud, cement, logging, and safety factors. The drilling itself is under the control of the drilling contractor, and most general support activities, such as catering and camp services, are approved by subcontract through that drilling contractor.

Mobilization and demobilization of drilling equipment to the drill site has taken place either by means of the ice roads constructed from the Prudhoe Bay area to the site for hauling of gravel and transportation of supplies, or via marine transport, with use of tug and barge arrangements for the movement of the equipment. Most ventures at the Sale BF sites have used both surface and marine modes for heavy moving during mobilization or demobilization, that is, the ice roads for winter operations and the barge mode during the summer. Air support has generally involved only the movement of personnel or light supplies needed from time to time. The model for mobilization, drilling and support and demobilization for a Beaufort Sea drilling program is summarized below.

Mobilization

Mobilization involved transporting the initial equipment, supplies and camp facilities from Prudhoe Bay to the site. The drill rig, rig camp,

drill pipe, casing, drill mud, etc. , were loaded at the drilling contractor's base camp near Deadhorse by the trucking company and hauled to the West Dock at Prudhoe Bay, where it was turned over to the marine transportation company for transshipment to the site. In addition to crane and forklift, the movement involved 10 oilfield bed tandem trucks, and required a crew of 16 to 22 persons. At the island, the trucking company unloaded the shipment, moved it to the drilling site, set up the camp , and stacked the pipe, prepared the casing, mud , etc. , and "rigged-up" the drill rig for exploration drilling. The camp was a standard 62- to 70-man rig camp. The equipment used for set up included two oilfield bed truck units, a 966 forklift, an 80-ton truck crane and 140-ton or larger crane. This equipment was operated by a six-man crew: two drivers, swamper, loader operator, crane operator and oiler. The entire operation from loading at the drilling company camp at Prudhoe Bay to completion of "rigging-up" and camp installation for this mid-summer operation required about nine days. .

Demobilization

Demobilization was accomplished in a seven-day operation in the winter. The main tasks were: rigging down the drill rig; dismantling the camp and other related facilities; loading the rig, camp and warehouse or other facilities on trucks and trailers; and transporting them via an ice road back to the drilling company camp near Deadhorse.

Equipment used in demobilization included an 80-ton truck crane, a 966 forklift, 10 oilfield bed tandem trucks, and miscellaneous support

equipment. The work crew ranged from 16 to 22 persons. This included the five-person "rigging down" crew, who were based upon the island while dismantling the drill rig and preparing the camp for return movement. The demobilization operation took seven days with two loads per truck per day, using the 10 trucks described above. Except for the five crew members based on the island, the remainder were based at Prudhoe Bay at the truck transport company's facilities near Deadhorse. The operation included unloading and stacking the material at the drilling company's camp near Deadhorse.

Camp Maintenance and Service During Operation

The truck transport company also provided service to the camp during the drilling operations via the ice road. This consisted of a load of fuel every other day. During operations, the drill rig and other facilities consumed about 4,500 gallons of fuel per day. Drinking water was provided onsite by a reverse desalinization unit as part of the camp equipment. Vacuum and disposal services for drilling mud were provided as needed. Sewage disposal services for the camp were provided by a self-contained disposal unit. Used muds and cuttings were typically disposed of on ice or in open water, unless contaminated in which case they were disposed of in the well annulus or hauled ashore to an authorized disposal site.

As indicated, the foregoing describes a typical mobilization-demobilization scenario, with marine transport one way and truck over an ice road on return. Seasonality is the basic determinant for mode of transporta-

tion. Costs vary by the addition of the tug crew and by the additional time (1½ to 2 days more) for marine transport compared to the ice road.

In a few instances, fuel and equipment delivered via the annual sealift have been off-loaded directly to locally operated barges for transport to the drill site. However, in most cases, material is moved at the same time as the rig and camp are mobilized. Fuel, water and food are subject to replenishment during drilling operations via ice road or occasionally by air for urgently-needed items. Personnel movement is usually by air or by personnel carrier via an ice road to close-in sites, such as the Sag Delta locations.

DRILLING COSTS AND WORK FORCE

The work effort and costs four the actual drilling operations in the Beaufort Sea programs have not varied as significantly as island construction. Drilling operations thus far in the Beaufort Sea area have generally resembled onshore or upland exploration in so far as the nature of the rigs, the size of the crews, and the actual onsite support. The major differences have involved the level of onsite support and the logistic difficulty in providing it. The level of support effort is largely governed by distance between the principal shorebase and drill site and the mode of support is dictated by seasonal conditions. As a following section dealing with onsite drilling program employment illustrates the size and composition of the drilling crew the level of operator inspection, the nature and extent of oilfield services, camp arrangements, etc., has not varied greatly from site to

site. The total onsite work force, including all of the necessary support and management generally runs from 50 to 70 people at various stages of the operation. Cost differences related to work force size have more been a product of the logistic support effort than of the drilling crew size or composition. Table 20 shows the typical onsite work crew employed for Beaufort Sea exploration programs. The principal variable in work force effort and expense has been the time required for drilling and testing the well. Drilling time is roughly proportionate to well depth, but can be significantly affected by delays or interruptions due to drilling problems encountered.

Table 22 in the following Employment Summary section shows the manpower and wages associated with major steps in the drilling program for each of the fifteen Sale BF exploration wells.

Employment and Wage Summary

Tables 21 and 22 summarize the labor effort and wage data for gravel island construction and exploratory drilling activities for Sale BF and Sale 71. The data are grouped according to the principal onsite activities, by individual gravel island and exploration well and by drilling season.

For reasons explained in the earlier section on research methodology, full employment details could not be obtained for every gravel island or exploratory well or for every category of work. Therefore, a methodology to estimate labor effort and wages was developed. The methodology

TABLE 20

EXPLORATORY DRILLING OPERATIONS

TYPICAL ONSITE WORK CREW

Lease Operator Supervision -	
Drilling Foreman	1
Administrative/Purchasing	1
Engineer[1]	1
Geologist[1]	1
Log Analyst[1]	1
Subtotal	3 to 5
Drilling Contractor Crew -	
Toolpusher	1
Driller	2
Derrickman	2
Motorman	2
SPS Operator	2
Floorman	6
Roustabout	5 to 6
Forklift Oprator	2
Mechanic	1
Welder	1
Electrician	1
Truck Driver	1 to 3
Subtotal	26 to 29
Oilfield Service Companies -	
Mud Engineering Services:	
Engineer (Prof.)	1
Second Engineer[2]	1
Subtotal	1 to 2
Cementing Services:[3]	
Service Engineer	2
Pump Equipment Operator	2
Subtotal	4 to 5
Oilfield Service Companies - (continued)	
Logging:[4]	
Engineer (Prof.	1
Operator	2
Subtotal	3 to 5
Catering Contractor:[5]	
First Cook	1
Cook/Baker	1
Helper	2
Bullcook	1
Subtotal	5 to 6
Weather Observation Contractor -	1
Medical Contractor -	1
Miscellanceous Roustabout/Labor Support Contractor -	3 to 5
Miscellaneous Equipment Maintenance, Supply/Warehousing, Air Support, Etc. -	6 to 10
TOTAL	53 to 69

[1] Onsite as needed.

[2] When peak operations require.

[3] One additional Engineer Operator when peak operations require.

[4] One additional Engineer and/or Operator when peak operations require

[5] Sixth crewmember when camp exceed 60 occupants.

Note: Above informaton covers onsite work on a 2-shift, 24-hour basis. Personnel work on a rotating basis (7 days on/7 days off or 14 days on/14 days off), therefore, number of personnel to provide total coverage is double crew size.

Source: Contractor Interviews.

TAMS 21

EMPLOYMENT SUMWARY , GRAVEL ISLAND CONSTRUCTION

ESTIMATED WORK HOURS & WAGES

SALS BF AND SALE 71 EXPLORATION PROGRAMS, 1980 83

	1981				1982				1983				Total	
	Endeavor/Resolution*		*Unnamed**		*Tern*		Seal		Cross**		Mukluk			
	Hours	$'s	Hours	$'s	Hours	$'s	Hours	's	Hours	$'s	Hours	's	*Hours*	$'s
Transportation														
Air	On-Call Only		On-Call Only		800	24,000	1,800	54, 000	On-Call Only		3,600	108,000	6,200	186,000
Marine	31,672	303,400	4,494	'43,050	--	--	--	--	1,712	18,480	33,705	363,825	71,583	728,755
Surface by Truck (pit to dock or via ice road)	16,872	359,896	42,000	741,300	***		***		22,848	420,142	144,768	3,550,464	266,488	5,071,802
SUBTOTAL	48,544	$ 663,296	46,494	$ 784,350	800	$ 24,000	1,800	$ 54 ,000	24,560	$ 438,622	182,073	$4,022,289	304,271	$ 5,986,557
Construction														
Ice Road	N/A	N/A	5,820	$ 110,212	3,696	$ 74,918	4,244	$ 87,057	3,984	$ 82,111	5,708	$ 117,642	23,432	$ 471,940
Materials Handling & Placement	63,936	1,418,489	76,260	1,641,321	141,400	3,451,096	324,000	7,964,060	32,520	685,148	205,000	5.125,010	846,116	20,285,124
SUBTOTAL	63,936	$1,418,489	82,080	$1,751,533	145,096	$3,526,014	328,224	$8,051,117	36,504	$ 767,259	210,708	$5,242,652	866,548	$20,757,064
TOTAL	112,480	$2,081,785	128,574	$2,535,883	145,896	$3>550,014	*330,024*	$S,105 ,116	61,064	$1,205,881	392,781	$9,264,941	1,170,819	$26,743,621

Note: Includes unadjusted direct wages only.

* Endeavor and Resolution Islands constructed at same time by same contractors. Work force hours and wages for both included here.

** Marine transportation for slope protection placement support and re-supply.

***Hours and wages for Surface Transportation included under Materials Handling & Placement.

Source: Operator and Contractor inter-views; Kevin Waring Associates estimates.

TABLE 22

EMPLOYMENT SUMMARY
ESTIMATED WORK HOURS & WAGES
SALE BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983

1980 - 1981

	Exploration Well Name									
	Challenge Island #1		Sag Delta #7		Sag Delta #8		Sag Delta #9		Sag Delta #10	
	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s
Mobilization										
Land Transportation & Handling	2,436	$ 51,835	1,914	$ 40,727	1,914	$ 40,727	2,436	$ 51,835	1/	
Marine Transportation	1,-498	14,350					1,498	14,350		
Air 'Transportation										
Subtotal	3,934	$ 66,185	1,914	$ -40,727	1,914	$ 40,727	3,934	$ 66,185	-0-	-0-
Drilling Operations										
Land Transportation & Handling	2,640	56,175	3, 480	74,050	3,828	81 ,455	3,480	74,050	4,176	$ 88,86(I
Air Transportation	2,740	150,700					600 2/	18,000		
Drilling Crew	75,350	1,507,000	39,050	7'81,000	41,800	836,000	53,350	1,087,000	33,550	671,000
Catering & Camp Svcs.	9,864	150,700	5,112	78,100	5,492	83,600	6,984	106,700	4,392	67,100
Oil Field Service Specialties	16,440	342,500	8,520	177,500	9,120	190,000	11,640	242,500	7,320	152,500
Miscellaneous Support [medical, weather, maintenance, labor)	16, 440	178,100	8,520	92,300	9,120	98,800	11,640	126,100	7,320	79,300
Subtotal	123,474	$2,385,175	64,682	$3,202,950	69,360	51,289,855	87,694	$1,654,350	56,758	$1,058,760
Demobilization										
Land Transportation & Handling	1,392	29,620	1,392	29,620	1,392 ,	29,620	1/		1,566	33,325
Marine Transportation										
Air Transportation										
Suotota1	1,392	$ 29,620	1,392	$ 29,620	1,392	$ 29,620	-0-	-0-	1,566	$ 33,325
TOTAL	128,800	$2,480,980	67,988	$1,273,297	72,666	$1,360,202	91,628	$1,720,535	58,324	$1,092,085

1/ Same drill rig used for Sag Delta #9 and #10.

2/ Air Support provided only until ice road opened.

TABLE 2 2

EMPLOYMENT SUMMARY
ESTIMATED WORK HOURS & WAGES
SALS BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983
(Continued)

1981 - 1982

	Alaska Island #1		Alaska State D#1		Alaska State F#1		No Name Island #1		OCS-Y 0191 #1 & #2	
	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s
Mobilization										
Land Transportation & Handling	2,436	$ 55,608	2,088	$ 47,664	2,262	$ 51,636	2,436	$ 51,835	2,436	$ 51,835
Marine Transportation	1,498	15,232	1,284	13,056	1,392	14,144	1,498	14,350	1,712	16,400
Air Transportation							360	10,800	140	4,200
Subtotal	3,934	$ 70,840	3,372	$ 60,720	3,654	$ 65,780	4,294	$ 76,985	4,288	$ 72,435
Drilling Operation										
Land Transportation & Handling	3,094	71,496	3,940	92,945	1,740	39,720	8,352	177,720	1,392	31,976
Air Transportation	8,800	242,000	2,700	81,000	422	126,600	3,560	106,800	3,020	90,600
Drilling Crew	121,000	2,530,000	74,250	1,552,500	116,050	2,426,500	97,900	2,047,000	83,050	1,736,500
Catering & Camp Svcs.	15,800	264,000	8,910	148,500	13,926	232,100	11,748	195,800	9,966	166,100
Oil Field Service Specialties	26,400	550,000	16,200	337,500	25,320	527,500	21,360	445,000	18,120	377,500
Miscellaneous Support (medical, weather, maintenance, labor)	26,600	308,000	16,200	189,000	25,320	295,400	21,360	249,200	18,120	211,400
Subtotal	201,694	$3,965,496	122,200	$2,601,445	182,778	$3,647,820	164,280	$3,221,520	133,668	$2,614,076
Demobilization										
Land Transportation & Handling	1,940	39,720	1,566	35,748	2,088	47,664	1,740	37,025	1,566	35,748
Marine Transportation	856	8,704			1,070	10,880				
Air Transportation										
Subtotal	2,796	$ 48,424	1,566	$ 35,748	3,158	58,544	1,740	$ 37,025	1,566	$ 35,748
TOTAL	208,224	$4,084,760	127,138	$2,497,913	189,590	$3,772,144	170,314	$3,335,530	139,522	$2,722,259

3/ OCS-% 0191 #1 was suspended on December 25, 1981. Tbe rig was moved to drill OCS-Y 0191 //2, then moved back to 0CS-% 0191 #1 on March 15, 1982. Employment data for both wells is consolidated here.

TABLE 22

EMPLOYMENT SUMMARY
ESTIMATED WORK HOURS & WAGES
SALE BF & SALE 71 EXPLORATION PROGRAMS
1980 - 1983
(Continued)

	1981 - 1982						1982 - 1983	
	Exploration Well Name[1]/							
	Jeanette Island		Tern Island #1		Tern Island #2		Seal Island #1	
	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s
Mobilization								
Land Transportation & Handling	4,176	$ 95,328	2,958	$ 72,709	696	$ 15,888	3,132	$ 76,986
Marine Transportation	428	4,352	2,223	21,945				
Air Transportation	240	7,200	220	6,600	80	2,400	180	5,400
Subtotal	4,844	$ 106,880	5,401	$ 101,254	776	$ 18,288	3,312	$ 82,386
Drilling Operations								
Land Transportation & Handling	3,240	74,205			720	15,708	720	16,758
Air Transportation	1,680	50,400	2,040	61,200	2,820	84,600	480	144,000
Drilling Crew	39,600	828,000	44,550	972,000	77,550	1,692,000	132,000	2,880,000
Catering & Camp Svcs.	5,400	90,000	7,992	133,200	11,520	192,000	18,720	312,000
Oil Field Service Specialties	8,640	180,000	9,720	202,500	16,920	352,500	28,800	600,000
Miscellaneous Support (medical, weather, maintenance, labor)	12,960	151,200	11,520	144,000	18,720	234,000	30,720	384,000
Subtotal	71,520	$1,373,80.5	75,822	$1,512,900	127,550	$2,570,808	213,473	$4,358,703
Demobilization								
Land Transportation & Handling	2,436	55,608	696	15,888	2,610	59,580	2,436	59,878
Marine Transportation	963	9,792						
Air Transportation	200	6,000						
Subtotal	3,599	$ 71,400	696	$ 15,888	2,610	59,580	2,436	59,878
TOTAL	79,963	$1,552,085	81,919	$1,630,042	130,936	$2,648.676	219,221	$4,500,967

1/ Tern Island #1 and #2 were drilled during open-water summer season. Marine transportation data listed under mobilization phase includes transportation support provided to drilling operations. Data for both wells are combined under Tern Island #1.

Also exploratory drilling on Seal Island began June 1, 1983, shut down temporarily and resumed November 1, 1983. Data for this well includes drilling acclivities through well completion on January 30, 1984.

Note: Includes unadjusted direct wages only.

source: Operator and Contractor interviews; Kevin Waring Associates estimates.

used information available from primary sources such as direct employers and secondary sources such as operators administrating contracts with primary sources. This data was supplemented by information about industry practice developed from interviews with supervisory and professional employees of contractors and their clients, and with representatives of labor unions who supply a significant portion of the labor force for construction and transportation work in support of North Slope exploratory operations.

The employment data have been estimated by hours and direct wages based upon the size and composition of the work crew for each functional category, adjusted for the duration of the particular activity. For example, the crew of a tug operating from the West Dock of Prudhoe Bay regularly consists of five persons with job categories work rules and compensation terms set by specific labor agreements. Paid work time and wages were calculated according to the provisions of the pertinent collective bargaining agreement. The estimates of total hours and costs were based on the actual time that the tug was on station for a particular project.

Estimates for work time and labor costs for surface (truck) transportation and general construction work involved in gravel island construction were prepared using a similar approach to that described immediately above.

Wage costs for a drilling crew are based upon daily summaries of employment costs, not including equipment costs, rather than a sum total of

individual hours and hourly rates. The figure used is an average of the information provided by the responding drilling companies for 26- to 28-person crews operating on a 24-hour basis. This use of a daily average figure for drilling crew hours and wages greatly simplified calculations without any material loss in accuracy.

The estimated wage costs for the workforces providing air transportation services, oilfield services, catering and related camp services, and miscellaneous other field support were calculated on a similar basis to the methodology used for drilling crew cost estimates, adjusted to reflect prevailing wage rates for the appropriate category of labor.

In all cases, the wage estimates include only direct wage payments, with no allowance for leave time, holidays, benefits or other labor-related costs .

This methodology, together with data obtained about the duration of individual functional tasks, has enabled us to estimate labor effort and costs attributable to the seven gravel island construction projects and to the 15 exploratory wells covered by this study. In view of the impracticality of attempting to compose the employment history of Beaufort Sea exploration programs from the scattered records of dozens of individual firms, we believe that this method of reconstructing hour and wage data can provide a more complete and accurate total picture.

GRAVEL ISLAND CONSTRUCTION LABOR EFFORT AND WAGES

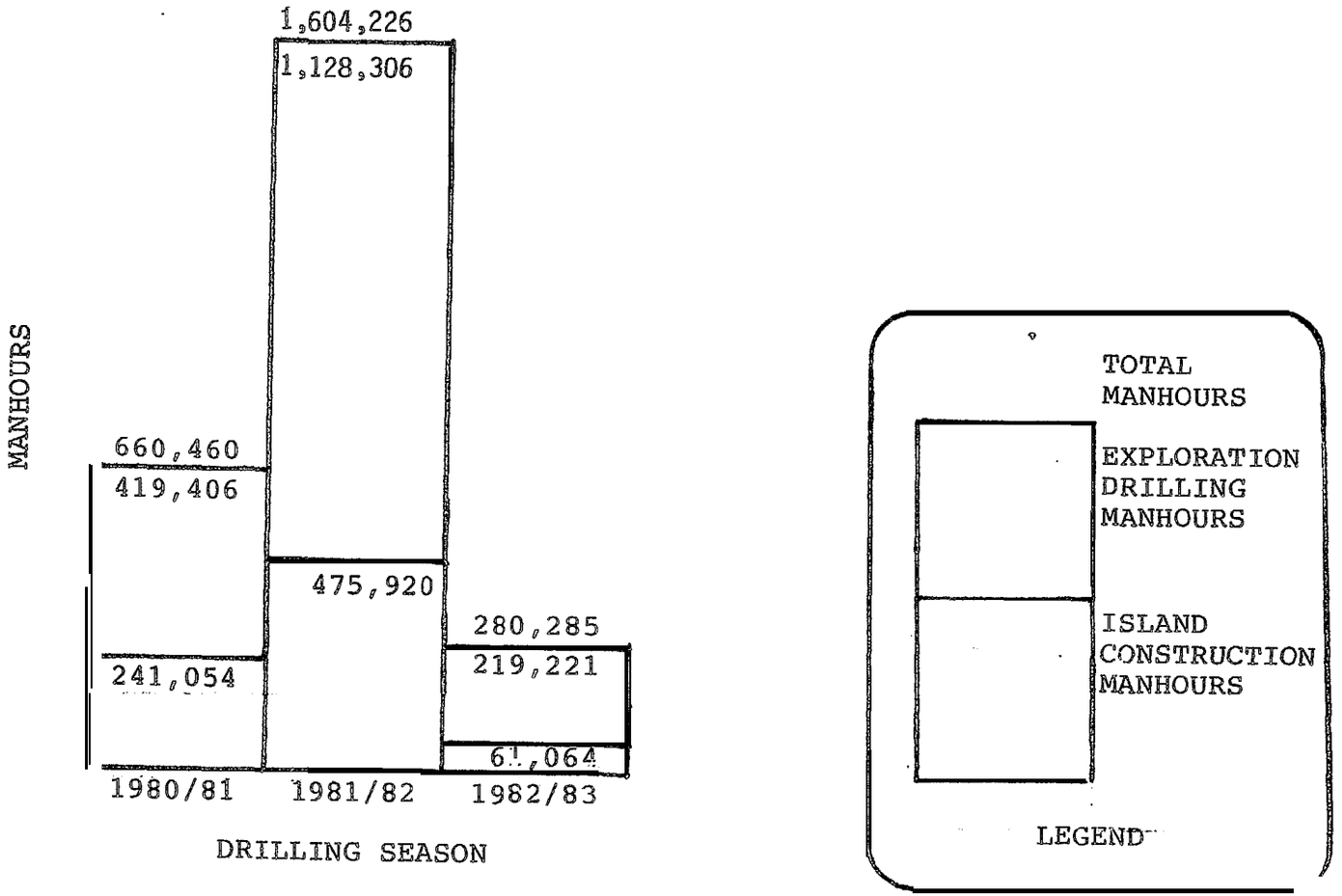
Table 21 and Figure 14 (Sale BF only) summarize the onsite hours and wages for the Beaufort Sea gravel island construction projects. For each island project, Table 21 provides data for (a) transportation support activities, by mode, and for (b) construction activities, broken down by ice road construction and materials handling and placement.

Most of the construction crews and other workers for island construction projects were quartered at existing camp facilities. For example, crews for Endeavor and Resolution Islands were based at Sohio's Construction Camp 1, while offshore crews for Tern and Seal Island were largely based at the Happy Horse Hotel at Deadhorse. For Tern Island, a large construction camp, was also maintained near the gravel pit by Shaviovik River. On the other hand, the Mukluk Island project required establishment of a 272-bed temporary camp at the Ugnu gravel pit for winter operations and a 150-bed camp plus a 110-bed barge camp at Thetis Island for summer construction operations. Because camp support arrangements were irregular and specific data difficult to obtain, this activity component was omitted for gravel island construction.

Since we were not able to obtain a breakdown for employment data for Endeavor and Resolution Islands (both islands were constructed by the same contractors at the same time), data for those two island projects are grouped. However, based on total cost and other construction data about these two islands (Table 18), it is estimated that Endeavor Island probably accounted for about 55 percent of hours and wages and Resolution Island for about 45 percent.

FIGURE 14

SALE BF ISLAND CONSTRUCTION & EXPLORATION DRILLING
HOURS OF EMPLOYMENT, BY DRILLING SEASON



Source: Derived from Tables 21 & 22.

As with other features of gravel island construction, the labor effort varied widely among the projects. For example, Resolution Island, previously noted to be the most modest island construction project, required an estimated 50,600 manhours of onsite labor. At the high extreme, Mukluk Island required about 393,000 manhours.

Table 23 summarizes island construction employment data by drilling season. In relation to the sale dates, it may be seen that, for Sale BF tracts, island construction began a few months after the December 1979 sale date, peaked in the second year after the sale and dropped off in the third year. This trend is illustrated in Figure 14. For Sale 71, Mukluk Island was, of course, begun in the winter following the sale and completed for use about a year after the sale.

The employment data confirm two plausible generalities about the labor requirements of gravel island construction projects. The five gravel islands built in relatively shallow water (Endeavor, Resolution, Unnamed, Tern, Cross) entailed substantially less labor effort and cost than the two deepwater islands (Seal, Mukluk). Likewise, the volume of fill required for island construction correlates closely with labor effort.

For the seven islands as a whole, the onsite employment amounted to 1,170,819 manhours and $26,743,621 in wages. The average per project was 167,260 manhours and $3,820,517 in wages.

TABLE 23

EXPLORATION EMPLOYMENT BY INDUSTRY

ESTIMATED WORK HOURS & WAGES

SALE BF AND SALE 71 EXPLORATORY PROGRAMS
BY DRILLING SEASON

	1980-81		1981-82		1982-83		Total	
	Hours	$'s	Hours	$'s	Hours	$'s	Hours	$'s
Gravel Island Construction								
Transportation	95,038	$ 1,447,646	2,600	$ 78,000	206,633	$ 4,460,911	304,271	$ 5,986,557
(Air)	(--)	(--)	(2,600)	(78,000)	(3,600)	(108,000)	(6,200)	(186,000)
(Marine)	(36,166)	(366,450)	(--)	(--)	(35,417)	(382,305)	(71,583)	(728,755)
(Surface)	(58,872)	(1,101,196)	(--)	(--)	(167,616]	(3,970,606)	(226,488)	(5,071,802)
Construction	146,061	3,170,022	473,320	11,577,131	247,212	6,009,911	866,548	20,757,064
Subtotal	241,054	$ 4,617,668	475,920	$11,655,131	453,845	$10,470,822	1,170,819	$26,743,621
Exploration Drilling								
Transportation	38,382	879,299	95,814	2.282,509	8,981	324,96?	143,177	3,486,775
(Air)	(3,340)	(168,700)	(26,282)	(880,400)	(660)	(149,400)	(30,282)	(1,198,500)
(Marine)	(2,996)	(28,700)	(12,924)	[328,855)	(2,033)	(21,945)	(17,953)	(179,500)
(Surface)	(32,046)	(681,899)	(56,608)	(1,273,254)	(6,2638)	(153,622)	(94,942)	(2,108,775)
Mining	296,160	5,987,000	796,630	16,757,000	160,800	3,480,000	1,253,570	26,224,000
Other	84,884	1,060,800	235,862	3,203,900	49,440	696,000	370,186	.4,960,700
Subtotal	419,406	$ 7,927,099	1,128,306	$22,243,409	219,221	$ 4,500,967	1,766,933	S34,671,475
TOTAL	660,460	$.12,544,767	1,604,226	.$33,898,540	673,066	$14,971,789	2,937,752	$61,415,096

Note: Includes unadjusted direct wages only.

Source: Operator and Contractor interviews; Kevin Waring Associates estimates.

EXPLORATION DRILLING LABOR EFFORT AND WAGES

Table 22 summarizes onsite drilling employment and wages for fifteen Sale BF exploration wells. For each well, the data is presented separately for the mobilization, drilling and demobilization phases. Within each phase, the data are further broken down by mode of transportation and by major drilling and support functions.

The drilling crews accounted for the greatest share of onsite labor, averaging about 60 percent of total manhours. Oil field services and miscellaneous support activities accounted for about 12 to 14 percent respectively and catering and camp services for another 7 percent. The remaining transportation and support activities accounted for relatively minor amounts of labor and wages.

As with gravel island construction projects, there was a wide range in the onsite labor effort required for drilling programs. Sag Delta #10 required the least labor -- 58,324 mahours, while Seal Island #1 required 219,221 manhours. For the fifteen wells overall, the onsite employment totalled 1,766,933 manhours and $34,671,475 in wages. The average per exploration well was 117,796 manhours and $2,311,432 in wages.

The factor accounting "for most of the variation among exploration wells was the duration of the drilling program. In some cases, drilling projects have been prolonged by adverse drilling conditions or problems, interruptions or even shutdowns. This necessitated extra onsite time

for drilling crews and other field support staff. Shell's Seal Island #1 was completely shut down during the fall whale migration season. Likewise, the other drilling projects with exceptionally high labor figures (e.g., Alaska Island #1, Alaska State F#1, No Name Island #1) were affected by adverse drilling conditions.

For Sale BF, the overall pattern of drilling activity, as shown in Figure 14, can be characterized as a fast start in the first drilling season (1980-81), a more intensive second season (1981-82) and a slackening of drilling activity in the third post-sale drilling season (1982-83). Because of the limited period of time for drilling since Sale 71, it is too soon to see any overall pattern of drilling activity.

IV. EXPLORATION MANAGEMENT AND ECONOMIC IMPACTS

Introduction

This chapter deals with a variety of topics related to lease management and impacts on regional economic development in the North Slope Borough and elsewhere in the state. The topics covered in this chapter are:

- o Permits and the effect of major permitting actions upon exploration programs, with a case study of the Mukluk Island construction project.

- o Seasonal Drilling Stipulations on seasonal drilling and their impact on the pace, level of effort and cost of exploration programs.

- o Mitigation Measures adopted to counter potential adverse impacts of exploration on the local economy.

- o Development Proposals, pending or proposed, associated with exploration activities for Sale BF and Sale 71.

- 0 Resident Workforce, which analyzes the residency pattern of the onsite workforce for Beaufort Sea exploration programs.

- o Economic Impacts on Regional Economies? describing the effects of Beaufort Sea exploration on regional economic development.

o Marine Surveys, reporting on post-sale marine geophysical survey work in the Beaufort Sea sale areas.

Permits

OVERVIEW OF PERMITTING PROCESS

Operators indicated that the permitting process was a major factor in determining the critical path for scheduling Beaufort Sea exploration projects. Figure 15 illustrates the general process for obtaining the major permits and other authorizations necessary for a permit to drill on a federal tract.

After the lease sale, among the first activities usually undertaken by an operator are site specific field surveys such as a geohazard survey, cultural survey, site biological survey and geotechnical survey. The geohazard survey is required for all offshore exploration projects. The geotechnical survey is required only for bottom-founded or fixed structures, not for floating drilling units. Cultural and biological surveys are only conducted when required by the regional supervisor of Minerals Management Service (MMS) Field Operations. Figure 15 summarizes the purpose of these studies and the types of information collected. Typically these surveys are done in the Beaufort Sea using marine vessels in periods of open' water. However, for some projects, such as Sohio's Mukluk, where the time frame dictated that the data be available earlier, these surveys were done in the winter by boring through the ice. The scope and methods used for the site biological survey are

usually tailored to each area based on recommendations of the Biological Task Force, which includes representatives of state and federal natural resource management agencies.

The two most significant applicant submittals in the permitting process for a Beaufort Sea project are 1) the exploration plan package which includes four components: exploration plan, environmental report, oil spill contingency plan, and coastal zone consistency certificate and 2) the platform verification review documents. Figure 15 details the information included in these components. The applicant submits the exploration package to MMS which then has ten working days to determine whether the package is complete. After MMS notifies the lessee of any necessary changes, the lessee has as much time "as needed to respond. Once MMS determines the package is complete, the applicant must submit 35 sets to MMS for distribution within the agency as well as to federal, state, local and other reviewing groups (Figure 15). MMS then has a regulatory limitation of 30 calendar days to complete a technical and regulatory review and take action. Typically reviewers have 20 days to submit their comments to MMS. Based on the information contained in the applicant's exploration package, analysis by MMS staff and comments from reviewers, the MMS staff prepares an environmental assessment of the exploration plan.

If MMS determines the project will have no significant effects, it prepares a "FONSI," a "finding of no significant impact." After MMS issues a determination, it notifies all the agencies, organizations, etc., who were sent copies of the submittal or notified of the submittal.

FIGURE 15

MAJOR PERMIT REQUIREMENTS FOR PERMIT TO DRILL

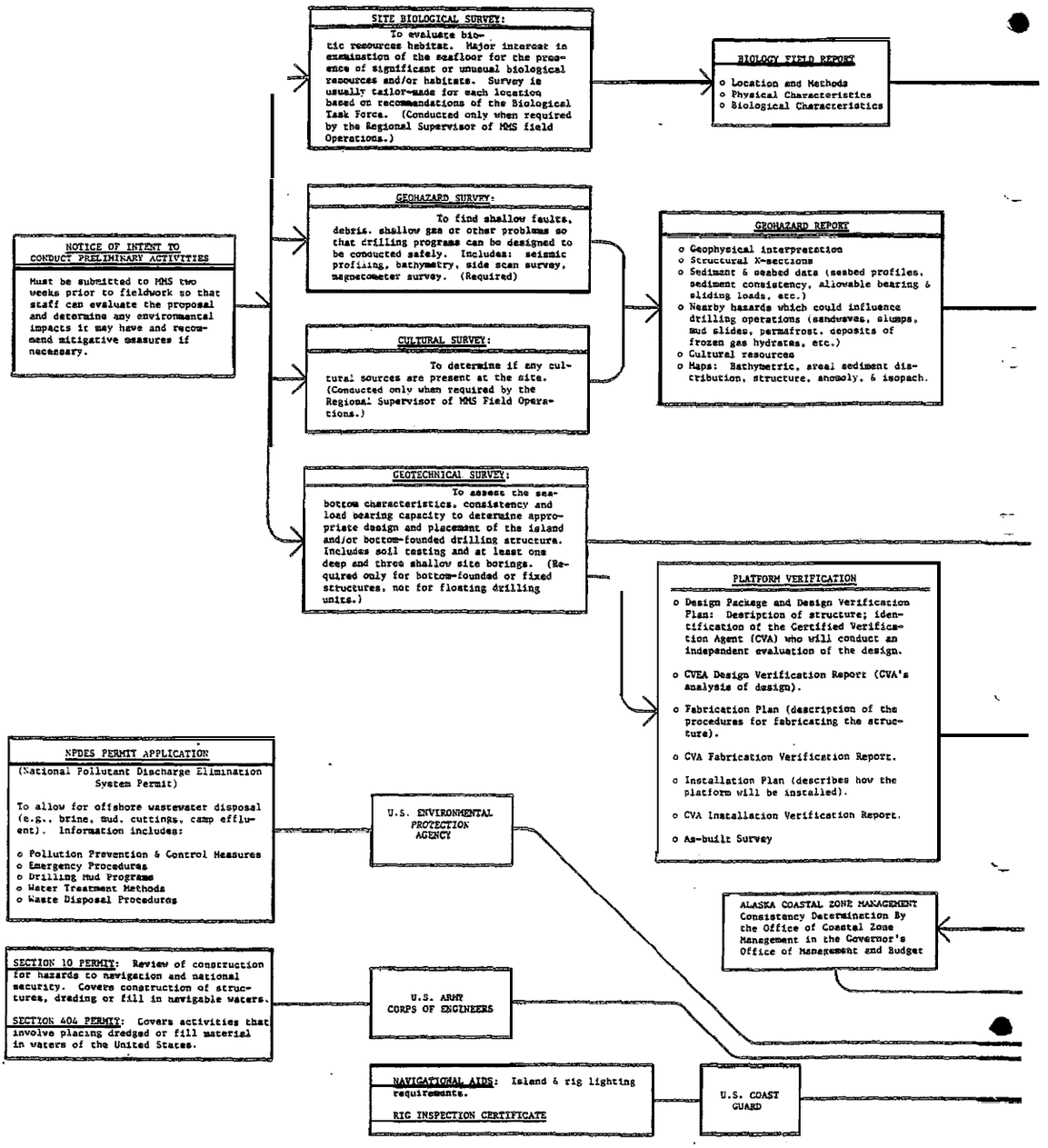
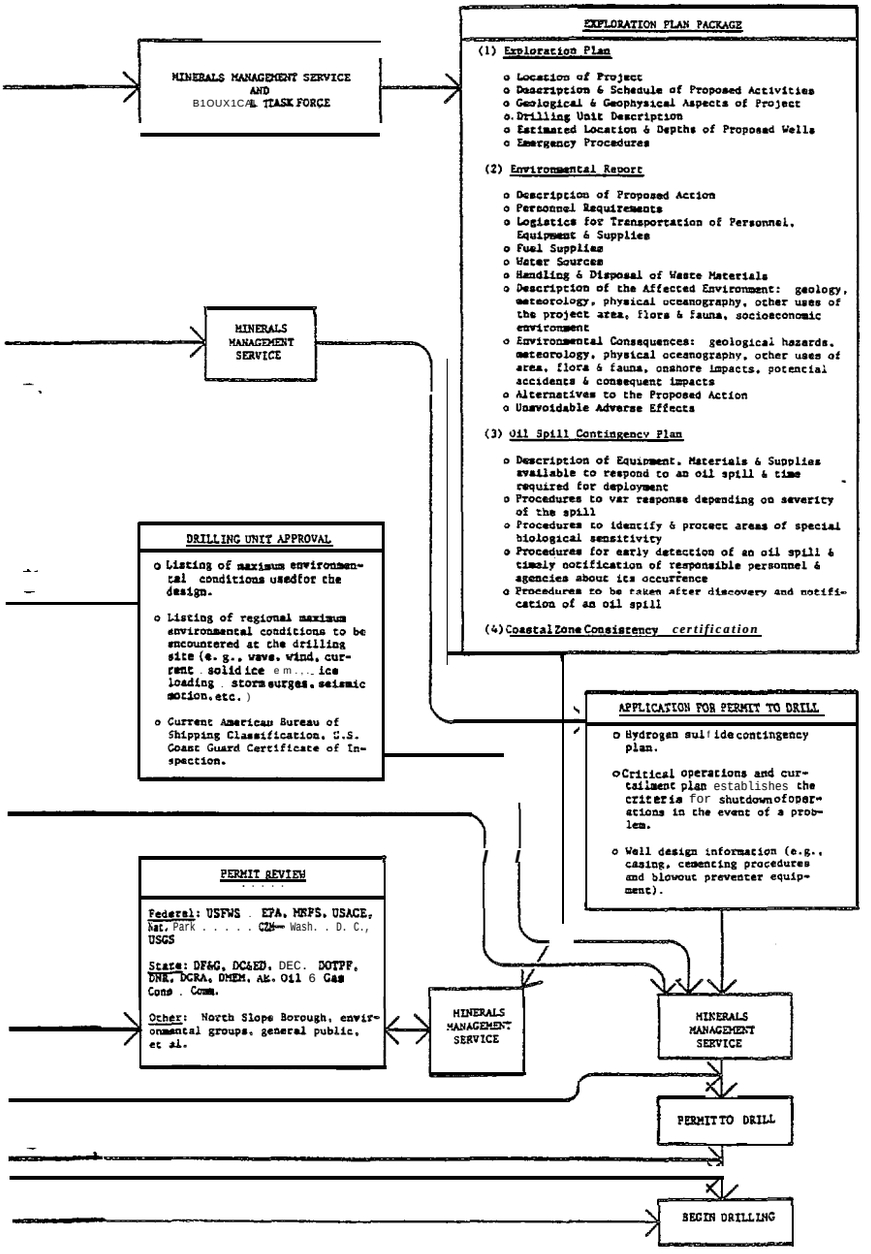


FIGURE 15

MAJOR PERMIT REQUIREMENTS
FOR PERMIT RO DRILL
(Continued)



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If MMS determines that an exploration project would have significant environmental effects, MMS has to prepare an environmental impact statement (EIS), which would likely take about two years. This has not yet happened in the case of Beaufort Sea exploration programs, for which environmental assessments have sufficed. However, if commercial quantities of oil are discovered and the operators propose development and production plans, MMS staff noted that it is very likely a new EIS will be required. Under provisions of the OCS Lands Act, as amended in 1978, the Secretary of Interior must declare at least one development and production plan in a "frontier area" (e.g., Beaufort Sea) to be a major action requiring the preparation of an EIS.

Although the MMS review process for the exploration package takes only 30 days, the Office of Coastal Zone Management (OCZM) in the Governor's Office of Budget and Management (now Division of Governmental Coordination) has 60 days to determine whether the project is consistent with the state's Coastal Zone Management Plan. OCZM also solicits comments from the state and local agencies and other groups shown in the permitting loop on Figure 15. Although all federal agency comments must be channeled through MMS, state, local and other reviewers have the option of submitting their input on the exploration package to MMS, OCZM or both agencies.

The application for the National Pollution Discharge Elimination System Permit (NPDES), which is required to discharge substances into United States' waters, is submitted by the applicant to the Environmental Protection Agency (EPA) where it is circulated for review and comment to

essentially the same permitting loop as the exploration package. This material takes six months to process prior to being issued. It must then be in effect 30 days before the first discharge may be made. Similarly, section 10 permits for the construction of structures, dredging or fill in navigable waters and Section 404 permits for placing dredged or filled materials in United States' waters are submitted to the U.S. Army Corps of Engineers which also circulates them for review to the permitting loop agencies. The permitting process for these Corps of Engineers' permits usually takes three to five months. Section 10 and Section 404 permits may also require a coastal zone consistency determination, unless described in detail in the exploration plan.

A multi-step platform verification process which includes the description, design, construction and installation of the fixed drilling platform must be approved by MMS. The U.S. Coast Guard also requires approval and installation of navigation aids for the island and rig lighting and a rig inspection certificate.

The permit to drill is usually the final permit issued. MMS cannot issue a permit to drill until the exploration plan has been approved by both the MMS and Coastal Zone Management review processes.

It should be noted that these are only the major steps in the federal permitting process. As will be seen in the following discussion of the permitting process for the Mukluk project, a large scale project often requires a much more complex array of permits, particularly state permits involved with gravel extraction shore-based facilities or offshore activities inside the three-mile limit.

MUKLUK PERMITTING PROCESS

Sohio's Mukluk project was the first exploration program implemented for Sale 71. The wellsite was located in eastern Harrison Bay about 60 miles west of Prudhoe Bay in 48 feet of water, beyond the barrier islands. The exploration plan called for fast-track construction of the most massive and costly man-made gravel island built so far for Beaufort Sea exploration.

The permitting process was a major consideration in planning for the Mukluk project. The timing was more critical than usual since the company acquired the lease on October 13, 1982 and set a target date of November 1, 1983 to begin drilling. Potential permitting problems ruled out some approaches to the project which might otherwise have been utilized. For example, a presentation to the 1984 Offshore Technology Conference entitled "Engineering and Construction of Mukluk Island" (Ashford, 1984) noted:

> Consideration was initially given to conventional winter construction by hauling gravel over ice road all the way to Mukluk. This scenario had to be abandoned because of permit schedule restrictions and because there was insufficient data available to evaluate the stability of the ice road so far from shore.
>
> Other possibilities such as the use of an arctic drilling structure, converted VLCC, or summer dredging an island using an offshore borrow source were also ruled out because of permit schedule restrictions .

Based on their experience with obtaining permits for other projects, Sohio staff anticipated that it would take approximately one year to

complete the permit/authorization process to begin drilling the Mukluk project. Table 24 summarizes the major permit/authorizations, their purpose, the primary agency contacts for each, and a timetable which shows dates filed, dates granted or denied, amendment dates and waiver dates. Sohio organized its permitting efforts into four major components: 1) Ugnuravik gravel pit, 2) Thetis Island stockpile, 3) island construction, platform verification and drilling, and 4) Oliktok Base Camp (later replaced with the Milne Point Pad "C" when the permit for the camp pad construction was denied). -

Sohio's Environmental Report, officially submitted to the MMS in May 1983, contained the company's projections of the critical dates by which each major permit/authorization needed to be approved to achieve a November 1, 1983 spud date.

Of the four components, the permitting for the Ugnuravik gravel pit proceeded more smoothly than the others. Only two minor permit/authorizations were not granted by their projected critical dates: the utility code exemption from the North Slope Borough. to allow a 250-man camp to maintain. its own facilities was granted about one week behind schedule and a letter of non-objection from Chevron was received two days later than originally anticipated. Overall, the -permit/authorizations for this component 'were all complete by February 3, 1983, only two days past the projected date.

Most permits for the Thetis Island stockpile component were granted within their planned timeframes. The Section 10/404 permit. for place-

TABLE 24

MUKLUK PROJECT PERMITTING PROCESS

Permit/Authorization	Purpose	Primary Agency Contacts	1982 Oct	Nov	Dec	1983 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Ugnuravik Gravel Pit																
Section 404	Placement of fill on wetlands.	USACE/CZM			0 10/28		1/31									
Material Sales Contract	Acceptance of new pit as a long-term source.	DLWM			0 11/12		1/26									
Land Use Permit	Construction of 6-7 mile ice rod & camp pad at pit site.	DLWM			0 12/15		1/14	2/1 A		3/4 A						
Temporary Water Use	Use of Lake Arnold & unnamed lakes nearby for ice road & camp uses.	DLWM/DF&G DEC			0 12/15		1/14			2/25 A						
Waste Discharge	Discharge of camp sewage effluent.	DEC			12/9		1/20									
NPDES	Discharge of camp sewage effluent.	EPA			0 12/15		1/20 W	Permit waived.								
Interim Zoning Ordinance	Development of new gravel source.	NSB			0 11/24			2/1	2/17 A							
Utility Code Exemption	Allow 250-man camp to maintain own facilities.	NSB					1/17	2/1 @								
Agreement with Private Parties	Nori-Objections to activities onother leases.	ARCO & Chevron			0 12/15		1/12	2/3 @ ARCO Chevron								

Primary Agency Contacts: USACE = U.S. Army Corps of Engineers; CZM = Coastal Zone Management; DLWM = Div. of Land and Water Management; DEC = Dept. of Enviornmental Consecration; ADF&G = Department of Fish and Game; EPA = Environmental Protection Agency; USCG = U.S. Coast Guard; NSB = North Slope Borough; USAF = U.S. Air Force; MMS = Minerals Management Service

Key: 0 = Date of permit orauthorization appl ication; @ = Date granted; D = Date Denied; A = Date amendment approved; W = Date permit waived

Source: Sohio AlaskaPetroleum Company.

TABLE 24
(Continued)

MUKLUK PROJECT PERMITTING PROCESS

Permit/Authorization	Purpose	Primary Agency Contacts
Thetis Island Stockpile		
Section 404 Waiver	Placement of fill on island.	USACE/CZM
Section 10/404	Placement of fill in U.S. waters.	USACE/CZM
Land Use Permit	One year permit to use island for staging operations.	DLWM
Waste Discharge	Discharge of camp & desalination plant effluent.	DEC
Interim Zoning Ordinance	Permit to use island for temporary staging operations.	NSB
Utility Code Exemption	Allow 75-man camp to maintain its own facilities.	NSB
Agreement with Private Parties	Lease acreage for stockpile.	Helmricks
Island Construction, Platform Verification & Drilling		
Geohazard Survey	Assess shallow drilling hazards, e.g., shallow gas.	MMS
Site Biological Survey	Assessment of organisms at site.	MMS
Platform Verification	Review of drilling structure	MMS
Exploration Plan/ Environmental Report	Review of exploration plan, SPCC.	MMS/CZM
Permit to Drill	Drilling program, environmental assessment.	MMS/CZM
Section 10 Nationwide Permit	Hazards to navigation and national security.	USACE

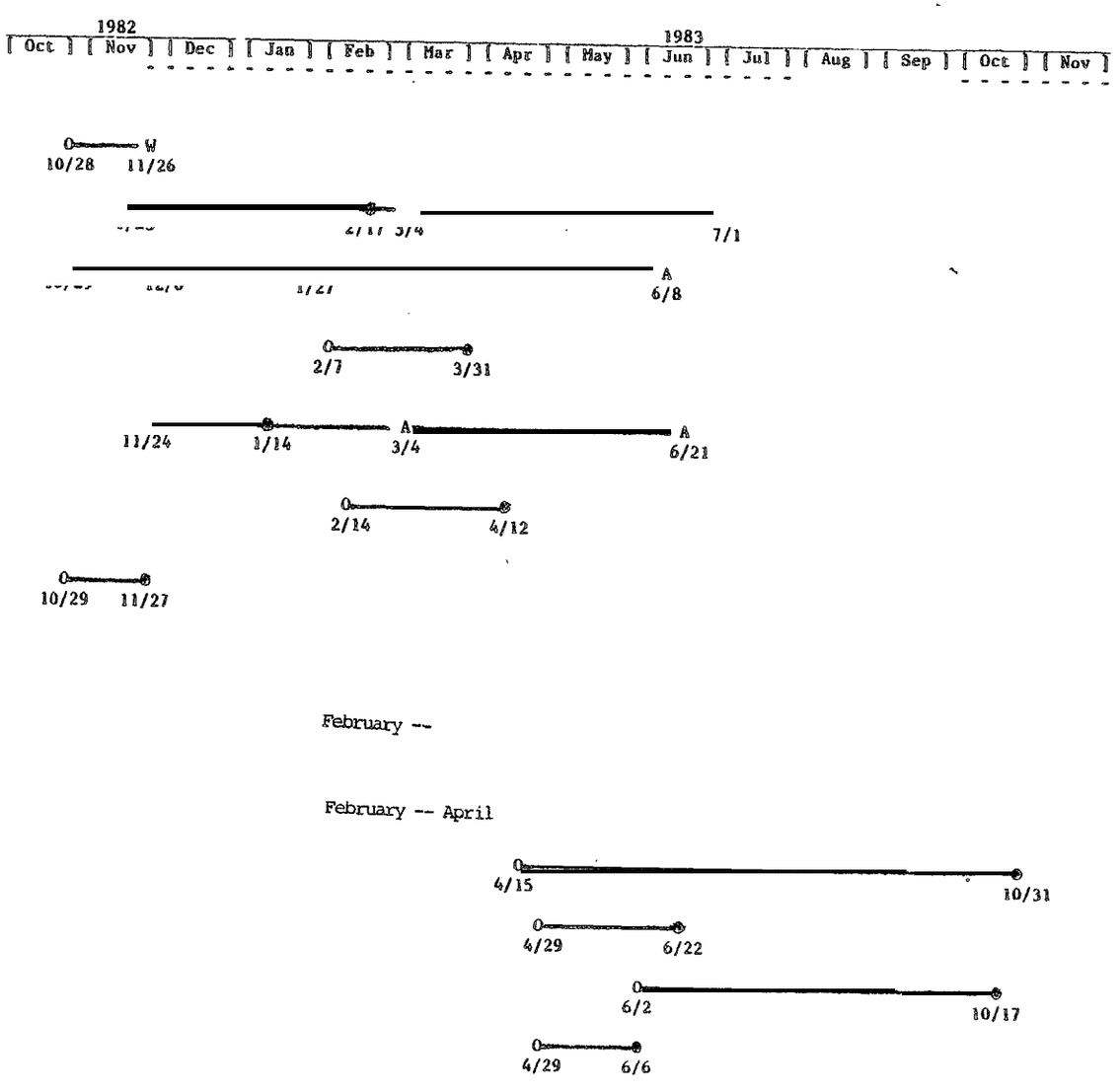

TABLE 24
(Continued)

MUKLUK PROJECT PERMITTING PROCESS

Permit/Authorization	Purpose	Primary Agency Contacts	1982 Oct	Nov	Dec	1983 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Island Construction, Platform Verification (Continued) & Drilling																
NAVAID	Notifications & marking of structurein federal waters.	USCG												9/8 9/28		
NPDES	Discharge of brine effluent, camp effluent, & mud & cuttings.	EPA/CZM						3/7						9/12		
NPDES (Barge Camp)	Discharge of sewage & desalination plants effluents.	EPA/CZM					2/7							7/28		
Private Non-objection	Designation of Operator;	Texaco/et al. Shell/et al.					2/18							7/15		
	Use of Oliktok dock for staging camp.	ARCO/ USAF					2/18	4/4								
							2/18	Denied								
Oliktok Exploration Base Camp																
Section 404	Place-mel,t of fill on wetlands.	USACE/CZM									6/3			D 7/15		
Surface Lease	Pad installation on state land.	DLWM									4/29			7/15		
Water Source	Water supply.	DLWM/DF&G	N/A													
Development Permit	New construction outside unit.	NSB									6/20			D 8/6		
Milne Point Pad 'C'																
Land Use Permit (Sohio Fi led)	Activities on pad, tundra, travel, ice road.	DLWM												9/21 10/12		
Lease Operat ions Amendment (Conoco Filed)	Placement of fill on tundra.	DMEM											8/22	9/22		
Developmen t Permi t (Conoco Filed]	Fill placement & activities.	NSB												9/6 10/3		
Sect ion 404 Amendment (Conoco Filed)	Fil 1 on wetlands.	USACE											8/22	4 9/30		

ment of fill in federal waters was two days behind schedule. The only significant delays involved the North Slope Borough which did not approve an interim zoning ordinance for a permit to use the island for temporary staging operations until more than two weeks past the company's projected date. Additionally, the North Slope Borough required a utility code exemption to allow the camp on the island to maintain its own facilities, a permit not anticipated in the company's original schedule.

Sohio indicated that. permits were required to stockpile gravel at Thetis Island by about January 1983. However, Sohio did not receive all of the necessary permits for the Thetis Island stockpile until April 12, 1983. In March 1983, Sohio determined that they needed to change the configuration of their gravel conveyor system on Thetis Island. This change necessitated amendments to the Section 10/404 permits, the land use permit and the interim zoning ordinance. For several months agency concerns over the proposed changes threatened to cause a one year delay in the entire Mukluk project. The land use permit and interim zoning ordinance were granted in June 1983. However, Sohio was able to get. the Section 10/404 approval by the critical July 1, 1983 deadline only by appealing to the directors of the NMFS and EPA who persuaded their local representatives to approve the amendments.

Permitting for the construction of Mukluk Island, the platform and drilling proceeded relatively smoothly. All permits were granted ahead of schedule except the platform verification, for which Sohio had set a desired date of April 15, 1983, but which was granted on July 7, 1983.

Sohio noted, "This approval process required a continuous stream of paperwork to answer reviewers' questions about design, safety and stability. It also became involved with the NMFS on the issue of bowhead whale monitoring." USCG approval was not granted for the NAVAID permit regarding notification and marking of structures in federal waters until September 28, 1982, nearly 2 months behind schedule, because it was considered incidental to the safety review.

Althought the Thetis Island stockpiling permit problems could have resulted in the most serious project setback, the project schedule was also jeopardized by the denial of permission to build a pad four a support base camp at Oliktok Point which would have been used later by the Kuparuk Unit and other exploration operators. Sohio worked on these permit approvals from April to August 1982 when final government denial was made on the grounds that 1) it was against state policy to build permanent facilities for exploration and 2) that it was a "critical habitat" area. (Sohio noted that, six months later, Arco received permits to build a similar pad for the same purpose as previously stated, on a location half a mile away.) As a fallback position, in August 1983, Sohio and Conoco agreed to utilize Conoco's existing Milne Point Pad "C" for a temporary camp and helicopter support station. Final permit approvals were granted for this by October 12, 1983. This delay and the shift to Milne Point greatly increased logistics costs, particularly due to longer helicopter flights. It should also be noted that Milne Point will be unavailable for this purpose in future years, as pipelines and active drilling will preclude casual use of the pads.

Overall, Sohio felt that the permitting process for Mukluk "seriously constrained the flexibility so necessary to complete a difficult and innovative task."

INDUSTRY PERSPECTIVES ON THE PERMITTING PROCESS

Several companies provided information regarding the dates they applied for major permits and when the permits were granted. Although they were reluctant to provide written comments regarding the permitting process, numerous company officials and staff members from the six operating companies in the study area gave informal verbal comments on the subject, but asked that they not be quoted directly. The section which follows summarizes the major issues and problems industry reported with the permitting process. The summary is meant to reflect industry's outlook on the permitting process as it has affected Beaufort Sea exploration and does not necessarily stand alone as a full and balanced account of permitting issues.

Major problems industry encountered with the permitting process included:

- Industry officials and staff members interviewed were satisfied with the performance of MMS staff in their handling of t-he permitting process. They felt that most MMS personnel: 1) carried out in an even-handed way their responsibilities to ensure that government requirements were met; 2) were knowledgeable about the technical aspects of oil and gas development; and 3) were supportive of oil and gas development.

o Industry officials indicated that most of their problems with the permitting process originated with other agencies and groups who were part of the commenting/review loop in the permitting process. The U.S. Fish & Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Environmental Protection Agency (EPA), and the Alaska Department of Fish and Game (ADFG) usually received the strongest criticism. Industry representatives felt that many of these government personnel were totally opposed to oil and gas development and used every opportunity to slow, stall or halt further development. One official commented: "the uninformed conjecture of one biologist's concern that 'something might happen' often carries more weight than our track record, statistical analysis and scientific studies." The U.S. Army Corps of Engineers was also criticized for not "balancing national needs with environmental concerns." An industry representative said, "In their determination to appease other agencies, the Corps will leave the applicant entirely on his own to convince the dissenting agencies to accept a compromise."

o Overlaps in state, federal and borough authority were cited by one industry official as a major problem in the existing permitting process:

> There are three levels of overlapping review and decision authority for Alaskan projects. The State has an approved Coastal Zone Management Program which gives them review authority for work on federal lands as well as the state lands. On state lands their authority covers permit decisions on separate surface and subsurface applications for the same project. Just as the state extends their

> authority offshore, the Federal government extends their jurisdiction onshore over state lands by requiring permits through the Corps of Engineers for any projects on wetlands or waters of the U.S. In the case of federal leases, the Corps of Engineers and the Department of Interior exert permit authority on the same projects. All aspects of the major reviews are virtually identical, only the characters and the political attitudes may differ.
>
> The North Slope Borough exerts wide-ranging authority for all projects onshore and out to the three mile limit offshore. Numerous other agencies conduct permit reviews for activities such as taking or discharging water, discharging of mud and cuttings, operating a camp, building temporary ice roads, seismic or field geology programs.

o In addition to the problem of overlapping authority, industry said the permitting process involved the same agencies in duplicative permitting loops. One industry representative gave the following description of the problem:

> A relatively small core group of cementing agencies reappear with different magnitudes of influence for each separate review ''phase. On the periphery there are a larger number of agencies which have limited entry into the action and generally are of less concern. All totaled, there is not a multitude of agencies so much as there are multiple opportunities for the same agencies to influence the outcome of the process to varying degrees.

A cited example of this duplication is the Sohio Mukluk project where EPA had permit review authority eleven different times over various aspects of the project:

1. Ugnuravik pit CZM State consistency review
2. Ugnuravik pit Clean Water Act Section 404 review
3. Thetis Island CZM State Consistency review
4. Thetis Island original Section 404 review

5. Thetis Island conveyor system amendment to the 404 permit
6. Thetis Island camp effluent discharge NPDES permit
7. NPDES mud and cuttings (and incidental effluents) discharge permit
8. Mukluk Exploration Plan, CZM State consistency review
9. Mukluk Exploration Plan, MMS review
10. Oliktok support pad CZM State consistency review
11. Oliktok support pad Clean Water Act Section 404 review

o With the exception of MMS staff, operators said some government personnel commenting on industry research, exploration plans, safety measures, etc., had little or no background in oil and gas exploration procedures and technology. As a result, some of the agency recommendations for changes and mitigative measures were unnecessary and some would actually have made the situation more hazardous. For example, one operator said that extra drilling shutdowns and startups and crew turnover necessitated by drilling interruptions were an added hazard. To counteract such problems, industry representatives said they often had to educate government personnel on subjects that are outside their realm of responsibility. For example, some companies have sponsored trips for agency personnel and local government representatives to see drilling and exploration operations in other areas.

o Some biologists take the stand that the conjecture of any potential negative impact on a habitat or animal population even if

the impact is only temporary, is sufficient reason to impede development. Example: This position on the part of the U.S. Fish and Wildlife Service and Alaska Department of Fish and Game almost prevented Sohio from using Thetis Island to stockpile gravel for the Mukluk project because of the perception of potential negative impact on a population. of nesting eiders.

o Studies which show deleterious environmental impacts are used repeatedly to block development, but industry-sponsored studies which show that impacts were not significant or did not occur are ignored. Example: An old study that found birds were disturbed by helicopters continues to be cited, while a study which documented that the nesting eider population on Thetis Island nearly tripled during the Mukluk project is heavily discounted. Another example of this sort cited by industry was the research on the Central Arctic Caribou Herd done annually since 1975 by the Alaska Department of Fish and Game. An industry memo noted:

> The reports supposedly receive department review prior to release but do not receive any additional peer review. Since these Progress Reports are the major source of biological information on the Central Arctic Caribou Herd they are instrumental in formulating and supporting permit stipulations and management philosophy.
>
> Recent Progress Reports infer that the Alaska Department of Fish and Game has stong evidence that petroleum development has displaced caribou from traditional calving areas and that cows and calves avoid the TAPS corridor. The results are increasingly restrictive and prohibitive permit stipulations.
>
> In recent months petroleum industry biologists and caribou biologists have closely examined these

Reports. Our preliminary conclusions are listed below:

- o The research is poorly designed and conducted
- o The research is subjective in places
- o The reports are replete with unsupported suppositions
- o Assumptions are often unstated and unsupported
- o Researchers have not documented natural variation
- o The reports are almost void of statistical analyses
- o Data do not support their conclusions.

The petroleum industry may be mitigating concerns that are false and certain onerous permit stipulations may not be necessary.

It is to our benefit to document problems inherent in these reports and to encourage Alaska Department of Fish and Game to prove their allegations and to improve the scientific quality of their reports.

The allegations in these Progress Reports are already being quoted by others and are being used to delay or impede petroleum exploration elsewhere.

o Operators felt government personnel naively expect industry to be able to lay out definitive plans and procedures in advance and view any later attempts to make changes as "bad faith," "piece-mealing," or an attempt to evade the regulatory process. Industry representatives noted that many of the Beaufort Sea projects involved application of new technology and methods under untested conditions. Part way into the project they may discover that a planned procedure or technology is inefficient or can be modified to improve safety. However, some government agencies use such changes to delay or stop a project. Example: When Sohio requested a change in the construction of a gravel conveyor system on Thetis Island (Mukluk project), the EPA and NMFS pressured the Corps of Engineers to re-open the entire

permit process to public comment. This would have effectively delayed the project for at least a year due to the weather window constraint. The EPA contended that the conveyor change would have a major impact on the island's bird population, a subject that Sohio said had been resolved in earlier discussions. Sohio was only granted permission to continue by appealing to higher levels in the EPA and NMFS in Juneau, Seattle and Washington, D.C.

o There is little appreciation among some government personnel for the cost of additional requested studies or compliance with additional conditions and mitigative measures. There is a general feeling on the part of government that the industry can afford the expense and time to fulfill such requests. Industry feels that these requirements are often simply harassment or delaying ploys which do little, if anything, to improve safety, efficiency or environmental mitigation.

o Some government personnel seem to believe that anyone working for an oil company does not care about the environment. Industry officials dispute this, noting their liability to pay for strong environmental damages. Additionally, many industry personnel are environmental and biological scientists with personal and professional commitments to their fields. One industry permitting staff member, a biologist, said he had never made a decision which he believed compromised the environment but continually had to respond to government requests to mitigate impacts for which there was little or no scientific basis.

- Government personnel, other than MMS, are often not sympathetic to the complex process involved in getting a permit to drill. One industry permitting staff member said, "They have no sense of balancing their concerns with other agencies or the state and national interest. They all feel that they are the only chance to provide public input." He noted that an agency may feel that there is no rush because drilling is 15 months away. However, their delay in approving a permit may seriously disrupt the critical path for the entire project. Denial or delay of approval to do work which must be done in a short time-frame due to seasonal limitations may delay a project for a year.

- The time from the point a permit application is submitted until it is granted is not an accurate measure of how long the permitting process takes or of the level of effort required. Industry often spends months doing field work, preparing reports, etc., in advance of a permit application. Industry also tries to work closely with agencies beforehand to anticipate and address potential objections prior to applying for a permit.

Seasonal Drilling Stipulations

BACKGROUND ON THE SEASONAL STIPULATIONS

The December 1979 Joint State/Federal Beaufort Sea Lease Sale included state and federal stipulations which limited exploratory drilling opera-

tions to between November 1 to March 31, with limited extensions pos - sible under specified conditions:

Federal Stipulation No. 8.

> Exploratory drilling and testing, and other downhole exploratory activities will be limited to the period November 1 through March 31, unless the Supervisor determines that continued operations are necessary to prevent a loss of well control or to ensure human safety. This stipulation will remain in effect for two years following issuance of the lease.

State Stipulation No. 9.

> Exploratory drilling and testing, and other downhole exploratory activities from surface locations outside the barrier islands will be limited to the period November 1 through March 31, unless the Director, Division of Minerals and Energy Management, after consulting with the Oil and Gas Conservation Commission, determines that continued operations are necessary to prevent a loss of well control or to ensure human safety. This stipulation will remain in effect for two years following issuance-of the lease.
>
> Exploratory drilling and testing, and other downhole exploratory activities from surface locations inside the barrier islands will be limited to the period November 1 through March 31, except the Director, Division of Minerals and Energy Management after consultation with the Biological Task Force may allow drilling and downhole activities to continue no later than May 15 if the lessee demonstrates the ability to operate safely and ice conditions justify; provided, however, that the Director, Division of Minerals and Energy Management after consultation with the Oil and Gas Conservation Commission may allow continued operations leading to shut down which are necessary to prevent loss of well control or to ensure human safety. This stipulation will remain in effect for two years following issuance of the lease.

Federal Stipulation No. 8 was scheduled to expire in July 1982. However, in May 1982 the Department of Interior announced that the drilling

season on federally managed tracts was extended to the 10-month period between November 1 and August 31. The two-month prohibition is designed to protect bowhead whales during their fall migration.

State Stipulation No. 9 expired in January or February 1982 (depending on dates of leases) and in May 1982 the state announced the following extended drilling season:

Inside the Barrier Islands.

- o Above the threshold* level: exploration and other downhole activities will be allowed year-round.
- o Below the threshold* level: exploration and other downhole activities will be allowed between November 1 and March 31, except at the mouths of major rivers, where drilling will cease April 30.
- 0 No drilling during whale migration,
- o Testing allowed year-round if casing has been set.

Outside the Barrier Islands.

- o Above the threshold* level: exploration and other downhole activities will be allowed year-round, except during whale migration.
- o Below the threshold* level: exploratory drilling will be allowed between November 1 and May 15.
- 0 Testing allowed year-round, if the casing has been set, except during whale migration.

* Threshold Level = the depth at which hydrocarbon deposits may be encountered.

The state also amounted that on a case-by-case basis, it would allow exploratory drilling and other downhole activities year-round, except during the fall bowhead migration. In order to obtain this approval, the lessee must demonstrate theoretical and physical capability to

detect, contain, clean-up and dispose of spilled oil in broken ice conditions.

Sale 71 included a seasonal drilling stipulation that was very similar to federal stipulation No. 8 for Sale BF. Stipulation No. 5 for Sale 71 read as follows:

Stipulation No. 5.

> Exploratory drilling and testing and other downhole exploratory activities will be prohibit-cd during the period September 1 through October 31, unless the DMMOFO determines that continued operations are necessary to prevent a loss of well control or to ensure human safety. This stipulation will remain in effect until termination of modification by the Department of the Interior after consultation with the National Marine Fisheries Service. "

Since the seasonal drilling stipulations had potential to affect the pace and level of effort for exploration, general industry opinion on these stipulations was reviewed and summarized. Additionally, operators for all Beaufort Sea exploration wells were interviewed to document what actual impacts the seasonal drilling stipulations may have had on their operations.

INDUSTRY TESTIMONY ON STIPULATIONS AT SALE BF AND SALE 71 HEARINGS

In testimony at hearings on the Joint Federal/State Sale and Sale 71, numerous oil industry officials objected to the proposed two month seasonal drilling restriction. Pertinent excerpts from this testimony are presented in Appendix E. Among the key claims made in industry test.i-

mony were that the proposed seasonal drilling restriction on exploratory drilling would:

- o Limit exploratory drilling to one well per year per rig.
- o Inflate the cost and time needed to assess leases.
- o Necessitate prolonged lease terms and exploration efforts.
- o Curtail the time available for well evaluation and test drilling.
- o Ignore industry's proven ability to operate in arctic waters without environmental damage.
- o Require assumptions about oil spill events that were not substantiated by drilling experience.

IMPACT OF SEASONAL STIPULATIONS ON DRILLING OPERATIONS

To date, there has been only limited documentation of the actual effects of seasonal drilling restriction on the pace and cost of exploratory drilling. In 1982, Dames & Moore published a report (Dames & Moore, 1982a) for the Alaska Division of Minerals and Energy Management on the State's season stipulation, but, at that time, little actual drilling experience had accrued. There is also a forthcoming paper, titled "An Analysis of the Operational Effects and Costs of the Federal Seasonal

Drilling Stipulation in the Alaska OCS", in preparation by John Lockert for the Minerals Management Service.

For the present study, the consultant team interviewed the six Beaufort Sea operators to obtain their outlook on the actual impact of seasonal drilling restrictions on exploratory drilling operations. The results of these interviews are summarized below. As an interpretative guideline to the responses, it is important to note that delays, costs and other effects associated with seasonal restrictions may not be wholly attributable to those restrictions alone. Exploration programs are complex undertakings making it difficult to isolate and measure the contributory role of any single factor upon final costs and schedules.

Each of the six operators was asked whether the seasonal drilling restriction had any of the following effects on their wells:

1) If the seasonal drilling stipulations had not been in force, would you have spudded this well earlier?

2) Were you forced to interrupt operations on this well because of seasonal drilling restrictions?

3) Did you do less exploration and testing on this well than you would have done if the seasonal stipulations had not been in effect?

4) Did you have to request extensions or waivers to do work on this well during the seasonally restricted period?

The operators were also asked to delineate how these effects affected their operations and estimate any additional costs incurred. Table 25 summarizes operator responses to the four questions for each well.

In response to the question: "If the seasonal drilling stipulations "had not been in force, would you have spudded this well earlier?", the answer was "yes" for 12 of the 17 wells in the study area. Two exceptions were Sohio's Sag Delta #10 and Exxon's OCS-Y0191 #2. In both cases, these were the second wells drilled from an artificial island. Another exception was Chevron's Jeanette Island #1 which was built on a natural barrier island. Chevron said that, due to the island's low profile, winter drilling was preferable because water typically washes over the island during the summer months. Sohio indicated that Mukluk would not have been spudded earlier as the project schedule was already tight. Shell also said Seal Island would not have been spudded earlier.

The difference in the date operators would have preferred to spud the wells and the date they were actually able to spud ranged from only six days for Shell's Tern Island #2 to 6.2 months for Gulf's Cross Island #1. Table 26 shows the preferred versus actual spud dates and the difference in months for each well.

Operators indicated that all of the wells which were spudded later than they would have preferred were more costly. Sohio indicated that spud-

TABLE 25

SUMMARY OF SEASONAL DRILLING RESTRICTION IMPACTS
ON WELL DRILLING OPERATIONS IN THE BEAUFORT SEA
Wells Spudded November 1, 1980 - November 1, 1983

Well	Operator	Island Type	Spudded Well Later	Inter-rupted Operation	Did Less Explor. & Testing	Requested Extensions
Challenge Island	Sohio	Natural	Yes	No	No"	No
Sag Delta #7	Sohio	Gravel	Yes	No	No	No
Sag Delta #8	Sohio	Gravel	Yes	No	Yes	No
Sag Delta #9	Sohio	Gravel	Yes	No	Yes	Yes
Sag Delta #10	Sohio	Gravel	No	No	No	Yes
Alaska Island #1	Sohio	Natural	Yes	No	Yes	Yes
Alaska State D#1	Exxon	Natural	Yes	No	Uncertain	No
Alaska State F#1	Exxon	Natural	Yes	No	Uncertain	Yes
No Name Island #1	Amoco	Natural	Yes	No	No	Yes
OCS-Y-0191 #1	Exxon	Gravel	Yes	No	Uncertain	No
OCS-Y-0191 #2	Exxon	Gravel	No	No	Uncertain	No
Jeanette Island #1	Chevron	Natural	No	N o	No	No
Tern Island #1	Shell	Gravel	Yes	Yes	Uncertain	Yes
Tern Island #2	Shell	Gravel	Yes	No	No	No
Seal Island #1	Shell	Gravel	No	Yes	No	No
Cross Island #1	Gulf	Gravel	Yes	Yes	No	Yes
Mukluk	Sohio	Gravel	Yes	No	No	No

Source: Kevin Waring Associates interviews of operators.

TABLE 26

EFFECT OF SEASONAL DRILLING STIPULATIONS ON WELL SPUD DATES

PREFERRED* VS. ACTUAL COMPARISONS

BEAUFORT SEA WELLS

Wells Spudded November 1980 - November 1983

Well	Operator	Spud Date		Preferred/ Actual Difference (in months)
		Preferred*	Actual	
Challenge Island	Sohio	8/15/80[1]	11/1/80	2.5
Sag Delta #7	Sohio	10/1/80	1/18/81	3.5
Sag Delta #8	Sohio	10/1/80	1/25/81	4.0
Sag Delta #9	Sohio	10/1/81	10/15/81	.5
Sag Delta #10	Sohio	10/20/81	10/20/81	0
Alaska Island #1	Sohio	8/15/81[1]	11/1/81	2.5
Alaska State D#1	Exxon	5/15/81	11/1/81	5.5
Alaska State F#1	Exxon	10/1/81	11/1/81	1.0
No Name Island #1	Amoco	6/81[2]	11/1/81	4.5
OCS-Y-0191 #1	Exxon	9/23/81	11/1/81	1.3
OCS-Y-0191 #2	Exxon	12/28/81	12/28/81	0
Jeanette Island #1	Chevron	12/24/81	12/24/81	0
Tern Island #1	Shell	4/3/82	5/29/82	1.9
Tern Island #2	Shell	10/10/82	10/16/82	.2
Seal Island #1	Shell	6/1/83	6/1/83	0
Cross Island #1	Gulf	4/23/83	11/2/83	6.2
Mukluk	Sohio	10/16/83	11/1/83	.5

* Preferred spud date is date the operator said the well would have been spudded in the absence of seasonal drilling stipulations.

NOTE: Prior to adoption of the two-tier drilling restriction in May 1982, the State of Alaska limited exploratory drilling to the period November 1 through March 31, with provision for extensions to May 15 under some circumstances.

1 Operator indicated the preferred spud date was "approximately one month after sea ice breakup" which typically occurs in mid-July.

2 Since no specific day of the month was indicated, it was assumed to be mid-month.

Source: Kevin Waring Associates interviews of operators.

ding its wells earlier would have meant "less standby costs. " Gulf cited three opportunities for savings: "Cheaper rig mobilization> no rig standby charges, no second ice road construction." Amoco noted that the "entire operational logistics had to be designed around a winter drilling season and ice conditions." Exxon and Shell were the only operators who specified the cost of delayed spud dates. Exxon estimated additional costs of $20,000 per day of rig standby costs. Shell estimated that the additional rig and standby equipment costs " for Tern Island #1 for 56 days amounted to $2,247,000 or $40,127 per day. Shell estimated that the six day delay on spudding Tern Island #2 cost an additional $380,000 or $63$300 per day.

There were three reported instances (Gulf's Cross Island, Shell's Tern Island #1 and Shell's Seal Island) where an operator incurred standby costs attributed to delay or interruptions related to the seasonal drilling restrictions. Gulf reported it could have mobilized to spud its Cross Island well as early as April 23 by ice road or July 10 by barge. To reduce standby cost, Gulf delayed mobilization until the end of July, and actual rig standby ran from August 7 until the November 2, 1983 spud date. Thus , the seasonal restriction delayed well spud by about 193 days, and contributed to 86 days of actual standby time, at rig standby costs of about $1.7 million. Shell had to shut down operations on Tern Island #1 from July 11 to July 22, 1982 at an estimated cost of $723,000. Due to seasonal restrictions Shell also shut clown Seal Island operations from July 25 to" November 1, 1983. During this period, rig standby costs, equipment rentals, and some logistical costs continued. Shell estimated that these costs added $2.4 million to the

well cost, or approximately $24,000 per day. Shell noted: "Additionally, there are costs of interrupting a continuous operation and delay in obtaining results which are difficult to quantify, but could be significant."

Operator answers to the question, "Did you do less exploration and testing on this well than you would have done if the seasonal stipulations had not been in effect?" were less definitive. The answer was "no" for Sohio's Challenge Island, Sag Delta #7, Sag Delta #10 and Mukluk; Amoco's No Name #1, Shell's Tern Island #2 and Seal Island, and Gulf's Cross Island #1. Exxon said that for all four of its wells the answer was "uncertain, but probable." The operator further noted: "In well planning (around seasonal drilling limitations) critical formation evaluation and testing had to be minimally designed or, at times, sacrificed." Sohio indicated that they did less exploration and testing on three of their wells:

> Sag Delta #8:
>
> Further testing of the Lisbourne Formation was deferred until the 'next drilling season.' This resulted in additional mobilization and demobilization costs.
>
> Sag Delta #9:
>
> In order to drill Sag Delta #9 and #10 in one artificial 'drilling season,' adequate testing of Sag Delta #9 was deferred to sometime in the future. Further mobilization and testing of the well has not been economically justified to date.
>
> Alaska Island #1:
>
> Adequate testing of the zone of interest was compromised for finishing the well at the end of the artificial 'drilling season.'

Chevron noted that the seasonal restrictions could have been a significant problem if Jeanette Island #1 had not been a dry hole. If oil had been discovered, Chevron said they probably would not have had enough time to test the well adequately or drill additional confirmation wells. Shell was "uncertain" regarding whether additional exploration and testing would have been done on Tern Island #1, but noted that "added well costs may have caused us to take less core."

In seven cases operators requested extensions or waivers to do work during the seasonally restricted period. Sohio requested and was allowed to spud its Sag Delta #9 and Sag Delta #10 wells about two weeks early. Sohio was also allowed to continue work on Alaska Island #1 after May 1 due to mechanical problems. Gulf indicated that it was granted an extension to continue work on Cross Island #1 into the seasonally restricted period. Amoco received a two-week extension on No Name Island #1 to test and clean up the location, but they noted that they did not do additional drilling. Exxon encountered the most significant problems with extensions in trying to complete work on Alaska State F#1. They had to get separate waivers from the State Division of Minerals and Energy Management (DMEM), and Alaska Department of Environmental Conservation (ADEC) and the North Slope Borough (NSB) to continue work until May 30. For granting these extensions the agencies imposed the following additional conditions and stipulations:

DMEM:

Whale monitoring and study program approved by Director, DMEM.

ADEC :

. . . ice monitoring and breakup reports and additional on-site oil spill response equipment.

NSB :

. . . inspection of location on 24-hour notification.

Shell noted that they had requested extensions or waivers which were not granted, but gave no specific details on the circumstances.

Operators were also asked if they would have drilled more Beaufort Sea wells if the seasonal drilling restrictions had not been in effect. Gulf, which only drilled one well in the period said, "yes," because "less costs per well equals more wells." Sohio, which drilled seven wells during the period said, "no, but the gross period of time to complete this seven-well exploratory program would not have taken as long." Amoco , which drilled one well during the period said the answer was "uncertain." They noted that "additional costs, logistic problems, and timing problems may have encouraged management to spend exploration money in other places." Shell said: "Additional wells could have been drilled from Seal had less time been spend waiting on drilling restrictions. The need for further drilling is currently being evaluated." As an overall comment Shell noted: "Seasonal drilling restrictions postpone evaluation of leases, which can impact the economics of discovery. Higher drilling costs also influenced future development plans and lease sale bids."

Mitigation Measures

The primary devices for mitigating potential adverse impacts of Beaufort Sea exploration programs were incorporated into lease stipulations attached to the sale tracts. Mainly, these stipulations addressed environmental concerns, such as possible adverse impacts upon critical biological habitat during peak periods of use by migrating whales and arctic fish, birds and other wildlife. The effect of these stipulations upon the timing and level of effort for Beaufort Sea exploration programs was addressed in the section on Seasonal Drilling Stipulations. There, it was noted that, while the motive of these stipulations was environmental protection, they did have significant> if coincidental, side effects upon the pace and level of exploration activity.

Apart from the lease stipulations, there seem to have been only limited formal measures specifically adopted to mitigate employment or other economic impacts of Beaufort Sea operations upon residents of the North Slope Borough. According to Borough staff, informal efforts were sometimes made to facilitate recruitment of interested residents for exploration site work. 'These efforts reportedly consisted mainly of notifying operators of the availability and interest of candidate employees. Gulf's Cross Island project, for which a number of residents were recruited, apparently was an exceptional case. Because of archaeological remains found near the exploration pad first proposed on Cross Island, Gulf was forced to negotiate with the North Slope Borough for an approved alternative exploration pad site. A provision of the agreement reached by Gulf and the Borough required resident hire for a share of the work crew at the exploration site.

The North Slope Borough also conducted a feasibility study for an industrial service base at Bullen Point toward the eastern edge of Sale BF near Flaxman Island. The development concept would be to promote development of a consolidated support center, similar to the Kuparuk Industrial Center. The consolidated center would centralize management of environmental impacts and facilitate resident employment while providing added revenues to the North Slope Borough. However, economic feasibility for the Bullen Point project depends on development of the Point Thompson Unit and, possibly, other reserves in that sector of the North Slope at a scale adequate to support development of a new satellite industrial center to the Prudhoe Bay/Deadhorse complex.

Development Proposals

In addition to the island construction, exploratory drilling, and other exploration support activities commenced before November 1, 1983, various projects were pending or proposed for the Sale BF and Sale 71 lease areas. These projects have been grouped into four categories: exploration islands; exploration wells; proposed field development projects; and support facilities. Additionally, there- are a number of proposed federal and state oil and gas lease sales, as well as a federal offshore gravel lease sale, pending in the immediate vicinity of Sale BF and the Diapir Sale. These projects and proposed lease sales could affect or be affected by the outcome of exploration and development programs for Sale BF and Sale 71 tracts.

EXPLORATION ISLANDS

As of April 1984, three artificial islands were proposed for installation to support exploration programs for Sale 71 tracts. First, Exxon has submitted an exploration plan to install the first CIDS during summer 1984 for exploratory drilling for its Antares Prospect about 120 miles northwest of the Prudhoe Bay service center. Second, Texaco's Fur Seal project proposed an artificial gravel island over the Mukluk structure at a site about 4.2 miles southeast of Sohio's Mukluk drillsite. After obtaining permits for island construction, Texaco suspended this project when the negative results of the Mukluk project became available. Third, Shell has filed an exploration plan for its proposed Sandpiper project. The exploration plan envisions construction of an artificial gravel island as a drilling base for up to four exploratory wells on the Harvard Prospect, about seven miles north-northeast of Beechey Point and 10 miles northwest of Shell's Seal Island discovery. Shell's final decision to proceed awaits the outcome of further tests of the Seal Island find.

"EXPLORATION WELLS

There were four exploration drilling programs pending as of November 1983, two in Sale BF and two in the Diapir Field, Sale. An exploration plan for a fifth exploration program, Texaco's proposed Fur Seal project, was submitted in October 1983 and withdrawn shortly thereafter.

Sale BF/Gulf Cross Island

Gulf's Cross Island exploration well is located next to Cross Island on a state-owned tract about 17 miles northeast of Prudhoe Bay. This exploration program was first announced by Tenneco in 1980, but exploratory drilling was delayed -due to controversy with the North Slope Borough over conservation of archaeological remains near the original proposed drillsite on Cross Island. The controversy was resolved in late 1982, under an agreement that Gulf would build an artificial island in a shallow bay on the landward side of Cross Island. By that time, Gulf had replaced Tenneco as the operating partner. Gulf. spudded its initial Cross Island well on November 2, 1983. Because of unforeseen fault patterns, the first exploration well did not hit the targeted formation, and Gulf drilled a second well deviated from the same borehole to explore an adjacent tract.

Sale BF/Shell Seal Island

Shell's Seal Island drilling unit covers six Sale BF tracts, including three state-managed tracts and three federally-managed tracts. Ownership of the federally-managed tracts is disputed. Shell's initial Seal Island Exploration well was spudded on June 1, 1983, but shut down before completion due to seasonal drilling restrictions. Drilling was resumed on November 1, 1983. In January 1984, Shell announced that it had discovered oil at three intervals and in March indicated its belief that the Seal Island discovery might prove commercially viable. The discovery well was on a state tract. A confirmation well targeted on

an adjacent federally-managed tract was spudded on February 5, 1984 and completed in April 1984.

Diapir Field/Sohio Mukluk

Sohio's Mukluk project exploration well was spudded on November 1, 1983. Due to conclusive negative findings, the well was plugged and abandoned in early 1984.

Diapir Field/Exxon Antares

Exxon's exploration plan for its drilling unit in the Diapir Field Sale anticipates' up to 22 exploration wells to be drilled after installation of the CIDS in summer 1984. Tentative plans are to initiate the first exploration. well in November 1984.

Diapir Field/Texaco Fur Seal

In late 1983, Texaco filed an exploration plan and obtained approval for its proposed Fur' Seal project to drill up to five exploration wells from an artificial gravel island about 4.2 miles southwest of the Sohio's Mukluk project. However, after the unfavorable findings of the Mukluk exploration well became known, Texaco and its partners cancelled the Fur Seal project..

PROPOSED FIELD DEVELOPMENT PROJECTS

As of April 1984, there were four field development projects under consideration at the periphery of Sale BF lease area. These were the Endicott Development Project, the Milne Point Unit, the Point Thompson Unit and the Lisburne Sands project.

The Endicott Development Project covers discoveries made by Exxon on Duck Island tracts acquired in State Sale 23 in September 1969 and by Sohio on two state-owned Sag Delta tracts acquired in Sale BF. Sohio has been designated as operator for an ownership consortium that includes Sohio, Exxon, ARCO, Union, Amoco, Doyon Limited, NANA Development Company, and Cook Inlet Region, Inc. Sohio has applied for an Army Corps of Engineers Section 404 permit and other federal and state permits for a proposed development scheme involving two gravel production islands, one of which will have waterflood facilities to maintain pressure, a causeway/pipeline and related production, transportation, and support facilities.

The Corps issued a Draft EIS in January 1984 examining Sohio's proposed production scheme and a number of alternatives. The Final EIS was published in August 1984, with the Corps permitting decision expected to follow before the end of 1984. In the meantime, the development scheme remains tentative pending further engineering and economic analysis after issuance of the Final EIS. The EIS estimated recoverable reserves at 280 to 423 million barrels of oil, with an initial production rate of about 100,000 barrels daily. No firm cost estimates are available for

the project, which is expected to exceed one billion dollars.

The Milne Point Unit proposed for development by Conoco encompasses upland and submerged tracts originally leased in the famed September 1969 Prudhoe Bay lease sale that netted the State of Alaska $900 million in bonus payments. The Milne Point Unit is about 35 miles northwest of Prudhoe Bay and about seven miles south of the nearest Diapir Field lease tracts. Cost of the proposed development program is estimated by Conoco at $787 million. In addition to further development drilling, major elements of the development program include a conditioning plant, water injection system, base camp, and an 11.5 mile, 14-inch pipeline. Construction is scheduled to begin in late 1984, with production to commence by 1986. While firm reserve estimates are not available yet, tentative estimates place recoverable reserves at about 100 million barrels, with a peak production of 30,000 barrels daily.

The Point Thompson Unit is east of Prudhoe Bay and includes major natural gas finds in the Point Thompson/Flaxman Island vicinity. Exxon, as a major owner of tracts in the area, has proposed expansion of the boundaries of the Point Thompson Unit to encompass potentially productive acreage in Sale BF and two other state lease sales. The economic feasibility for development of the Point Thompson Unit depends on construction of a natural gas pipeline or other system to transport production to markets.

The Lisburne Group underlies part of the Prudhoe Bay/Sadlerochit formation. Arco, as operator for a group including Exxon and Sohio, has

applied for permits to" develop the Lisburne field_. Plans call for construction of an offshore gravel production island, a 2½-mile filled causeway and upland production wells. The project is estimated to cost $1.44 to $2.0 billion, with production of about 100$000 barrels beginning late 1986 or early 1987.

SUPPORT FACILITIES

Kuparuk Industrial Center

The Kuparuk Unit oilfield, located 40 miles west of Prudhoe Bay, began production in December 1981. By the mid-1980s, it is expected to become the second largest U.S. producing field. The field contains an estimated 1.25 to 1.5 billion barrels of recoverable reserves. In early 1984, Kuparuk had 170 wells and was producing 120,000 barrels per day. It is estimated that the field will have 750 to 800 wells by the late 1980s and be producing 250,000 barrels per day.

The field is operated by ARCO Alaska, Inc. which plans to spend $7.2 billion to develop the Kuparuk Unit. ARCO has a central productions facility and an operation center which can house 300 ARCO workers. Other ARCO facilities include a water treatment plan, powerplant, airstrip, hanger, warehouse, and 200-foot communications tower. In 1982, ARCO completed a new $5 million dock at Oliktok Point to serve the Kuparuk field. The dock can handle up to 2,350-ton modules and carriers .

In August 1983, construction began on the $68 million, 53-acre Kuparuk Industrial Center, designed to house support services for the Kuparuk Unit oilfield operations west of Prudhoe Bay. The center, located one mile northeast of ARCO's Kuparuk River Production Facility, is scheduled to be completed in August 1984. It is designed as an operating base for firms which provide support services and materials to oilfield operators. The center is the first consolidated service-base operation on the North Slope. Rather than allowing the Kuparuk service facilities to sprawl, as happened at Prudhoe Bay, the North Slope Borough negotiated an agreement with an industrial coalition led by ARCO to restrict oilfield services facilities to a single oilfield service base. The center is expected to house some 250 people and dozens of oil field service firms. Onsite facilities will include office space, utilities, 60,000 square feet of heated shop and warehouse space, 27 acres of outside pad storage, vehicle and equipment facilities, a recreational facility, and a variety of other facilities and services for its tenants.

The Kuparuk Industrial Center is being developed by the North Slope Borough which envisions that the facility will be a long-term revenue source which can also enhance employment and business opportunities for North Slope residents. The project is expected to create at least 70 new jobs for North Slope Borough residents. By controlling the design and operation of the center, the Borough also hopes to minimize adverse disturbances to local wildlife populations and habitats.

The financing and operation of the center is overseen by a five-member board appointed by the Borough Mayor and confirmed by the Borough

Assembly. Its current membership includes representatives of ARCO, Sohio, and BP Alaska Exploration. The center will be operated by Piquniq Management Corporation, a consortium of Native corporations assisted by Inchcape Logistics and Oilfield Services, an internationally experienced service base operator. While the Kuparuk Industrial Center is primarily meant to support Kuparuk Unit operations, it is possible that some of the facilities and services might also be used for offshore support.

PROPOSED LEASE SALES

Diapir Field OCS Sale 87

The Diapir Field Sale 87 is scheduled for August 1984. The Draft EIS was issued in September 1983. The proposed lease offering extends east, west and seaward of Sale BF and the Diapir Field Sale. As originally proposed, the lease offering included over 16 million acres. However, the offering of approximately 8.7 acres west of Point Barrow was deferred in the proposed notice of sale (Federal Register, March 13, 1984), reducing the offering to about 8.6 million acres.

State Oil and Gas Sale 43 - Beaufort Sea

This state sale, scheduled for May 1984, encompasses about 298,385 acres of submerged lands from the western part of Harrison Bay to a point about nine miles west of Pitt Point. The sale area is south of the western half of the federal Diapir Field sale. The state rates the petroleum potential in the area from moderate to high.

State Oil and Gas Sale 43a - Colville Delta/Prudhoe Bay Uplands Exempt

The Colville Delta portion of this state sale includes coastal and submerged tracts amounting to 46,080 acres. These tracts were originally proposed for, later deleted from, State Sale 39. Because of industry interest, these tracts have been rescheduled for lease offering in May 1984 in conjunction with Sale 43. Petroleum potential is regarded by the state as moderate to high.

State Oil and Gas Sale 50 - Camden Bay

The Camden Bay sale includes barrier islands and submerged tracts east of previously lease tracts near Flaxman Island and offshore the Arctic National Wildlife Refuge. The sale is scheduled for May 1987. Petroleum potential is regarded by the state as moderate to high. Ownership of the submerged tracts is disputed by the federal government and, like other Beaufort Sea disputed tracts, is the subject of litigation pending for hearing by a Special Master appointed by the U.S. Supreme Court.

Arctic Sand and Gravel Lease Sale

MMS has proposed a federal lease offering of submerged sand and gravel resources. The proposed lease area essentially coincides with the Sale BF and Diapir Field Sale offerings. The sale intended to make offshore sand and gravel sources available to federal. OCS leaseholders for construction of gravel islands for Sale BF and Sale 71 exploration and production. To date, all gravel and sand for island construction has

be-en transported from mainland sources or salvaged" from abandoned manmade islands, but these options become less economic as exploration programs probe deeper offshore waters. A Final EIS was issued in March 1983, but the lease sale, first scheduled for October 1983, has been indefinitely postponed.

Resident Workforce

The purpose of this section is to examine the residency pattern of the Sale BF and Sale 71 workforce. The place of residence for workers on remote projects is a matter of critical importance for economic and community' impact assessment. Residency patterns generally determine where workers maintain their households and families, spend their income, and generate secondary economic impacts. Residency defines the project's income and demographic impact upon the immediate region, upon distant bedroom communities and on the State as a whole. It also determines the location and extent of demand for housing, community facilities and services and other elements of community life attributable to the remote project.

Until recently, it was reasonable to assume that large oil and gas or other mineral development projects would have significant impacts upon the resident workforce of Alaska and, particularly, upon the area where the project was sited. The familiar example is the trans-Alaska oil pipeline project, for which significant disruptions were forecast and did in fact occur. However, those disruptions were largely a product of the small size of the qualified Alaskan labor force compared to the

scale of the project's labor demand. Nationwide publicity also attracted many people to Alaska in search of high paying employment. Additionally, many employed Alaskans sought to improve their situations by leaving permanent positions in Anchorage, Fairbanks and elsewhere in the state, in favor of higher wages afforded by the extended work hours and timing of the oil pipeline project. The net effect was substantial turmoil throughout Alaska's labor force.

Similar forecasts were made for the proposed, now delayed, Alaska Natural Gas Transportation System Pipeline, though industry and government studies indicated a less severe workforce disruption than was the case for the oil pipeline. Among the reasons for this moderation were the sheer growth that had occurred in Alaska's workforce, an accompanying increase in the number of residents with skills and work experience appropriate to the gas line project, and the overall growth of the transportation, construction and other support industries.

Total employment in Alaska's oil and gas industry has increased dramatically since the pre-oil pipeline years. According to Alaska Department of Labor employment data, petroleum industry employment has now stabilized at about 7,500 jobs, centered principally in the North Slope and on the western Kenai Peninsula. This status quo conditions the effect of exploration employment upon the resident workforces of the North Slope, Fairbanks/ Interior, and Anchorage/Southcentral regions. The Alaskan phenomena of remote site work was once limited mainly to the construction industry and the far flung defense electronics and information networks. Today, it also embraces the workers at the North Slope oil and gas fields, including the Beaufort Sea exploration projects.

The "week on -- week off," "two weeks on -- two weeks off" commuters and short-term construction workers fall within this grouping. This work arrangement means many workers do not live near their principal place of work, that workers at an exploration camp may indeed reside in Fairbanks, Anchorage, or elsewhere in Southcentral or other regions of Alaska, or even outside Alaska. Thus, the principal impact of onsite exploration employment may be felt in the Fairbanks/Interior and Anchorage/Southcentral regions of the state rather than upon North Slope communities.

Unfortunately, for the present study, we were not able to obtain comprehesive empirical data on the residency of the Beaufort Sea workforce. Specific reasons for this were:

- o The oil companies which function in the role of lease operators perform as contract managers; they have few direct employees.
- o Dozens of contractors and subcontractors are involved in the exploration enterprise as independent contractors.
- o There *is* no governmental requirement nor is there an economic or managerial need for employers to collect and retain residency data.

In short, there is no central source of data on residency, nor any practical method of retrieving this information in a common format specifically from the employers of Beaufort Sea exploration employees.

Furthermore , the notion of "residency" is embroiled in ambiguity. The legality of definitional criteria for the term "resident" is continually being called into question in both federal and state courts in Alaska in litigation about employment benefits and status, taxation, State revenue sharing and other residency-linked programs. Practically, it is hard to determine residency consistently over time for a highly mobile interstate workforce whose choice of residence tends to follow the availability of employment. Last year's (and last job's) interstate commuter becomes this year's (and this job's) resident hire.

Still, there are other pertinent data and studies that can be used, along with employment data collected in this study, to estimate the contribution of Beaufort Sea exploration programs to employment and income for residents of Alaskan subregions.

The key studies and data series useful for this purpose include:

- o Alaska Department of Labor, Special Census for Oil Related Worksites in the North Slope Borough, 1982.

- 0 Alaska Department of Labor, Statistical Quarterly.

- o Bureau of Economic Analysis, U.S. Department of Commerce series data on income by place of work and place of residence.

- o Institute of Social and Economic Research, University of Alaska, Technical Report No. 8.5, A Description of the Socioeconomic of the North Slope Borough.

In addition to these studies, we have drawn upon circumstantial evidence derived from our interviews with employers, lease operators and labor union dispatching officials, along with information about the home base of many North Slope contractors, specifically including local firms such as Pingo Services and joint ventures involving Alaska Native corporations such as the NANA Regional Corporation.

As part of the study interview program, exploration operators were asked to provide information about residency of their Beaufort Sea exploration projects. However, residency data was generally not available. Too few responses were received to support general conclusions. Instead, we used the above-cited Alaska Department of Labor Special Census of Oil Related Worksites to make some estimates of the residency pattern of Beaufort Sea workers. This Special Census was conducted in January and February of 1982. Some 6,306 workers quartered at oil field work camps on the North Slope were asked to name their usual place of residence.

The findings of this Special Census are shown in Tables 27 and 28. Some 77.3 percent of the North Slope oil field workers claimed residency in Alaska. The Anchorage (39.6%) or Fairbanks (17.3%) regions were home for a majority of oil field workers, followed by Kenai Peninsula Borough (6.9%), Matanuska-Susitna Borough (6.5%), the North Slope Borough (2.4%) and the rest of the State (4.1%).

Based on the premise that the residency of Beaufort Sea exploration program workers during during 1980-83 resembled the distribution found in this comprehensive 1982 survey, Table 29 shows the estimated alloca-

TABLE 27

PLACE OF RESIDENCE OF WORKERS
AT OIL-RELATED WORKSITES IN THE NORTH SLOPE BOROUGH, 1982

Rank	State	Number Naming State as Usual Place of Residence	Percent
1	Alaska*	4,874	77.3
2	Washington	264	4.2
3	California	204	3.2
4	Texas	185	2.9
5	Montana	84	1.3
6	Oregon	73	1.2
7	Oklahoma	5 4	0.9
8	Colorado	52	0.8
9	Idaho	47	0.'7
10	Louisiana	44	0.7
	All Other States	390	6.2
	Foreign Countries	35	0.6
	TOTAL	6,306	100.0

* Includes persons claiming no usual place of residence.

Source: Alaska Department of Labor. "Special Census Results for Oil Related Worksites in the North Slope Borough," in Alaska Population Overview, 1982.

TABLE 28

PLACE OF RESIDENCE OF ALASKAN WORKERS
AT OIL-RELATED WORKSITES IN THE NORTH SLOPE BOROUGH, 1982

Rank	Locality	Number Naming Area as Usual Place of Residence	Percent of Number Naming Alaska as Usual Place of Residence	Percent of Total[1] Number
1	Anchorage, Municipality of	2,496	51.3	39.6
2	Fairbanks - North Star Borough	1,094	22.6	17.3
3	Kenai Peninsula Borough	437	9.1	6.9
4	Matanuska-Susitna Borough	413	8.0	6.5
5	North Slope Borough*	178	3.7	2.8
All Other Census Areas		256	5.3	4.1
	TOTAL	4,874	100.0	77.3

* Includes persons claiming no usual place of residence.

1 Total number of persons was 6,306 which included 1,432 persons residing outside Alaska.

Source: Alaska Department of Labor. "Special Census Results for Oil Related Worksites in the North Slope Borough," in Alaska Population Overview, 1982.

tion of Beaufort Sea workers by place of residence. (Note that manhours have been converted into manyear equivalents of 1,920 working hours.) By these calculations, Beaufort Sea operations provided as many as 647 full-time onsite jobs for Alaskan residents in the peak year of 1981-82, and a total of 1,185 job-years for the three-year period 1980-83. Anchorage residents claimed slightly over half of these jobs.

Employment impacts of Beaufort Sea operations on North Slope Borough residents was a topic of special concern to this study. By our estimating method, North Slope residents accounted for an average annual onsite employment of 10 workers, 24 workers and 10 workers in the 1980--81, 1981-82 and 1982-83 drilling seasons, respectively (Table 29).

Conversely, by crude estimate, Beaufort Sea onsite employment was estimated to account for about 0.6 percent of total North Slope resident employment during 1981 and 1.2 percent in 1982 (Table 30). This estimate was obtained by assuming that the resident proportion of total annual employment in the North Slope Census Division for 1981 and 1982 was about 20 percent. The 20 percent figure was based on the datum that, in 1980, residents accounted for 21.4 percent of total earned income in the North Slope Census Division (Table 31).

If these estimates are sound, then direct onsite employment. for Beaufort Sea exploration operations has been a trivial source of direct employment for North Slope Borough residents. This is consistent with our interviews with operations, contractors, union personnel and North Slope Borough staff, which produced no hard data or opinions to counter the

TABLE 29

ALLOCATION OF ONSITE EXPLORATION EMPLOYMENT
BY PLACE OF RESIDENCE
SALE BF & SALE 71, 1980-1983

Place of Residence	Manyears of Employment 1980-81	1981-82	1982-83	1980-83
Anchorage, Municipality of	136	331	139	606
Fairbanks - North Star Borough	60	145	61	266
Kenai Peninsula Borough	24	58	24	106
Matanuska-Susitna Borough	23	55	23	101
North Slope Borough	10	24	10	44
Rest of Alaska	14	34	14	62
Subtotal	267	647	271	1,185
Outside Alaska	77	190	80	347
TOTAL	344	837	351	1,532

Source: Kevin Waring Associates estimates.

TABLE 30

ESTIMATED NORTH SLOPE BOROUGH RESIDENT EMPLOYMENT
BEAUFORT SEA EXPLORATION PROGRAMS

Year	Average Annual Total Employment	Resident Employment	Beaufort Sea Employment	Beaufort Sea Employment as a % of Total Resident Employment
1981	8,761	1,752	10	0.6%
1982	9,638	1,928	24	1.2%

Source: Alaska Department of Labor Statistical Quarterly; Kevin Waring Associates estimates.

TABLE 31

NET LABOR & PROPRIETORS' INCOME BY RESIDENCY STATUS
BARROW-NORTH SLOPE CENSUS DIVISION
1970 - 1980
($1,000's)

Year	Total Net Labor & Proprietors' Income	Income of Residents of Region	Income of Non-residents of Region	Resident Income as % of Total
1970	36,028	9,822	26,206	27.1
1971	28,671	10,267	18,404	35.8
1972	23,296	9,806	13,490	42.1
1973	21,392	10,771	10,621	50.4
1974	33,037	14,966	18,071	45.3
1975	231,229	26,221	205,008	11.3
1976	323,469	37,954	285,515	11.7
1977	235,811	40,861	194,950	17.3
1978	264,226	44,450	219,776	16.8
1979	221,276	48,687	17'2,589	22.0
1980	249,581	53,457	196,124	21.4

Source: Bureau of Economic Analysis, U.S. Department of Commerce.

conjecture that, for whatever reason, Beaufort Sea exploration did not draw significantly upon the permanent resident labor pool.

There is also evidence in long-term employment data published by the Bureau of Economic Analysis to support the finding that there is little overlap between the permanent resident workforce and the North Slope oil field workforce (Table 31). Over the most recent period (1970-1980) for which Bureau of Economic Analysis data has been released, the resident share of total income earned in the North Slope Census Division has ranged from over half in the pre-pipeline era (1973) to as little as 11.3 percent during the 1975 peak of North Slope pipeline construction. As late as 1980, residents accounted for about only 21.4 percent of income earned by employees at work in the North Slope Census Division. Since most resident employment is concentrated at Barrow and other indigenous communities residents must account for an even smaller share of employment at remote oil field operations.

Examination of annual income data by residency status in Table 31 demonstrates that there is virtually no correlation between resident income trends and total income earned in the census division. Since formation of the North Slope Borough in 1972, resident income has grown steadily and rapidly in a pattern that matches closely the trend of North Slope Borough revenues and expenditures> regardless of large fluctuations in total regional income caused by North Slope oil field activities. Indeed, the borough government has emerged as the dominant employer of permanent residents. This is also suggested by Table 32 which shows a steady growth in income derived from state and local governmental employment despite the rise and fall of mining and construction income.

TABLE 32

TOTAL REGIONAL INCOME

BARROW-NORTH SLOPE CENSUS DIVISION

1970 - 1982, BY INDUSTRY

($1,000's)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Private Sector	33,862	25,680	19,539	16,580	26,585	229,299	318,649	225,493	250,477	199,929	225,314	418,076	497,639
Mining	17,544	11,755	7,088	4,091	9,155	40,906	48,744	90,645	124,007	133,956	145,352	218,749	206,576
Construction	10,943	8,129	4,989	2,616	9,984	158,759	235,582	91,533	84,182	25,171	34,240	128,003	191,331
Transportation/Pub. Utl	1,999	2,439	2,889	4,350	3,244	14,294	11,614	14,953	16,389	15,329	15,999	16,285	19,062
Services	3,067	3,059	3,899	4,350	2,596	13,493	18,248	24,196	17,701	12,415	13,104	34,383	61,027
Other	309	298	674	1,173	1,606	1,847	4,461	4,166	8,198	13,058	16,619	20,656	19,643
Public Sector	3,633	4,406	5,364	6,227	8,571	11,901	17,625	22,722	27,775	33,571	37,641	46,069	55,072
Federal Gov't	2,875	3,360	3,769	4,062	3,900	4,538	4,669	4,070	4,139	4,417	4,667	4,206	3,010
State/Local Government	758	1,046	1,595	2,165	4,671	7,363	12,956	18,652	23,636	29,160	32,974	41,863	52,062
TOTAL	37,495	30,086	24,903	22,807	35,156	241,200	336,214	248,215	278,252	233,506	262,955	464,145	552,711

Source: Bureau of Economic Analysis, U.S. Department of Commerce: 1970-1980. Alaska Department of Labor Statistical Quarterly: 1981-1982.

The comparative lack of direct impact of North Slope oil field operations on the North Slope workforce was documented in ISER's recent study, A Description of the Socioeconomic of the North Slope Borough. That report concluded that "the primary source of social and economic change on the North Slope between 1973 and 1983 has been the North Slope Borough." Because of the job opportunities created for residents by the borough in their home communities, residents have preferred to work where they live. Some local residents have also worked with locally owned companies that have been subcontractors for some of the prime construction companies for exploratory work. For example, resident subcontractors and workers have taken part in ice road construction in conjunction with principal contractors.

Speculatively, the likely direction for enhanced participation of North Slope residents in exploratory related employment would be in the operation of support facilities such as the Kuparuk Industrial Center currently being developed by the North Slope Borough, partly to promote resident hire.

As opposed to adverse impact upon the resident work force in Alaska, one principal effect of exploration employment has been the growth of that workforce and its increased technical capability. In addition to the direct employment and training of residents for employment in the oil and gas industry generally and in exploration work in particular, many workers in the related oilfield support industries have taken advantage of the work schedules at the exploratory sites to relocate to Alaska. While we cannot document the extent of this trend, it is presumably one

of the principal reasons for the significant increases in the labor forces in the Fairbanks, Anchorage, Matanuska-Susitna, and Kenai areas of the state. These individuals have elected to relocate to Alaska rather than to pursue the longer range commute to other residence locations in the "Lower 48."

In a general way, exploration employment has prompted programs to train Alaska's resident workforce. In response to the labor needs of the exploration industry, the Alaska Vocational Technical Center at Seward set up a training program" for drilling and related activities. This program commenced in 1977-78 and through' 1983 had produced a total of 259 graduates, of whom 193 were placed with companies engaged in drilling or orther oilfield service and Support work. A brief description of that program follows.

The course is designed to train students as rotary helpers for the Alaska petroleum industry. Instruction covers the areas of welding safety , offshore and land-based drilling rigs, industrial tool identification and use, safe rigging practices, emergency trauma technician training, basic operation of drilling equipment, and maintenance of pumps and gasoline engines. The students are introduced to the various functions and occupations in the petroleum industry. The classes are approximately 50 percent classroom and 50 percent hands-on training. Upon successful completion of the course, the student is qualified to begin work as a roustabout and for advancement to roughneck after gaining enough experience to prove performance abilities.

The Alaska Department of Labor Special Census found that residency patterns varied for different occupational groups, as shown in Table 33. Again, interviews with employers and union officials tended to confirm these patterns. Reportedly, the place of residence of drilling and direct oil field service support has changed considerably in recent years as individuals relocated to Alaska to take advantage of continued employment opportunities. Employers and labor organizations estimate that the. construction workforce at exploration sites approximated 90 percent residency in Alaska, with about half coming from the Anchorage and Fairbanks areas, respectively. As for transportation, surface (truck) transport is generally handled by a predominantly resident workforce. Pilots and aircraft mechanics are generally from the Anchorage area. Marine transport crews are aboard vessels which are registered out of Seattle and are usually from that area rather than from Alaska.

Data on minority and female participation in the exploration work force are not available, inasmuch as there are no specific reporting requirements that would necessitate the maintenance and reporting of information at that level of detail within the exploration workforce.

Economic Impacts on Regional Economies

This section traces the impacts of local purchases of goods and services by resident firms and workers on the overall economy of several regions.

TABLE 33

PLACE OF RESIDENCE OF ALASKAN WORKERS
AT OIL-RELATED WORKSITES IN THE NORTH SLOPE BOROUGH, 1982

Type of Camp	Total	Number Naming Alaska as Usual Place of Residence*	Number Naming Usual Place of Residence Outside of Alaska	Percent Naming Alaska as Usual Place of Residence
Operations	963	876	87	91.0
Trades, Construction	1,884	1,352	532	71.8
Oil Rig	1,431	1,140	291	80.0
Seismic	219	135	84	61.6
Tech. Services & Fabrication	106	59	47	55.7
Government	35	34	1	97.1
Ground Transportation .	284	219	65	77.1
Air Transportation	60	49	11	81.7
Supply, Services, Repair	404	297	107	73.5
General	920	713	207	77.5
TOTAL	6,306	4,874	1,432	77.3

* Includes persons claiming no usual place of residence.

Source: Alaska Department of Labor. "Special Census Results for Oil Related Worksites in the North Slope Borough," in Alaska Population Overview, 1982.

REGIONAL PERSONAL INCOME

Resident employment generated by Beaufort Sea exploration programs was discussed in a previous section. It was estimated that Alaskan residents supplied about 77 percent of the work effort for Beaufort Sea exploration. Anchorage and Fairbanks were the dominant places of residence for Alaskan workers. By a method similar to that used to allocate Beaufort Sea employment by place of residence, the personal income earned by Beaufort Sea onsite employees has been geographically distributed. That is, direct wages have been prorated to place of residence in proportion to the place of residence of oil field workers generally, as determined in the Alaska Department of Labor Special Census.

Table 34 shows the estimated allocation of direct wages, by year and place of residence, for onsite Beaufort Sea employees for the three drilling seasons covered in this study. In all, it is estimated that Beaufort Sea exploration contributed $47,426,000 in direct wages to Alaska residents over the three-year period. Anchorage residents, of course, received the largest share (over $24 million) of resident wages, followed by Fairbanks residents (nearly $11 million). North Slope Borough residents received about $1.7 million in direct wages over the three years.

Not included in above account of direct income benefits are the secondary impacts accruing from the multiplier effect.

TABLE 34

ALLOCATION OF ONSIT% EXPLORATION WAGES
BY PLACE OF RESIDENCE
SALE BF & SALE 71, 1980-1983

Place of Residence	Wages ($1,000) 1980-81	1981-82	1982-83	1980-83
Anchorage, Municipality of	$ 4,968	$13,424	$ 5,926	$24,318
Fairbanks - North Star Borough	2,170	5,864	2,597	10,631
Kenai Peninsula Borough	866	2,339	1,038	4,243
Matanuska-Susitna Borough	815	2,203	981	3,999
North Slope Borough	351	949	423	1,723
Rest of Alaska	514	1,390	608	2,512
Subtotal	9,684	26,169	11,573	47,426
Outside Alaska	2,861	7,730	3,399	13,990
TOTAL	$12,545	$33,899	$14,972	$61,416

source: Kevin Waring Associates estimate.

ECONOMIC CYCLES

In order to put the regional distribution of Beaufort Sea exploration employment into comparative perspective, the share of Beaufort Sea employment attributed to the five top-ranked regions was measured against total average annual regional employment. The comparison was made for the two most recent years (1981 and 1982) for which Alaska Department of Labor employment series data was available.

Table 35 shows the results of this comparison. Beaufort Sea direct onsite employment accounted for about 0.2 percent of total statewide employment in 1981 and about 0.4 percent in 1982, the peak year of Beaufort Sea activity. Based on the regional comparisons, it appears that the Matanuska-Susitna Borough was proportionately more affected by Beaufort Sea operations than any other region of the State. In 1982, the Matanuska-Susitna Borough's share of Beaufort Sea employment was estimated to equal 1.3 percent of employment within the Borough. In rank order after Matanuska==Susitna Borough in 1982 were the Kenai Peninsula Borough (0.7%), Fairbanks North Star Borough (0.6%), Municipality of Anchorage (0.3%) and, lastly, the North Slope Borough (0.2%).

Based on the above estimates of the relative contribution of Beaufort Sea employment to regional economies, it can be conjectured that the income impacts of Beaufort Sea exploration upon regional economies was too marginal in comparison to other sources of employment and income to generate a significant boom/bust cycle. Instead, Beaufort Sea employment may better be seen as having only a minor influence on employment

TABLE 35

SALE BF & SALE 71 ONSITE EXPLORATION EMPLOYMENT
AS A PERCENT OF TOTAL EMPLOYMENT BY PLACE OF RESIDENCE
1981 - 1982

	1981			1982		
	Average Annual Employment	Allocation of Sale BF & Sale 71 Onsite Employment	Allocation as % of Annual Employment	Average Annual Employment	Allocation of Sale BF & Sale 71 Onsite Employment	Allocation as % of Annual Employment
Municipality of Anchorage	87,338	136	0.2%	96,615	331	0.3%
Fairbanks North Star Borough	22,863	60	0.3%	24,812	145	0.6%
Kenai Peninsula Borough	7,960	24	0.3%	8,609	58	0.7%
Matanuska-Susitna Borough	3,702	23	0.6%	4,383	55	1.3%
North Slope Borough	8,761	10	0.1%	9,638	24	0.2%
Rest of Alaska	54,632	14	0.0%	55,769	34	0.1%
TOTAL	185,256	267	0.2%	199,826	647	0.4%

Sources: Alaska Department of Labor, Statistical Quarterly; Kevin Waring Associates estimates.

and income trends in the general economy, tending either to amplifying growth slightly or partly offset an economic downturn.

PURCHASES FROM LOCAL SUPPLIERS

Specific dollar volume figures for purchases from local suppliers were not available from the operators nor from the major subcontractors, This report., therefore, will draw from information developed regarding those companies which provide support services in the Prudhoe Bay area generally, those companies which have provided contractual and support services for Beaufort Sea exploration programs, and information obtained about transportation of materials to the Prudhoe Bay area for use in exploration programs.

As was the case when dealing with employment opportunities and numbers, the sources of supplies and the identity of the companies which provide services is difficult to fix in terms of residency or derivation. For example, the only commodity that is actually produced in the local area (North Slope) is fuel from the topping plants operated by the major producers at Prudhoe Bay. Also , the only resident-owned companies serving the North Slope area are those that are owned by the regional Native corporation or one of the village corporations. These companies generally provide additional employment opportunities for local residents, in addition to the overall ownership, either directly or through joint ventures, and participate in the management of the enterprise. Examples include the Pingo Corporation, owned by the village corporations of Anaktuvuk Pass, Atkasook, Kaktovik, Nuiqsut, Pt. Hope and

Wainwright; and subsidiaries of the NANA Regional Corporation such as NANA Oilfield Services, NANA-Mannings and NANA/Purcell Security Services.

With reference to the large numbers of companies listed in this report. as having operations and operation bases at Prudhoe Bay, all of them are either Alaska based companies or interstate companies with substantial operations and investment in Alaska. Over 90 percent of the companies holding contracts for work in connection with Beaufort Sea exploration meet either Alaska based or significant investment criteria. These include the geophysical companies drilling companies, oilfield service companies , oil spill cleanup organizations, air and marine transportation companies, construction and equipment contractors and the various catering, camp services, and general miscellaneous service providers.

"Based upon the indicated Alaska involvement of these several companies and the *source* of the labor force with which they operate, as indicated in other sections of this report, it is plausible to estimate that the use of Alaskan based or Alaskan involved companies in the exploration work would exceed the 75 percent level. As noted in Table 33, the labor force engaged in those operations approximates that same proportion.

In the case of consumable supplies such as fuel, food stuffs, lubricants, drill pipe, drilling mud, cement, etc., it is a fair assumption that all of these supplies originate outside the State of Alaska, excepting motor fuel manufactured directly at Prudhoe Bay. During the past several years, however, considerable prepurchase and storage was

accomplished at various locations in Alaska as opposed to direct shipment from the "Lower 48" to the actual operation at Prudhoe Bay. The most significant impact of this type of operation is upon the Fairbanks area and the Anchorage and Kenai areas in Southcentral Alaska. These are the major shipping and storage locations with Fairbanks being at the terminus of the Alaska Railroad and being the closest surface shipping point or air shipping point; Anchorage being a combined shipping and storage point; and the Kenai area with major petroleum industry involvement. The past five years have brought an accelerated use of the Dalton Highway as a shipping route to Prudhoe Bay, particularly for commodities, equipment and supplies since it permits storage in Anchorage or Fairbanks and rapid movement to the exploration site when needed rather than requiring heavy bulk storage in the immediate vicinity of Prudhoe Bay.

Food stuffs and related supplies for camp operations are generally purchased in Anchorage and shipped by the most practical means to Prudhoe Bay and to the exploration site. This may include ground transportation and, for perishables, more likely air transport. In some instances, food stuffs are air lifted directly from Portland or Seattle to Deadhorse, but this is generally done with supplies for large facility planned menu requirements rather than for imediate consumption at small exploration camp sites.

The question has been raised as to whether these operations have had any adverse impact on the availability of supplies and services for permanent residents of the North Slope Borough. The finding generally is

that it has not. Arguably, the demand for air passenger and cargo services generated by petroleum-related exploration activities may have had positive effect on the frequency and cost of air transportation services to Barrow.

Marine Survevs

Marine geophysical surveys are conducted. to evaluate the oil-bearing potential of potential exploration areas. While the bulk of these surveys are commonly undertaken in advance of the lease sale, additional surveys may be conducted to gather additional geological data in preparation for exploration drilling decisions.

Table 36 lists permits issued by the State of Alaska for seismic and geophysical survey work in the Beaufort Sea area after Sale BF.

In contrast to geophysical work in most offshore areas, much of the marine survey work in the Beaufort Sea was conducted from the ice surface rather than from marine vessels. This is evident in the dates shown for permits in Table 36. Also, because of the technical expertise required for geophysical surveys, this work is predominantly contracted to specialized firms headquartered outside Alaska. Some larger geophysical companies do maintain staff and equipment in Anchorage and on. the North Slope.

Exxon's geophysical operations for its Antares project in Sale 71 provide an example of how these survey programs are conducted. Exxon

commissioned three types of marine surveys: 1) common depth point (CDP) surveys; 2) velocity surveys and 3) high resolution shallow hazard surveys. The CDP seismic survey was conducted with geophone cable and a vibrator. The velocity surveys were obtained by lowering a geophone into the borehole at various predetermined depths and then recording signals transmitted from an air gun energy source. In the winter of 1982-83, high resolution geophysical survey and coring programs were conducted to determine if any shallow geologic hazards existed. The work was done by Marine Technical Surveys of Stafford, Texas between February 17 and March 22, 1983. A total of 43 miles of seismic data was collected. The data was analyzed by Harding-Lawson Associates of Novato, California."

TABLE 36

STATE PERMITS ISSUED FOR SEISMIC/GEOPHYSICAL
SURVEY WORK IN BEAUFORT SEA AREA
1980 - 1983

Permit No.	Applicant	Contractor or Client	Location	Dates	Energy Source/Method	No. Line Miles
80-171	'Western Gee.	Western Gee.	Harrison Bay	11-15-80 to 5-15-81	N/A	292.76
80-176	Harding Law.	Group	Beaufort Sea	7-25-80 to 11-25-80	N/A	475
80-176	Exxon	G.S.I.	Harrison Bay	1-1-82 to 5-31-82	Vibrators	106
81-222	Shell	G.S.I.	Harrison Bay	1-1-82 to 5-15-82	Vibrators	103
.81-227	Chevron		Harrison Bay	1-15-82 to 5-15-82	Vibrators	173.62
82-228	G.S.I.	Sohio	Harrison Bay	1-1-81 to 5-15-82	Vibrato KS	374.7
81-230	Arco	G.S.I.	Harrison Bay	1-1-82 to 5-25-82	Vibrators	N/A
81-240	Amoco	CGS/Sefel/ Milti	Harrison Bay	2-1-82 to 5-15-82	Vibrators	296
82-005	G.S.I.	Mobil	Harrison Bay	2-10-82 to 5-15-82	Vibrators	1.53
82-017	Arco		Harrison Bay	1-1-82 to 5-1-82	N/A	N/A
82-146	Exxon	Western Gee.	Cross Island	7-1-82 to 10-31-82	Airgun	N/A
82-148	G.S.I.	Sohio	Peard Bay/ Harrison Bay	7-1-82 to 10-31-82	Airgun	N/A
82-204	G.S.I.	Sohio/Exxon/ Union/Amoco/ Arco	Sag. R. Delta (offshore)	2-1-83 to 5-20-83	Vibroseis	1,207
82-213	G.S.I.	Sohio	Harrison Bay	1-1-83 to 5-20-83	Vibroseis	N/A

TABLE 36

(Continued)

STATE PERMITS ISSUED FOR SEISMIC/GEOPHYSICAL SURVEY WORK IN BEAUFORT SEA AREA

1980 = 1983

Permit No.	Applicant	contractor or Client	Location	Dates	Energy Source/Method	No. Line Miles
82-224	G.S.I.	Sohio	Cross Island (offshore)	2-1-83 to 5-20-83	Vibroseis	14
82-275	G.S.I.	Sohio	Sag Delta/ Prudhoe Bay (on/offshore)	1-15-83 to 5-20-83	Vibroseis	33
83-34	Amoco	Sefel	Harrison Bay (offshore)	3-24-83 to 5-30-83	Vibroseis	93
83-44	Western Gee.	Shell	Beaufort Sea	7-15-83 to 11-1-83	Airgun	60
83-45	Wester Gee.	Western Gee.	Beaufort Sea	7-15-83 to 11-1-83	Arigun	300
83-51	Exxon	G.S.I.	Cross/Stockton Island	7-1-83 to 10-31-83	Airgun (MV GSI Alaskan)	109
83-58	Western Gee.	Group Survey	Reindeer/ Cross Island	7-15-83 to 11-1-83	Airgun (MV Arctic Star/ Western Aleutia)	35
83-63	Sohio	Sohio	Beaufort	7-21-83 to 9-1-83	Airgun (MV GSI Marina/ GSI Alaskan)	420
83-64	Sohio	Sohio	Beaufort	7-21-83 to 9-15-83	Airgun (MV GSI Alaskan/ Krystal Sea)	420
83-70	G.S.I.	G.S.I.	Beaufort	8-26-83 to 11-30-83	Airgun	30
83-71	Gulf	G.S.I.	Cross Island	8-26-83 to 11-30-83	Airgun	53.02

Source: Alaska Department of Natural Resources, Oil & Gas Division

V. SUMMARY OF FINDINGS

This chapter summarizes the most important factual findings of this monitoring study, with some comments on the applicability of these findings for scenarios for future arctic exploration.

The Final Environmental Impact Statements offered hypothetical exploration scenarios for Sale BF and Sale 71. These exploration scenarios were used in the FEIS to illustrate the range of potential environmental, socioeconomic and other impacts attributable to each sale. For each FEIS, the mean exploration scenario was used as a basis for detailed analysis. Table 37 compares the number and timing of exploration wells assumed in the Environmental Impact Statements with the actual exploration history to date.

For Sale BF, industry was able to mount and execute more exploration programs sooner than the FEIS assumed. The FEIS mean scenario assumed that two wells would be drilled in the first season and six more in the second season. In fact, five wells were drilled in the initial season and another nine in the second season. This performance is made more noteworthy by the fact that eight of the fourteen wells drilled during the first two seasons were emplaced on artificial gravel islands whose construction added, of course, to the lead time rquired to mobilize for exploratory drilling. However, in the next two years, only three more exploration wells were initiated.

TABLE 37

EXPLORATORY WELLS , SALE BF AND SALE 71

FEIS MEAN SCENARIO FORECAST AND ACTUAL

Drilling Season	Sale BF		Sale 71	
	FEIS	Actual	FEIS	Actual
1980-81	2	5		
1981-82	6	9		
1982-83	6	1		
1983-84	7	2[a]	4	1
Subtotal	21	17	4	1
1984-85	2	N/A	9	2[b]
1985-86	1	N/A	10	N/A
1986-87	-		9	N/A
TOTAL	24		32	

a - Cross Island and Seal Island #2.

b - Exploration plans for proposed drilling projects submitted by Exxon (Antares) and Shell (Sandpiper).

The cumulative number of Sale BF wells (17) actually drilled or committed by the 1983-84 season is fairly close to the number (21) assumed in the FEIS mean scenario. This record indicates that, despite adverse environmental and logistic conditions and despite stipulations, permit requirements and other regulatory constraints, industry was clearly able to solve the physical and institutional obstacles and carry out a significant and effective exploration effort.

In the case of Sale 71, the exploration record is short, for only a brief time has elapsed since the sale. The FEIS mean scenario assumed that thirty-two wells would be drilled over the first four drilling seasons, including four exploration wells in the first season and nine in the second season. The actual pace of exploration will certainly lag well below that rate in the first two seasons. Indeed, it now seems very unlikely that the expectations for exploration reflected in the FEIS scenario will ever be fulfilled. The ill-fated Mukluk project was the only exploratory well undertaken in the first drilling season. Only two more wells, Exxon's Antares project and Shell's Sandpiper project, are now proposed for the 1984-85 season. With respect to prospects for new exploration programs in future years, it is important to note that pre-exploration interest was heavily concentrated on a single prospect, the Mukluk structure. More than 75 percent of Sale 71 receipts were accounted for by successful bids on an group of fourteen adjacent tracts overlying the Mukluk structure. The disappointing result for Sohio's initial exploratory well on the Mukluk project appears to have dissipated any further drilling interest in that structure. In view of the relatively low level of bidding interest displayed for the rest of Sale 71 tracts, it seems unlikely the scenario forecast for Sale 71 will be realized.

The qualitative impact of the Beaufort Sea exploration upon the Prudhoe Bay enclave's facilities and labor force can not simply be equated to the incremental demand for facilities and services attributable to Beaufort Sea projects. Well before the Beaufort Sea OCS sales, Prudhoe Bay/Deadhorse was a highly developed industrial enclave already possess-

ing most of the transportation, industrial personnel support and other infrastructure typically needed to support Beaufort Sea operations. On the other hand, Prudhoe Bay/Deadhorse did not and does not have a permanent pool of resident workers. Instead, the enclave draws from the labor pool in other areas of Alaska and beyond for its workforce as needed. Overall, the Beaufort Sea exploration programs comprised a substantial industrial undertaking. Even so, they were greatly outweighed by other Prudhoe Bay petroleum industry employment and accounted for no more than perhaps two to three percent of average annual employment in the Prudhoe Bay area during any single year. -1

Artificial gravel islands served as drilling platforms for a majority of exploration wells to date. However, Exxon's decision to employ a CIDS for its Antares project may be a harbinger for a shiftin industry preference for relocatable drilling platforms, at least for drilling projects in moderately deep waters or sites further offshore. In these cases, relocatable structures may offer significant cost advantages over gravel islands, including caisson-retained islands.

Because of the number of gravel islands built for Beaufort Sea exploration, the construction and transportation industries accounted for a large share of onsite employment. Wintertime island construction and drilling operations permitted use of ice roads to truck large volumes Of gravel and drilling supplies to the exploration site. On the other hand, there was relatively minor use of marine supply systems compared to typical *remote offshore* exploration programs, partly because of the overland access provided by the Dalton Highway and ice roads. Likewise,

there was less use made of helicopters and crew boats for transport of personnel and supplies.

Total onsite employment for Beaufort Sea exploration programs for the 1980-83 period was estimated at about 1,532 manyears of which 1,185 manyears or 77 percent was provided by Alaskan residents. In absolute terms, Anchorage and Fairbanks regions supplied most of the resident workforce for Beaufort Sea exploration, followed by Kenai Peninsula and Matanuska-Susitna Boroughs. The North Slope Borough trailed these four regions in its share of resident employment.

The North Slope Borough's indigenous economy offers virtually nothing in the way of locally made industrial goods, equipment and services needed by the industry. Most equipment and supplies are either delivered directly by barge to Prudhoe Bay or relayed by truck or airfreight from points of entry in southcentral Alaska (Anchorage? Seward, Whittier, Valdez). Some of these goods and supplies may be drawn from inventories stockpiled at Fairbanks, Anchorage or the Kenai area. In this respect, this economic pattern for Beaufort Sea operations resembles the general relationship between North Slope petroleum industry operations and the indigenous economy.

Total Alaska resident wages earned during the three years of exploration amounted to about $47,426,000. It was presumed that resident wages were attributable to home communities in the same proportion as employment.

While Beaufort Sea exploration made a significant contribution in absolute terms to jobs and wages in Alaskags economy, this contribution did not amount to a share of overall regional economic activity sufficient to generate adverse growth impacts in any region.

The sale stipulations on seasonal drilling affected the choice Of logistic arrangements and island construction and drilling strategies. According to data provided by the operators, the seasonal stipulations often.. added to the worktime and overall cost of exploration projects. Also by report of the operators, the seasonal stipulations adversely affected the time available for well testing. Time extensions were frequently sought in order to complete well testing, but not always approved.

APPENDIX A

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APPENDIX B

SALE BF EXPLORATION SCENARIO ASSUMPTIONS

Reproduced from Beaufort Sea
Final Environmental Impact Statement

Table I.B.4.d.-2
Intermediate Case
Summary of Basic Assumptions

Sale acreage offering (combined Federal and State)	208091 hectares (514,192 acres)
Recoverable oil	750 million barrels
Recoverable gas	1.625 trillion cubic feet
Peak oil production	151,000 barrels per day
Average annual	29 million barrels per year
Peak gas production	112 million cubic feet per day
Average annual	22 billion mbit feet per year
Exploration activity:	
Support and supply facilities:	
existing	1/ 1
constructed	0
Onshore drill sites:	
remote	4
accessible	1
Artificial islands:	
ice	2
shallow water; sandbag retained (summer.)	4
shallow water; sandbag retained (winter)	2
sacrificial beach	7
Exploratory wells	20
Delineation wells	4
Development activity:	
Artificial islands:	
shallow water; sandbag retained (summer):	
existing	0
constructed	2
sacrificial beach:	
existing	0
constructed	2

See footnotes at end of table. continued

Table I.B.4.d.-2
Intermediate Case
Summary of Basic Assumptions--continued

Production and service wells	2/ 118	
Offshore trunk pipelines	10	miles
Onshore pipelines	10	miles
Support and supply facilities:		
existing	3/ 1	
constructed	1	
Production processing facilities	4/ 1	
Direct land requirements:		
Short-term developed area (ice)	58	hectares (144 acres)
Long-term developed area (gravel construction)	377	hectares (943 acres)
Total onshore development (gravel construction)	227	hectares (565 acres)
Total offshore development	209	hectares (523 acres)
Total development	436	hectares (1,087 acres)
Gravel Requirements:		
Gravel from onshore source	1,850,640	cubic meters ($2,435,000\ yd^3$)
Gravel from offshore source	9,740,280	cubic meters ($12,816,000\ yd^3$)
Total gravel	11,591,320	cubic meters ($15,251,000\ yd^3$)
Petroleum refineries in Alaska	0	
Support and supply vessels (exploration):		
Workboats	1-3	
Hovercraft	1-3	
Support and supply vessels (development):		
Workboats	1-3	
Hovercraft	1-3	
Helicopter support (exploration)	2-6	
Helicopter support (development)	3	
Annual oil shipped by tanker (Valdez)	55	million barrels per year

See footnotes at end of table.

continued

Potential discharge of cleaned muds, cuttings, and formation waters to the marine environment.

Muds (bbls)	792,400
Cuttings (cu. yds.)	99,926
Formation waters (mmbbls)	375-3,750

1/ Assumes use of existing facilities at Prudhoe Bay.
2/ Includes 44,800 feet of submarine pipeline and 8,000 feet of pipeline elevated on a gravel causeway-.
3_/ Includes operation headquarters, work camp, permanent roads, aircraft runway, dock, and staging area.
4/ Includes one pump station (located on offshore platform) and one flow station (onshore)

Note: For a detailed description of exploration and production facilities, see appendix 4.

Sources: See sources for table I.B.4.d.-1.

APPENDIX 11- BASIC EMPLOYMENT ASSUMPTIONS

This appendix estimates the employment that may be generated as a result of the proposal. Summary tables of direct and total employment 'are included at the beginning of section III.C.2 for the minimum, intermediate, and maximum cases. The detailed development assumptions and rationale used are included in the following pages.

Introduction: Workforce estimates for the exploration and development scenarios described in section I are derived from various sources. Primary among them is experience gained from North Slope exploration and development activity, including Prudhoe Bay, Alyeska Pipeline Construction, onshore exploration in NPR-A, nearshore Beaufort Sea exploration, and available information from Canadian Arctic exploration activities. Trade literature on the oil, gas, and pipelining industries and the Alaskan construction industry have been consulted extensively, and discussions have been held with representatives of the petroleum and construction industries in Alaska.

However, it must be recognized that exploration and development activity in the Beaufort Sea will be a unique undertaking in important respects. Prudhoe Bay development was an arctic, but not an offshore experience. Offshore experience elsewhere in Alaska, in other parts of the United States, and in the North Sea are not directly relevant to the Beaufort Sea because of the difference in environments. Although there has been extensive exploration in the Canadian Arctic, there has been no gas or oil field development.

Development of the Prudhoe Bay field may have many similarities with an offshore Beaufort Sea effort to recover oil and gas. Certainly remoteness, climate, and environmental sensitivity of the Arctic region are critical determinants of the schedule, cost, and labor requirements of exploration and development.

Virtually all of the labor-intensive construction work involved with development- will occur in a social and technological enclave similar to that built at Prudhoe Bay. For example, the modular approach to construction of arctic field facilities, in which buildings and equipment are prefabricated outside Alaska and shipped to the field for installation, is sound and can be expected to be used in future arctic work. The Prudhoe Bay experience has also demonstrated the penalties in manpower productivity that are imposed by remoteness, climate, and wintertime darkness of the arctic environment. There is an annual average individual productivity loss of some two and one half times compared to similar work performed in an average setting in the contiguous 48 States (Chandler, 1977) (Dames & Moore, 1978). This lost labor productivity factor does not include the large labor requirements for support of an arctic field work force.

Some difficulties are also experienced in attempting to extrapolate directly from the Prudhoe Bay experience. A major difficult-y in drawing on the manpower requirements actually experienced at Prudhoe Bay and the

related North Slope development activity is the lack of readily available information on the manpower requirements. Neither the industry nor the State has developed a comprehensive statistical statement of the manpower requirements for construction and operation of the major components of the field.

Another difficulty is that the Prudhoe project was the first of its kind, and much money and manpower were expended in the process of learning how to build in the Arctic.

Furthermore, the Beaufort Sea field sizes hypothesized are much smaller than the Prudhoe Bay field which, at 9.6 billion barrels, is one of the largest in the world. By comparison, the largest discovery analyzed is 1.25 billion barrels, or about 13 percent of the bonanza Prudhoe Bay field. Thus, the labor force requirements to develop Beaufort Sea fields will differ vastly from those necessary to develop the Prudhoe Bay field, and any extrapolation from the Prudhoe experience must take this disparity into account.

It must also be kept in mind that exploration, and to some extent development, of fields in the central Beaufort Sea area off Prudhoe Bay would benefit from the existing Prudhoe Bay infrastructure, such as crew camps, roads, airfields, communications facilities, and oil field warehouses and shops. The Prudhoe Bay development had to supply all its own support facilities.

In addition to the difficulties of extrapolating manpower requirements for Beaufort Sea operations from previous experience, there are general difficulties forecasting manpower requirements for hypothetical exploration and development programs. Many factors will influence actual labor requirements. The labor requirements estimated for each scenario *conform* within reasonable bounds, given the assumptions used, to estimates developed by the State of Alaska (Petroleum Development Study North Slope of Alaska, 1977) and Dames & Moore (Beaufort Sea Region Petroleum Development Scenarios, 1978). However, actual employment may vary significantly depending on the following factors.

The most important factor-is the engineering technology that is developed for drilling and producing in offshore arctic waters. It is too early to specify the techniques that will be used, and the related manpower requirements.

The availability of gravel is also an important factor. The farther the borrow site is from the facility, the more workers and time will be required. A related variable is the time available for facilities construction, although to a large degree, workers can be substituted for t ime.

Manpower requirements could also be influenced by environmental stipulations contained in lease agreements. Regulations could specify certain techniques and operations which would increase manpower needs. Regulations and stipulations not currently incorporated in the existing body of law or regulation are not presumed in impact assessment in this environmental statement.

Union contract covering Beaufort Sea operations may also affect employment levels. Factors such as crew size requirements and work period limitations could be affected.

Finally, conditions specific to the site may affect employment. For example, control of drifting snow at offshore sites will be a routine, natural event that must be considered. Placement and alignment of ice roads, construction of snow berms and fences, and ice conditions (e.g., ridges, winter storms, and their duration), or miscalculation thereof, will affect employment. The arctic can pose an unending series of operating problems; experience will reduce the effort needed to offset them; however, they will not be completely eliminated.

Statement of Estimated Development Activity: In the following pages, total employment is estimated by task, i.e., exploration drilling, development drilling, etc., and work months. Peak annual total employment and average annual total employment are shown. Only direct total employment, i.e., field work force requirements, are estimated here. The indirect, or "supporting" work force such as trade and service workers, is estimated from average annual total employment using the Institute of Social and Economic Research Man-in-the-Arctic (MAP) econometric model.

Discussion of employment is divided into exploration, development construction, development drilling and operations phases. The estimates are expressed in terms of mining and construction employment only, though these definitions are used somewhat loosely in that, for example, (direct) transportation workers are included. This is done to more clearly portray exploration and development activities, e.g., supply functions, though with a minor compromise of the Standard Industrial Code classification system.

The following tables show direct employment estimates that have been made for each scenario phase (exploration development construction operations). Note that total direct employment will be greater than the sum of all (onsite) crews working at any one time. This is because a portion of the total employment is always on rotation or rest break, away from the work site. For example, construction crews may work nine weeks on site and take one week off; operations and administrative personnel typically work one week on and have one week off. Thus, employment is a multiple of crew size and rotation, hence the work force identified with each function is multiplied by a rotation factor to determine total employment.

Construction employment is estimated at 1.1 times crew size (one week off divided by nine weeks on equals .11); drilling and other petroleum employment at 1.5 times crew size (one week off divided by two weeks on equals .5). These factors are defined as rotation factors.

Exploration: After issuance of leases, exploratory drilling will be initiated. Operations are assumed to begin during the first half of 1980 and continue through 1986. The possible timing of exploratory and delineation well drilling is shown at table 1.

It is assumed that the majority of exploration wells would be drilled from onshore or artificial islands in the approximate ratio of one to three. For environmental assessment purposes, it is assumed that one of the offshore platforms constructed in both 1983 and 1984 are ice islands, the remainder of offshore platforms are assumed to be artificial soil or gravel islands.

Any mobile drilling unit used would be limited to activity from approximately June or July through September or October. Exploratory or delineation wells drilled from, e.g., sunken barges would obviate the need for construction. of artificial soil or gravel islands on a one for one basis. To the extent such technologies are used, gravel usage and disturbance at borrow sites as explained in section I are overstated. For an overview of potential mobile drilling systems use in the Beaufort Sea the reader is referred to Thomas A. Hudson, 1978, Mobile Drilling Systems for the Beaufort Sea. BLM/NOAA OCSEAP Beaufort Synthesis Meeting, Barrow, Alaska, January 24-27, 1978. Presentations by the Arctic Research Committee of the Alaska Oil and Gas Association.

A maximum of 5 exploratory rigs are estimated to be active at any one time. Adequate delineation of the assumed oil and gas field discoveries is estimated to be accomplished as follows: 4 expendable delineation wells would be drilled, one in 1982, one in 1983, and two in 1984. On average, an exploration or delineation well is assumed to require 130 days to complete.

It is anticipated that exploration activity would make maximum use of existing, or modified, facilities in the Prudhoe Bay vicinity. Existing docks, airstrips, service company facilities, aircraft and vehicle maintenance shops, and other facilities should be adequate to accommodate exploration needs. For field development, support and supply facilities would be established near the producible fields to reduce logistics limes.

It is assumed operators would attempt to make maximum use of the summer months for supply and construction purposes. Therefore, it is assumed . that the majority of offshore artificial gravel platforms would be constructed during the summer. Similarly, it is assumed that operators will attempt to stockpile sufficient bulk materials, e.g., tubular

Table 1
Intermediate Case
Exploratory Drilling Schedule

Year	Number of Wells Drilled[1]		Offshore Platforms Constructed[3]	Number of Rigs Working
	Onshore[2]	Offshore		
1979				
1980				
1981	1	1	1	2
1982	2	4	3	5
1983	2	4	3	5
1984		7	5	5
1985		2	2	2
1986		1	1	1
1987				
Total	5	19	15	20

1/ Includes 24 exploration wells. Four expendable wells are assumed drilled to define each producible field discovered.

2/ The second onshore site is *assumed* to require a connecting gravel road, all others are assumed to use snow or ice roads.

3/ One of the platforms constructed in both 1983 and 1984 are assumed to be ice islands. All others are assumed to be artificial soil or gravel islands.

Source : Alaska OCS Office, 1978.

goods, mud and cement, housing units, and a water treatment plant at the well site via, for example, "sea lift" barge operations to allow for well completion with a minimum of heavy goods resupply. Personal communications with Atlantic Richfield Company, Anchorage, Alaska, 1978, and Exxon, USA, Anchorage, Alaska, 1978. The practical effect of these assumptions is to limit the majority of exploration construction and supply activity to the summer months and drilling operations to the winter months, though year-round operations are presumed to be allowed. Note from table 1 'chat two ice islands and one winter constructed artificial gravel island are assumed.

Table 2 shows the estimated construction work force required for construction of onshore gravel pads, connecting gravel or snow and ice roads and for offshore artificial gravel islands and ice islands. The employment estimates are intended to be representative subject to the qualifications described at the outset of this section, reflecting the experience of North Slope operators and contractors to date. Site maintenance is not included; maintenance and support activities are discussed with exploratory drilling operations. Winter built gravel islands are assumed constructed. by removing ice at the site and backfilling with gravel trucked over the ice from onshore borrow sites. Summmer constructed gravel islands are assumed to be constructed using suction dredge or clamshell barges. Fo r an overview of offshore artificial island construction designs and methods, the reader is referred to the presentations by the Arctic Research Committee of the Alaska Oil and Gas Association to the BLM/NOAA OCSEAP Beaufort Sea Synthesis Meeting, Barrow, Alaska, January 24-27, 1978.

Table 3 shows the estimated workforce requirements for exploratory drilling and support activity. The estimates are representative of the workforce required by a single operator undertaking a drilling program with a single drilling unit, assuming (primarily) winter drilling operations. Also, the figures reflect the relatively limited experience of operating in the Beaufort Sea. For example, allowance is made for site maintenance employment of 14. This reflects construction and maintenance of snow and ice berms, moats, roads, and airstrips. Greater experience in design, placement, and alignment. of these may very well reduce maintenance activity significantly (personal communication with Union Oil Company of California, Anchorage, Alaska, November 1, 1978). Yet, particularly severe winter storms, e.g., in terms of blowing snow, may increase maintenance requirements.

Similarly, supply support employment will depend upon site specific conditions, time of year, methods of surface transport, and operator and drilling contractor policies. The estimates attempt to incorporate allowances for varying surface transport modes, i.e., truck, bay (shallow draft) tugs and barges, cat trains, work boats and (as one experienced observer stated) some "Buck Rogers" vehicles, e.g., hovercraft. Obviously,

Table 2
Intermediate Case
Exploratory Onshore Pad and Offshore Island Construction

	Total Employment	Work Months
Work Force Requirements:		
Onshore:		
Onshore gravel pad:		
40 workers[1] x 2 months x 1.3 rotation[2]	52	104
Gravel road (10 miles)[2][3]:		
50 workers x 2.7 months x 1.3 rotation	65	176
Snow and ice road[2][4]:		
24 workers x .7 months x 1.3 rotation	31	22
offshore:		
Ice island:		
54 workers x 2 months x 1.1 rotation[5]	60	120
Artificial gravel island:		
136 workers x .3 months x 1.1 rotation[5]	150	450

1/ Dames & Moore, 1978, p. 264.

2/ Personal communication with Don Williams, Crowley Environmental Services Corporation, Anchorage, Alaska, October 6, 1978.

3/ Assumes a 10 mile gravel haul.

4/ Assumes a water haul of five miles or less. Assumes the road is onshore, however, it is also likely that a nearshore (ice road) route could be used. In the latter case, "construction" effort needed may be little more than scraping the surface smooth, i.e., construction employment could be near zero.

5/ Dames & Moore, 1978, p. 256.

Table 3
Estimated Personnel Requirements
Exploratory Drilling and Support

Personnel Requirements: Each exploratory drilling rig.

	Onsite	Offsite	Total
Drilling rig[1]			
Drilling crew[2]	12	6	18
Drilling support[3]	16	10	26
Camp staff[4]	7	7	14
Total drilling contractor personnel	35	23	58
Site maintenance[5]	10	4	14
Engineering and well service			
Operator personnel[6]	*	*	8
Well service[7]	*	*	10
Total engineering and well service personnel			18
Supply support operations			
Supply operations[8]	6	2	8
Helicopter service[9]	5	3	8
Total supply support personnel	11	5	16
Total personnel requirements	56	32	106

Footnotes to table 3

1/ Personal communication with Nabors Alaska Drilling, Inc., Anchorage, Alaska, November 1, 1978. Drilling contractor employment will vary with the type of rig used, support. effort dictated by site conditions and contractor policy. That is, other drilling contractors may employ more personnel, others fewer.

2/ Includes drillers, derrickmen, motormen, and floorhands.

3/ Includes rig supervision, mechanics, welders, electricians, roustabouts , forklift operators, and water haulers.

4/ Includes cooks, bullcooks, bakers, and sewer plant operators.

5/ Personal communication with Fred Duthweiler, Union Oil Company of California, Anchorage, Alaska, November 1, 1978. Includes motor patrols, truck drivers, and dozer, front end loader, and plow operators.

6/ Includes technical staff, e.g., geologists and engineers, directly associated with offshore drilling operations. These personnel would also perform duties relating to an entire exploration and drilling program. They are included here to reflect the "headquarters" staff functions associated with such a program.

7/ Includes mud loggers, mud engineers, directional survey personnel, well loggers, cementers, and special crews which periodically perform specialized well service functions.

8/ Includes materials handlers, marine personnel (open water season), hovercraft personnel (freezeup and breakup)., and truck drivers (winter).

9/ Personal communication with Walt Benard, Evergreen Helicopters of Alaska, Anchorage, Alaska, November 1, 1978. Includes pilots, copilots, mechanics, and dispatchers.

all modes would not be used simultaneously, but the allowances are in line with North Slope experience (see Dames & Moore estimates, 1978, p. 257).

Personnel movements between well sites and Prudhoe Bay transfer points are expected to be via helicopter. Helicopter service employment estimates assume on helicopter per active rig plus at least one common backup, i.e., at least one aircraft would be available at any-time to handle an emergency. Personnel requirements do not differ significantly assuming, e.g., use of 'I'win Otters in appropriate circumstances and in fact, such uses probably will occur.

APPENDIX C

SALE 71 EXPLORATION SCENARIO ASSUMPTIONS

Reproduced from Diapir Field
Final Environmental Impact Statement
Proposed Oil & Gas Lease Sale 71

Table II.B.1.a.-1
Beaufort Sea Sale 71
Mean Base Case Scenario

Estimated Schedule of Development and Production

Sale Year	Cal. Year	Expl. & Delin. Wells		Production			Trunk Pipelines	Shore Terms	Production	
				Platforms[1/] and	Production & Service Wells					
		No.	Rigs	Equipment	No.	Rigs	Miles	No.	Oil MMbbl	Gas Bcf
0	1983									
1								1		
2	1985	4	2							
3		9	3							
4		10	3							
5		9	3							
6								.1		
7	1990			3			98	.4		
8				5	60	8	66	.3		
9				4	90	12		.2	126	85
10					90	12			320	240
11					90	12			424	317
12	1995				90	12			400	306
13					42	6			293	220
14									200	150
15									140	105
16									103	77
17	2000								78	58
18									59	45
19									47	35
20									37	28
21									30	23
22	2005								24	19
23									21	15
24									18	13
25									15	11
26									13	9
27	2010								11	8
28									9	7
29									8	6
30									4	3
Totals		32		12	462		164	2	2,380	1,780

Source: USGS, 1981.

1/ Platforms in this scenario refer to gravel islands.

IV. ENVIRONMENTAL CONSEQUENCES:

A. Basic Assumptions for Impact Assessment

Under the terms of the proposed action, 372 blocks for a total of 743,$28 hectares (1.8 million acreas) would be leased for oil and gas exploration and development. For the block deletion alternatives, the areas are as follows: Alternative IV, 670,653 hectares (1,657,183 acres); Alternative V, 645,045 hectares (1,593,907 acres); Alternative VI, 673,363 hectares (1,663,879 acres); and Alternative VII, 679,915 hectares (1,680,068 acres). According to USGS estimates, undiscovered recoverable resources resulting from the mean case of the proposed actionare2.38billionbarrelsofoiland1.78trillion cubic feet of gas.

This section **quantifies** impacts which could result from the proposed lease sale. All figures are relative to the mean case since the mean case is used for quantification of probable levels of developmental activity. (See Appendix F for a summary of minimum and maximum impacts.) There are, however, many areas in which it is difficult to quantify impacts due to lack of data and variable factors that affect any potential development.

For each impact analysis all pertinent laws of the United States, including USGS Operating Orders for the OCS, are assumed to be in effect. The Operating Orders and some laws would mitigate certain impacts. Further, the discussion of cumulative effects contained in each impact section is based on the interrelationship of this proposed action as well as other major, current, and proposed projects. Section IV.A.7. and Appendix B discuss projects considered in preparation of the cumulative effects assessment.

Since this environmental statement does not forecast or predict. the future, potentially affected communities should not use this EIS as a "local planning document." The facility locations and scenarios described in this document, which are only representative of the locations and scenarios that presently seem likely, serve simply as a basis for identifying characteristic activities and resulting impacts for this EIS. They do not represent a BLM recommendation, preference, or endorsement of facility sites or development. schemes.

1. Activities Associated with Exploration: Exploratory operations in the proposed sale area should generally follow from similar exploration in the joint Federal/State Beaufort Sea lease sale area and in submerged state lands offshore the mid-Beaufort Sea coast. Description of exploration operations for this leasing proposal draws from the considerable experience in exploratory work in both the U.S. and Canadian Beaufort Seas. Some circumstances are different; these will be noted below. It should be noted that site conditions, economic factors, resource requirements, and environmental considerations may yield different exploration plans for each well and drill site in the sale area. Specific assumptions on exploration operations and scheduling are indicated below. These are intended to cover the range of exploration operations and practices likely to occur in the proposed sale area.

a. "Exploration Activity: Table II.B.1.a.-1 shows a schedule of exploration drill site construction and placement, along with exploratory drilling. During 1987, the year of maximum exploratory activity, drilling rigs located on at least three platforms are expected to complete 10 exploratory wells. In the exploratory period, some 32 wells may be completed. An average of two or three exploratory wells may be drilled from each drill site, be it a gravel island or other structure; directional drilling will allow adjacent tracts to be drilled from the same drill site. More exploration drill sites may be used if operators wish to expedite the exploratory drilling program in the early years of the lease term. The exploration schedule shown in Table II.B.1.a.-1 assumes considerable efficiency of each drill site. Assuming no seasonal drilling restriction, a maximum of three wells could be drilled from a single drill site in a calendar year.

b. Timing of Exploration: The exploration program assumes year-round drilling operations. Table II.B.1.a.-1 shows that exploratory drilling would occur in the second (1985) through the fifth years of the lease term (1988). If seasonal drilling restrictions were to be imposed in the proposed sale area, the number of years required to complete an exploratory drilling program would be extended. However, in the early *years* of the lease term with seasonal restrictions, the same number of exploratory drill sites may be developed in order to access the most promising geologic structures. The exploratory drilling program assumes hydrocarbon discoveries in the first year of drilling (1984). A field delineation, as well as additional exploration activity, continues from the second (1985) through the fifth (1985) years after the lease sale. Although potential lessees in the proposed sale 71 area may consider these exploration assumptions to be optimistic USGS considers them to be reasonable for scenario specification in the environmental assessment.

c. Lease Term: The lease term for leases issued to high bidders in OCS sale 71 is assumed. to be 5 years (standard for all OCS sales). The period of the lease term should not significantly alter the environmental impacts analyzed in this EIS. The OCSLA, as implemented through MMS regulations governing operations on the OCS leasehold, allows for continuation of the lease term if the lessee is either drilling for hydrocarbons or has a well capable of producing hydrocarbons.

d. 'Types of Exploratory Drill Sites: The term "exploration drill site" refers 'to a surface design built for exploratory drilling operations. The types of drill sites used in the proposed sale 71 area will most likely, or most frequently, be artificial islands. The use of artificial islands as exploration drill sites has been common both in the American and Canadian Beaufort Seas. The type of island construction has varied between the two areas in both design and construction materials. Artificial islands constructed in the Canadian Beaufort have been composed of sand and gravel and have been emplaced on the seafloor by means of suction dredges. Drill sites in the American Beaufort have, until recently, been constructed on natural barrier islands. Although some pioneering structures were composed entirely of ice, currently industry plans to construct sand and gravel islands in shallow waters within the Barrier Islands. No artificial islands have yet been built outside the land fast ice zone. Different types of artificial islands may be constructed, depending upon water depth, distance from shore,

availability of borrow materials, and ice conditions. Thus, islands may be constructed of gravel, sand, and/or silt or combinations thereof. Gravel is the preferred borrow material; however, its availability and cost of transport from borrow sources may require other materials which are more accessible. The design of artificial islands may incorporate sacrificial beaches, steel/concrete caissons, protective moats, and other design features depending upon the circumstances in order to prevent damage and destruction due to the effects of erosion and ice movement.. Refer to Appendix 4 of the BF FEIS regarding details on exploration island design.

Ice islands are also possible drill sites in the more shallow waters of the proposed lease area. However, in comparison to other types of drill sites, ice islands pose the following disadvantages: (1) the islands are susceptible to movement in adverse weather and ice conditions; and (2) as drill sites they are temporary structures which can be used for only one winter's operations.

For operators desiring a reusable exploration structure, a modified drilling barge may be suitable for exploration of proposed sale 71 blocks. The barge would be mounted on a gravel bed which would be similar to the basement. of a gravel island; and it would be designed to arctic specifications, e.g., the vessel would withstand ice forces encountered in shallow waters and the shorefast ice region and in the absence of pressure ridging. Once in place, the drilling barge would be sunk into position on the submerged gravel pad basement. Barges could be protected by a surrounding gravel berm or by a support ice-breaking vessel (see support and logistics functions below). Operating depths for this platform type would be approximately 20 to 60 feet.

Artificial islands have been built in 20 meters (60 ft) of water in the Canadian Beaufort Sea/MacKenzie Delta area by ESSO Resources, Canada, using dredged silt and sand. As an exploration platform, gravel (artificial) island technology is possible for most of the blocks in the proposed sale 71 area. Recently, Canadian Beaufort operators have created an artificial island in 72 feet of water using concrete caissons. The use of concrete caissons will extend artificial island construction into deeper waters and produce a structure more capable of resisting ice movement. However, beyond a certain water depth, artificial islands become less economical in comparison to drillships particularly in the exploratory mode. This exploration scenario assumes that a drillship will be used at least once in the deepest waters of the proposed sale area. It also assumes that at least two wells will be drilled from the drillship.

e. Location of Exploratory Drilling: The location of drilling platforms and exploration wells in the proposed sale area will generally follow a sequential movement from nearshore to offshore over the lease term. That is, operators are likely to drill first in shallow waters with shorefast ice conditions where prior exploration experience is greatest. Operators will then move seaward to deeper waters, encountering grounded pressure ridges and greater ice movement. However, the primary factor influencing the pattern of exploratory drilling will be the discovery of prospective geological structures by geophysical methods and the placement of wells in locations on or near these structures.

f. Test Structure Requirement: The joint Federal/State Beaufort Sea lease sale included a requirement in the information to lessees whereby lessees could not place platforms or structures on blocks located in

13-meter-deep waters beyond the barrier islands until a test platform or structure of a similar type to be drilled from had been in existence in sale-area waters deeper than 13 meters for two winter seasons. The requirement for such a "test structure" is not anticipated to be needed for exploration of tracts in the proposed sale 71 area. It should be noted that the USGS Platform Verification Program requirements, the requirement for use of best available and safest technology (BAST) (as required by the OCSLA), and other pertinent provisions of the USGS Arctic Operating Orders are expected to yield experimental and new platform design features for blocks with more hazardous ice conditions in the proposed sale area.

g. Support and Logistics Functions: Support and logistics functions for exploration operations include the following: The Prudhoe Bay industrial subdivision is expected to function as the principal forward support base for OCS operators and their subcontractors. The support facilities of the Prudhoe Bay unit operators are not expected to be available for exploration purposes in this proposed leasing region. However, lease arrangements may be made between the proposed sale 71 operators and the Prudhoe Bay unit operators for using unit facilities that are available and not at capacity utilization.

It is possible that a new exploration support base could be established closer to the proposed lease area if subdivision leasing arrangements can be established with federal (BLM), state (DNR), *or* private (village corporation] land owners. Locations for new exploration support camps may be at Camp Lonely in the NPR-A near Cape Halkett or near Oliktok Point east of the Colville River Delta. These new exploration facilities are not assumed in this scenario or their environmental impacts analyzed since, although possible, a new exploration base is not considered likely. If a new exploration support base is proposed, an environmental assessment of its potential impacts will be prepared in conjunction with exploration plan approval.

Onsite drilling operations will be supported by mobile support facilities which will be transported to the drill site. The drill rigs will be specially designed arctic rigs which are also mobile.

A newly designed arctic class support vessel may function both as a work boat and an ice breaker to support exploration operations. Its function may initially involve continual and/or periodic movement around submerged drilling barges to break up the ice cover and maintain a rubble field around the barge. Thus this vessel represents an active ice-defense mechanism in comparison to passive mechanisms used in past gravel island design.

h. Transportation: Transportation for support. of exploration operations includes the following:

Borrow Materials: Dredges will be used to move offshore borrow sources, while conventional surface transport equipment will be used to move onshore borrow sources. Onshore borrow removal will occur during the winter months when ice roads are in place, while offshore borrow removal for island construction will normally occur in the summer months when open water conditions prevail. Operators may also remove offshore borrow material during winter months if effective and economic methods for doing so become available. A combination of these transport and construction methods is expected in the proposed sale

area because of the volume of borrow requirements and variation in tract distance from shore. Refer to Appendix D regarding borrow removal requirements in the proposed lease area.

Support Goods: Support goods will be transported by air, marine, and surface modes (truck) to the North Slope and thereafter to the drill site. The heaviest equipment willbe transported by barge to the platform site. The barges may be left in place to over-winter in the ice in certain tract locations where ice conditions are suitable. This arrangement would provide additional deck surface area beyond the limited surface area available on exploration gravel islands.

Ice roads will be constructed from the drill site to shore support facilities and/or the Deadhorse industrial subdivision. Personnel and light materials will be transported by aircraft from drill sites to the Deadhorse facility. No permanently improved roads are expected to be constructed onshore from the Deadhorse facilities to proposed sale 71 support bases and/or drill sites solelyfor purposes of exploration.

A critical concern to the operators is access to offshore exploration platforms during the fall freeze-up and spring break-up periods. Presently, access by vessels or surface vehicles is effectively prohibited because of unstable ice conditions during the fall and spring periods. Proposed sale 71 operators may develop 'and utilize air cushion or similar vehicles to respond to these conditions. The air cushion vehicle may have optimum application eventually in the nearshore and farshore areas while avoiding the intermediate ice zones where shorefast ice meets the moving ice pack. Using this transport concept is possible during sale 71 exploration; however, this is not assumed with this scenario. It should be noted that the air cushion vehicle is being investigated to serve several uses in arctic oil and gas exploration.

APPENDIX D

R. A. ASHFORD, SOHIO CONSTRUCTION CO.

ENGINEERING AND CONSTRUCTION OF MUKLUK ISLAND

OTC 4670

Engineering and Construction of Mukluk Island

by R.A. Ashford, *Sohio Construction Co.*

ABSTRACT

This paper describes the design, planning and construction of Mukluk Island, the largest and most exposed artificial gravel island in the Alaskan Beaufort Sea.

The Island was constructed in two stages, with gravel being hauled over ice road from a shore-based pit to a natural island and stockpiled in winter and then transported by barge to site the following summer. The unusual construction techniques adopted to ensure successful project completion in unpredictable arctic conditions are described.

INTRODUCTION

Mukluk Island is located in South Harrison Bay at the junction of OCS Sale 71 lease blocks 191, 192, 205 and 206. It is 150 miles north of the Arctic Circle, 60 miles west of Prudhoe Bay and 20 miles north of the Colville River Delta in 48 feet of water. It is the first gravel island to be built in Harrison Bay and the site is the most remote, most exposed and the deepest water location of any island built to date in the Alaskan Beaufort Sea.

From the date of the lease sale on October 13, 1982, Sohio Construction Company had one year to plan, design and construct Mukluk Island, including obtaining the thirty-three necessary permits from various regulatory authorities.

Within that year, inspite of unusually severe ice conditions in the Summer of 1983, Mukluk Island was successfully completed and the drilling *rig* moved onboard.

CONSTRUCTION PLANNING

Preliminary design of the island indicated that a steep 1 vertical to 3 horizontal side slope would be feasible. For a 350-foot diameter work surface, the volume of gravel would be approximately 1.25 million cubic yards including an" "allowance for losses. Gravel was known to be available onshore close to Oliktok Point, approximately 30 miles from the Mukluk site. Methods of transporting this quantity of gravel within the next year were investigated.

Consideration was initially given to conventional winter construction by hauling gravel over ice road all the way to Mukluk. This scenario had to be abandoned because of permit schedule restrictions and the need to carry out the geohazard survey prior to commencing construction.

Other possibilities, such as the use of an Arctic drilling structure, converted VLCC, or summer dredging an island using an offshore borrow source *were* also ruled out because of permit schedule restrictions.

Construction of the island by barge haul directly from shore was not practical due to the greater distance involved and shallow water depth close to shore. We calculated the available barge capacity was insufficient to haul this distance with barges only partially loaded because of the draft limitation. Also, the docking facility at Oliktok Point would be used for incoming Sealift module offloading and would therefore not be available for much of the summer.

A construction plan was developed including hauling the gravel to a temporary stockpile on a natural island during the winter and transporting it by barge to site the following summer. This had the advantage that the ice road from shore would be in protected shallow water with little risk of severe ice movements during late winter.

Thetis Island was chosen as the site for the temporary stockpile because of its location and because the 12-foot water depth contour is within 500 feet of the southwest corner of the island. A general map of Harrison Bay is presented in Figure 1.

Flat-deck barges ranging from 1100- to 3000-cubic yard capacity were available on the North Slope. Most of these barges, and the tugboat fleet, were not ice strengthened but had previously been used in

the Prudhoe Bay area for various cargo and gravel hauling operations in open water.

Gravel from the stockpile was to be loaded on the barges using conveyor systems mounted on two gravel causeways. The gravel would then be transported to site where it would be offloaded using cranes equipped with dragline buckets. These cranes would initially be placed on two barges which would be anchored at the site. Once the gravel pile broke surface, these cranes would be transferred onto the new island and offloading continued. Both the barge loading and offloading systems were to be capable of a sustained production rate of 2500 cubic yards per hour.

The barge fleet was chosen to achieve an average haul rate of 40,000 cubic yards per day, allowing nine hours complete barge cycle time, including loading and offloading, the 40-mile round trip and a 20 percent downtime, due to weather and equipment problems. For the 1.25 million cubic yard total haul, this resulted in an expected 31-day duration for the gravel haul. In the event that the gravel haul fell behind schedule, we planned to utilize additional barges and tugboats that would arrive with the 1983 Sealift.

We planned to start sandbag slope protection installation on day eight of the gravel haul; and, at a rate of 750 bags per day, complete the 17,000 bag slope protection in 23 days.

Including mobilization. and demobilization time, and installation of a dock, well cellars, fuel pits, etc. on the island, the total construction time was estimated to be 45 days.

Available but limited data indicated we would be able to start summer construction work about July 23, although all equipment was to be mobilized by July 15 in the event of an early breakup. In part, our schedule was governed by the possibility of late season storms delaying construction and damaging the island in September or October.

ISLAND DESIGN

Design Conditions

Mukluk Island has a design life of three winter drilling seasons. It must therefore survive two open-water seasons after the summer in which it was constructed. It is common practice to design offshore structures to withstand the extreme conditions expected to occur once in a duration of five times the design life of the structure. Thus the 10-year return period maximum wave height was used to calculate the freeboard required to prevent excessive wave overtopping and to calculate the stability of the slope protection.

Since, at the time Mukluk was designed, ice loads were known with less reliability than wave heights, Sohio chose the 20-year return period maximum winter ice load as appropriate. The design winter ice load represents the case of first-year winter ice completely surrounding the island and in a breakout condition, that is with the ice pushing against the island and about to fail in crushing. Loads corresponding to multiyear floes and consolidated ridges proved to be less critical than the spring breakout condition.

The ice load increases through the winter as the ice thickness increases, reaching a maximum at spring breakout. This was significant for the Mukluk design since the seabed soil shear resistance also increases with time as it consolidates under the weight of the island.

Geotechnical properties of the seabed were derived from borings taken at the end of 1982. Gravel fill properties were also derived from borings taken at the borrow pit location.

A complete list of design parameters is given in Table 1 and a section through the island side is shown in Figure 2.

Ice Criteria

A probabilistic approach was used to define design ice loads. The relevant parameters included:

1. Ice thickness variation with time.
2. Peak indentation pressure variation with temperature and strain rate.
3. Ice movement and movement rate.
4. Air temperature.

From these data, a design ice load for each month of the winter was obtained using a Monte Carlo statistical simulation. Each winter season was assumed to include eight major ice movement events and a series of 4000 winter seasons were simulated. The maximum load from each simulated winter was then collected and analyzed month by month, resulting in the estimated ice load for each return period. The ice load increases with ice thickness from November to April when the 20-year return period load is 290 kips per foot of island diameter at the middepth of the steel sheet.

Geotechnical Conditions

The soil stratigraphy at the Mukluk site consists of an upper layer of low plasticity silts and clays extending down to bonded permafrost at about 24 feet below the mudline.

The initial soil strength profile was developed from triaxial test data accounting for both sample disturbance and strength anisotropy. The undrained shear strength decreases from 1.3 ksf at the mudline to 0.5 ksf above the permafrost table.

Oceanographic Criteria

A 10-year return period wave height of 12 feet was selected based on a proprietary wave hindcast study of Harrison Bay. A positive storm surge value of 3 feet was used also based on a hindcast analysis.

Island Stability

Mukluk Island has an adequate factor of safety against failure under both gravity and ice loads. The results are summarized in Figure 3. Slope stability increases after the end of construction as the foundation soils consolidate and gain in shear strength.

Similarly the island resistance to bottom sliding failure under ice load also increases through the winter. Initially, this strength increase is more than offset by the increasing ice load, so the factor of safety against bottom sliding decreases, reaching a minimum in March, after which it increases,

For both the gravity stability analysis and the ice load resistance, a three-dimensional analysis was used.

A minimum island freeboard of 17 feet is required to provide an adequate factor of safety against truncation failure at the waterline under ice load. The foundation soils are expected to settle up to 4 feet during the life of the island, so to compensate for this, the island was to be overbuilt to a +21-foot elevation.

Design for Wave Attack

The freeboard required to reduce wave overtopping to 5 percent of waves in the design storm is 25 feet. The freeboard to resist ice loads is lower than this, so a berm of gravel bag's is placed around the periphery of the work surface on the exposed west, north and east sides to bring the effective freeboard up to 25 feet. As the island settles, the berm will be raised to maintain the necessary 25-foot freeboard.

The short design life and accelerated construction schedule resulted in a choice of gravel bags for slope protection. The 2- and 4-cubic yard polypropylene gravel bags would be placed over synthetic filter cloth with varying overlap depending on the location on the island side slope. Two-cubic yard bags were only to be used on the lower part. of the slope where 4-cubic yard bags would be too heavy for placement by crane at the exceptionally long reach. The greatest bag overlap would be used 'on the exposed side of the island close to the waterline.

Previous experience with Arctic islands has shown that the sandbag slope protection is susceptible to slow deterioration in severe storms, especially if ice floes are continually washed against the island. Replacement of damaged or dislodged bags is then necessary to prevent erosion of the island gravel. Fortunately this is fairly easily accomplished so the island can be maintained for several years.

Hel i deck

It was a drilling requirement that a helideck be located outside the 350-foot diameter work surface. To maintain adequate slope stability, the 1 vertical to 3 horizontal slope could not be exceeded. Thus, a gravel helideck meeting both these requirements was proposed, forming a "pimple" outside the main island.

WINTER CONSTRUCTION

Construction of the 150-foot wide, 8-mile long offshore ice road between Oliktok Point and Thetis Island began on January 12. The floating section of the ice road, approximately three miles long, was 8 feet thick. On January 29, construction of the six-mile tundra ice road from the Ugnuravik Gravel Pit to Oliktok Point began. A 270-man temporary camp was set up at the intersection of the tundra ice road and the existing gravel road to Oliktok Point to house the work force. Gravel hauling commenced on February 22 using a combination of 30-cubic yard Maxihaul end-dumps and Fruehauf and Load King bottom dumps with a total of 40 vehicles operating. This start date was one week behind schedule due to unseasonably warm weather. For part of the haul period, 50-cubic yard capacity Euclid B70 bottom dumps supplemented the main fleet hauling to a rehandling stockpile on the grounded section of the ice road. This enabled us to recover the initial schedule slippage and the gravel haul was completed on April 15 with 1.3 million cubic yards hauled.

SUMMER CONSTRUCTION

On April 15, mobilization of equipment and support facilities from Prudhoe Bay to Thetis Island began using the ice road from Oliktok Point. The 252-man camp on Thetis Island was set up and commissioned. In May, construction of two gravel causeways at the southern side of the stockpile began. A docking facility was constructed at the end of each causeway such that three barges could be docked simultaneously, one on either side of the western causeway and one on the end of the eastern causeway as shown in Figure 4. This arrangement was chosen to match the loading capacity with the loaded draft of the various barges.

In June, when the air temperature was above freezing, the contractor started working the surface of the stockpile to accelerate thawing and drainage. Conveyor systems, mobilized from the Lower-48, were set up on each causeway with drive-over ramps so the conveyers could be fed by bottom dump trucks. The conveyor system on the western causeway split the gravel four ways so each barge was loaded at two points. No splitting arrangement was used on the eastern causeway. The conveyor loading operation was ready to load gravel at our estimated early start date of July 15.

During the last week of July, the marine fleet of tugs and barges had been mobilized from the West Dock in Prudhoe Bay. Two flat-deck barges had been outfitted with 4-point anchoring systems and heavy duty fenders on each side. Cranes, equipped with dragline buckets, were placed on these barges for offloading the gravel from the hauling barges.

For three weeks the gravel haul was delayed by almost 100 per-cent ice cover along the western half of the route from Thetis Island to Mukluk Island.

With icebreaking assistance, one crane barge was anchored at site and the first gravel offloaded on August 8. The site was located to within one meter using the Syledis Navigation System. In spite of heavy ice conditions throughout most of August, the gravel haul was completed on September 19. 1.0 million cubic yards of gravel was removed from the stockpile on Thetis Island, at. an average haul rate of 23,000 cubic yards per day. The highest daily haul rate achieved was 38,000 cubic yards. When navigating through ice, the barge cycle time averaged 13 to 14 hours compared to the planned time of nine hours. By the time the route became ice free in early September, slope protection installation on the island caused delays in offloading gravel so the planned cycle time was rarely achieved.

The output of the two conveyor systems on Thetis Island proved to be 2200 cubic yards per hour. Offloading barges only approached this rate early in the construction when the dragline cranes were operated from the anchored barges.

During gravel placement, the underwater profile of the island was periodically mapped using an echo sounder. This enabled us to direct. further gravel placement within the design outboard profile.

Between August 30 and September 29, 11,954 gravel bags, mostly of the 4-cubic yard size were placed on the island slopes. The underlying filter cloth had proven difficult to install, especially in stormy conditions. Bag placement was very slow, particularly for bags placed underwater. Two bagging plants were operated on the island, each with an optimum capacity of 40 bags per hour. A third bagging plant was kept in reserve in case of breakdown. Up to three cranes were used simultaneously, each with an optimum placement rate of 20 bags per hour. During September, the increasing hours of darkness and foul weather hindered the slope protection installation. The most severe constraint was the congestion on the island surface as the island elevation was built up from +5 feet to +21 feet. During this period only one bag plant and two cranes were used.

On September 17, a sudden slippage of the gravel occurred along the north side of the island. This was probably caused by placing new fill above saturated gravel. The area was monitored closely and no further movement occurred, although small settlements did occur on other parts of the island.

During September, well cellars and conductor pipe were set into the island and a dock was built on the southwest perimeter of the island. The dock consisted of stacked hollow concrete blocks previously used as the dock on Endeavor Island built by Sohio to the east of Prudhoe Bay.

By September 25, new ice had begun to form around the island, hampering final bag placement and demobilization work. Construction was completed on September 30 and the rig move started the same day.

In addition to the camp on Thetis Island, a 7: barge mounted camp was moored close to the i: from mid-August to the end of September. The barge could not. be brought to site for' the f week of offshore construction due to ice, ** work force was transported from Thetis Islan helicopter. When the camp barge came on site, change by helicopter was discontinued and pers were transported to the island from the barg crewboat. During slope protection installation second camp barge with accommodations for 25 men utilized making a total of 100 men at the Mu site.

CONSTRUCTION PROBLEMS AND SOLUTIONS

Ice Road Maintenance

Unusually warm weather delayed completion of offshore ice road and halted the gravel ha three days. The haul schedule was regaine increasing the haul fleet and using a surge pi mile 7 on grounded ice. Euclid B70s with app imately $0-cubic yard capacities were used to from the pit to Mile 7, the gravel was dumped reloaded into the 30-cubic yard bottom dumps transported to Thetis Island. Occasional cracks occurred in the ice road and were rep with large steel plates. Another problem was gravel which caused warming and melting of u lying ice, especially during late March and April

Ice Conditions

Heavy ice concentrations at the Mukluk site, the route between Thetis and Mukluk, delayed loading gravel at Mukluk until August 8, fro expected start date of July 23. At this time, Canadian Class IV icebreaker M. V. Ikaluk was h to assist the initial gravel placement. The breaker was used to break large ice floesupwin the project, then smaller vessels pushed bro away from the anchored crane barge. The M. Ikaluk was later replaced by the M. V. Kalvik, a Canadian Class IV icebreaker, and icebreaking tinued through August. Other icebreaking vess including an icebreaking barge, were employee needed.

When the island was above water, ice tend become grounded on the windward slopes. Since ice was liable to become buried under newly p fill, it was lifted away by crane or pushed aw boat before it became grounded.

The new island was abandoned twice during Au because of approaching heavy ice concentr Without icebreaker assistance, it would have impossible to safely place equipment and perso on the island during August when pack ice was al within a few miles of the site.

Aerial reconnaissance was used extensively to in tigate ice conditions upwind of the site. Wh movement became complex due to changes in direction, a vessel was designated as a "drift b and would drift with the ice and plot its cou We found that ice generally moved to the righ the wind direction, but this varied with the siz the floe. The ice encountered was mostly first

ice, fragments of last year's ridges, but some multiyear ice was present.. Floes more than 1000 feet across and 30 feet thick approached the project site on several occasions and would have overridden the partially completed island had they not been broken up.

Ice concentrations in excess of 50 percent coverage along the barge route from Thetis Island to Mukluk Island caused severe delays throughout August. The tug and barge fleet, with few exceptions, was not ice strengthened. When ice did not immediately threaten the Mukluk site, but was concentrated along the route, the barges were convoyed closely behind the icebreaker to enable them to pass through the ice. This proved successful but interrupted the barge cycle with several barges arriving to load or offload together and with barges having to wait for others to join the convoy.

Ice floes became grounded in the shallow water around the loading docks on Thetis Island. This frequently hindered the barges from coming alongside the docks. We used tugboats to push this ice out of the way and regain access to the loading docks.

Dragscrapers

The method of scraping gravel from a loaded barge such that it fell between this barge and the barge on which the crane was mounted proved very successful. However, once the dragscraper crane was placed on the island, offloading proceeded at a much slower rate. The gravel itself impeded further offloading and the gravel could no longer be dumped in its final position and had to be rehandled.

The dragscrapers proved very inefficient when used to haul material upslope where the island had been overbuilt and gravel placed outside the design profile. The dragscraper cranes also interferred with slope protection placement. To alleviate these problems, we offloaded gravel directly using dozers and front end loaders working off the loaded barges, Consequently, some gravel was left outside the design profile.

Drainage

Much of the above-water fill was first placed underwater and dragged upslope using the dragscrapers and consequently had a very high water content. Drainage of this fill was prevented by freezing conditions and by further' placement of fill directly onto the island from the barge. This resulted in a minor slumping of the fill across the north side of the island. No further fill was placed in this area for several days and no further slumping occurred.

Ice Damage

All of the flat-deck barges used for the gravel haul sustained ice impact damage and several developec cracks at the bow. Temporary repairs were effected on these barges to maintain watertight integrity anc allowing continued service.

Tugboat hull damage was less extensive than barge damage because the tugboats were used in the pushing mode at the stern of the barge, and were therefore protected by the barge. Some ice impact damage to rudders and propellers occurred. but in only one case did this cause significant downtime.

To avoid damage entirely would have caused unacceptable schedule slippage. Therefore, we maintained a sufficiently slow haul speed as to keep ice impact damage to a minimum, avoiding damage severe enough to halt operations.

Slope Protection

The continuous presence of ice around the new island delayed slope protection installation until August 30. After this, filter cloth placement and bagging were frequently hindered by ice or bad weather. The large panels of filter cloth (210 feet x 50 feet) were difficult to handle and "necked" in the center during high wave conditions. During the second week of September, with approximately 5000 bags placed, we decided to eliminate further slope protection below the -24-foot elevation. This reduced the effective design life of the slope protection to one year, but additional bags could be placed and the island upgraded to its original design at a later date.

CONCLUSIONS AND RECOMMENDATIONS

1. The construction of Mukluk Island in South Harrison Bay was a most successful project in that absolutely critical shcedule dates were achieved under extraordinary conditions. The feasibility of gravel islands in Harrison Bay has been established farther from shore and in deeper water than ever before. Of necessity, novel construction methods were adopted; however, the project was achieved using existing equipment available on the North Slope of Alaska.

2. Future summer construction work at similar sites in the Beaufort Sea should include provision for adequate ice management support. *Just* what will constitute adequate support will depend on the construction work and its duration, the projected duration of the construction season, and the required level of confidence in successful completion of the work.

3. The open-water season is variable in duration and start date in Harrison Bay. Ice conditions during the open-water *season* are also variable, ranging from 0 to 50 percent ice cover. There are insufficient records to predict even normal ice conditions during the summer in most of the Beaufort Sea. Since there appears to be a very high variability between years, construction planning must be conservative.

4. Until the Mukluk construction. sumer offshore work off the North Coast of Alaska had been confined to relatively shallow, ice-free water. The Mukluk construction is unique in that tugboats and barges without ice-strengthening *were* operated successfully in severe ice conditions, although the cost of repairing resultant, damage was significant. Those barges and tugboats that were ice-strengthened sustained considerably less ice impact damage than those that were not. We estimate that strengthening

the bow of each gravel haul barge to *A B S* Ice Class 1C would have substantially reduced, but not eliminated, the ice impact damage. However, retrofitting ice strengthening on the barges used for construction prior to starting work could not have been justified by reduced repair costs for this project.

5. For future islands to be built by methods similar to Mukluk, careful consideration of the sequence of gravel placement such that rehandling is minimized, and of the geotechnical properties of the fill during construction could reduce some of the logistics and settlement problems encountered on Mukluk.

6. Placement of filtercloth and gravel bags for slope protection on a large island at an exposed location such as Mukluk proved to be inefficient and expensive, as it delayed the gravel haul and placement of the fill above water. Slope protection installation from a large barge would have alleviated this problem. However, there . . a strong incentive to find a more practical form of slope protection. Articulated concrete mat or similar slope protection could prove cost effective because of reduced construction time and increased confidence in success.

ACKNOWLEDGMENTS

Permission from the Standard Oil Company (Ohio) to publish this paper is gratefully acknowledged. In constructing Mukluk Island, the contributions made by many Sohio employees, as well as the several contractors involved in the project is also acknowledged.

Table 1. Mukluk Parameters

Water depth:	48 ft
Work surface:	350-ft diameter
Island freeboard:	+21 ft (at end of construction)
Island side slope:	1 vertical to 3 horizontal
Design ice load:	290 kips/ft
Design wave height:	H_s 12 ft
	H_{max} 22.5 ft
Maximum settlement in three years:	-4 ft
Freeboard required to resist truncation failure under ice load:	+ 17 ft
Freeboard required to resist wave overtopping:	+ 25 ft
Berm height. on north, west, east sides:	+ 25 ft

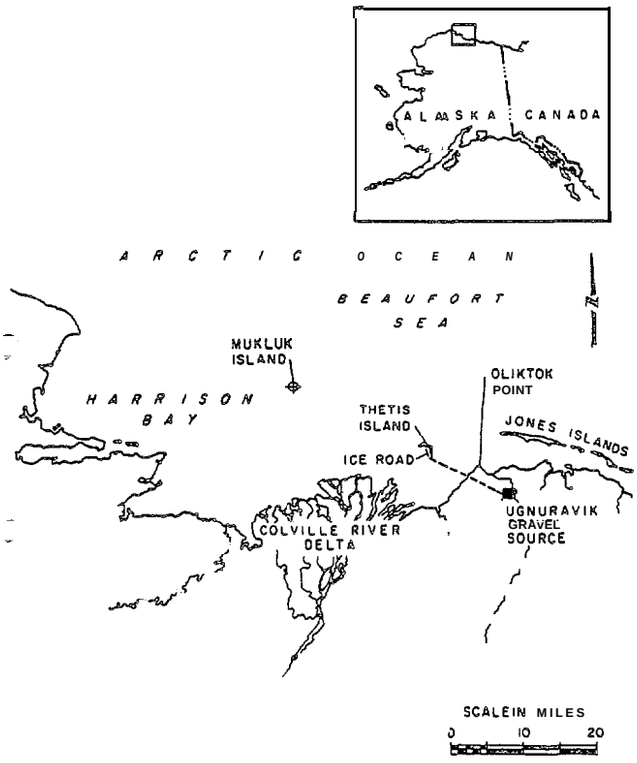

Fig. 1—Mukluk Island location

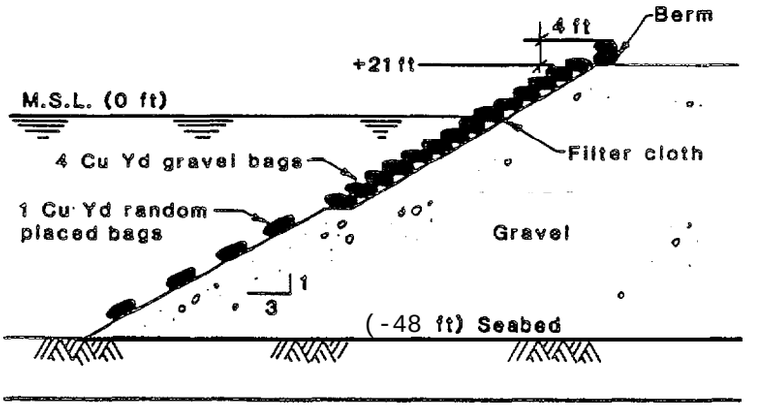

FIGURE 2 . ISLAND SECTION SHOWING SIDE SLOPE

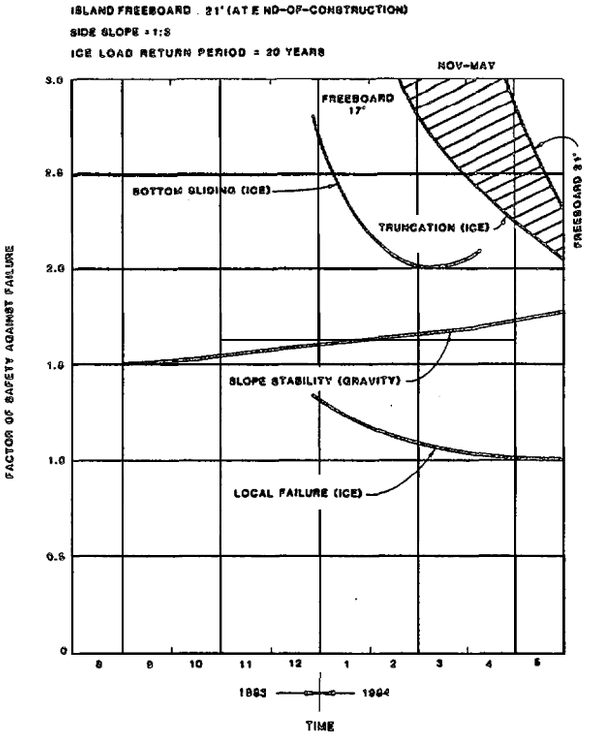

Fig. 3—Summary of island stability

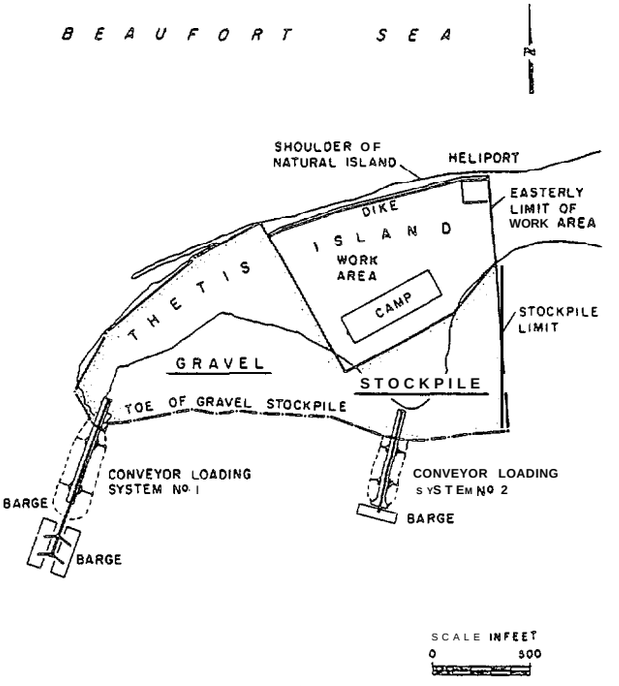

Fig. 4—Layout of Thetis Island work area

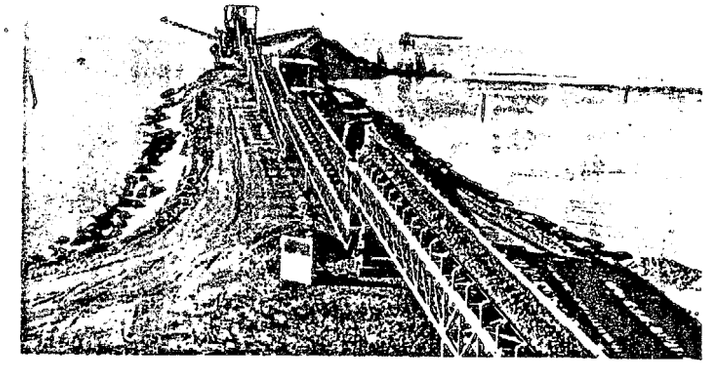

FIGURE 5 - LOADING GRAVEL BY CONVEYOR SYSTEM ONTO A BARGE AT THETIS ISLAND.

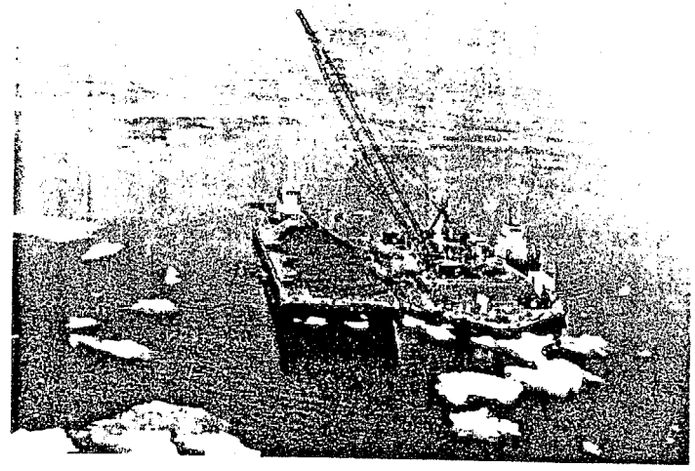

FIGURE 6 – OFFLOADING GRAVEL USING BARGE MOUNTED DRAGLINE CRANES AT THE MUKLUK SITE.

FIGURE 7 – HEAVY ICE CONDITIONS NEAR THE MUKLUK SITE DURING CONSTRUCTION.

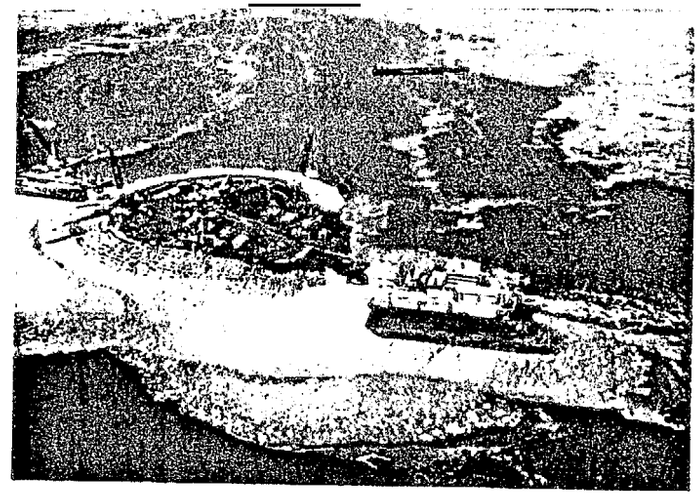

FIGURE 8 – NEW ICE FORMING AROUND MUKLUK DURING INSTALLATION OF SLOPE PROTECTION; CAMP BARGES IN THE FOREGROUND.

APPENDIX E

EXCERPTS FROM INDUSTRY TESTIMONY ON STIPULATIONS OF SALE BF AND SALE 71 HEARINGS

EXCERPTS FROM INDUSTRY TESTIMONY ON

STIPULATIONS OF SALE BF AND SALE 71 HEARINGS

Alaska Oil and Gas Association at Sale BF EIS Hearings.

> This measure would effectively prevent the drilling of more than one well per rig per year and in some cases even one well per rig per year would not be possible; therefore, the time required to assess reserves with due diligence would be at least doubled and in some bases tripled; with corresponding increases in cost. (Testimony, p. 26)

Sohio Testimony at Sale BF EIS Hearings.

> Several of the measures proposed in the EIS as mitigating measures which we believe are unnecessary would have a serious negative impact upon operations in the leased tracts. Just as an example, the three measures we consider may have the greatest impact on operations are sections 1.9, the relief well contingency; 2.1, of the seasonal limitation on operations; and 2.12, the enforced removal of exploratory gravel islands. Adoption of these three mitigating measures alone could essentially double both the cost of exploratory operations in the Beaufort Sea and the time necessary to complete the exploratory phase. (p. 38-39)
>
> . . . climatic conditions themselves provide further strict time limitations on winter drilling. Given the necessity of using ice roads for transporting heavy loads to the offshore site, it is presently unreasonable to anticipate the commencement of drilling activities until mid-January. This mitigative measure would thus limit the industry to an unrealistic 2½ month drilling period. In the more remote locations this could result in at least two if not three years being required to drill and fully test one exploratory well, compared with three wells per year under unrestricted but safe conditions. . . it is unlikely that a company with even a modest lease holding could reasonably evaluate its tracts within a ten-year lease term unless it had the financial ability to mount several concurrent operations. (p. 43-44)

Arco Exploration Company on Sale 71 FEIS.

> The time table . . . is optimistic. If the seasonal drilling restrictions (as applied to Beaufort Sale #BF) remain, the number of exploratory wells drilled is going to be spread over a larger time frame, beyond the suggested 5th year (1988) . . .

Arco applauds the BLM for proposing a lowering of the seasonal drilling restriction to two months, but we feel that the seasonal drilling restriction should not be a part of this lease sale. This restriction is burdensome and lessens the cost efficiency of a project. No data, to date, is available that indicate environmental damage has or would occur in the Alaskan offshore to support such a restriction. (p. L-9)

Exxon Company, USA on Sale 71 FEIS.

Exxon continues to object to any seasonal drilling restriction. The general objective of this restriction is to minimize impact on bowhead whales. We heartily support the objective, but reject the method . Exxon and industry in general have strongly contested the restrictions on leases acquired in the 1979 Beaufort Sea sale . . . Exxon believes the most important reason is industry's demonstrated ability to operate in a safe and environmentally acceptable manner in arctic waters. Industry's record in OCS drilling is outstanding. The DEIS recognizes that there is "a low probability" of major spills from exploration activities during September and October. In the unlikely event of an oil spill, industry's clean-up capability will undoubtedly mitigate environmental impacts.

Effective exploration will require a primary lease term longer than the five-year term assumed . . . A ten-year lease term is essential . . . This need becomes particularly acute in the event that seasonal drilling restrictions are imposed. (p. 17-18)

Exxon Company, USA on Sale 71 EIS.

Although the proposed time of seasonal restriction is a reduction from previous restrictions, we still feel it is unnecessary. The restriction is based on the premise that loss of well control is a common occurrence , that all well control problems result in large oil spills, and that this spillage occurs for extended periods. None of these assumptions are true. These restrictions consistently ignore the record of offshore oil and gas operations , and improvements in technology. We again reference industry's offshore drilling record in an effort to demonstrate industry's technological improvements and to allay concerns about oil spills. During the period 1972-1978 there were only 46 incidents of lost well control throughout the United States OCS. Most of these were of short duration and only three resulted in oil spillage. The total volume of oil

spilled from these three incidents was 725 barrels. Gas was released from the other 43. Only seventeen incidents occured during exploratory drilling and none resulted in oil spillage. In fact the DEIS on page 154 recognizes that exploration has a lower risk of spillage than development. The record for Alaskan operations is even better than the entire US OCS. Since 1957, 1,450 wells have been drilled in Alaskan waters; yet there have been no drilling accidents that resulted in loss of oil.

A restriction of drilling operations for a two-month duration would impose costs disproportionate to the time of suspended operation. In addition to substantial costs requird to maintain the rig at the location while not performing productive work, certain otherwise wasteful operations may also be required. To safely suspend an exploration well when drilling is restricted, either casing must be run or cement plugs must be set to isolate the exposed formations. Since drilling shutdowns are not likely to occur when casing strings would otherwise be required, several negative impacts can result:

a) Extra casing strings may be required. This may force the operator to give up his deeper drilling objective, because the telescoping effect makes it impractical to work inside successively smaller casing diameters.

b) The operator may be forced to curtail important evaluations? such as coring and logging in order to reach a logical casing point prior to a required shutdown. Such lost information can only be obtained by drilling a second, duplicate well.

c) The operator may need to demobilize several weeks earlier to avoid being caught between casing points by a shutdown. This would further lengthen the unproductive period.

We hope that the response to this comment in the Final Environmental Impact Statement will indicate that the Secretary has reconsidered the need for seasonal drilling restriction and that this restriction will have been deleted. (p. L-20)

Sohio Alaska Petroleum Company on Sale 71 FEIS.

Sohio recommends that the proposed seasonal drilling restriction be dropped.

Although the proposed two-month seasonal drilling restriction is obviously a considerable improvement over the seven-month restriction presently enforced on State and Federal Beaufort Sea leases, even in its attenuated form, it is impossible to justify on *objective* scientific grounds. [because] . . . (1) the risk of a major oil spill based upon past industry experience in Alaska and the Lower 48 is extremely low; (2) oil spill Technology and techniques exist and would result in cleanup of most oil spilled; (3) safety, training and spill prevention techniques on exploration rigs make an oil blowout an extremely unlikely event; and (4) disturbance to the bowhead whale from offshore petroleum operations has not and will not have significant harmful impacts on this endangered species.

In addition to the lack of scientific justification for this seasonal drilling restriction, it is also important to consider the negative economic impacts of a two-month drilling shutdown. An operator has very little flexibility of action in a well being drilled up to the September 1st shutdown date. To leave a large section of open, uncased hole exposed for two months is to invite losing the hole due to its walls collapsing inwards. It is preferable to case the hole prior to suspending it for the two months shutdown. However, the decision to case a hole is determined by the geology and the proposed total depth of the well, not by the time of year. It has been calculated that if a casing point is reached between August 5th and September 1st, it is economically advantageous to suspend the well immediately after setting the casing and then remain shutdown until November 1st.

Actual rig, crew and associated equipment costs of a Sohio rig operating on a typical exploration well on an island in the shallow areas of the Beaufort Sea are $150,000/day in an operational mode and $75,000 in a standby phase. These figures are not hypothetical but real rates which Sohio regularly incurs.

Using those figures, it is possible to calculate the cost to an affected well of the shutdown. The minimum cost is $5.5 million, a figure which can escalate to $10.2 million depending on the circumstances of the well . . . It is quite realistic to forecast that an exploratory well drilling site in the sale area will cost from $15 to $100 million . . . The actual drilling of the well itself will probably cost from $15 to $30 million, the final amount being determined largely by the time it takes to complete the well. Consequently, the $5.5 to

$10.2 million extra costs caused by the two months shutdown quoted above do not take into account the value of the large amount of money used for pad construction.

These additional drilling costs would ultimately translate to increased costs for consumer and decreased revenues for government.

Finally, this stipulation would also delay, the ultimate production of critically needed energy resources from this high potential lease sale area due to the greater time required to explore, test and delineate discoveries.

APPENDIX F

DISCUSSION 0F'METH0DOLOG% FOR EMPLOYMENT HOURS AND COST INFORMATION FOR EXPLORATION AND ARTIFICIAL ISLAND WORK

The information in this appendix is intended to provide a basic understanding of the methodology used to develop the employment 'work hours and labor cost information appearing in Tables 21, 22, and 23.

The understanding of this methodology will be enhanced by considering the information in Table 14 (Air Support Operations), Table 15 (Marine Logistics), Table 18 (Gravel Island Summary Data), Table 19 (Exploration Well Data Summary] , and Table 20 (Exploration Drilling Operations, Typical of On-Site Work. Crew), as well as Tables 21, 22, and 23 themselves. All information on construction and logistical operations related directly to work sites was developed as a unit or sequentially, and the information on sizes of crews, work weeks, numbers and types of personnel, actual results achieved, etc. are essential to the overall calculation of work hours and labor costs.

As further definition, the term "labor cost", as used in this repot, refers directly to gross wages paid and does not include fringe benefit information, housing or housing allowances, food provided or allowances therefor, or any other direct or indirect monetary or in-kind forms of compensation.

Therefore, crew size, trip data, aircraft or vessel types, and duration of assignments relate directly to the work hours and labor costs reflected in succeeding tables. Similarly, the volume of material moved, nature of equipment, distances, and mode of transportation for gravel island construction, as appear in Table 18, relate directly to the work hours and labor costs in the summaries appearing in Tables 21, 22, and 23.

In Table 19, key factors include length of time between well spud date and completion date, mode of transportation to and from the drill site, and other support features. Similarly, the composition of the typical on-site work crew, as described in Table 20, provides the basis for the calculation or estimation of work hours and labor costs.

The basic methodology in ascertaining work hours and labor costs for exploratory well operations began with a determination of number of individual workers involved in a particular unit of work on a daily equivalent basis. For example, in land transport and handling of a drill rig, classifications involved include crane operators oilers, drivers, swampers, and a foreman or pusher. The numbers of personnel on an operation requiring single shifting or double shifting are considered and total work hours per day arrived at for that unit of work. Collective bargaining agreements or actual wages paid, as provided by contractors for a particular year, e.g., 1981, 1982, or 1983, were then applied against those work hours, on a classification-by-=classification basis. Consideration for overtime hours compensation was also put within that calculation. The end result is a number of hours for a daily operation of that unit and the daily labor costs for that function.

The same methodology was utilized in estimating the hours involved and the costs for labor to operate a tugboat for one day, provide air transportation for one day, provide the services of a drilling crew for one day, offering catering services for the one day, provide oil field services support for that one day, and have on hand the miscellaneous support required for the one day period of time. In all cases, the

labor cost was calculated from prevailing wages for the particular period of time, utilizing labor agreement rates whenever these were available and applicable.

An important consideration was ascertaining through interview, the number of days involved in the work which was performed. This provided a direct relationship to daily work hours and labor costs in order to arrive at the estimated or extrapolated data appearing, in this case, in Table 22, "Employment Summary of Estimated Work Hours and Wages." As a means of verification of, the estimates resulting, interviews with contractor management personnel included requesting from them their daily or weekly labor cost data. This was used for comparative purposes with the calculated data and for adjusting estimates as necessary to arrive at realistic hours and dollar figures.

Essentially, the same methodology was used to" provide estimates of hours and dollars for gravel island construction, with the principal difference being the variation in the size of work crews on a daily basis. Some gravel island construction projects required rather considerable use of air transport backup for workers, and some required almost none, except on-call services. Some necessitate considerable marine support, and some required none. The surface movement of the gravel from extraction at the pit to either a dock for water transport or all the way to the site via ice road, was a consistent feature. However, the extra handling of multi-mode transport required more time and cost than transport via an all-surface mode. Also , construction of an ice road, as applicable could introduce additional time and cost factors.

The basis for the time and cost estimates was principally interviews with contractor management personnel, plus extensive review of any written information that dealt with the size of crews, estimated work hours for a project, details of changes in work methods or systems, and the type of equipment used.

As in the exploration program calculations, it was necessary to ascertain, by interview or estimate, the composition of the work crew, as well as the size, and then apply the work shift methods in effect for work hours and the applicable labor rates for that period of time, adjusted for overtime or other factors consistent with the labor agreements or practice of the employer.

Different levels of reliability of information can result from this approach. However, there was no reasonable alternative to provide pragmatic data for this report. In those cases where it has been possible to review results, the opinion of those management people with whom discussions were held was that the resulting estimates were within the general parameters of their estimating procedures. There was no indication of a plus or a minus percentage error probability.

In the reviews conducted, it appears that the reliability for gravel island construction was highest when related to the Endeavor/Resolution Island sites in 1980/81. The most definitive contractor management interviews took place in connection with that program. A reasonable sampling of the companies involved in actual drilling or in support activities during and following the calculation of information supports

the use of the methodology, although there is no reason to expect that it would approach the accuracy of individual company pay records if those were indeed available for review. The methodology utilized is consistent with the cost estimating procedures of some of the companies with whom discussions were held, in that some utilized a unit time and cost factor, while others used total work hours and costing on an overall basis.

To illustrate the methodology in operation, the calculations for construction of the Endeavor/Resolution Island sites (Table A-1) and exploratory drilling for Jeanette Island No. 1 (Table A-2) are shown below.

Example Calculation

Estimated Work Hours and Wages

Mobilization, Drilling, Demobilization

Jeanette Island No. 1

The general method for calculating the employment hours and wage summary for each exploratory well, including mobilization and demobilization appears in the section titled Research Methods. As indicated in that section, each work segment was expressed in daily equivalents constrtuted from interviews with managerial personnel in each area of work and from salary and wage information applicable during the appropriate work year. The prototypical work force daily equivalents for exploratory wells are shown immediately below.

1. Land Transport and Handling:	# of Workers		# of Shifts		Work Hours
Crane Operators	2	x	2	=	48
Oilers	2	x	2	=	48
Drivers	10	x	1	=	120
	5	x	1	=	60
Swampers	2	x	2	=	48
Foreman "	1	x	2	=	24
Daily Total					348

Using wages applicable for the specified crew during the 1981-82 season, the daily wages, including overtime, total $7,944.

2. Marine Transportation:	Paid Work Hours/Day	Accrued Hours Time-off	Total Hours
Master	12	10	
Mate	12	10	
Engineer	12	9	
Deckhand	12	9	
cook	12	9	
Daily Total	60	47	107

Using wage rates applicable to the 1981-82 season, per union agreement, the daily wage costs incurred for the specified crew totals $1,088.

3. Air Transportation:	Daily Work Hours
Pilot	10
Co-pilot	10
Daily Total	20

Daily labor costs for all aircraft for 1981-82 season are estimated at $600.

4. Drilling Crew:

Toolpushers plus 27-man crew average,

Crew composition as specified in Table 20.

Total daily work hours include overtime as estimated by consensus of discussions with drilling companies' management.

Estimated total daily work hours: 550 hours

Estimated total daily labor cost: $11,000

5. Catering Contractor Crew:

Six person crew, comprised as shown in Table 20.

Estimated total daily work hours: 72 hours

Estimated total daily labor costs: $ 1,200

6. Oilfield Service:

Ten persons comprised as shown in Table 20.

Estimated total daily work hours: 120 hours

Estimated Total daily labor costs: $ 2,500

7. Miscellaneous Support (Weather, Medical, Other Miscellaneous:

Ten persons comprised as shown in Table 20.

Estimated total daily work hours: 120 hours

Estimated total daily labor costs: $ 1,400

The example worked out in Table A-1 displays the calculations supporting the employment wages and hours data for Jeanette Island No. 1. This exploratory well was selected for illustration because it employed all three aspects of transportation (land or ice road, water, and air).

TABLE A-1

EXAMPLE CALCULATION
ESTIMATED WORK HOURS AND WAGES
GRAVEL ISLAND CONSTRUCTION
ENDEAVOR/RESOLUTION
1980

CONSTRUCTION CONTRACTORS (2)

GRAVEL PIT TO DOCKSIDE STOCK PILE - SINGLE SHIFT, 12 HOURS

Work Force	No.	Shifts	Cumulative Hours/Day Worked	Total Straight Time (O/T Equivalent)	Pay Rate (Straight Time)	Total $'s Per Day	No. of Days	Hours Worked	Total Payroll ($)
Superintendent	1	1	12	(Salaried)	--	101	74	888	22,274
Foreman	2	1	26	28	21.50	602	74	1,776	66,5423
Operators	2	1	24	28	20.47	573	74	1,776	42,402
Oilers	2	1	24	28	18.26	511	74	1,776	37,814
Laborers	6	1	48	56	15.40	862	74	3,552	63,788
Drivers	6	1	72	84	17.25	1,449	74	5,328	107,226
Mechanics	1	1	12	14	20.47	287	74	888	21,209
Service Oilers	1	1	12	14	19.92	279	74	888	20,637
TOTAL	19	(19)	228			4,864		16,872	359,896
DOCK TO SITE WORK - AL2, DOUBLE SHIFT, 2 - 12 HOURS									
Supervision/General Assignment									
Superintendent	2	2	48	(Salaried)	--	1,704	74	1,552	80,096
Foreman	3	2	72	86	21.50	1,806	74	5,328	133,644
Mechanics	5	2	120	140	20.47	2,865	74	8,880	212,069
Service Oilers	2	2	48	56	19.92	1,116	74	3,552	82,548
SUBTOTAL	12	(26)	988			1,991		21,312	517,357
Dock									
Operators	2	2	48	56	20.67	1,166	74	3,552	54,828
Oilers	2	2	48	56	18.26	1,023	74	3,552	75,669
SUBTOTAL	4	(.s)	96			2,169		7,104	160,497
General Site Work									
Operator-Dragl ine	1	2	24	272	20.47	573	74	1,776	42,414
Operator-Crane	1	2	24	28	20.67	573	74	9,775	42,414
Oiler	2	2	48	56	18.26	1,022	74	3,552	75,66'3
Operator-Loader	1	2	24	28	20.47	57-3	74	1,776	42,414
Drivers	2	2	48	56	17.25	966	74	3,552	71,484
Surveyors	3	.2	72	84	17.65	1,483	74	5,328	109,712
SUBTOTAL	10	(20)	240			5,190		17,760	384,107
Sandba8sine/Protective									
Operator-Lender	2	4	48	56	20.47	1,146	74	3,552	84,828
Operator-Crane	1	2	24	2%	20.47	573	74	1,776	42,414
Oiler	1	2	24	28	18.26	511	74	1,776	37,834
Laborers	6	12	144	168	15.40	2,587	74	10,656	191,452
SUBTOTAL	10	(20)	240			4,817		17,760	356,528
TOTAL	36	(72)	1,564			19,167		63,936	1,418,489
MARINE TRANSPORTATION									
Master	4	4	48	(÷40)*	@260.00/day	1,040	74	6,512	76,960
Mate	6	6	48	(÷60)	@225 00/day	900	74	6,512	66,600
Engineer	4	6	46	(÷36)	@182.50/day	730	74	6,216	54,020
Deckhand	4	8	48	(÷36)	@180.00/day	720	74	6,216	53,280
Cook	4	4	48	(÷36)	@177.50/day	710	74	6,216	52,540
TOTAL	20		260	(÷188)		b,100		31,672	303,400

* Authorized time off accumulates for payment during scheduled time off.

Note: Marine transportation utilized three tugs full-time for transport, plus one work tug and one personnel boat one-half time each during the 74-day construction period. Therefore, a 4-boat equivalent was used for calculations.

Crew members are paid on a daily basis pursuant to union agreements. These agreements provide for payment to be accumulated for authorized time off during scheduled periods off duty upon the employee return to home port. For purposes of this report, the actual work time (12 hours) has been increased by authorized time off (9 or 10 hours depending on classification) to reflect pay hours; and the daily rate increased to include provision for that payment.

TABLE A-2

EXPLORATION WORK HOURS AND WAGES

JEANETTE ISLAND NO. 1

	Days	Hours /Day	($)Wages /Day	Total Hours	Total ($)Wages
MOBILIZATION					
Land Transportation & Handling	12	348	7,944	4,176	95,328
Marine Transportation	4	107	1,088	428	4,352
Air Transportation	12	20	600	240	7,200
SUBTOTAL				4,844	106,880
DRILLING OPERATIONS					
Land Transportation & Handling[1]	45	72	1,649	3,240	74,205
Air Transportation	84	20	600	1,680	50,400
Drilling Crew	72	550	11,500	39,600	828,000
Catering & Camp Services	75	72	1,200	5,400	90,000
Oil Field Service Specialties	72	120	2,500	8,640	180,000
Miscellaneous Support[2]	72	180	2,100	12,960	151,200
SUBTOTAL				71,520	1,373,805
DEMOBILIZATION					
Land Transportation & Handling	7	348	7,944	2,436	55,608
Marine Transportation	9	107	1,088	963	9,792
Air Transportation	10	20	600	200	6,000
SUBTOTAL				3,599	71,400
TOTAL				79,963	1,552,085

[1] Includes surface pad and ice road construction and maintenance.

[2] For Jeanette Island No. 1, based on actual data, included an average of fifteen persons rather than ten persons as provided forinformula.

APPENDIX G

LIST OF PROJECT CONTACTS

Acknowledgement

During our research for this project, the consultant team sought information from many persons in private industry, labor organizations and public agencies. These informants were exceedingly generous with their time and forthcoming with their knowledge. We are thankful for their help and have sought to make accurate use of their contributions.

List. of Project Contacts

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