Technical Report No. 164

OCS Study MMS
2002 – 066

Arctic Economic Impact Model for Petroleum Activities in Alaska (Arctic IMPAK)

Final Technical Report

U.S. Department of the Interior
Minerals Management Service
Alaska Outer Continental Shelf Region

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December 2002

The study was funded by the Minerals Management Service, U.S. Department of the Interior, Washington, D.C. under Contract Number 01-98-CT-30907 and Purchase Order Number 01-02-PO-85307.

Document is available to the public through the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Fax: 703-605-6900, www.ntis.gov

STUDY TITLE: Update of Oil Industry Labor Factors for Alaska Manpower Model

REPORT TITLE: Arctic Economic Impact Model for Petroleum Activities in Alaska (Arctic IMPAK)

CONTRACT NUMBERS: Contract Number 01-98-CT-30907
Purchase Order Number 01-02-PO-85307

SPONSORING OCS REGION: Alaska

APPLICABLE PLANNING AREAS: Beaufort Sea, Chukchi Sea, Hope Basin

FISCAL YEARS OF PRODUCT FUNDING: FY 1998 and 2002

COMPLETION DATE OF REPORT: December 2002

COST: FY 1998 $131,503
FY 2000 $11,676
FY 2001 $39,481
FY 2002 $35,108

CUMULATIVE PROJECT COST: $217,768

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KEY WORDS: Beaufort Sea, IMPLAN, OCS Arctic Subregion, oil industry, economic impacts, employment, earnings, input-output, manpower.

BACKGOUND: Production of oil and gas in the offshore Alaskan Arctic relies upon a set of technologies unlike those used anywhere else in the world. Remote locations, temperatures of 60 degrees below zero, and shifting ice flows that rule out traditional platforms, waterborne craft and sea-floor pipelines are just a few of the challenges that must be overcome. The solutions include roads and islands built of ice, man-made gravel islands, pipelines buried below the ocean floor, and cold weather retrofitted vehicles and equipment that are run for years without ever being turned-off.

Economic impact modeling of these activities also requires a set of methods that are unique. Readily available regional economic impact models contain production functions that are based on national averages. These national-level input coefficients cannot accurately reflect the unique arctic production function. These models are also unable to accurately trace the regional distribution of purchases made by the industry or the workers who commute to the site. Finally, these readily available models do no have enough detail to accurately model the differing impact of specific projects.

This report describes the development of a first step model that can be combined with a readily available regional model to produce more accurate estimates of economic impacts. The first step model utilizes vectors of purchases, disaggregated by both geographic area and activity, to allow a more accurate accounting of the inputs required for a specific project. The vectors are constructed by coding detailed engineering estimates of inputs to the individual activities. These direct inputs can then be used to stimulate the standard regional impact models.

OBJECTIVES: The Outer Continental Shelf Lands Act, as amended, established a policy for the management of oil and natural gas in the Outer Continental Shelf (OCS) and for protection of the marine and coastal environments. The Act authorizes the conduct of studies in areas or regions to determine the "environmental impacts on the marine and coastal environments of the OCS and the coastal areas which may be affected by oil and gas development." The U.S. Minerals Management Service (MMS) is the administrative agency responsible for leasing submerged Federal lands.

The National Environmental Policy Act (NEPA) of 1969 requires use of the natural and social sciences in any planning and decision making that may have an effect on the human environment. To this end, the MMS prepares Environment Impact Statements (EIS) and environmental assessments (EA); acquires marine environmental data; analyzes data, literature surveys, socioeconomic studies, and special studies; and holds public conferences. These undertakings often call for assessing the regional economic impacts of a proposal such as a lease or a sale.

In the past, an assortment of models and methods were used to estimate economic impacts, and these typically varied by planning areas. At present, the existing models used to develop direct OCS and secondary employment projections for the Alaska OCS Region are outdated and do not produce results comparable to other OCS regions such as the Gulf of Mexico. As a result, regional comparisons are difficult to make. Section 18 of the OCS Lands Act, however, requires that the U.S. Department of the Interior prepare a 5-year schedule of lease sales that considers "an equitable sharing of developmental benefits and environmental risks among the various regions." For this reason, MMS decided to standardize the approach used to estimate regional economic impacts and has settled on IMPLAN, an economic input-output model, for that purpose.

To facilitate EIS work for Alaska's OCS Arctic subregion and to develop a tool for the "equitable sharing" analysis, a new model was developed. It can estimate industry employment and expenditures, by region, of offshore oil exploration and development (E&D) activities in the Beaufort Sea. The new model is known as the Arctic Impact Model for Petroleum in Alaska (Arctic IMPAK). Unlike the current model, this new model is designed to produce a set of outputs that can be used to stimulate IMPLAN.

In a parallel but separate study, a similar model was developed for the Sub-Arctic Alaska Subregion. This second model is known as Sub-Arctic IMPAK.

DESCRIPTION: The Arctic IMPAK model forecasts the input requirements needed to carry out oil exploration and development on Alaska's Arctic OCS. In the previous section, the methods used to develop vectors of commodity and labor input requirements on a per unit basis were described. Multiplying these vectors by projected annual activity levels developed from an E&D scenario generates estimates of the total input requirements for each year in the forecast horizon.

The Arctic IMPAK model is contained in a Microsoft Excel platform and is driven by data from the E&D report, as well as other data, which are manually input into the model. Since the activities listed in the E&D reports are not identical to those used in IMPAK, the model has to convert the E&D data into the corresponding IMPAK activity levels.

The model inputs are then transposed into a matrix compatible with the regional input-output matrices. An Excel array function is used to accomplish the task. The transposed input is then multiplied by each region's input-output matrix to yield the total direct impacts by region and IMPLAN sector. Again, an Excel array function is used to accomplish the matrix multiplication. Note that each year in the forecast horizon requires a separate formula.

STUDY RESULTS: The final output is a matrix that provides total input requirements by IMPLAN sector separately for each year and geographic area. This output then becomes the input for the Microsoft-Access model developed by the MMS. The MMS model estimates the ripple effects in each corresponding, proximate onshore area.

REPORTS: Jack Faucett Associates, Inc. 2002. Arctic Economic Impact Model for Petroleum Activities in Alaska (Arctic IMPAK), Final Technical Report. Prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska. Technical Report No. 164.

MODELS: ARCTIC IMPAK: An Economic Impact Model on CD-Rom

CONTENTS

LIST OF EXHIBITS

GLOSSARY

BP	British Petroleum, Inc.
Cat	Caterpillar, Inc.
COTU	Crude Oil Topping Unit
CPU	Central Processing Unit
BEA	Bureau of Economic Analysis
E&D	Exploration and Development
GPS	Global Positioning System
IBT	Indirect Business Taxes
IFR	Instrument Flight Rules
IMPAK	Impact of Petroleum Activities in Alaska
I-O	Input-Output
KW	Kilowatt
Margin	A cost category that splits the purchase price of a commodity into various cost components. These categories include the production margin, transportation margins (the cost of shipping a finished product from the factory gate to its ultimate destination), wholesale trade margins, and retail trade margins. A margin rate is a margin cost divided by the total purchase price of the commodity.
MLLWL	Mean Low Level Water Level
MMS	Minerals Management Service
NIPA	National Income and Product Accounts. A national accounting system published by the U.S. Bureau of Economic Analysis.
NSB	North Slope Borough
OCS	Outer Continental Shelf
PCE	Personal Consumption Expenditures. These numbers reflect household purchases of commodities and services in an area and should be used to estimate the induced impacts in a region. The

	figures are derived from estimates of disposable income (total income minus taxes and savings) and take into account differences between where income is earned and where it is spent.
PF	Permanent Fund
Production Coefficient	The cost of a production input divided by total industry output.
Production Manpower	This term is used to identify personnel directly involved in oil exploration, development and production activities. Management and overhead personnel who are not directly involved in the activities are not included.
RPC	Regional Purchase Coefficient. The percentage of demand accounted for by local production or a particular geographic region.
RTK	Real Time Kinematic
SIC	Standard Industrial Classification
SUV	Sport Utility Vehicle
TAPS	Trans-Alaska Pipeline System
VP	Vibration Point. A geographic location used seismic surveys.
VSM	Vertical Support Member. A supporting framework used to elevate pipelines several feet above ground.

INTRODUCTION

The Outer Continental Shelf Lands Act, as amended, established a policy for the management of oil and natural gas in the Outer Continental Shelf (OCS) and for protection of the marine and coastal environments. The Act authorizes the conduct of studies in areas or regions to determine the "environmental impacts on the marine and coastal environments of the OCS and the coastal areas which may be affected by oil and gas development." The U.S. Minerals Management Service (MMS) is the administrative agency responsible for leasing submerged Federal lands.

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In the past, an assortment of models and methods were used to estimate economic impacts, and these typically varied by planning areas. As a result, regional comparisons were often difficult to make. Section 18 of the OCS Lands Act, however, requires that Interior prepare a 5-year schedule of lease sales that considers "an equitable sharing of developmental benefits and environmental risks among the various regions." For this reason, MMS decided to standardize the approach used to estimate regional economic impacts and has settled on IMPLAN, an economic input-output model, for that purpose. Using one model will help ensure consistency from region to region. IMPLAN is the most widely used input-output model for estimating regional economic impacts.

The existing models used to develop direct OCS and secondary employment projections for Alaska are outdated and do not produce results comparable to other regions such as the Gulf of Mexico. The analysis of lease sales proposed in the OCS Oil and Gas Leasing Program for 2003-2007, will require data on the possible impacts on coastal and offshore areas resulting from E&D activities in the Arctic Subregion of the Alaska OCS.

To facilitate EIS work for Alaska's North Slope Borough (NSB), this study develops a new model that estimates industry employment and expenditures, by region, of offshore oil exploration and development (E&D) activities in the Beaufort Sea. The new model is known as the Arctic Impact Model for Petroleum Activities in Alaska (Arctic IMPAK). Unlike the current Manpower model, the revised model produces a set of output that can be used to stimulate IMPLAN.

In a parallel but separate study, a similar model was developed for the Sub-Arctic Alaska Subregion. This second model is known as Sub-Arctic IMPAK.

THE CURRENT MODELING PROCESS

Analysis of lease sales in all areas begins with the Exploration and Development (E&D) Scenarios. The DBMat refers to any model that translates the E&D Scenario into direct effects as a first-step model. Direct effects are defined as those resulting from the first round of spending by companies working directly on an OCS project(s). The first-step model must estimate the level of industry expenditure (or employment) and how that spending/employment is allocated to onshore geographic areas. The MMS calls the spending allocation to industry a "cost function" and these cost functions are used to customize the inputs for IMPLAN.

In Alaska, the current first-step model is the Manpower model. It simply converts OCS activities levels (number of wells drilled, platforms installed, pipeline miles laid, etc.) into estimates of direct employment using ratios such as employees per mile of pipelines laid. It was developed in the late 1970s and then refined in the early 1980s. The main objective of this study is to update this model.

The second-step model is used to estimate the additional impacts that result as the initial spending reverberates throughout the economy. These secondary impacts are often referred to as indirect and induced effects. Such models must be developed specifically for OCS or must be customized to reflect the unique expenditure and commuting patterns of OCS-related companies and their employees. For Alaska, these problems are exacerbated by the fact that national models like IMPLAN often use national multipliers due to inadequate local data.

In Alaska, the second-step model currently being used is the Rural Alaska Model (RAM), developed by the University of Alaska. Like Manpower, RAM is a set of spreadsheets that uses simple multipliers to estimate results. It was originally built in the early 1980's and updated in 1995. Another option for use as a second-step model for Alaska is the Man-in-the-Arctic Program (MAP) model developed by the University of Alaska Anchorage for MMS in the 1980's. This model estimates indirect and induced impacts at the state level, rather than at the regional level.

PURPOSE AND OBJECTIVE

The purpose of this study is to develop a model to replace the Manpower Model for E&D activities that place in the Arctic OCS. Since the early 1980s, there have been significant technological changes in offshore E&D activities. In addition, the production process used in Alaska's arctic regions differs significantly from the process used in the sub-Arctic regions. E&D activities specified in the current model were examined and revised.

As stated above, MMS would prefer to use very similar procedures and the same modeling software in each region to ensure comparability across regions. This would improve the quality of the *equitable sharing analysis*. However, the unique conditions in Alaska may result in questionable results from some of the readily available national models such as IMPLAN.

Therefore, before adopting IMPLAN for use in analyzing Alaskan activities, MMS would like to run some tests and compare IMPLAN results with results generated by RAM.

In developing the new model, the latest available data were used to develop employment and expenditure factors for the revised E&D activities. With these updated factors, projections of direct and indirect employment impacts in the sub-Arctic region will be more accurate. With more accurate projections, stakeholders will have more confidence n the economic sections of an EIS. More accurate projections may also be used in decisions regarding post-lease mitigation.

The new first-step model converts E&D inputs into direct employment and expenditure impacts for the North Slope Borough (NSB), the rest of the state of Alaska, and the rest of the United States. Expenditure impacts are itemized by IMPLAN sector. It is expected that MMS will enter these impacts into IMPLAN to estimate the indirect and induced effects.

This study meets MMS needs to verify IMPLAN-based outputs by developing a first step model that produces consistent inputs for RAM and IMPLAN. This could also include MAP, if MMS deems it affordable and worthwhile.

ORGANIZATION OF THE REPORT

The economic impact of a particular set of oil and gas activities on the North Slope will depend on both the size of the project and the set of technologies chosen. In the first chapter of the report, alternate technologies are first defined and then the most reasonable and likely set of technologies are chosen.

In the second chapter, these choices are then contrasted with the categorization of activities contained in basic MMS projections of economic activity and a set of twenty-three activities chosen for inclusion in the model. The activities are then defined in terms of the support activities required including (hotel/camps, personnel transport, ice roads, helicopter support and barge support.). Finally for the chosen set of twenty-three activities, a basic unit of activity (mile of pipeline, number of barrels, etc.) is chosen.

The third chapter examines alternative modeling processes for determining the economic impact of Beaufort Sea OCS development. The chapter begins with an examination of the modeling issues that arise due to the unique aspects of Beaufort Sea OCS development. Next, the three key economic models are reviewed followed with shorter synopses of a few additional models. The three key models include the Manpower model, the Rural Alaska Model (RAM) and IMPLAN. The basic purpose and functions of the models are reviewed and their strengths and weaknesses are analyzed. The chapter closes with two sections, the first of which discusses the current modeling approach. The second proposes some alternatives and identifies the preferred alternative.

The fourth chapter provides a detailed summary of the engineering and economic information collected for the various activities. Included are general descriptions of the engineering specifics of the activity, the sources of the data, and summaries of manpower requirements, capital needs and fuel and material inputs.

The fifth through ninth chapters provide overviews of the methods used to develop the inputs to the 26 activities. In some sense, this study develops a production function for each activity, where the production function is defined in terms of expenditures for various types of inputs. These inputs can be broadly grouped into the following categories: labor, purchased services, capital and materials with the latter including raw, intermediate and energy material and inputs. Labor inputs are discussed in Chapter Five, purchased services in Chapter Six, capital inputs in Chapter Seven and material inputs in Chapter Eight. The ninth chapter describes how expenditure patterns were developed for several special activities that are treated differently than the other activities in the model. Among these are government activities, the Trans-Alaska Pipeline System (TAPS), and local gas development.

The tenth and final chapter provides an overview of the IMPAK model. Included are sections on model inputs and outputs.

The per-unit cost/manpower vectors developed in chapters five through nine serve as a foundation for the IMPAK modeling software described in chapter ten. In Appendix B, these vectors are itemized by region, activity and major input category.

1 IDENTIFICATION OF ECONOMIC ACTIVITIES

The economic impact of a particular set of oil and gas activities on the North Slope will depend on both the size of the project and the set of technologies chosen. In this chapter alternate technologies are defined and described. In the following chapter, the set of technologies most likely to be used on the North Slope are chosen for further analysis..

The basis for the description and evaluation of the technologies available and likely to be used is based on two major information sources: the Draft Beaufort/Northstar EIS published in June of 1998 and a series of interviews with industry personnel conducted specifically for this study.

1.1 OVERVIEW OF OIL AND GAS ACTIVITIES

The development of offshore oil and gas involves a series of distinct economic activities. These activities are generally categorized into two phases, exploration and development/production with multiple activities occurring under each phase. Specific activities include the following:

Exploration:

- Seismic Surveys - Exploratory seismic surveys collect data used to interpret subsurface geology. These surveys also occur during production.

- Exploration Drilling - Exploration drilling is conducted to confirm the presence of recoverable resources, and to evaluate potential volumes. Several wells are typically required to provide sufficient data to prepare a development/production plan.

Development/Production:

- Development/Production Drilling - This activity typically involves the installation of several oil production wells. In addition, reservoir development may require water or gas injection wells. Operation of production wells involves routine well maintenance procedures, some of which require a workover rig (a type of drill rig).

- Oil and Gas Processing - Processing facilities may be located at the production site if sufficient space is available, or they may be located at a distant site. Sometimes produced fluids are only partially separated into oil, gas, and produced water components prior to transport to offsite processing facilities.

- Transportation of Produced Fluids - Produced fluids may be transported from offshore sites by pipeline, marine tankers, or barges during open water, and pipelines or trucks during winter. Pipelines, railroad, and trucks may be used year-round at onshore locations. Existing offshore production facilities are connected to shore by gravel causeways which protect pipelines. Buried subsea pipelines have never been used in the Alaskan Beaufort Sea, but were tried in the Canadian Arctic. Subsea buried pipelines are planned for the Northstar and Liberty projects.

- Facility Decommissioning and Abandonment - When a production facility reaches its economic limit, wells are plugged and surface structures may be removed. Facilities may be reused in place, transported for use at another location, removed for salvage or disposal, or prepared for abandonment in place.

In addition, construction and operation of these facilities frequently results in the need for development of gravel mines, freshwater sources, roadways (including ice roads), airstrips/heliports and waste collection and disposal systems. Other economic activities related to these activities include personnel transport to and from the region, related activities such as hotels, transportation of equipment and environmental protection schemes, especially those related to oil spill protection and cleanup.

An important part of the technology not discussed in detail in the draft Beaufort/Northstar EIS are ice roads and ice islands. The following description of the technology for these roads was developed from several interviews conducted specifically for this study.

Ice road construction takes about a 40-man crew, a small grader and snow blower equipped with floats (capable of operation on 8 inches of ocean ice), four Rollagon pumpers, three water trucks, two dump trucks, one ice mill, one grader, and nine pickup trucks. The first step is to proceed on about 8 inches of ice with the small grader and snowblower removing the snow from the ice road path. This can normally occur about the last half of December. The snow removal process is ongoing through construction and the ice road service life (about May 1st). Next, the Rollagon pumpers are placed in service. They drill and pump in the same operation. They relay around each other up and down the ice road until the ice is thick enough for larger vehicles. The road is then staked with reflectors to identify the profiled road edges. Fresh water and milled ice chips are used to make ramps from shore to the ice and supplement the salt water drill/pump operation. The ice chips are hauled with dump trucks and the fresh water with water trucks equipped with fan spray nozzles. Any cracks that appear are repaired with fresh water to keep the road from separating and drifting. The construction process continues until the road is thick enough or grounded to handle the loads for which it will be used, including drilling rigs.

The same process is used in ice island construction; however, the entire island must freeze to the bottom and ground. Ice chips and fresh water are used as much as possible to insure the island is stronger than the surrounding sea ice. All equipment must be back on shore by May 1st. Bags of sand are used to protect the island edges from moving sea ice.

A brief description of oil and gas facilities and technologies that may be applicable to development in the Alaskan Beaufort Sea is presented in the following subsection.

1.2 SEISMIC SURVEYS

Seismic surveys are conducted to collect subsurface geologic data. Although primarily associated with exploration, seismic surveys are sometimes conducted in producing fields to provide data used to refine field development plans. In the Arctic, offshore seismic surveys are conducted during open water periods (August to September) or winter time (February to April). Open water surveys are conducted by a survey vessel equipped with an air gun to create a sound wave and a towed array of hydrophores to record these reflected wound waves. Support vessels are often used for logistical support and ice management activities.

During the winter, seismic surveys are conducted from the ice surface. The sound source for these surveys is a large vibrating plate mounted on a wheeled vehicle. Geophones are placed on the ice surface and record reflected sound waves.

An interview for this study was conducted with an individual who was on a drill ship about 200 miles west of Barrow Alaska (10 miles from Russian waters).

This individual was also involved with offshore surveys on ice. Travel on the sea ice is not safe until some time in January until approximately May 1st. A seismic cat train consists of about 115 men, 3 D8 Cats, 9 Bombardiers, 6 Nodwell geo-phone rigs, 1 Foremost CPU data collection rig, 1 966 snowplow and 2 support modules. A survey crew goes out first staking four lines about ten miles long. These are followed by the snowplow leveling the larger drifts followed by six Nodwells with "jug hounds" setting four rows of Geo-phones that are then connected to the Foremost CPU data collection rig. Eight to ten shaker trucks are then positioned along the ten-mile long line. The vibrations are collected to form a map of underground formations.

1.3 OIL AND GAS DRILLING METHODS

Characteristics such as water depth, distance from shore, and reservoir characteristics such as depth, thickness, degree of faulting, permeability and porosity, and areal extent will determine drilling options. There are two drilling methods: 1) conventional vertical drilling in which the well is drilled straight down; and 2) directional drilling in which the well is drilled at an angle.

Production from a vertical well is limited to the portion of the reservoir located beneath the wellhead, and multiple surface locations would be required to develop a reservoir that has a large areal extent. In contrast, directional drilling allows for access to multiple bottom hole locations from a single surface facility. A large number of surface structures are not practical for cost, logistic, safety, and environmental reasons.

Directional drilled wells typically cost approximately two to three times more than a conventional vertical well. Much of the additional cost is associated with the equipment to ensure wells intersect the desired locations. Directional wells also take more time to drill because they are often much longer.

The location of the reservoir and technology limit the range of drilling sites. The range of locations include onshore, on existing offshore islands or a new offshore location.

1.4 OFFSHORE PRODUCTION STRUCTURES

Selection of drilling and production structures is based on the site-specific environment of the offshore reservoir and project economics. In addition, oil recovery and processing methods, options for transportation of product, people and supplies, and relationships between onshore and offshore facilities influence structure location. This section presents a brief description of the components of drilling and production facilities and a comparison of drilling and production structure options.

Components of Production Facilities

Drilling Rig and Associated Equipment: The drilling rig contains power generation units, a drilling mud system (tanks, cuttings removal screens, pumps), a cementing system, and a storage area for drill pipe, drilling mud, cement, and well casing.

Oil/Gas/Water Separator System: One to three multi-phase bulk oil separators are used to decrease the pressure of produced fluids and remove natural gas and water. Separators are located on the offshore structure and/or onshore sites.

Water Treatment and Injection System: Water produced with the oil is routed to a clarification system consisting of a series of vessels that separate oil from water by gravity, electrical, or centrifugal force. Clarified water is pumped to a disposal well or a pipeline.

Gas Dehydration and Compression System: Gas removed from produced reservoir fluids is routed to coolers that use air and/or seawater for cooling, and into vessels that separate the remaining water from the gas. Low pressure gases are compressed by a series of turbine-driven and/or electric-driven compressors. The gas may be injected to the reservoir, used on site as fuel, or transported by pipeline.

Seawater Systems: Seawater is used for fire suppression, for waterflood, to supply potable water, and to cool processing equipment.

Emergency Flare: Flares are tall structures with a small stream of gas feeding a continuous pilot flame. that protects processing systems during startups and shutdowns, and provides emergency gas pressure relief.

Chemical Treatments: Includes tanks and small electric-driven pumps to inject chemicals such as emulsion breakers, corrosion inhibitors, biocides, and anti-foaming agents into producing wells and pipelines.

Electric Power Generation: Electricity is provided by at least one main and one emergency generator.

Fire Suppression: The main components of this system are water storage pump and distribution piping.

Other facilities include offices and a control room, a potable water system, a wastewater treatment system, heating and cooling systems, storage and shop areas, and living quarters. Ship docking facilities and a helicopter landing area are also likely.

Gravel Islands

Because a natural island would function similar to an artificial island, differentiation will not be made here.

Manmade gravel islands are constructed by placing gravel on the seafloor until the mounded gravel is above sea level. After an island is created, slope protection may be used to prevent erosion by waves and moving ice. Historically, the practical limit of water depth for a man-made gravel island appears to be about 50 feet (15.2 m) because of the logistic and economic constraints related to the amount of gravel required to create an island in deeper water. However, in theory, the water depth for gravel islands is not limited. The location of the source material for the island and hauling time/distance greatly influences its cost. Usually at least some of the material would be brought from a site on land because sediments dredged from the seafloor tend to be too soft to support facilities.

Gravel islands typically have side slope ratios of approximately 1:3 (vertical:horizontal), with the island surface 10 to 23 feet (3 to 7 m) above sea level. Some islands were constructed with side slopes as flat as 1:20, resulting in a beach-like slope structure that can withstand the elements without affecting the integrity of the island's working surface. Sandbags, interlocking concrete blocks or mats, or steel walls may be used to help protect island slopes from wave and ice erosion. Gravel islands are inexpensive to repair by replacing or reshaping gravel and slope protection. Construction costs for gravel islands typically range from $10 to $40 million, depending on size of the island and water depth.

Ice Islands

Ice Islands are created by pumping seawater onto the frozen sea ice sheet until the ice is grounded or is thick enough to accommodate the weight of a drilling rig. Ice islands would be used for exploration drilling for only one winter because they melt.

Mobile Bottom-Founded Structures

Mobile, bottom-founded structures are those that rest on the seafloor, but can be floated and towed to different locations. Designs for mobile, bottom-founded structures were developed to conduct offshore exploratory drilling in the Arctic during the 1980s. Several different one-of-a-kind structures of this type were used and remain in Arctic or northern waters.

One of a kind structures such as the Caisson Retained Island (CRI) and the concrete caisson island (Tarsiut), were designed to increase slope protection and decrease gravel fill requirements over a conventional gravel island.

The caisson island designs are limited to 11.5- to 70-ft (3.5 to 21 m) water depth and have demonstrated durability and stability in ice.

The Concrete Island Drilling Structure (CIDS) consists of a steel base that rests on the seafloor and a concrete unit that extends through the surface water/ice zone. CIDS has drilled four exploration wells in the Alaskan Beaufort Sea.

The CIDS was not designed for oil and gas development/production activities; however, the owners have proposed to modify CIDS to accommodate such facilities. Proposed modifications include reconstructing the current drilling equipment layout, adding production equipment, allowing space for 22 wells, and an additional deck for a maximum of 35 wells. The CIDS is limited to 35- to 55-ft (10.7 to 16.8 m) water depths and would require modifications in dry dock costing approximately $70-75 million.

The Mobile Arctic Caisson (Molikpaq) is an eight-sided steel caisson constructed as a continuous ring, creating a hollow center which is filled with sand or gravel and working top deck. The caisson has outer dimensions of approximately 366 ft (112 m) per side at the base and approximately 241 ft (73 m) per side on the working deck. The caisson is divided into 12 ballast compartments filled with sea water.

The Molikpaq began operations in 1984 and has drilled 10 wells in the Canadian Beaufort Sea. The Molikpaq was not designed to support oil and gas development/production activities. However, the owners proposed to modify the Molikpaq to accommodate development/production facilities.

The Molikpaq is limited to 30- to 130-ft (9 to 40 m) water depths and would .require modifications to accommodate a long-term development/production program with modification costs expected to be between $85 and $112 million.

The Single Steel Drilling Caisson (SSDC) is a modified, very large crude carrier (super tanker) that conducts exploratory drilling operations in open water and ice. The SSDC has been previously used to drill exploration wells in the Alaskan Beaufort Sea; however, only one location is in the project area.

The SSDC was not designed for oil and gas development/production activities; however, the owners proposed to modify SSDC to accommodate drilling and production facilities. Proposed modifications include reconstructing the current drilling equipment layout to add production equipment and allow space for 30 to 40 wells. Long-term maintenance requirements are unknown.

The SSDC is limited to 25- to 100-ft (7.6 to 30 m) water depths and .would require modifications to accommodate a long-term development/production program with modification costs estimated to be approximately $113 million.

These bottom-founded structures or others that could be designed and constructed to meet specific project needs are feasible options within the limits discussed for drilling and production structures in the Alaskan Beaufort Sea. The structures have a record of success in withstanding sea ice and other cold weather operating conditions.

Sinkable Island Drill Ship (SIDS)

Interviews for this study discovered an additional bottom founded structure that can be floated from site to site that was not mentioned in the literature. The SIDS is a very large barge equipped with a drilling rig. The ship is loaded with drill stem, casing, drilling mud, and all the other major supplies necessary to drill several wells. It is then towed to a drilling site that has been prepared by a barge with a large crane on it to assure the bottom does not have any large rocks and is fairly level. The SIDS is then positioned over the drill site and sunk to the bottom in 30 to 50 feet of water. "Flex-a-barges" deliver day to day supplies. These barges are constructed with individual sections that can be added or subtracted to change the barge sizes to meet the needs of the day. Power drive sections can also be added or subtracted. The barges have a three to 4-man crew and can be used from mid July to the first part of October. Ice road support can begin in January and continues until May. Only helicopter support can be used from October to January and May to mid-July. The interviewee also has crew boats, fuel barges, and camp barges that can be used for exploration and drilling island support.

Subsea and Subterranean Structures

In areas where ice movements or gouging of the seafloor would endanger an exposed structure, facilities could be placed deep enough below the seafloor to prevent damage. Construction of such facilities would be expensive, and would generally require a large reservoir or special site conditions to justify this expense.

A subsea cavern is similar in design to an underground mine. A cavern would likely have an access tunnel from land which would also be used for removal of excavated material and for transport of produced oil and gas to shore.

Subsea silos, similar in concept to underground missile silos, have been considered to develop the Kuvlum reservoir in the Alaskan Beaufort Sea. The conceptual design includes produced oil and gas reaching shore through a trenched pipeline. Plans for this development or other silos in the Alaskan Beaufort Sea are not anticipated in the near future.

Subsea Templates

Seafloor templates, which rest on the surface of the seafloor, are used in many offshore regions as a drilling guide and to house wellheads. Drilling equipment is positioned over a template and wells are drilled and brought into production using pipelines. A seafloor template with multiple wells is more economical than single well templates, but also increases the size of the structure that rests on the seafloor. The largest operating multi-well seafloor template is in the Gulf of Mexico.

Seafloor templates could be used in water depths greater than 200 feet (61 m) in the Alaskan Beaufort Sea, where ice grounding or gouging do not occur. At these depths, a floating vessel would be used to drill the wells. It may take a full 2- to 3-month summer season to drill a single well.

Floating Drilling Structures (Seasonal Use Structures)

Floating drilling structures have limited usefulness in the Arctic unless conventional designs are modified for ice protection. Even with modifications, a floating structure is not considered suitable for year-round development/production activities because it could be moved and/or damaged by ice. Seasonal drilling and workover activities in combination with a seafloor template or subsea silo enclosed template are potential production-related uses of floating drilling structures. Ice islands could be used to extend the potential workover schedule.

Jackup Drilling Platforms are towed and positioned over a specific drilling location. Three legs are lowered to the sea floor. Jackup platforms have been used to support exploratory drilling activities in waters less than 100 feet (30 m) deep.

Semi-Submersible Drilling Vessels are self-powered or towed steel-hulled platforms that are positioned over a specific drilling location. Semi-submersibles can operate in waters between 100 and 1,000 feet (30 and 305 m) deep.

Drillships are self-powered, steel-hulled platforms that are positioned over a specific drilling location. Drillships have operated in the Beaufort Sea since 1976. Drillships can operate in waters between 100 and 1,000 ft (30 and 305 m) deep.

The Conical Drilling Unit (Kulluk) is a one of a kind floating exploration drilling vessel designed for extended season arctic operations in light to moderate ice conditions. It is towed to and positioned over a drilling location. The double-walled, inward-sloping hull is in the form of an inverted cone that flares at the bottom causing ice to break downward and away from the hull. The Kulluk has drilled one exploration well in the Alaskan Beaufort Sea and is considered practical in up to 328 ft (100 m) water depths.

1.5 OIL AND GAS RECOVERY

Varieties of technologies, ranging from those relatively unchanged for more than a century to modern state-of-the-art technologies, are used for oil and gas recovery. These technologies are usually referred to as primary, secondary, or enhanced (tertiary) recovery.

Primary Recovery

Primary recovery (or "natural blowdown") uses only the reservoir's natural pressure to force crude oil from the underground reservoir. As the reservoir is depleted, pressure drops, resulting in a decline in recovery rates. Natural blowdown was used with the earliest oil wells and results in an average recovery of only 5 percent to 20 percent. Some developments employ natural blowdown early, and then add a secondary recovery method.

Natural blowdown is a reasonable option for a fairly large reservoir, or one that would have difficulties in implementing pressure enhancement. A deep water site could be developed with sea floor templates and natural blowdown using minimal investment.

Secondary Recovery

Secondary recovery options are designed to improve oil recovery from the reservoir. This is accomplished by boosting or maintaining reservoir pressure or by lifting fluids in individual wells. Secondary recovery options include injecting gas or water into the reservoir to maintain reservoir pressure as oil, gas, and water are produced. These secondary recovery methods include gas lift, reservoir maintenance with gas (gas cycling), reservoir maintenance with water injection, and waterflood.

Availability of water or gas from another source is a factor in choosing an appropriate secondary oil recovery technology. A combination of recovery methods may be used, depending upon reservoir characteristics.

<u>Gas lift</u> involves injecting natural gas at high pressure to introduce small bubbles into the oil/water column in the well. The gas bubbles lighten well fluids, allowing them to rise. Gas lift is effective particularly if the reservoir contains heavy, thick oil or if it has high water content. Gas lift requires a gas supply, either from the producing reservoir or an external gas source. The amount of gas needed is small relative to gas cycling and usually can be supplied by the producing reservoir.

<u>Gas cycling</u> involves reinjecting natural gas through dedicated injection wells into a reservoir's overlying gas layer (the reservoir's gas cap) or into the oil producing zone. The reinjected gas preserves or enhances reservoir pressure. Because gas cycling requires 1 to 1.5 times the amount of gas normally produced daily, an external, supplemental natural gas source may be necessary. Typical reserve recovery rates range from 45 percent to 65 percent.

Water Injection is use where oil/gas reservoirs have aquifers beneath the oil reservoir and water injected into the underlying aquifer causes upward pressure on the oil layer. Some of the water injected may be produced water separated from reservoir fluids. One to two times the amount of fluid produced from the reservoir is required. Water from another source, such as seawater, can be treated and injected. Water is injected at pressures above existing reservoir pressure through dedicated water injection wells. Typical water injection recovery rates are 35 percent to 45 percent of reserves.

Waterflooding involves injecting treated produced water or seawater directly into the oil reservoir through dedicated injection wells. Water is injected in a specific pattern, to flush oil toward oil production wells. Typical reserve recovery rates range from 40 percent to 50 percent of reserves.

Enhanced (Tertiary) Recovery

These options can be employed once secondary recovery options are no longer effective. Enhanced methods include chemical flooding, miscible flooding, and thermal techniques. Chemical flooding methods (e.g., polymer, surfactant, and alkaline flooding) improve oil flow by the addition of chemicals. Miscible flooding uses carbon dioxide, nitrogen, or hydrocarbons as a solvent. Thermal processes add heat to improve oil flow. Enhanced recovery is not considered until recovery declines dramatically. Only miscible flooding with hydrocarbons has been used on the North Slope.

1.6 OIL AND GAS PROCESSING

Produced reservoir fluids are processed by separating crude oil, water, and gas. The processing facilities for an offshore reservoir may be located offshore, onshore, or with parts in both locations. Processing requirements depend upon reservoir characteristics, production rates, and secondary recovery methods. These requirements also differ depending upon a reservoir's distance to shore and proximity to existing facilities. Considerations for determining an appropriate processing option include distance to existing processing facilities, method for transporting product, and size of production structure required for processing facilities.

Fluids produced at the wellhead are called "three-phase fluids." Partial processing removes much of the gas and some of the water from the oil. Pipelines can be used to transport unprocessed, partially-processed, or fully-processed crude oil. Pipelines carrying three-phase fluids are not technically feasible for distances greater than 12 miles (19.3 km) because inconsistent mixtures make pumping difficult. Tankers and barges are unable to transport three-phase fluids because they are not pressurized. Fully processing the crude oil fluids produces both uniform crude oil that then can be transported by a variety of vessel types and a uniform gas product that can be reused on site for secondary recovery or transported by pipeline.

Because of the cost of processing equipment, a small reservoir may not support a processing facility; however, in combination with others, it may be economical. Offshore reservoirs within the range of a three-phase pipeline could be developed by connecting to existing processing facilities. If excess capacity is not available, the distance is too long, or transport of mixed-phase fluids is to be avoided, processing can be done at a new offshore site.

Site-specific concerns influence selection of a processing site, but the more likely factors are reservoir economics and product transportation. In water depths less than 100 ft (33 m) where a stable structure can be placed and protected from ice, full processing is expected to be proposed because it avoids three-phase transportation problems. In deeper water, other alternatives may be considered. Since none have been seriously considered however, it is difficult to predict what technology may be proposed.

1.7 TRANSPORTATION OF PRODUCT

Transportation of oil and gas products to world markets could be accomplished by a variety of methods such as vessels, pipelines, railroad, or trucks. It is expected that the existing TAPS pipeline and Dalton Highway would be used onshore rather than developing duplicate facilities. For offshore there are no existing pipelines, ports, fuel storage, or shipping facilities. Thus new systems would be required. Some reservoirs may be located in areas which prohibit use of the TAPS or the Dalton Highway so new onshore systems may also be proposed. Listed below are transportation options and a summary of their limitations.

Offshore:

- Tankers to market - product must be processed to crude, ice breaker support required, seasonal shipping.
- Barges to coastline - same as tankers plus shoreline transfer and onshore facilities required.
- Pipeline to shoreline - three-phase, gas, or crude oil transport possible; new pipeline required; year-round operation.

Onshore transportation:

- Railroad - product must be processed, new railroad system required, year-round operation.
- Trucks - product must be processed, year-round on existing roads.
- Pipeline - three-phase, gas or crude oil transport possible; use of new or existing pipelines including existing common carrier pipelines and the TAPS; year-round operation.

Railroad and truck is unlikely to occur because of the perceived need to find additional oil to keep TAPS in operation as Prudhoe Bay production declines. Rail and truck transportation also have higher spill risk than pipelines because of increased transfers. For these reasons, use of either railroad or truck transport of crude oil from the North Slope is considered unlikely. Use of tankers, barges, and pipelines are discussed below.

Tankers

If an offshore production facility has full processing, tankers could carry the oil directly to world markets. Such a system would require a mooring and loading system and large capacity storage to hold products between callings. Small and super tankers require a minimum of 60 ft (18.3 m) and 120 feet (36.6 m) of water depth, respectively. Therefore, a channel must be dredged in shallower waters. Alternatively, a pipeline to a tanker loading site in deeper water could be constructed. Ice management would be required for much of the year. The use of tankers was attempted in 1969, however, it was determined that tankering could not compete economically with an onshore pipeline system. Offshore reservoir development may reopen the question of tankering.

Barges

Barges could be used for transport of crude oil between an offshore site and the shoreline. A dock, such as existing facilities at Oliktok Point, West Dock, East Dock, and Badami may be used to reach the required water depth. Occasional or frequent dredging may be required. Barges usually can operate between late July and mid- September; however, ice breaker support would be required to extend the shipping season. Barge transport would also require construction of a loading/unloading facility connected by pipeline to the TAPS. Barges also present an increased risk for oil spills to occur during barge loading/unloading activities.

Barging crude oil to the shoreline for transport through the TAPS may be feasible. When a pipeline cannot be constructed, barging may be the only remaining option; however, this is likely to result in only seasonal production from the offshore site.

Pipelines

Pipelines could transport three-phase fluids or crude oil to the coastline and on to existing oil and gas facilities or to the TAPS. Pipeline installation may occur on gravel-filled causeways, elevated pile-supported structures, the seafloor, or buried or drilled beneath the seafloor. A combination of these methods may be used.

Once pipelines reach the coastline, onshore pipelines constructed on elevated vertical support members (VSMs) or other types of pipelines would depending on the landfall site, join existing routes, tie-in to a common carrier pipeline, or be the first pipeline in the area.

Onshore Pipelines Corridor: Onshore pipelines installed on elevated VSMs are currently the conventional method on the North Slope. Selection of an onshore pipeline route would consider environmental issues, project cost, and access to the pipeline. These factors may include maximizing use of existing disturbed area such as pipeline corridors, avoiding high value fish and wildlife habitat, minimizing length and expense, and avoiding conflicting land uses.

Gravel-filled Causeways: Causeways are manmade structures that connect offshore facilities to the mainland. They are constructed by placing gravel onto the seafloor. Pipelines are installed on top of or within the causeway. The causeway protects the pipeline from waves and ice, and provides access for maintenance. Gravel-filled causeways can be continuous or broken by openings that allow small vessels, water, and organisms to pass. The breaches are bridged for vehicle travel and pipeline support.

Causeway construction is most practical when the offshore facility is located in shallow water and close to shore. Existing causeways are 3 to 5 miles (5 to 8 km) in length and extend to water depths of 12 to 14 ft (3.4 to 4.3 m). Impacts of causeways on coastal circulation and fish movements preclude their use along some portions of the coastline.

Elevated Pile-Supported Structures: A pile-supported pipeline would extend above sea level allowing water and fish to pass unimpeded; but possibly presenting an impediment to navigation. Due to winds, wave action, and ice forces, it is most suited for facilities close to the shore. Even in the bottomfast ice zone, the pipeline would be at risk from moving ice during breakup and freeze-up. Due to costs and the limited distance they could be used offshore, this option is not considered reasonable.

Installed on the Seafloor: A pipeline from an offshore facility may be laid directly on to the seafloor in many regions. In Alaska, however, ice would likely rupture or damage pipelines out to depths of about 200 feet (61 m). In deeper water pipelines could be laid on the seafloor.

Buried Beneath the Seafloor: The only arctic subsea buried pipeline was constructed in the Canadian Beaufort Sea in 1978. The pipeline was tested by allowing a limited quantity of gas to flow from a well that was never placed into operational service. It was intended to become part of a larger transportation scheme, but these facilities were never built. Since the pipeline was not placed into service, there was no program of monitoring or maintenance. The pipeline was officially abandoned in 1996, 18 years after it was constructed. As part of abandonment, a limited survey was undertaken which showed no apparent damage.

Pipelines buried beneath the seafloor could avoid damaging effects from ice. Methods for installing pipelines beneath the seafloor by trenching include:

- Plowing - a device similar to a farmer's plow is pulled along the seafloor.

- Jet sledding - high pressure water jets are towed along the seafloor.

- Conventional backhoe trenching - conventional backhoe equipment can be used from the sea ice surface.

Selection of a pipeline buried trench excavation method in the Alaskan Beaufort Sea would depend upon water depth, time of year, length of pipeline, seafloor sediments, equipment availability, and pipeline depth.

Another option would be to directionally drill and then pull pipe through the tunnel created. Directionally drilled pipelines have been installed beneath large rivers and barrier islands. A small diameter pilot hole is drilled, and a reamer attached and pulled back through the hole to increase the diameter.

Offshore Buried Pipelines, Landfall Location Alternatives: The point where an offshore buried pipeline intersects the coastline is called a pipeline landfall location. Pipeline landfall locations may require onshore gravel pads to accommodate pipeline valves and leak detection equipment. Equipment at these landfall locations would also require vehicular access, or a helipad.

Offshore Buried Pipelines, Corridor Alignments: The determination of offshore pipeline alignments connecting an offshore oil and gas development/production facility with a pipeline landfall location may consider environmental issues, construction cost, construction feasibility, and obvious hazards.

1.8 FACILITY ABANDONMENT OR REUSE

When production ceases, facilities would be abandoned in accordance with terms of individual leases. Abandonment could range from complete removal to a shut down mode with most facilities left intact for future use. Requirement are decided when the field is abandoned because of the unknown future uses. Possible uses of an island structure include other oil and gas projects, a deepwater port facility, scientific research projects, or a shelter for travelers. A mobile production structure could be relocated for use at another reservoir. Pipelines are likely to be reused only if production continues, or to supply fuel for activities or housing. Housing facilities on an island may be of interest to local government, businesses, or individuals.

If no uses for facilities can be identified, structures may be removed. Removal involves similar activities to construction. Mobile production structures are easiest to remove, with islands and pipelines the most difficult. Some facilities, (e.g., pipelines) could be abandoned in place.

2 SELECTION OF ECONOMIC ACTIVITIES

In this chapter the most reasonable and likely set of technologies to be used in the Beaufort Sea OCS are chosen. First, the available technologies are contrasted with the categorization of activities contained in basic MMS projections of economic activity (numbers of wells drilled, pipeline laid, etc.). Next, the most likely activities are selected. These primary activities are then defined in terms of the secondary support activities required, including personnel transport, lodging, helicopter support, etc. Finally, a basic unit is chosen for selected activities (miles of pipeline, number of barrels, etc.).

2.1 EXPLORATION AND DEVELOPMENT (E&D) SCENARIOS

MMS analysis of lease sales in all areas begins with the exploration and development (E&D) scenarios. The first step economic model to be constructed in this study must be able to convert E&D inputs into the direct economic effects of the oil and gas development activities. These direct impacts then become inputs to the second step model, which calculates indirect and induced impacts. Therefore, it is crucial that the activities that are chosen to be modeled, and the measurement units that those activities are defined in terms of (i.e. miles of pipeline), are consistent with the information provided in the E&D scenarios. This section focuses on the consistency of potential activities with the E&D reports.

Exhibit 2-1 provides a reprint of a sample E&D report Lease Sale 195. As was the case for much of the preceding discussion of oil and gas production technology, the E&D scenarios are divided into three major phases (with each presented in the table on a separate page) including exploration, development/production and transportation.

EXHIBIT 2-1: SAMPLE E&D REPORT: REPRESENTATIVE DEVELOPMENT SCHEDULE FOR SALE 195

Year	Exploration Wells	Delineation Wells	Exploration Drilling Rigs	Production Platforms	Production Wells	Injection Wells	Production Drilling Rigs	Offshore Pipelines (miles)	Oil Production (MMbbl)	Oil Production (MMbbl)	Combined Oil Production (MMbbl)
2003											
2004											
2005											
2006											
2007	1		1								
2008	1		1								
2009		2	1								
2010	1		1								
2011											
2012	2		2	1	3	3	1	10			
2013	1	2	2		10	4	1		7.9		7.9
2014		2	1		10	4	1		15.7		15.7
2015									15.7		15.7
2016				1	3	3	1	30	15.7		15.7
2017				1	13	7	2		13.0	21.5	34.5
2018					20	8	2		10.7	28.6	39.4
2019					10	4	1		8.8	28.6	37.5
2020									7.3	28.6	35.9
2021									6.0	28.6	34.7
2022									5.0	28.6	33.6
2023									4.1	25.2	29.3
2024									3.4	22.2	25.6
2025									2.8	19.5	22.3
2026									2.3	17.2	19.5
2027									1.9	15.1	17.0
2028										13.3	13.3
2029										11.7	11.7
2030										10.3	10.3
2031										9.1	9.1
2032										8.0	8.0
2033										7.0	7.0
2034										6.2	6.2
2035										5.4	5.4
2036										4.8	4.8
2037											
	6	6		3	69	33		40	120	340	460

Exhibit 2-2 summaries the activities and units provided in a sample of E&D reports that were reviewed. Note that the activities listed in the E&D report begin after seismic surveys and end before abandonment. The E&D reports also does not address the effort expended on recovery activities or processing including whether the processing will take place onshore, offshore or both. They do cover the major primary activities such as wells drilled, platforms installed, lengths of pipelines constructed and oil produced. They generally also contain measures of some secondary or support activities such as helicopter flights, supply boat trips, tons of discharges, and area surveyed.

EXHIBIT 2-2: ACTIVITIES AND UNITS PROVIDED IN MMS E&D REPORTS		
Phase	**Activity**	**Unit**
Exploration	Exploration Well Drilling	Number
	Delineation Well Drilling	Number
	Drilling Discharges – Muds	Short Tons
	Drilling Discharges – Cuttings	Short Tons
	Helicopter Flights	Number
	Supply Boat Trips	Number
	Shallow-Hazards Site Surveys	Square km
Development/Production	Platform Installation	Number
	Production and Service Well Drilling	Number
	Total Production	MMbbl
	Peak Yearly Production	MMbbl
	Monthly Helicopter Flights	Number
	Monthly Supply Boat Trips	Number
	Drilling Discharges – Muds	Short Tons
	Drilling Discharges – Cuttings	Short Tons
	Shallow-Hazards Site Surveys	Square km
Transportation	Offshore Oil Pipeline Installation	Km
	Onshore Oil Pipeline Installation	Km

The E&D reports also make some assumptions as to technology. For example, under product transportation only pipelines are mentioned. Under exploration, no structures are mentioned. Under production, platforms are referred to, but since traditional platforms cannot be used in the Beaufort Sea, this term is probably used in a generic sense.

2.2 SELECTION OF MOST LIKELY TECHNOLOGIES

The discussions in the previous sections clearly indicate that there are a large number of potential technological alternatives for oil and gas activities. For example, approximately fifteen potential drilling structures were identified. Given the complexity of modeling the technologies, it is crucial to select the most likely technologies and to concentrate on modeling the production functions and the economic impacts of those technologies.

Exhibit 2-3 provides a listing of the technical options for oil and gas activities in the Alaskan Beaufort Sea. This exhibit was developed by combining a variety of tables and materials from the Draft Beaufort Sea/Northstar EIS, supplemented by interviews conducted for this study. For each major activity, the table defines the alternate technologies, their characteristics, and the reasons they were considered or eliminated. The technologies that were chosen for use in this study are highlighted in underlined print.

The following is a summary listing of the chosen technologies:

- Drilling Method: Directional
- Seismic Surveys: From Ice
- Winter Exploration Structures: Ice Islands
- Summer Exploration Structures: Mobil Exploration Gravity Platforms
- Deep Water Exploration Structures: Exploration Drill Ships
- Shallow Water Development Production Structures: Manmade Gravel Islands
- Medium-Depth Water Development Production Structures: Bottom-Founded Platforms
- Deep Water Development Production Structures: Sub-sea Development Wells
- Oil and Gas Recovery: Gas Cycling
- Oil Processing: Full Offshore Processing
- Product Transportation: Pipelines
- Abandonment: In Place

Originally only a single technology was chosen for each category of activity. However, MMS requested enhancements to the model to allow more flexibility and to allow for analysis of activities in deeper water that are forecasted to take place in the future. Ice islands represent the most favored technology at present but other options include mobile exploration gravity platforms (SIDS, CIDS, SSDC, caisson, etc.), and drill ships were considered economical and environmentally friendly options. Currently, ice islands are the favored technology, but as exploration moves to deeper water, the use of alternate technologies will become more likely.

EXHIBIT 2-3: TECHNICAL OPTIONS FOR OIL AND GAS ACTIVITIES IN THE ARCTIC OCS

Phase	Activities	Reason For Consideration or Elimination
Drilling Methods	· Directional Drilling Technology	· ***Can access multiple bottom hole locations for single surface location.***
	· ***Vertical Drilling Technology***	· ***Only accesses reservoir directly beneath drilling location.*** · ***Multiple drilling locations increases costs and environmental impacts.***
Seismic Surveys	· ***From Boat***	· ***Summer Only***
	· From Ice	· ***Winter Only*** · ***Lower environmental impact***
Drilling Structures	· ***Onshore Drilling***	· ***To far from reservoir.***
	· ***Barrier Islands***	· ***Environmental value is too high.***
	· ***Bottom-founded Structures*** - Caisson Retained Island(CRI) Designs and Tarsiut Island (Concrete CRI)	· ***Relocation difficult as caissons ballasted with sand.*** · ***Redesign and construction of a new caisson structure would be very expensive.*** · ***Owners proposed to modify to accommodate production facilities (22-35 wells).***
	- Concrete Island Drilling Structure (CIDS)	· ***Designed for arctic in water depths of 35 to 55 ft (10.6 to 16.8 m).*** · ***Demonstrated long-term durability.*** · ***High cost to convert to production facility.***
	- Mobile Arctic Caisson (Molikpaq)	· ***Owners proposed to modify to accommodate production facilities (40 wells).*** · ***Designed for arctic in water depths of 30 to 130 ft (9 to 39.6 m).*** · ***Demonstrated durability.*** · ***High cost to convert to production facility.***
	- Single Steel Drilling Caisson (SSDC)	· ***Owners proposed to modify to accommodate production facilities (30-40 wells).*** · ***Can operate in arctic in water depths of 25 to 100 ft (7.6 to 30 m).*** · ***Demonstrated durability.*** · ***High cost to convert to production facility.***
	- ***Manmade Gravel Islands***	· ***Proven technology, 17 constructed. in Beaufort Sea.*** · ***Useful to approximately 50 ft (15.2 m) water depth.*** · ***Can withstand high lateral load ice forces.*** · ***Less expensive to design, construct, and maintain than other structures.***
	- ***Seafloor Templates***	· ***Usable in water depths over 200 ft (61 m) where ice gouging does not occur.*** · ***Water depth too shallow.***
	- Subsea Silos	· ***Unproven in Beaufort Sea but conceptual design addresses potential hazards.*** · ***Caisson-protected subsea templates have been used in arctic*** · ***High cost.***
	· ***Floating Structures*** - Jackup Drilling Platforms	· ***Not designed to operate in ice or support production.*** · ***Could support summer exploration.***
	- Semi-Submersible Drilling Vessels	· ***Not designed to operate in ice or support production.*** · ***Could support summer exploration.***
	- Conventional Drillships	· ***Not designed to operate in ice or support production.*** · ***Could support summer exploration.***
	- Conical Drilling Unit (Kulluk)	· ***Not designed to operate in ice or support production.***
	- ***Ice Islands***	· ***Melt in summer but low environmental impact and cost.***

EXHIBIT 2-3: TECHNICAL OPTIONS FOR OIL AND GAS ACTIVITIES IN THE ARCTIC OCS

Phase	Activities	Reason For Consideration or Elimination
		· ***Supports winter exploration.***
	· ***Subsea Cavern***	· ***Unproven concept not yet demonstrated as technically or economically feasible.***
	· *Sinkable Island Drill Ship (SIDS)*	· ***Demonstrated technology.*** · ***Useful to approximately 50 ft.*** · ***Demonstrated durability although suffers occasional ice damage*** · ***Can be used year round.*** · ***Extremely low environmental impact and cost*** · ***Relatively easy to relocate***
Oil and Gas Recovery	· ***Natural Blowdown (Primary Recovery)***	· ***Recovery rates of 5% to 20% are not economic.*** · ***Usable on large reservoirs with difficulties implementing pressure enhancement.***
	· ***Secondary Recovery*** - Gas Lift	· ***Effective if the reservoir contains heavy, thick oil or has high water content.*** · ***Not appropriate because of composition of Northstar reservoir.*** · ***Gas supply available in the Alaskan Beaufort Sea.*** · ***Can be integrated with other recovery methods.***
	- ***Gas Cycling***	· ***Highest recovery rates of 45% to 65%.*** · ***Can be integrated with other recovery methods.*** · ***Useful for light oils that flow easily.***
	- Water Injection	· ***Recovery rates of 35% to 45% are not economical.*** · ***Can be integrated with other recovery methods.***
	- Waterflood	· ***Recovery rates of 40% to 50%. (50% to 60%)*** · ***Can be integrated with other recovery methods*** · ***Best backup method.***
	· ***Enhanced (Tertiary) Recovery***	· ***Not considered because options are unknown.***
Oil Processing	· *Full Offshore Processing*	· ***Secondary oil recovery techniques can be incorporated.*** · ***Transport sales quality oil directly from production facility.*** · ***Lowest environmental impact.***
	· ***Partial Offshore and Onshore Processing***	· ***Difficult transportation of three-phase fluids by pipeline.*** · ***Multiple locations increases environmental impact.***
	· ***Full Onshore Processing***	· ***Offshore production structures can be smaller.*** · ***Difficult transportation of three-phase fluids by pipeline.*** · ***Environmental impacts too high onshore.***
Product Transportation	· ***Tankers and Barges***	· ***Greater spill risk.*** · ***High cost for facilities and dredging.***
	· ***Pipeline on a Gravel Causeway***	· ***Provides protection of pipeline and access for maintenance.*** · ***Negative environmental impacts*** · ***High cost for bridges.***
	· *Pipeline Buried Beneath Seafloor*	· ***Avoids damaging effects from ice.*** · ***Safest option with lowest impact***
	· ***Pipeline Installed on Seafloor***	· ***Risk of damage or rupture from ice.*** · ***Can be used only in water depths over 200 ft (61 m).***
	· ***Elevated Pile-supported Structure***	· ***Would be exposed to winds, wave action, and ice forces.*** · ***Structure could impede passage of vessels/barges.***

EXHIBIT 2-3: TECHNICAL OPTIONS FOR OIL AND GAS ACTIVITIES IN THE ARCTIC OCS

Phase	Activities	Reason For Consideration or Elimination
Spoil Disposal	· ***Onshore***	· ***Saline material kills terrestrial vegetation.***
	· ***Shallow water***	· ***Sediments block water circulation and navigation.***
	· *Outside Barrier Islands*	· ***Achieves good dispersion of waste material.*** · ***Does not impede water circulation or navigation.***
Abandonment	· *In Place*	· ***Preserves key facilities for reuse and shelfer.***
	· ***Removal***	· ***Returns environment closer to original state.***

Notes: ft = Foot or Feet
Km = Kilometer(s)
m = Meter(s)
% = Percent
TAPS = Trans Alaska Pipeline System

Construction of alternate data for seismic surveys on ice and by boat were also considered, but given the relatively small size of this activity it was not deemed worth while to do so as the economic differences are not significant. However, it is recognized that both methods of seismic surveys are likely. Gravel islands, full offshore processing and pipeline transport were clearly superior both technologically and environmentally when compared to other current options. However, as production moves to deeper waters the slope requirements and the resulting size of the islands gravel islands will make them prohibitively expensive. As a result, bottom founded platforms might be expected to replace gravel islands once water depths reach over 15 meters and sub-sea wells would replace bottom founded platforms once water depths reach over 35 meters.

2.3 SELECTION OF ECONOMIC ACTIVITIES FOR MODELING

Many of the economic activities associated with oil and gas production share common elements such as well drilling, seismic surveys, ice road construction, spoils disposal, headquarters support, etc. Since the labor, material and equipment inputs to these secondary or support activities are similar across the more primary activities, it is advantageous to separate these components from the primary activities.

Exhibit 2-4 provides a listing of what were considered primary activities. Twenty-one activities are listed in roughly chronological order. Note that the construction and operation of facilities are separated, as operation often continues several years. The primary activities include:

- Seismic Surveys on Ice
- Construction of an Ice Exploration Island
- Movement of a Drill Ship or Bottom Founded Platform

- Operation of an Exploration Drill Ship in Calm Waters
- Operation of an Exploration Drill Ship in Rough Waters
- Operation of a Mobil Exploration Gravity Platform
- Drill Exploration Well
- Construction of a Gravel Production Island - Place Gravel
- Construction of a Gravel Production Island - Install Erosion Protection Systems
- Installation of Processing, Recovery and Other Production Island Equipment
- Drill Production Well
- Production and Operation Including Processing, Recovery and Pumping
- Construction of a Small Gas Only Production Facility
- Operation of a Small Gas Only Production Facility
- Construction of Offshore Pipelines
- Construction of Onshore Pipelines
- Construction of Sea Floor Pipelines
- Perform Well Workover
- Landbase Operations
- Spill Contingency
- Abandonment

Also included in Exhibit 2-4 is a listing of the secondary or support activities. Five of these activities have been identified including:

- North Slope Support
- General Personnel Transport
- Ice Roads
- Helicopter support
- Barge support

It is important to rigorously define each activity to insure that there is no double counting. It is also important to ascertain whether the secondary activity varies depending on the primary activity it is associated with. For example, there are differences between ice roads used during construction and the ice roads used during the normal operating phase. This is because ice roads during construction need to handle a bigger load and therefore need to be thicker.

The primary and secondary activities are structured so that if a unit of primary activity is stimulated, a predetermined amount of the required secondary activities are stimulated. For example, if a production island is in operation, a certain amount of helicopter support flights will occur. The number of helicopter flights will vary based on certain aspects of the scenario, such as the distance of the project from shore and the number of islands in operation.

EXHIBIT 2-4: PRIMARY AND SECONDARY ACTIVITIES - DRIVERS AND DEFAULT FACTORS

Primary Activities	**Units**	**Secondary Activities** **2. North Slope Support**	**3. General Personnel Transport**	**4. Ice Roads**	**10. Helicopter Support**	**11. Barge Support**
		Per 300 Person Camp Per Year	Per Day	Per 10 Miles	Per Day	Per Day
1. Survey on Ice	Per Month				X	
5. Ice Exploration Island	Per Island	X	X	X	X	
6. Move Drill Ship/Platform	Per Day				X	
7. Operate Drill Ship in Calm Waters	Per Day				X	X
8. Operate Drill Ship in Rough Waters	Per Day				X	X
9. Operate Mobile Exploration Platform	Per Day			X	X	X
12. Exploration Wells	Per Well	X	X		X	
13. Production Wells	Per Well	X	X		X	
14. Well Workover	Per Workover		XX		X	
15. Place Gravel Island	Per Cubic Yard	X	X	X		
16. Gravel Island Protection	Per Island	X	X	X		X
17. Equip Production Island	Per Island	X	X	X	X	X
18. Operate Production Island	Per Year		XX	X	X	X
19. Construct Gas Production Facility	Per Facility	X	X			
20. Operate Gas Production Facility	Per Year	X	X			
21. Construct Offshore Pipeline	Per Ten Miles	X	X	X		
22. Construct Onshore Pipeline	Per Ten Miles	X	X	X		
22. Lay Sea Floor Pipeline	Per Ten Miles	X	X		X	X
24. Landbase Operations	Per Year	X	XX			
25. Spill Contingency	Per Year	X	X			
26. Abandonment in Place	Per Island	X	X		X	X

2.4 UNITS

In order to model the impacts of a particular oil and gas development it is necessary to have estimates of the size of the development. These estimates, such as the E&D scenarios provided in Exhibit 2-1, define the development in terms of number of wells, miles or kilometers of pipelines, etc. Exhibit 2-4 also provides units for the majority of the activities. These units were designed to be as compatible as possible with the E&D scenarios. At the same time they need to match with the engineering and cost data that are available. A glance at the data provided in Appendix A of the Draft Beaufort Sea/Northstar EIS clearly indicates that all units are in inches, feet and miles. Therefore, all estimates are in customary U.S. measures.

2.5 GEOGRAPHIC AREAS

The original purpose of the IMPAK research was is to model the economic impact of Beaufort Sea OCS development. The original study focused on existing proven technologies used in that area. The analysis was later extended to the sub-arctic in a parallel but separate study. Also included was the development of a simplified model based on both studies that could be used to model the costs of local gas production and processing. In this version of the Artic IMPAK model, additional technologies were added that allow the modeling of the impacts of oil and gas developments that might occur in the future using emerging technologies in deep sea areas. One such area for which no specific model was built, but in which MMS is interested, is the Chukchi Sea/Hope Basin.

MMS had originally requested that the study provide a rough rule of thumb to the effect that costs in that part of the Arctic OCS would require a certain percentage adjustment for all manpower and costs. According to engineering study staff, their best estimate is that a factor of two over traditional Beaufort Sea OCS development technologies could be used to estimate costs. However, the deep water technologies that have been added in the latest iteration of the model allow for a more accurate approach. Drilling in these areas would be conducted using a drill ship in rough seas (Activity 8). Note that the necessary supporting activities are all mileage-based including moving the drill ship (Activity 6), helicopter support (Activity 10), barge support (Activity 11), and sea floor pipelines (Activity 23). Most of the other activities do not require mileage adjustments and their cost do not vary by location including geological survey (Activity 1), well drilling and workovers (Activities 12 through 14), island operations (Activity 18), and abandonment (Activity 26). The only potential problem is if a new landbase is constructed. This is because the model assumes that existing facilities in Barrow will be used. Several activities include only operating costs including north slope support (Activity 2), land base operations (Activity 24) and spill contingency (Activity 25). However, in most circumstances, engineering study staff believes that the use of Barrow as the landbase is the most likely scenario.

3 MODELS AND MODELING APPROACHES

The purpose of this chapter is to examine alternative modeling processes for determining the economic impact of Beaufort Sea OCS development. The chapter begins with an examination of the modeling issues that arise due to the unique aspects of Beaufort Sea OCS development. Next, the three key economic models are reviewed followed with shorter synopses of a few additional models. The three key models include the Manpower model, the Rural Alaska Model (RAM) and IMPLAN. The basic purpose and functions of the models are reviewed and their strengths and weaknesses are analyzed. The chapter closes with two sections, the first of which discusses the current modeling approach. The second proposes some alternatives and identifies the preferred alternative.

3.1 MODELING ISSUES

Activities associated with the exploration and development of oil reserves generate employment and income for workers employed in those activities. In economics these types of consequences are often termed direct impacts. The total economic impact on the regional economy includes not only these direct economic impacts, but also what economists refer to as indirect impacts. Indirect impacts refer to the jobs and earnings created in industries that support the primary exploration and development activities. These impacts might include, for example, additional jobs resulting from increased transportation related to E&D activities such as ferrying workers to/from platforms or from southern to northern Alaska. Finally, employees spend part of their earnings that were originally generated either directly or indirectly from the E&D activities. These expenditures give rise to induced impacts, which are defined in economics as the additional employment and income generated as a result of this spending.

From an economic standpoint, oil and gas exploration and development activities in the Beaufort Sea are unique. The economic impacts are the direct result of a large, but relatively short-term, natural resource extraction activity that is based on new and innovative technologies. This activity is supported by boomtown like small towns and various support industries providing transportation and other services and infrastructure. These activities are all overlaid upon a low technology culture that relies, in the long-term, upon the land, the natural wildlife and a set of non-western traditional knowledge and skills.

In some sense, the success of OCS development will be judged by how little damage is done to the environment. It is an almost ironic juxtaposition to traditional economic development that the criterion for success should be how little evidence of the intrusion of man is left when the oil fields are abandoned.

As is the case with mining towns, the long-term economic development effects are, in part, the development of infrastructure. In the case of North Slope oil development activities, these effects include items such as roads, airports, utilities, governmental structures, gravel islands with shelters, and other facilities that can be used by residents either during or after the oil and gas related activities. Other economic effects include the jobs, income and spending generated during the actual exploration, development and production phases. Also included are the income provided through royalty payments for near shore projects shared with Alaska by the Federal Government.

The sum of impacts depends to a large extent on the number of interacting industries in the study area. This number is heavily influenced by the physical size of the geographic area under consideration. The impacts tend to increase with increases in the size of the region. It can be seen, therefore, that the quantity of impacts measured depends upon the definition of the study area and can vary significantly depending on whether the vantage point is at the county (boroughs in Alaska), state or national level. In many cases, it is useful to be able to isolate the impacts that accrue to different geographic levels. Having a single consistent model for this purpose ensures that different impact magnitudes are the result of different geographic absorption rates rather than differences in model assumptions.

In all cases it is important to take into consideration all of the regional impacts that will result from the stimulus. The size of the geographic area may also influence this consideration. For example, the direct impacts on a small region may be less than the direct impacts on a larger region. This can happen if the smaller area lacks industries which are present in the larger area. Another example highlights what can happen if a stimulus is simply transferred from one area to another area. Consider a manufacturing plant that moves from one county in a state to a different county in the same state. At the county level, the old county will experience negative impacts (e.g., job losses) whereas the new county will experience positive impacts. At the state level, the net impacts may be zero or very small since the gains in one county are offset by losses in another county.

Economic activity often includes unintended or non-priced effects or byproducts. For example, automobile use creates air pollution while OCS oil and gas production involves the potential for spills and the disruption of natural ecosystems. Economists refer to these non-market impacts as externalities. The costs of externalities can be internalized. Examples in the Arctic OCS include spill contingency operations and abandonment activates. To the extent externalities are internalized they are included in the economic impacts measured by Arctic IMPAK. To the extent impacts are not internalized, such as any spilled oil that is not recovered, the economic impacts are not quantified in the model.

In assessing economic activities, it is often desirable to consider the distribution of impacts across socio-economic groups or generations. For example, for the economic impacts considered in this study, it will be interesting to determine the proportion of those filling high skill, high paying jobs that will leave the area after they have completed short term work assignments with those who stay. It will also be interesting to determine what the fate will be for Alaska Natives. When the development and production has been completed there may not be work on this kind left in the local area. Alaska Natives may be left with the choice of moving to find similar skilled or semi-skilled work or change to some other cash job. Another choice may be to return to their village and rely on traditional subsistence. Returning to this lifestyle may be difficult because subsistence hunting skills may be diminished or difficult to readjust to.

Therefore, while OCS economic activities create jobs and income, these impacts, as discussed in the preceding paragraphs, should be considered in light of transfers, externalities and distributional impacts. In this study, attempts will be made, where practical, to consider these issues or to point out modeling approaches that might facilitate consideration of these issues. For example, use of the IMPLAN model allows impacts to be calculated by region and by socio-economic group. This advantage of this model is worth highlighting.

Finally, while the purpose of this study is to examine and develop tools to measure economic impacts, it is important to differentiate between "impacts" and "benefits." Impacts are merely a measure of the amount of economic activity and can be defined in terms of jobs, income or expenditures. An economic benefit, on the other hand, is traditionally defined as a change in consumer surplus, or a return that can not be attributed to a resource or factor of production.

3.2 THE MANPOWER MODEL

The Manpower Model was created in the late 1970's and refined in the early 1980's to project the number of workers directly employed in proposed OCS exploration, development, and production activities. These data have historically been used in other models to predict secondary employment and population. The employment data from the Manpower Model and the secondary employment and population data are used in Environmental Impact Statements.

The employment factors in the Manpower Model are based on information, no more current than the early 1980's, from industry on the actual number of workers used for 20 work units covering a range of activities from exploration and development to production. Unfortunately, no documentation of the methodology or sources used to construct the model are available.

For the most part, it is fairly certain that the employment factors in the Manpower Model are no longer valid. Since the early 1980's, technology has changed to the extent that the input variables should be reexamined and adjusted. Moreover, the current Manpower Model has one set of activities and labor factors for all of Alaska. These units and labor factors were developed based on activities for the more southern portions of Alaska and are not readily applicable to Arctic operations. For example, the current model assumes that platforms will be the primary technology, while such structures cannot withstand the ice forces in arctic environments.

The Manpower Model is a spreadsheet model that is divided into three main parts. The first part contains the labor factors that were collected. The second part contains projections of manpower by work units and tasks. The third part contains projections of manpower by job type. The portions of the model that contain the projections are linked to and are based upon the labor factors.

Structure of the Manpower Model

The current manpower model estimates petroleum industry related employment generated from exploration, development and production activities. These activities are defined in terms of the units and tasks listed in Exhibit 3-1.

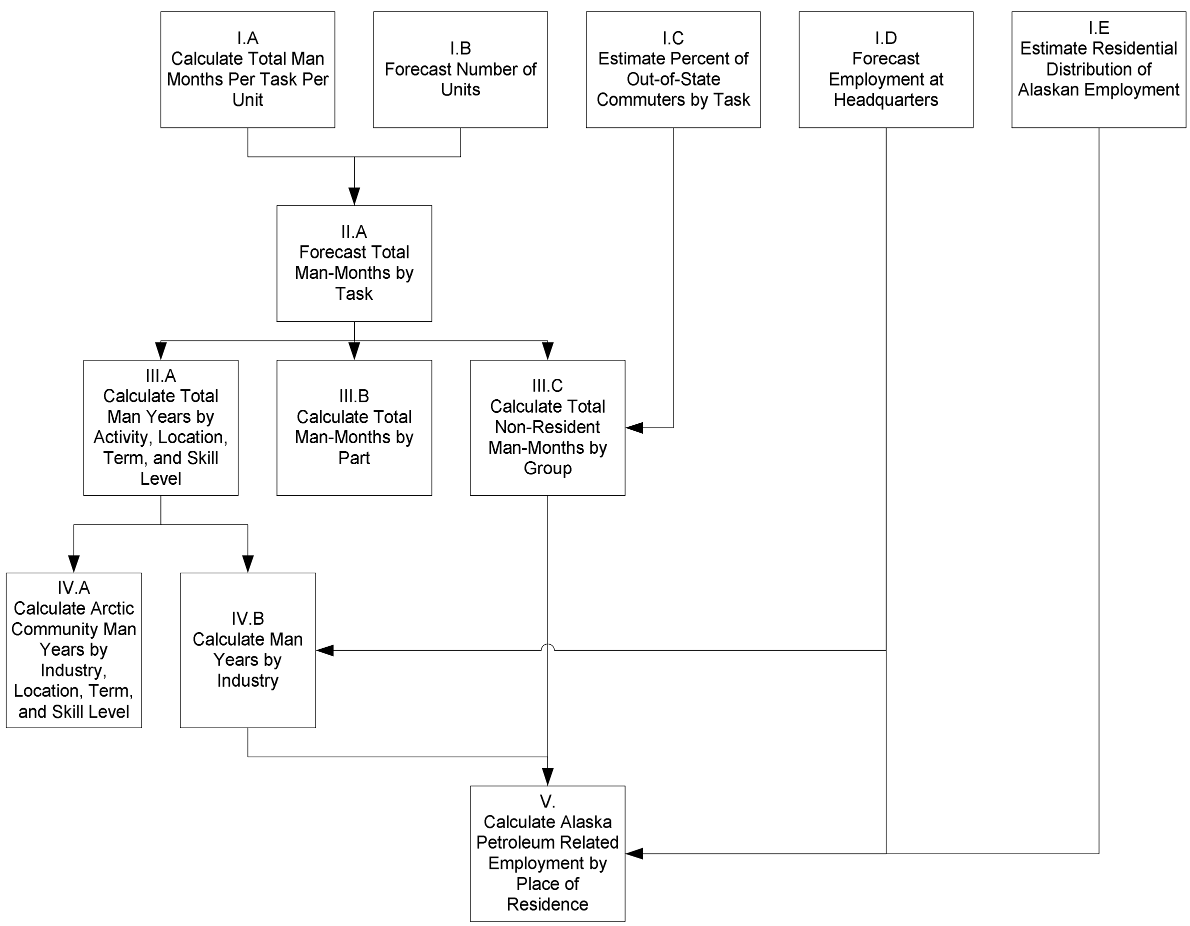
Exhibit 3-1: Unit and Task Descriptions

UNIT	Unit Description	TASK	Task Description
UNIT 1	Number of Exploration and Delineation Wells Drilled	Task 1	Drilling Crew Activities
		Task 1A	Helicopter Support for Drilling
		Task 1B	Supply/Anchor Boats for Drilling Support
		Task 1C	Longshoring Support for Drilling
		Task 1D	Other Onshore Work in Support of Drilling
UNIT 2	Number of Exploration Shore Bases Constructed	Task 2	All Shore Base Construction Activities
UNIT 3	Number of Exploration Shore Bases Constructed	Task 3	All Base Operations (Except Tasks 1A - 1D)
UNIT 4	Number of Geophysical or Geological Surveys Conducted	Task 4	All Work by Survey and Boat Crews
UNIT 5	Number of Exploration Islands Constructed	Task 5	All Island Construction Activities
UNIT 6	Number of Production Platforms and Equipment Installed	Task 6	All Work by Platform Installation Crews
		Task 6A	Helicopter Support-Platform Installation
		Task 6B	Tugboat Support for Platform Installation
		Task 6C	Supply/Anchor Boat Support for Platform Installation
		Task 6D	Longshoring for Platform Installation
		Task 6E	Other Onshore Support for Platform Installation
UNIT 7	Number of Offshore Loading Platforms Installed	Task 7	All Work by Platform Installation Crews
		Task 7A	Helicopter Support for Platform Installation
		Task 7B	Tugboat Support for Platform Installation
		Task 7C	Supply/Anchor Boat Support for Platform Installation
		Task 7D	Longshoring for Platform Installation
		Task 7E	Other Onshore Support for Platform Installation
UNIT 8	Number of Production Shore Bases Constructed	Task 8	All Shore Base Construction Activities
UNIT 9	Number of Production or Service Wells Drilled	Task 9	All Work of the Drilling Crews
UNIT 10	Offshore Oil Pipe Layed (100's of Miles)	Task 10	All Work of the Laying Barge Crews
		Task 10A	Helicopter Support for Pipe Laying
		Task 10B	Tugboat Support for Pipe Laying
		Task 10C	Supply/Anchor Boats for Pipe Laying
		Task 10D	Longshoring Support for Pipe Laying
		Task 10E	Other Onshore Support for Pipe Laying
UNIT 11	Onshore Oil Pipe Layed (100's of Miles)	Task 11	All Pipeline Laying and Related Activities
UNIT 12	Number of Marine Oil Terminals Constructed	Task 12	All Related Activities
UNIT 13	Number of Onshore Oil Pump Stations Constructed	Task 13	All Related Activities
UNIT 14	Number of Production Islands Constructed	Task 14	All Related Activities
UNIT 15	Number of Production Platforms Operating	Task 15	All Work of Platform Operations Crews
		Task 15A	Helicopter Support for Platform Operations
		Task 15B	Supply/Anchor Boats for Platform Operations
		Task 15C	Longshoring for Platform Operations
		Task 15D	Other Onshore Work for Platform Operations
UNIT 16	Number of Major Platform Maintenances Performed	Task 16	All Work of Platform Maintenance Crews
UNIT 17	Number of Production Island Maintenances	Task 17	All Work of Island Maintenance Crews
UNIT 18	Number of Production or Service Well Workovers	Task 18	All Work of Workover Crews
UNIT 19	Number of Production Shore Bases Operating	Task 19	All Base Operations
UNIT 20	Number of Marine Oil Terminals Operated	Task 20	All Terminal Operations Activities

The model itself already contains labor factors in the form of estimates of labor requirements per unit of activity. These factors are stimulated by entering into the model estimates of the amounts or numbers of each activity that will take place as a result of the lease sale or other governmental action under examination. The combination of these estimates of the amounts or numbers of each activity is referred to by the Minerals Management Service (MMS) as an Exploration and Development (E&D) scenario. Such scenarios are hypothesized outside of the model and comprise the main inputs into the Manpower Model, which then uses them to calculate two primary outputs: (1) petroleum related employment generated in Alaska by place of residence, and (2) petroleum related employment generated in the study area (in this case, the North Slope Borough).

The internal calculations can be divided into five levels, each with one to five steps, as depicted schematically in Exhibit 3-2 and described below.

Exhibit 3-2
Flow Chart of Arctic Man-Power Model



Level I: Input Parameters

This level of the model includes primarily a variety of data that provide the inputs or parameters to the modeling procedure. These estimates are developed outside of the model. Some are specific inputs to a particular model run and some are the basic parameters of the model that would change only if the model were updated or refined.

- Step I.A.: Calculate Total Man-Months Per Task Per Unit

For each unit and task, this step provides the input values for and calculates the product of the following variables: task crew size, number of shifts, number of rotations, number of tasks per unit, and duration of the task in months. The estimates for these variables were developed outside of the model and are used as model parameters. Both the variables and the resulting product are assumed to remain constant over the forecast horizon.

- Step I.B.: Forecast Number of Units

These forecasts are estimated outside of the model. As discussed above they are developed from an E&D Scenario. The forecast numbers of units are used as model inputs. Forecasts for the following units are provided including:

1) Exploration & delineation wells drilled
2) Exploration shore bases constructed
3) Exploration shore bases operating
4) Geophysical-Geological surveys conducted
5) Exploration islands constructed
6) Production platforms and equipment installed
7) Offshore loading platforms installed
8) Production shore bases constructed
9) Production or service wells drilled
10 Hundreds of miles of offshore oil pipe laid
11) Hundreds of miles of onshore oil pipe laid
12) Terminals constructed
13) Onshore oil pump stations constructed
14) Production islands constructed
15) Production platforms operating
16) Major platform maintenance operations performed
17) Production island maintenance operations performed
18) Production or service well workovers
19) Production shore bases operating
20) Marine oil terminals operating

Generally the E&D scenario contains forecasts for a few of the above items and the remaining items are based on certain "rules of thumb." For example, islands are assumed to require maintenance after a certain number of years.

- Step I.C.: Estimate Percent of Out-of-State Commuters by Task

For each unit and task, an estimate of the percentage of the jobs held by out-of-state commuters is provided in the model. The estimates for this variable were developed outside of the model and are used as model parameters. The estimates for this variable are assumed to remain constant over the forecast horizon.

- Step I.D.: Forecast Employment at Headquarters

Estimates of employment at headquarters are developed outside of the model. Because these estimates are forecast outside of the model, the numbers are not necessarily related to the number of units forecast.

- Step I.E.: Estimate Residential Distribution of Alaskan Petroleum Related Employment

The estimates of the residential distribution of Alaskan petroleum related employment are developed outside of the model and are used to distribute Alaskan residents who work in the petroleum industry to geographic residential locations in Alaska. The percentages are used as model inputs and are held fixed over the forecast horizon. The residential areas and percentages used include Anchorage (63.2%), Fairbanks Census Division (6.4%), South Central Alaska Region1 (22.2%), and the rest of Alaska (8.2%). 100% of the people who work at headquarters are assumed to live in Anchorage.

Level II: Forecasts by Task

In this level, the estimates of the amount of labor to complete a task are multiplied by the forecasts of the number of times the task will be performed in each year to provide a forecast of labor by year for each task.

- Step II.A.: Forecast Total Man-Months by Task

This step calculates the product of Step I.A (Total Man-Months per Task per Unit) and Step I.B (Forecast Number of Units), producing a forecast time series of total man-months by task. For example, it is estimated in Step I.A that conducting a geophysical-geological survey will require

[1] Includes the following 1970 census divisions: Matanuska-Susitna, Valdez-Chtina-Whittier, Cordova-McCarthy, Seward, Kenai-Cook Inlet, and Kodiak. This does not include the municipality of Anchorage which is usually considered a part of the South Central Alaska Region.

150 man-months and in Step I.B that one survey will be required in year 2003. As a result, the forecast is that for that task 150 man-months of work will be required.

Level III: Man Year Forecasts

In this level, the forecasted estimates of manpower by task are combined in several tabulations including activities, locations, terms, skill levels, parts and groups. These tabulations are divided, for discussion purposes, into three main steps with activities, locations, terms, and skill levels as the first group, parts as the second and groups as the third.

- Step III.A.: Calculate Total Man-Years by Major Activity (Mining, Construction, Air Transportation, Marine Transportation), Location (Onshore/Offshore), Employment Term (Short-term/Long-term), and Skill Level (skilled/unskilled)

This step converts the total man-months by task forecast (calculated in step II.A) into a forecast of man-years by major activity, onshore/offshore location, length of employment, and skill level. The conversion is based on an assignment of each task to a major activity (mining, construction, air transportation, or marine transportation), an onshore or offshore location, a short-term or long-term task, and a skill level (skilled or unskilled)[2]. These assignments are specified in the program's aggregation formulas and are not easily modified by the user. The task assignments are shown in Exhibits 3-3 and 3-4. Exhibit 3-3 presents assignments by task while Exhibit 3-4 presents tasks by assignment. Note that tasks 2 and 8 do not have any assignments. As there is no documentation for the model there is no indication as to why these tasks were not assigned and no logical reason was evident.

[2] Four of the tasks (11, 12, 13, and 15) divide the total task manpower estimate between skilled and unskilled labor rather than just assigning it to one of the categories.

Exhibit 3-3: Activity, Location, Term, and Skill Level Assignments by Task

UNIT	Unit Description	TASK	Task Description	Major Activity	Location	Term	Skill Level
UNIT 1	Number of Exploration and Delineation Wells Drilled	Task 1	Drilling Crew Activities	Mining	Off-Shore	Short Term	Skilled
		Task 1A	Helicopter Support for Drilling	Air Transportation	On-Shore	Short Term	Skilled
		Task 1B	Supply/Anchor Boats for Drilling Support	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 1C	Longshoring Support for Drilling	Marine Transportation	On-Shore	Short Term	Unskilled
		Task 1D	Other Onshore Work in Support of Drilling	Mining	On-Shore	Short Term	Skilled
UNIT 2	Number of Exploration Shore Bases Constructed	Task 2	All Shore Base Construction Activities				
UNIT 3	Number of Exploration Shore Bases Constructed	Task 3	All Base Operations (Except Tasks 1A - 1D)	Mining	On-Shore	Short Term	Unskilled
UNIT 4	Number of Geophysical or Geological Surveys Conducted	Task 4	All Work by Survey and Boat Crews	Mining	Off-Shore	Short Term	Skilled
UNIT 5	Number of Exploration Islands Constructed	Task 5	All Island Construction Activities	Construction	Off-Shore	Short Term	Unskilled
UNIT 6	Number of Production Platforms and Equipment Installed	Task 6	All Work by Platform Installation Crews	Mining	Off-Shore	Short Term	Skilled
		Task 6A	Helicopter Support-Platform Installation	Air Transportation	On-Shore	Short Term	Skilled
		Task 6B	Tugboat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 6C	Supply/Anchor Boat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 6D	Longshoring for Platform Installation	Marine Transportation	On-Shore	Short Term	Unskilled
		Task 6E	Other Onshore Support for Platform Installation	Mining	On-Shore	Short Term	Skilled
UNIT 7	Number of Offshore Loading Platforms Installed	Task 7	All Work by Platform Installation Crews	Mining	Off-Shore	Short Term	Skilled
		Task 7A	Helicopter Support for Platform Installation	Air Transportation	On-Shore	Short Term	Skilled
		Task 7B	Tugboat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 7C	Supply/Anchor Boat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 7D	Longshoring for Platform Installation	Marine Transportation	On-Shore	Short Term	Unskilled
		Task 7E	Other Onshore Support for Platform Installation	Mining	On-Shore	Short Term	Skilled
UNIT 8	Number of Production Shore Bases Constructed	Task 8	All Shore Base Construction Activities				
UNIT 9	Number of Production or Service Wells Drilled	Task 9	All Work of the Drilling Crews	Mining	Off-Shore	Short Term	Skilled
UNIT 10	Offshore Oil Pipe Layed (100's of Miles)	Task 10	All Work of the Laying Barge Crews	Mining	Off-Shore	Short Term	Skilled
		Task 10A	Helicopter Support for Pipe Laying	Air Transportation	On-Shore	Short Term	Skilled
		Task 10B	Tugboat Support for Pipe Laying	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 10C	Supply/Anchor Boats for Pipe Laying	Marine Transportation	Off-Shore	Short Term	Skilled
		Task 10D	Longshoring Support for Pipe Laying	Marine Transportation	On-Shore	Short Term	Unskilled
		Task 10E	Other Onshore Support for Pipe Laying	Mining	On-Shore	Short Term	Skilled
UNIT 11	Onshore Oil Pipe Layed (100's of Miles)	Task 11	All Pipeline Laying and Related Activities	Construction	On-Shore	Short Term	40% Skilled, 60% Unskilled
UNIT 12	Number of Marine Oil Terminals Constructed	Task 12	All Related Activities	Construction	On-Shore	Short Term	20%Skilled, 80% Unskilled
UNIT 13	Number of Onshore Oil Pump Stations Contstructed	Task 13	All Related Activities	Construction	On-Shore	Short Term	20%Skilled, 80% Unskilled
UNIT 14	Number of Production Islands Constructed	Task 14	All Related Activities	Construction	Off-Shore	Short Term	Unskilled
UNIT 15	Number of Production Platforms Operating	Task 15	All Work of Platform Operations Crews	Mining	Off-Shore	Long Term	90% Skilled, 10%Unskilled
		Task 15A	Helicopter Support for Platform Operations	Air Transportation	On-Shore	Long Term	Skilled
		Task 15B	Supply/Anchor Boats for Platform Operations	Marine Transportation	Off-Shore	Long Term	Skilled
		Task 15C	Longshoring for Platform Operations	Marine Transportation	On-Shore	Long Term	Unskilled
		Task 15D	Other Onshore Work for Platform Operations	Mining	On-Shore	Long Term	Skilled
UNIT 16	Number of Major Platform Maintenances Performed	Task 16	All Work of Platform Maintenance Crews	Mining	Off-Shore	Long Term	Skilled
UNIT 17	Number of Production Island Maintenances	Task 17	All Work of Island Maintenance Crews	Construction	Off-Shore	Short Term	Unskilled
UNIT 18	Number of Production or Service Well Workovers	Task 18	All Work of Workover Crews	Mining	Off-Shore	Long Term	Skilled
UNIT 19	Number of Production Shore Bases Operating	Task 19	All Base Operations (Except tasks related to Units 6, 7, 10, and 15)	Mining	On-Shore	Long Term	Unskilled
UNIT 20	Number of Marine Oil Terminals Operated	Task 20	All Terminal Operations Activities	Mining	On-Shore	Long Term	Skilled

Exhibit 3-4: Aggregation of Task Man-Months in Step 3A

Major Activity	Location	Term	Skill Level	Tasks
Mining	On-Shore	Short Term	Skilled	1D, 6E, 7E, 10E
			Unskilled	3
		Long Term	Skilled	15D, 20
			Unskilled	19
	Off-Shore	Short Term	Skilled	1, 4, 6, 7, 9, 10
			Unskilled	Blank
		Long Term	Skilled	90% of 15, 16, 18
			Unskilled	10% of 15
Construction	On-Shore	Short Term	Skilled	40% of 11, 20% of 12, 20% of 13
			Unskilled	60% of 11, 80% of 12, 80% of 13
		Long Term	Skilled	Blank
			Unskilled	Blank
	Off-Shore	Short Term	Skilled	Blank
			Unskilled	5, 14, 17
		Long Term	Skilled	Blank
			Unskilled	Blank
Air Transportation	On-Shore	Short Term	Skilled	1A, 6A, 7A, 10A
			Unskilled	Blank
		Long Term	Skilled	15A
			Unskilled	Blank
	Off-Shore	Short Term	Skilled	Blank
			Unskilled	Blank
		Long Term	Skilled	Blank
			Unskilled	Blank
Marine Transportation	On-Shore	Short Term	Skilled	Blank
			Unskilled	1C, 6D, 7D, 10D
		Long Term	Skilled	Blank
			Unskilled	15C
	Off-Shore	Short Term	Skilled	1B, 6B, 6C, 7B, 7C, 10B, 10C
			Unskilled	Blank
		Long Term	Skilled	15B
			Unskilled	Blank

- Step III.B.: Calculate Total Man-Months by Part

In this step, the forecast of man-months by task (generated in step II.A.) are aggregated into three categories or "parts." No titles or definitions of the individual "parts" are provided and no reasons why they are calculated is given. Part 1 is the sum of the man-months associated with units 1-8; Part 2 is the sum of the man-months associated with units 9-15; Part 3 is the sum of the man-months associated with units 16-20. The forecast time series produced in this step do not feed into any other steps.

- Step III.C.: Calculate Total Non-Resident Man-Months by Group

In this step, the number of man-months performed by non-resident workers are estimated for each task and then aggregated into seven "groups." No titles or definitions of the individual "groups" are provided and no reasons why they are calculated is given. The number of man-months associated with non-resident workers is estimated by taking the product of the outputs generated in steps I.C. and II.A. above. The aggregation scheme is as follows: Group 1 includes all tasks in units 1-4; Group 2 includes all tasks under unit 5-6, plus task 7 under unit 7; Group 3 includes tasks 7A - 7E under unit 7, plus all tasks under unit 8-9; Group 4 includes all tasks under units 10-11; Group 5 includes all tasks under units 12-14, plus Task 15 and Task 15A under unit 15; Group 6 includes tasks 15B-15D, plus all tasks under units 16-17; Group 7 includes all tasks under units 18-20.

Level IV Man Years by Location and Industry

In this level, the forecasted estimates of manpower are combined in several tabulations in a similar manner to Level III. At this level, however, tabulations also include a dimension for the industry the manpower is associated with. In one step, manpower is developed for the Arctic only with detail by industry, location, term and skill level. In a second step, total manpower by industry is calculated, with headquarters employment added in.

- Step IV.A.: Calculate Arctic Community Man Years by Industry (Air Transportation, Marine Transportation, Island), Location (Onshore/Offshore), Employment Term (Short-term/Long-term), and Skill Level (skilled/unskilled)

This step distributes each task's total manpower forecast to various industry, onshore/offshore location, employment term, and skill-level categories. It also specifies whether or not the jobs associated with a particular task are located in the Arctic community. For most tasks one hundred percent of the jobs are assumed to be located in the Arctic community; however, one hundred percent of the jobs associated with tasks 5, 14, and 17 are assumed to be located elsewhere. Distribution of task manpower to jobs located in the community is shown in Exhibit 3-5. These distributions are specified in the program's aggregation formulas and are not easily modified by the user. The percentages used to distribute the manpower are assumed to remain constant over the forecast horizon. The forecasts generated in this step do not feed into any other steps.

Exhibit 3-5: Assignment of Task Manpower to Local Community

UNIT	Unit Description	TASK	Task Description	Industry	Location	Term
UNIT 1	Number of Exploration and	Task 1	Drilling Crew Activities	Marine Transportation	Off-Shore	Short Term
	Delineation Wells Drilled			Island	Off-Shore	Short Term
		Task 1A	Helicopter Support for Drilling	Air Transportation	On-Shore	Short Term
		Task 1B	Supply/Anchor Boats for Drilling Support	Marine Transportation	Off-Shore	Short Term
		Task 1C	Longshoring Support for Drilling	Marine Transportation	On-Shore	Short Term
		Task 1D	Other Onshore Work in Support of Drilling	Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 2	Number of Exploration	Task 2	All Shore Base Construction Activities	Air Transportation	On-Shore	Short Term
	Shore Bases Constructed			Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 3	Number of Exploration	Task 3	All Base Operations (Except Tasks 1A - 1D)	Air Transportation	On-Shore	Short Term
	Shore Bases Constructed			Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 4	Number of Geophysical or	Task 4	All Work by Survey and Boat Crews	Marine Transportation	Off-Shore	Short Term
	Geological Surveys Conducted			Island	Off-Shore	Short Term
UNIT 5	Number of Exploration Islands Constructed	Task 5	All Island Construction Activities			
UNIT 6	Number of Production Platforms	Task 6	All Work by Platform Installation Crews	Marine Transportation	Off-Shore	Short Term
	and Equipment Installed			Island	Off-Shore	Short Term
		Task 6A	Helicopter Support-Platform Installation	Air Transportation	On-Shore	Short Term
		Task 6B	Tugboat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term
		Task 6C	Supply/Anchor Boat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term
		Task 6D	Longshoring for Platform Installation	Marine Transportation	On-Shore	Short Term
		Task 6E	Other Onshore Support for Platform Installation	Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 7	Number of Offshore Loading	Task 7	All Work by Platform Installation Crews	Marine Transportation	Off-Shore	Short Term
	Platforms Installed			Island	Off-Shore	Short Term
		Task 7A	Helicopter Support for Platform Installation	Air Transportation	On-Shore	Short Term
		Task 7B	Tugboat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term
		Task 7C	Supply/Anchor Boat Support for Platform Installation	Marine Transportation	Off-Shore	Short Term
		Task 7D	Longshoring for Platform Installation	Marine Transportation	On-Shore	Short Term
		Task 7E	Other Onshore Support for Platform Installation	Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 8	Number of Production Shore	Task 8	All Shore Base Construction Activities	Air Transportation	On-Shore	Short Term
	Bases Constructed			Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 9	Number of Production or	Task 9	All Work of the Drilling Crews	Marine Transportation	Off-Shore	Short Term
	Service Wells Drilled			Island	Off-Shore	Short Term
UNIT 10	Offshore Oil Pipe Layed	Task 10	All Work of the Laying Barge Crews	Marine Transportation	Off-Shore	Short Term
	(100's of Miles)			Island	Off-Shore	Short Term
		Task 10A	Helicopter Support for Pipe Laying	Air Transportation	On-Shore	Short Term
		Task 10B	Tugboat Support for Pipe Laying	Marine Transportation	Off-Shore	Short Term
		Task 10C	Supply/Anchor Boats for Pipe Laying	Marine Transportation	Off-Shore	Short Term
		Task 10D	Longshoring Support for Pipe Laying	Marine Transportation	On-Shore	Short Term
		Task 10E	Other Onshore Support for Pipe Laying	Marine Transportation	On-Shore	Short Term
				Island	On-Shore	Short Term
UNIT 11	Onshore Oil Pipe Layed (100's of Miles)	Task 11	All Pipeline Laying and Related Activities	Island	On-Shore	Short Term
UNIT 12	Number of Marine Oil Terminals Constructed	Task 12	All Related Activities	Island	On-Shore	Short Term
UNIT 13	Number of Onshore Oil Pump Stations Constructed	Task 13	All Related Activities	Island	On-Shore	Short Term
UNIT 14	Number of Production Islands Constructed	Task 14	All Related Activities			
UNIT 15	Number of Production	Task 15	All Work of Platform Operations Crews	Marine Transportation	Off-Shore	Long Term
	Platforms Operating			Marine Transportation	Off-Shore	Long Term
				Island	Off-Shore	Long Term
				Island	Off-Shore	Long Term
		Task 15A	Helicopter Support for Platform Operations	Air Transportation	On-Shore	Long Term
		Task 15B	Supply/Anchor Boats for Platform Operations	Marine Transportation	Off-Shore	Long Term
		Task 15C	Longshoring for Platform Operations	Marine Transportation	On-Shore	Long Term
		Task 15D	Other Onshore Work for Platform Operations	Marine Transportation	On-Shore	Long Term
				Island	On-Shore	Long Term
UNIT 16	Number of Major Platform	Task 16	All Work of Platform Maintenance Crews	Marine Transportation	Off-Shore	Long Term
	Maintenances Performed			Island	Off-Shore	Long Term
UNIT 17	Number of Production Island Maintenances	Task 17	All Work of Island Maintenance Crews			
UNIT 18	Number of Production or	Task 18	All Work of Workover Crews	Marine Transportation	Off-Shore	Long Term
	Service Well Workovers			Island	Off-Shore	Long Term
UNIT 19	Number of Production	Task 19	All Base Operations	Air Transportation	On-Shore	Long Term
	Shore Bases Operating		(Except tasks related to Units 6, 7, 10, and 15)	Marine Transportation	On-Shore	Long Term
				Island	On-Shore	Long Term
UNIT 20	Number of Marine Oil	Task 20	All Terminal Operations Activities	Marine Transportation	On-Shore	Long Term
	Terminals Operated			Island	On-Shore	Long Term

- Step IV.B.: Calculate Total Man Years by Industry

In this step the matrix of total man years by location, employment term, and skill level calculated in Step III.A are aggregated into forecasts of petroleum related employment by industry. The industries include mining, transportation (with sub-categories for air and marine transportation), and construction. Employment at headquarters, forecast in step I.D, is added to the mining industry forecasts.

Level V: Man Years by Alaska Residents

In this level, estimates are made of the man years supplied by Alaska residents by their place of residence within Alaska.

- Step V.A.: Forecast Total Petroleum Related Man Years Performed by Alaska Residents by Place of Residence

The final step in the manpower model distributes forecast man years held by Alaska residents to residential areas. Total man years held by nonresidents, forecast in step III.C, are subtracted from total industry man years calculated in step IV.B. to produce estimates of the total man years held by Alaska residents. These results are then distributed to residential areas using the percentages developed in step I.E.

Analysis of the Manpower Model

The Manpower model has the advantage of having been estimated specifically for the oil and gas industry in Alaska whereas other available models contain data at more aggregate activities. These models have production functions or input coefficients or labor factors that are based on national level statistics and technologies. Most available input-output based models were constructed based on data for the oil and gas extraction industry at the national level and therefore do not accurately portray the specifics for arctic operations.

The model also has the advantage of treating the industry as a set of events that can be combined in different proportions to produce a final output. If the model calculated manpower solely on total dollars spent or barrels produced, it could not accurately measure the differences in impact from alternative production options or circumstances.

On the other hand, since the model only is concerned with labor inputs it fails to recognize that differences in production methods may create differences in impacts. Two different production scenarios may utilize the same amount of labor but result in much different impacts on the local economy. For example, one production scenario may use high technology such as caisson islands supported by helicopters while another might rely on ice roads and gravel islands. The former would use more highly skilled imported labor and imported equipment while the latter would use more local labor and materials.

One set of problems related to Manpower is the lack of documentation. There are no descriptions of where and how the data were obtained or processed, what assumptions were made or what the problems and solutions were. As a result, assessing the validity of the model is hampered.

A current shortcoming of the Manpower Model is that the units/activities appear less than comprehensive. An example of the lack of comprehensive coverage is that the model does not appear to address the costs of spill protection or the abandonment/cleanup that would be faced when production is terminated. At present, calculation of the effects of a spill on the economy are estimated outside the model by taking the size of a hypothetical spill as a proportion of the *Exxon Valdez* oil spill. No estimates of the permanent spill contingency workforce are included.

To respond to this shortcoming, it is clear that the beginning and end of the activity stream that is modeled needs to be defined better. Moreover, these points probably should differ depending on whether the impact assessment is conducted at the state level or whether it is conducted at the local level. For example, for a North Slope assessment the stream may end when oil enters the Trans-Alaska Pipeline System (TAPS); for a state level assessment, however, there are activities in Valdez associated with transferring the oil from TAPS to vessels that need to be incorporated in the model.

In addition, the activities and data need to be updated to reflect production processes currently used on the North Slope. This is perhaps less a critique of the model than an observation that models of this type have a limited period of usefulness and must be updated on a regular basis.

3.3 THE RURAL ALASKA MODEL

The Rural Alaska Model (RAM) is currently the second step model used by MMS for assessing secondary economic impacts on Alaska's North Slope Borough. Under the current modeling procedure, total direct employment impacts in the oil industry are estimated in the first step model (the Manpower Model) and then entered into RAM which estimates secondary and ancillary impacts.

The RAM model was developed by the University of Alaska and consists of a set of worksheets in a spreadsheet workbook. The RAM is actually a collection of ten models, one for each of ten local regions, one of which is the North Slope Borough.

Structure of the RAM

The North Slope Borough RAM consists of three linked modules: a demographic module, a government fiscal module, and an economic module. Many of the variables in these modules, but not all of them, are affected by the total direct employment impacts on the oil industry. For example, the fiscal module calculates the resulting changes in property taxes and in government expenditures and revenues. The demographic module estimates population and migration changes due to total employment changes in the oil industry. Finally, economic variables affected by direct employment impacts on the oil industry include labor demand, labor supply, total employment, and unemployment.

Many of the variables are broken down by residential (residential vs. non-residential) and/or Native (Native vs. non-Native) aspects. Further detail is often provided by aggregate sector: e.g., government, construction, endogenous support, et cetera. Each sector estimate relies on a single parameter (multiplier) computed outside of both models. There is also a dynamic component in RAM. In other words, the value of a given variable at time "t" may be a function not only of other variables at time "t" but also of variables at time "t - 1".

To estimate secondary impacts, RAM relies on an economic base modeling approach. In other words, total employment in the economy is related to employment in the economic base, which is typically defined as the industrial sector. This relationship is defined in terms of an "endogenous support" parameter, which is simply the ratio between total employment and base employment. In the original North Slope version of RAM, constructed in the 1980's, these parameters were estimated by Gunnar Knapp at the University of Alaska Anchorage.

A schematic of RAM is provided in Exhibit 3-6. Note that the schematic only details the relationships between variables which are directly or indirectly stimulated by total oil industry employment. The equations that comprise the variables in the schematic are shown in Exhibit 3-7.

Exhibit 3-7 RAM Equations

Line Number	Variable	Equation
316	Total Population	Non Resident Population + Resident Population
320	Non-Resident Population	Non-Resident Employment * Ratio of Non-Resident Population to Non-Resident Employment
365	Per Capita Operations Revenue Limit	Total Population * Per Capita Operating Revenues
372	Property Taxes for Operations	The minimum of the Per Capita Operations Revenue Limit, the Maximum Tax Rate for Operations, and the Maximum Total Tax Rate.
373, 385	Total Operating Revenues	Non-property Tax Operating Revenues, Interest Revenues, and Property Tax Operating Revenues
375	Total Property Taxes	Property Taxes for Operations + Property Taxes for Debt Payments
376	Total Revenues	Total Operating Revenues + Property Taxes for Debt Payments
400	Total Employment in Government Operations	Operations Expenditures * Employment Parameter for Government Operations
403	Total Employment in Endogenous Support	Employment Parameter for Endogenous Support * Total Resident Employment
404	Basic Oil Industry Employment	Data Input
408	Total Employment	The Sum of Employment in Government Operations, Government Construction, Private Construction, Endogenous Support, Basic Oil Industry, Other Basic Activities, and Non-Local Government
409	Total Non-Oil Employment	Total Employment - Basic Oil Industry Employment
424	Labor Demand for Natives in Government Operations	Total Employment in Government Operations * Maximum Share of Natives in Government Operations
427	Labor Demand for Natives in Endogenous Support	Total Employment in Endogenous Support * Maximum Employment Share of Native in Endogenous Support
428	Labor Demand for Natives in Basic Oil Industry	Basic Oil Industry Employment * Labor Force Participation Rate for Natives
431	Total Non-Oil Labor Demand for Natives	Labor Demand for Natives in Government Operations, Government Construction, Private Construction, Endogenous Support, Other Basic Activities, and Non-Local Government
439	Native Non-Oil Employment	If Total Non-Oil Labor Demand for Natives > (Native Labor Supply - Minimum Native Oil Employment) then Native Labor Supply - Minimum Native Oil Employment; else Total Non-Oil Labor Demand for Natives
440	Native Labor Supply for Oil Industry	If Non-Oil Labor Demand for Natives > Native Labor Supply-Min Native Oil Employment, then Min Native Oil Employment; else, (Native Labor Supply-Min Native Oil Employment-Non-Oil Native Labor Demand)*Native Labor Supply Parameter +Min Native Oil Employment
442	Native Oil Employment	If Labor Demand for Natives in Basic Oil Industry Employment > Labor Supply for Natives in Basic Oil Industry, then Labor Supply for Natives in Basic Oil Industry; else, Labor Demand for Natives in Basic Oil Industry
443	Total Native Employment	Native Oil Employment + Native Non-oil Employment
444	Native Unemployment Before Migration	If Total Native Employment > Native Labor Supply, the 0; else Native Labor Supply - Native Labor Employment
445	Native Unemployment Rate Before Migration	Native Unemployment / Native Labor Supply
448	Employment of Natives in Government Operations	Labor Demand for Natives in Government Operations / Total Non-Oil Labor Demand for Natives * Native Non-Oil Employment
451	Employment of Natives in Endogenous Support	Labor Demand for Natives in Endogenous Support / Total Non-Oil Labor Demand for Natives * Native Non-Oil Employment
457	Employment of Non-Natives in Government Operations	Total Employment in Government Operations - Native Employment in Government Operations
458	Employment of Non-Natives in Endogenous Support	Total Employment in Endogenous Support - Native Employment in Endogenous Support
463	Employment of Non-Residents in Basic Oil Industry	Basic Oil Industry Employment - Native Oil Industry Employment
465, 322	Total Employment of Non-Residents	Non-Resident Employment in Non-Local Government + Non-Resident Employment in Government Funded Construction + Non-Resident Employment in Basic Oil Industry
467	Total Resident Employment	Total Native Employment + Total Non-Native Employment
475	Out-Migration of Native Workers	If Native Unemployment Rate (UR) Before Migration (NURBM) > Max UR (MUR), then (NURBM-MUR) * Native Labor Supply (NLS); else, if NURBM > End of Period UR for Previous Year (EPURPY),then Share of Newly Unemployed Who Leave * (NURBM-EPURPY)*NLS; else 0
476, 28	Out-Migration Share of Native Adults	Outmigration of Native Workers / Native Adult Population
477, 478	End of Period Native Unemployment Rate	Native Unemployment Rate Before Migration - (Native Outmigration / Native Labor Supply)

Analysis of the RAM

Compared to more complex regional input-output model such as IMPLAN or REMI, RAM is somewhat simple. It relies on a total of six parameters per year to estimate the secondary impacts. However, given the small size of the North Slope economy, as well as the fact that a large component of the economy is subsistence/traditional, this may not be a serious disadvantage.

Applying a large complicated model to a small economy such as the North Slope Borough can result in less accurate forecasts than those predicted by more simple models. Large models such as IMPLAN rely upon thousands of parameters, many of which are based upon state or national level data. Error is introduced, therefore, whenever such parameters do not correspond with the realities of the local economy. It should be remembered that RAM was updated in 1995 with the best data available for the North Slope.

One disadvantage of RAM is that it does not isolate specific economic effects which may be useful to MMS analysts. For example, it does not differentiate between indirect and induced impacts; nor does it specify which impacts are attributable to residents and non-residents. A model such as IMPLAN, on the other hand, can be used to model such questions. Due to the size and nature of the

North Slope economy, the secondary impacts are going be comprised mostly of induced effects: IMPLAN could be used to estimate the induced impacts attributable to residential spending, the induced impacts attributable to non-residential spending, and induced impacts attributable to other sources of income such as the Alaska Permanent Fund.

Moreover, while the indirect impacts may be less significant, some impacts will accrue to margins such as the transportation and retail trade sectors. IMPLAN can be used to estimate those impacts even thought the primary manufacturing activity itself takes place outside of the region. And again, it may be possible to isolate the indirect impacts due to an increase either in resident jobs or in non-resident jobs. Looking at both indirect and induced impacts, it may be possible to estimate the total secondary impact of non-residential spending and jobs on resident income and jobs.

The other disadvantage of RAM is that it does not come with a state or national level geographic model which can be used to assess impacts on the entire state of Alaska or on the U.S. as a whole. While another model could be used for this purpose, it would not be fully consistent with RAM and would be difficult to tell whether differences in magnitude were due to differences in absorption or due to differences in model assumptions.

This lack of a state or national model is important because MMS has a need to evaluate impacts across regions. Section 18 of the OCS Lands Act requires that Interior prepare a 5-year schedule of lease sales that considers "an equitable sharing of developmental benefits and environmental risks among the various regions." MMS has made the decision to use IMPLAN for equitable sharing analysis. RAM is therefore at a disadvantage both because it does not provide the data required for the equitable sharing analysis and because it does not provide data directly comparable with IMPLAN.

3.4 THE IMPLAN MODEL

The calculation of indirect and induced impacts requires an economic model that can appraise impacts through multiple tiers of expenditures. One such model is IMPLAN, a regional economic modeling system developed by the U.S. Department of Agriculture's Forest Service in cooperation with the Federal Emergency Management Agency and the U.S. Department of Interior's Bureau of Land Management. The model was then maintained by the University of Minnesota before being spun off to a private group in Minnesota. The IMPLAN model was recently selected by MMS to estimate the impact of E&D activities for all geographic areas other than Alaska.

Structure of the IMPLAN Model

IMPLAN uses input-output analysis (a method of examining relationships between producers and consumers in an economy) to analyze the effects of an economic stimulus on a specified economic region

IMPLAN provides data at three basic geographic levels: national, state, and county (boroughs in Alaska). These geographic units, or customized regions based on zip codes, can be combined to construct any regional grouping the user desires. The ease with which alternative regional aggregations can be constructed while preserving critical trade flow information, is a principal advantage of IMPLAN.

There are two major components in the IMPLAN model: a descriptive model and a predictive model. The descriptive model is represented by accounting tables that describe the trade flows between producers and consumers in the region. The trade flow data provides information that detail not only describes intra-regional flows, but also flows between the study area and the "rest of the world". The descriptive model also incorporates Social Accounting Matrices (SAMs), which show money flows between institutions: e.g., taxes paid by consumers to governments and transfer payments from governments to businesses and households

The predictive model consists of a set of multipliers that can be used to forecast changes in the economy. Multipliers are the means by which the initial change is translated into direct, indirect, and induced impacts. Thus, IMPLAN can be used to predict the regional economic repercussions due to changes in supply or demand or due to changes in model parameters (e.g., income tax rate).

Analysis of the IMPLAN Model

The IMPLAN multipliers are based upon the descriptive model and are computed only after the regional economic accounts have been completely defined. This is an important advantage of IMPLAN. In the descriptive model, all of the model parameters can be changed to reflect a particular scenario or situation. Consequently, the resulting multipliers embody such changes. Examples of parameters that can be changed include regional purchase coefficients, margin rates, and production coefficients. These concepts are defined in the following paragraph.

Industry ***production coefficients*** are calculated as the quantity of a given production input (e.g., steel) divided by industry output. For each commodity, ***regional purchase coefficients*** specify the percentage of demand accounted for by local production. ***Margin rates*** are used to divide the total cost of a commodity (from the buyer's point of view) into various cost categories: e.g., the production margin is the cost of the commodity at the factory gate where it was produced; transportation margins reflect transportation costs involved in delivering the product from the factory to the buyer; and wholesale and retail margins are associated charges paid for those services.

Some regional models, such as RIMS II, only provide the multipliers for evaluating economic impacts and do not provide the descriptive accounts that can be used to developed custom multipliers. Since they are not able to incorporate specific conditions in a local economy, the impacts predicted by these models are usually less accurate than impacts predicted by a model such as IMPLAN.

IMPLAN conducts its analysis for 528 industrial sectors, primarily a mix of 4-digit and 3-digit SIC sector detail. This highly detailed sectoring plan is critical in input-output modeling, where the production function determines the indirect impacts associated with increased output in an industry. In a highly aggregated sectoring plan (for example, 2-digit SIC level) the production function coefficients and impact multipliers are averaged over all the different firms that comprise each 2-digit SIC group. Therefore, a specific facility of interest may have a production process that differs substantially from that represented at the 2-digit SIC level. Modeling impacts at the 4-digit level reduces the inaccuracies associated with industry aggregations.

Impacts can be evaluated for an individual event or for groups of events. The ability to group events is an important feature that can be used to deal with aggregation problems. For example, IMPLAN's wholesale trade sector consists of numerous industries with very different production processes. Note that the wholesale trade production function represents an average of all of these different industry production processes. If the focus of analysis is on only one of these wholesale trade industries, stimulating the entire wholesale trade sector may lead to large inaccuracies if that industry's production process is very different from the average wholesale trade sector production process.

A more accurate approach might use a procedure such as the following: (1) determine the production function of the individual industry; (2) determine the change in the industry's output and the associated input changes for each sector; (3) for each input, stimulate that sector's output with the change calculated in (2). Stimulating a sector's output is an individual event in IMPLAN. The ability to combine the stimulation of all of the input sectors (i.e., individual events) into a group makes it possible to model industry output change more accurately.

A similar approach could be used to stimulate IMPLAN using an OCS E&D scenario. The production function for OCS oil and gas development would need to be determined and multiplied by the levels of output specified in the particular E&D scenario. The resulting inputs in each year could become an event that is used to stimulate IMPLAN.

3.5 OTHER REGIONAL AND LOCAL ECONOMIC MODELS

In addition to the RAM and IMPLAN models, there are several other economic models that could be used as the second step model to calculate the indirect and induced impacts of OCS oil and gas activities. These include the Regional Economic Models, Inc. (REMI), the Regional Industrial Multiplier System (RIMS), and The Man-in-the-Arctic Program (MAP) model. These models are described in more detail in the following paragraphs.

REMI

The REMI (Regional Economic Models, Inc.) model is a dynamic regional input-output model created and sold by the consulting firm of the same name. It has been used and continually refined since 1980 to reveal the economic and demographic impact that public policy initiatives or external events may have on a local or regional economy and population. REMI is available in 14-sector, 53-sector and 172-sector versions, all of which are available in Windows format. The REMI model is calibrated to many sub-national areas for forecasting and policy analysis.

The structure of the model incorporates inter-industry transactions and endogenous final demand feedbacks. In addition, the model includes substitution among factors of production in response to changes in relative factor costs, migration in response to changes in expected income, wage responses to changes in labor market conditions, and changes in the share of local and export markets in response to changes in regional profitability and production costs. The model combines several different kinds of analytical tools including economic-base, input-output, and econometric models and has the ability to account for business cycles.

REMI’s structure can be summarized as exogenous demands driving an iterative solution of output and endogenous final demands. REMI estimates relative regional prices - wages, production, costs, and profitability - which contribute to the region’s competitiveness. Competitiveness is reflected in changes in the regional purchase coefficients and export market share coefficients. This simulation agenda is somewhat ambitious and the REMI models are consequently very complicated. The REMI model is available for purchase, rental or individual studies and at different levels of industry detail.

While the REMI model also has an excellent reputation, MMS decided to use a static I-O model, because MMS wanted to be able to change the way it grouped onshore geographic units for analysis. Changing "regions" requires that the model be rebuilt, something that is quite easy for the user to do with IMPLAN but very time consuming or expensive with a dynamic model such as the REMI model. In addition, the IMPLAN model is already being used by several MMS contractors, is easier to understand, and is less expensive than the REMI model.

RIMS II

In the 1970's, the U.S. Department of Commerce, Bureau of Economic Analysis developed a method for estimating regional I-O multipliers known as RIMS (Regional Industrial Multiplier System). In the 1980's, BEA completed an enhancement of RIMS known as RIMS II. RIMS II is based on an accounting framework called an I-O table which shows for each industry the industrial distribution of inputs purchased and outputs sold.

A typical I-O table in RIMS II is derived mainly from two data sources: BEA's 1992 national I-O table, which shows the input and output structure of nearly 500 U.S. industries, and BEA's 1995 regional economic accounts, which are used to adjust the national I-O table to show a region's industrial structure and trading patterns. RIMS II multipliers can be estimated for any region composed of one or more counties and for any industry, or group of industries, in the national I-O table. Users must provide geographically and industrially detailed information on the initial changes in output, earnings, or employment that are associated with the project or program under study. The multipliers can then be used to estimate the total impact of the project or program on regional output, earnings, and employment.

The RIMS II method for estimating regional I-O multipliers is basically a three step process. In the first step the producer portion of the national I-O table is made region-specific by using four-digit SIC location quotients (LQs). RIMS II uses LQs based on two types of data: BEA's personal income data (by place of residence) for LQs in the service industries; and BEA's wage-and-salary data (by place of work) for the LQs in the nonservice industries. The household row and the household column from the national I-O table are made region-specific in the second step. In the last step, the Leontief inversion approach is used to estimate multipliers. This inversion approach produces output, earnings, and employment multipliers, which can be used to trace the impacts of changes in final demand on directly and indirectly affected industries.

The greatest disadvantage of the RIMS II model is the lack of flexibility. For example, RIMS does not allow for the creation of custom multipliers based on specifics of the Alaska economy. This is an essential part of improving the accuracy of the impact estimates and creating these custom multipliers can easily be done with IMPLAN. Moreover, since MMS has already chosen to use IMPLAN for other regions, this model would not provide comparable results for the equitable sharing analysis.

MAP

The Man-in-the-Arctic Program (MAP) model was developed by the University of Alaska-Anchorage for the Minerals Management Service (MMS) in the 1980's. Using direct OCS employment projections from the Manpower Model and Exploration and Development scenarios from MMS, the MAP can project indirect and induced employment, State government revenues, and the sum of local government revenues within Alaska.

According to staff at the University of Alaska Anchorage Institute of Social and Economic Research, the MAP model is updated when the Institute has received contracts for which using the MAP was appropriate. This has generally occurred every year or so.

One drawback of the MAP model is that the Institute would require funds to update it and charges a fee for each run. In addition, as MMS has already chosen to use IMPLAN for other regions, this model, like RIMS and REMI, would not provide comparable results for the equitable sharing analysis.

3.6 CRITIQUE OF CURRENT MODELING PROCEDURE

The current procedure for modeling the economic impact of oil and gas exploration and development on the North Slope has both strengths and weaknesses. Many of these are inherent to the two models, Manpower and RAM, used in the analysis. Others are an outgrowth of the combination of the two models.

As discussed earlier, the Manpower model has the advantages of having been estimated specifically for the oil and gas industry in Alaska and of treating the industry as a set of events that can be combined in different proportions to produce a final output. On the other hand, since the model only is concerned with labor inputs it fails to recognize that differences in production methods may create differences in impacts. Moreover, it is poorly documented, current activities appear less than comprehensive and there is a need to update the model to reflect production processes currently used on the North Slope. Finally, the structure of the current Manpower model is inflexible in that many parameters are held fixed for the forecast horizon and are imbedded in equations such that they are not easily adjusted.

The RAM model also has the advantage of being specifically tailored to the local area as well as benefiting from a recent update. While it is somewhat simple this may be an advantage compared to the errors that might result from applying a large complex model based on state and national data to a small unique economy. On the other hand, RAM does not differentiate between indirect and induced impacts, nor does it specify which impacts are attributable to residents and non-residents. It also may be too simplistic in the assumption that the ratio of indirect to direct impacts is independent of the level of activity or the technology used. A final disadvantage of RAM is that it does not come with a state or national level geographic model which can be used to assess impacts at the state or national level.

The combination of the two models also introduces some additional disadvantages. One is that all of the Manpower output is reduced to a single number, total oil industry employment excluding headquarters employment, for entry into the model. All of the rich detail on skill levels, industry, Native/non-Native employees, and onshore/offshore location is lost. A second concern is the extent to which the definition of what is part of the oil industry may not be consistent between the two models. The Manpower model contains a variety of activities that together comprise the model's definition of the oil industry. At the same time, the RAM model has a multiplier based on economic base modeling approach where total employment in the economy is related to employment in the economic base. However, if the economic base is defined in a vastly different manner in this model than in the Manpower model this may result in an improper accounting of indirect activities. These indirect activities are the support functions, often not provided by the oil companies, but supporting their operations.

3.7 ALTERNATIVE MODELING PROCEDURES

The current modeling, especially with an updated Manpower model, appears capable of providing reliable estimates of economic impacts for the local area. However, additional alternatives exist that may also provide credible local estimates. At the same time these alternatives may also offer several other desirable features including:

- Estimates of impacts for the entire state
- Estimates of impacts for the other states or areas including national estimates
- Estimates that are consistent with MMS economic impact estimates for E&D activities in other regions
- Separate estimates of indirect and induced impacts
- Estimates of distributional impacts.

The remainder of this chapter examines alternative methods that might be employed to model economic impacts. Alternative methods for modeling economic impacts that will be examined include:

- New Manpower model and RAM
- New Manpower model and MAP
- The full vector approach (Artic IMPAK) with alternative "national model"
- The full vector approach (Artic IMPAK) with IMPLAN

The ***full vector approach*** refers generally to the project team's proposal to develop complete I-O vectors for each sub-activity, rather than just labor inputs as originally envisioned by MMS. A basic setup of the data to be developed for this approach is provided in Exhibit 3-8. Note that his exhibit merely provides a simplified example of what the output of this procedure would look like. The sectors provided are merely examples as is the format of the data. Actual tables are developed and provided in later chapters of this report.

The remainder of this section will describe each of the alternative approaches, discuss their potential strengths and weaknesses, and estimate the difficulties in developing the data and models to utilize each method. Alternative approaches will then be ranked and the top alternatives to the current methodology will be identified.

EXHIBIT 3-8: BASIC SETUP OF TABLE FOR NEW MANPOWER MODEL, ARCTIC IMPAK

SIC CODES	IMPLAN Sectors	Expenditures	% Spent in Study Area	% Spent in Alaska	% Spent in Rest of U.S.
1. 131 (Natural gas & crude petroleum	38	$$	X%	X%	X%
2. 132 (Natural gas liquids)	37	$$	X%	X%	X%
3. 1629 (New gas utilities & pipeline construction)	50	$$	X%	X%	X%
4. 1629 (misc. nat. res. Fac. construction	53	$$	X%	X%	X%
5. 1381, 1382, 1389 (New well drilling, O&G ex., other O&G svcs.)	57	$$	X%	X%	X%
6. 2899 (Chemicals, nec)	209	$$	X%	X%	X%
7. 291 (Petroleum fuel)	210	$$	X%	X%	X%
8. 324 (Hydraulic cement)	232	$$	X%	X%	X%
9. 3317 (Steel pipe)	258	$$	X%	X%	X%
10. 3443 (Fabricated plate work)	284	$$	X%	X%	X%
11. 3462 (Iron & steel forgings)	290	$$	X%	X%	X%
12. 3511 (Turbines)	307	$$	X%	X%	X%
13. 3531 (Const. mach. & equip.)	311	$$	X%	X%	X%
14. 3533 (O&G field machinery)	313	$$	X%	X%	X%
15. 3559 (Spec. ind. Mach. Nec)	331	$$	X%	X%	X%
16. 3561, 3563 (Pumps & compress.)	332	$$	X%	X%	X%
17. 3613 (Switchgear)	356	$$	X%	X%	X%
18. 3731 (Shipbuilding)	392	$$	X%	X%	X%
19. 3823 (Instrumentation)	403	$$	X%	X%	X%
20. 44 (Water transport.)	438	$$	X%	X%	X%
22. 45 (Air transport.)	437	$$	X%	X%	X%
22. 58 (Eating/drinking places)	454	$$	X%	X%	X%
23. 7359 (Misc. equip. rent/lease)	473	$$	X%	X%	X%
24. 8731, 8732, 8734 (Test/resrch. Svcs.)	509	$$	X%	X%	X%
25. 871 (Envir./engineering svcs.)	508	$$	X%	X%	X%
26. 872, 879 (Acctg./misc. bus. Svcs.)	507	$$	X%	X%	X%
EMPLOYEE COMPENSATION	NA	$$	X%	X%	X%
Wage Rate					
Total Man-Hour Per Year					
Total Man-Months Per Task Per Unit					
Duration of Task (Months)					
Total Task Workforce Per Unit					
Task Crew Size					
Shift Factor					
Rotation Factor					

New Manpower Model and RAM

In addition to developing expenditure vectors the project team compiled employment and payroll figures for each unit and activity. This allows for a full accounting of the first round direct impacts in terms of both expenditures and employment. As was past practice, it is still possible to use the sum of the direct employment impacts (residential + non-residential, excluding impacts at headquarters) to stimulate RAM.

Since the updated manpower model is more comprehensive in terms of the activities incorporated, the direct impacts may be higher than previously estimated. Such an outcome would also result in relatively higher estimates of the secondary impacts.

Given the use of RAM, the criticisms of RAM cited above would apply to this approach.

New Manpower Model and MAP

While it is conceivable that the manpower model could provide inputs that would allow the MAP model to estimate economic impacts this option was never seriously considered due to the cost of the MAP model and the fact that it would not provide comparable results for the equitable sharing analysis. The same criticisms hold true for using the MAP model together with the full vector approach.

Full Vector Approach (Artic IMPAK) With Alternative "National Model"

The full vector approach could be applied with an alternative national model. However, as described above, REMI and RIMS II, the two most widely used alternatives, have drawbacks in terms of cost and flexibility, respectively. In addition, these models would not provide comparable results for the equitable sharing analysis. For MMS to develop its own national model would require too much staff time and expertise. Relying on lesser-known models would raise questions of future availability and other concerns.

Full Vector Approach (Artic IMPAK) with IMPLAN

The IMPLAN model provides the best alternative to the continued use of Manpower and RAM. Such a modeling scheme will provide detailed breakdowns on local impacts as well as state and national data that will be comparable to the IMPLAN generated data for other areas under study by MMS. The main questions concern the accuracy of the local impact data that will be generated by IMPLAN as compared to the more locally tailored RAM model. The belief is that the detailed first step model employing the full vector approach (Artic IMPAK) will provide such a complete version of local first round impacts that IMPLAN will be capable of accurately generating the secondary impacts.

The following paragraphs discuss some of the technical considerations in the application of the IMPLAN model.

For each activity, the updated Manpower Model will generate employment estimates, capital assets used (e.g., number of helicopters), and a vector of input expenditures (including payroll). How those data are brought into IMPLAN will depend upon whether the activity is a construction activity or an operations activity.

If the activity is an operations activity, the data will probably be entered in the following way. First, each intermediate input used in the operation will be mapped to an IMPLAN sector. Second, those sectors will be stimulated with output changes that depend upon the activity level. Third, personal consumption expenditure (PCE) vectors in IMPLAN will be simultaneously stimulated based upon worker earnings due to the activity. Here several considerations will come into play. For instance, the earnings will have to be converted into disposable income estimates using tax and savings rate information. Since there are nine PCE vectors in IMPLAN, each one associated with a different income group, it will also be possible to allocate the earnings among these income groups or to select one of them. Another consideration is the different expenditure patterns that may be exhibited by residents and non-residents: if this is the case, it may be desirable to divide the earnings between to these two groups, and then customize their expenditure patterns.

If the activity is a construction activity, a few additional steps and/or considerations may be required. For example, the construction activity may include the purchase and installation of industrial machinery (i.e., equipment investment), which is not an intermediate input per se. These investments still should be mapped to IMPLAN sectors and the output of those sectors stimulated according to the associated activity level. At this point, the analyst has a choice in how to proceed. One avenue is to stimulate the correct construction sector with the difference between the total construction cost and the equipment investment. This is the easiest approach to take and does not require multiple adjustments of the PCE vectors. However, using this approach it would not be possible to incorporate the different expenditure patterns between the residents and non-residents. The other approach is to follow the approach outlined for operations. While this approach will probably yield more accurate results, the analyst should avoid mapping any of the inputs into IMPLAN's construction sector. Doing so could result in double counting and exaggerated impacts for some sectors.

Another consideration will be how to treat the use of heavy equipment such as earth-moving equipment and bulldozers. Engineering cost will be developed for the use of such equipment. However, in some instances the equipment may be rented whereas in other instances it may be owned by the company and a depreciation charge incurred. The first instance results in an economic stimulus to the region; no stimulus is generated by the depreciation of the asset. Some rules of thumb or estimates may be needed to allocate these types of costs.

In using IMPLAN, the two other primary considerations will involve the use of margins and regional purchase coefficients (RPCs). Retail margins should be used with the PCE vectors and investment margins should usually be applied to the stimulation of the industrial sectors. The IMPLAN margins will probably need to be modified to take into account the special circumstances on the North Slope.

Regional purchase coefficients should also be used whenever possible: i.e., with the PCE vectors and the industrial sectors. Using RPCs with the PCE vectors makes sense since many retail goods may be acquired outside of the North Slope (e.g., in Fairbanks). Note that even if an RPC is set to zero (meaning that the commodity is not produced locally), margin sectors in the region such as transportation and wholesale trade can still be stimulated. Again, these adjustments to the standard IMPLAN RPCs will probably be required to reflect the special circumstances on the North Slope.

4. ENGINEERING DESCRIPTION OF THE ACTIVITIES

The purpose of this study was to develop economic data characterizing the inputs to the activities that comprise the exploration and development process in the Alaskan OCS. The beginning point in developing these data was the collection of detailed engineering descriptions of the activities. These descriptions provide details on the economic inputs to the activities including labor, materials, and equipment. For labor, these descriptions include information on the numbers and pay rates for the various workers employed for each task. For materials, these descriptions include information on the cost and quantity. For capital, information was often gathered on the numbers and types of equipment purchased, along with separate estimates of the costs of shipping these pieces to the North slope and retrofitting them for the harsh arctic environment

The following sections provide a summary of the information collected for the various activities including general descriptions of the engineering specifics of the activity, the sources of the data, and summaries of manpower requirements, capital needs and fuel and material inputs.

4.1 SEISMIC SURVEY

The manpower and input vector estimates were developed for one month of a geological geophysical seismic survey on ice. Generally, ice in the Beaufort Sea will support survey equipment from January 1st to May 1st, limiting survey work to those months. Surveys can also be conducted on water, but this is generally not the case.

Surveys on ice are conducted using a caravan of vehicles designed to operate on the sea ice. These vehicles are often “tracked” vehicles (i.e., they use “tracks” rather than tires). The majority of these “tracked” vehicles are manufactured by the Caterpillar Company and therefore the vehicles are often referred to as “cats” and the survey caravan as a “cat train”.

The average contract price per day for a seismic survey setup, including the cat train, is $120,000 per day according to the contractors interviewed for this study. Assuming 30 days per month, costs for a month would be $3.6 million. These are actual construction costs. It is assumed, based on interviews with industry personnel conducted for this study that, by including costs of oil company personnel permits, leases, royalties purchased services and all other resources, the total dollar cost would be double to $240,000 per day or $7.2 million per month.

The analysis of the seismic survey activity is based on a series of interviews supplemented by the engineering and economic experience of project staff. Interviews that were conduct with the following sources:

- A cat train manager for a firm providing cat train support for seismic surveys
- A truck operator for a seismic survey company

- The owner of a firm providing cat train support for seismic surveys
- The owner of a seismic survey company
- An Anchorage equipment firm sales person who is assigned to the North Slope Territory
- The owner of a fuel/aviation firm

Overview of the Activity

The remainder of this section provides the engineering information that was collected from the interviews and other sources. Included is general information on the activity and as well as more specific information on capital, labor and material inputs.

In general, to conduct a survey, a cat train company provides support for a seismic survey company. In the case study, the cat train provider that was interviewed provides support on a regular basis to one of the survey companies that were interviewed. In the paragraphs that follow, a short summary of the seismic survey process is provided, followed by sections describing the seismic survey camp, and the capital equipment, labor and fuel requirements.

The first step in conducting a survey is to run seismic lines. These lines may run 20 miles a day requiring the entire cat train to move 20 miles per day. The lines consist of four ten-mile-long geophone lines run a quarter of a mile apart and connected to a CPU data collection unit. After the lines are set, two groups of five shaker trucks stop to shake the lines at vibration points every 1/6th mile. The trucks "leap frog" between the center two jug lines. The lines establish basic data over an entire lease area.

As the lines produce areas of interest, the next step is to set up a grid to profile the geological and geophysical characteristics of these areas. A grid consists of eight geophone lines, a quarter of a mile apart and ten miles long. The geophone lines ("jug lines") are connected to a CPU data collection unit ("dog house"). This unit may be mounted on a “Foremost” truck or on a sleigh pulled by a “Nodwell,” which is a track vehicle similar to a snow cat used at a ski area. Two groups of five shaker trucks then "leap frog" across the jug lines at quarter mile intervals, working up and down the grid until the ten miles of line have been covered. The shaker trucks stop at every vibration point (VP). The shakes are initiated by a tone from a controller in the doghouse, and all five trucks in a group shake at once. A shake consists of four, two second shakes-one to set the plate and three to record data. There are eight VP's between each jug line. About 500 VP's per day are common and require 16 to 18 hours a day to accomplish.

Grid profiling requires the camp to move two to three miles every two days. If fuel is delivered by air, each camp move would require a runway to be plowed 1,500 feet long to accommodate service from twin otters. If DC-6 fuel planes are used, a 5,000 feet airstrip is plowed.

Camp Support

Surveys on ice require four D-7 cats, one Model 65 Cat Challenger, one 966 Cat loader and six operators with the cat train company, and around 94 personnel and associated equipment with the survey company. The D-7 winch cats are used on ice as their total weight is 51,000 pounds each. The Challenger is a rubber tracked vehicle and is much faster than a steel tracked vehicle.

The cat train consists of six strings, each pulled by one of the D-7 cats, the 966 loader or the Model 65 Challenger. A string is a series of sleighs pulled by one of the cats. The makeup of each of the six strings is as follows:

String #1 - Office String of Three 60-foot Sleighs (or units)

The first sleigh in this string is a generator unit with a 500 gallon fuel tank. The rear half of the generator unit contains toilets, showers, and a washroom. The second sleigh is an office unit, consisting of offices, a piece of equipment for snow melting, and staff sleeping quarters. An incinerator is also towed behind this string.

String #2 - Kitchen String of Three 60- foot Sleighs

The first sleigh in this string is a generator unit with a 500 gallon fuel tank. The rear half of the generator unit is a mechanics shop. The second sleigh is the kitchen and dining area. The third is kitchen storage and quarters for the cooks.

String #3 - Quarters String of Three 60-foot Sleighs

The first sleigh is the generator unit, with fuel tank. The rear half of this first sleigh is the spare parts house. The second and third units are crew sleeping quarters.

String #4 - Cat Train Camp Support String of Three 60-foot Sleighs

The first sleigh in this string is a generator unit with a 3,000 gallon fuel tank. The rear third of this generator unit contains toilets, showers, and washer and dryers. The second unit contains sleeping quarters with offices. The third sleigh contains sleeping quarters with storage. A junk sleigh may be towed behind this string, used for anything from spare tires, iron, and anything that has to be hauled back. This string is towed with a 966 Cat loader. A loader has many tasks on the train including loading snow into the snow melter.

String # 5 - Fuel String of Two 60-foot Sleighs

This string has two 60-foot sleighs, with two 3,000-gallon fuel tanks on each sleigh for a total of 12,000 gallons.

String #6 - Fuel String with Survival Unit

This string is the previous fuel string with the addition of an 8- foot survival unit, which is towed along to haul fuel from sources up to 70 miles away. A Cat Challenger Model 65 is used to pull this string, as the rubber tracks allow speeds three times that of a D-7, or approximately seven to ten MPH.

Equipment Purchase Cost and Location

The Cat Train equipment lasts about 10 years and then has to be replaced or rebuilt. In practice, this equipment is usually replaced rather than rebuilt. The following information was gathered on Cat Train equipment purchase location and cost.

- The D-7 winch Cats cost $360,000 and are purchased in Anchorage, at NC Machinery (NC). Arctic fitting costs average around $7,000 and shipping to the Slope costs $3,000.

- A Challenger 65 costs $190,000 at NC. It is then equipped with an angle blade for $20,000, prepared for the arctic for $6,000, and shipped for $3,000.

- The Cat 966-bucket loader costs $260,000 at NC, with an additional $10,000 for arctic preparation and $3,000 for shipping to the Slope.

The following seismic equipment lasts about seven years and has to be replaced. Rebuilding is not practical due to technology changes with this type of equipment.

- Seismic recording lines, including the CPU or “doghouse,” cost about $2,000 per channel, or $6 million for this 100-man setup

- Ten Shaker trucks cost about $450,000 each, delivered to the Slope.

- Survey equipment costs around $300,000 including RTK and GPS.

- The Nine Nodwells that are used for jug trucks, personnel carriers and trouble-shooting were purchased for $2 million dollars total, delivered to the Slope.

- A 100-man camp, made by Arctic Camps, costs $2.2 million dollars, delivered to the Slope. The camp includes all of the modular sleigh mounted equipment, fuel tanks and quarters.

Fuel Supply and Cost

If the survey is being conducted in the area of the Prudhoe Bay infrastructure, rubber tired Delta fuel trucks may shuttle fuel that is refined at the Crude Oil Topping Unit (COTU) plant in Prudhoe Bay. They haul 2,500 gallons per load. These trucks will normally haul to the end of the ice roads, and then pump their load onto the Challenger fuel string. The Challenger may travel up to 70 miles to deliver fuel to the Cat Train. During the winter months on a cat train, all of the equipment runs 24 hours a day, as it is very difficult to warm equipment and to start in the Arctic.

The generators use an average of 150 gallons of fuel per day. The cats also use 150 gallons per day. With all of the other equipment running 24 hours a day, the total fuel consumption for a 100-man cat train is 3,600 to 4,500 gallons per day. Most of the fuel used for surveys on ice is refined at the COTU in Prudhoe Bay at a cost of $1.00 per gallon. The average cost for the Delta trucks to deliver the fuel is $0.50 per gallon. The Challenger rents for $77 per hour and $100 each for the fuel sleighs, for a daily cost of about $3,324 per day. The fuel cost per month for Prudhoe refined fuel is $121,500 (not including transportation costs for the Delta trucks or the Challenger fuel string).

If the survey is being conducted greater than 70 miles from a fuel storage source, a DC-6 fuel plane delivers fuel from Fairbanks for $6,000 per load. However, according to sources interviewed for this study, fuel planes have not been used in several years. The cat train cats clear a 5,000 foot runway for the fuel plane.

Fairbanks fuel is around $0.65 per gallon at the North Pole Refinery, plus $0.11 per gallon trucking to the airport and $6,475 per flight, for a delivered cost of $2.23 per gallon. The cost per flight is based on $9.25 per statute flight mile from the Fairbanks Airport. The costs for longer flights to the Chukchi and Hope Basin can be calculated based on this cost figure.

Personnel and Overhead Costs

Most of the 100 survey crew members work 4 weeks on and 2 weeks off. As a result, about a 30 percent over hire is required. For the permanent employees (about half), there is a $7.00 per hour benefit package. Workdays lasting 16 to 18 hours are common; so a lot of overtime, at time and a half, is paid. Meals are $37.00 per day per person. Overhead runs 38%.

The 100 personnel are paid as follows:

- Six catering staff at $14.00 per hour
- Four surveyors at $300 a day contract and three at $150 per day
- Six Cat train operators at $16.00 hour
- Crew includes 35 staff at $7.00 per hour, 8 staff at $8 per hour, 10 staff at $9 per hour and 6 staff at $12 per hour
- The remaining 12 personnel at $4,583 per month salary.

4.2 NORTH SLOPE SUPPORT

The development of oil and gas resources on the North Slope is carried out in a remote environment where all but a handful of local Native workers require short-term room and board.

As a result, most of the workers involved in the various activities are housed in employer provided hotel/camp type facilities. These facilities are most often run by contractors.

The manpower and input vector estimates for this activity were developed based on costs for an actual 300-person hotel/camp. The owner of a facility of this type was among those interviewed for the study, and this source provided much of the manpower and cost data used in the estimates.

The estimates assume that capital costs for the construction of the facility are sunk and are therefore not included in the estimates. This provides the most accurate estimate of economic impact, because it is unlikely that the activities to be modeled will require the construction of new hotel/camp facilities. According to the interviews conducted for this study, it has been at least 12 years since a new camp has been built. On the other hand, an old Native construction camp was recently renovated for the Northstar project. As such, the costs of maintaining facilities are included in the cost estimates, as these costs are ongoing.

In this study, these food and lodging activities are considered a secondary activity. As a result, the level of this activity is determined by the levels of the primary activities that utilize workforces that require these services. In the primary activities, employers are assumed to pay $75 per day ($110 per day for supervisory personnel) for each worker that will be housed in a hotel/camp. These payments are summed in the model and used to stimulate this vector. The daily rate of $75 a day for food and lodging was developed from the interviews and verified based on the experience of study personnel. The higher rate of $110 per day for supervisory personnel covers the cost of office space and a private bath.

Total yearly revenue for the hotel/camp is estimated based on a capacity of 300 lodgers of whom two-thirds are assumed to be at the $75 per day rate and one-third are at the $110 rate. Furthermore, the hotel/camp is assumed to have a 365 day a year operating period and an average occupancy of 80 percent. The resulting annual revenue estimate is $7,592,000.

The remainder of this section provides engineering information that was collected from interviews and other sources. Included is general information on the activity and as well as more specific information on capital, labor and material inputs.

Overview of the Activity

According to the interviews, a resident staff of 20 is required to operate a 300-person hotel/camp. However, total employment is thirty as ten more personnel would normally be on leave (time-off). Ninety percent of the staff is unskilled at a cost of $300 per day. Ten percent is skilled at a cost of $400 per day. Ninety percent of the staff is Alaska hire with the remaining ten percent drawn from the other 49 states. Fifteen percent of the total staff is Native hire.

Major activities include the provision of food, laundry of linens and towels, provision of electricity and heat, provision of water and sewer services and the maintenance of the property.

The following paragraphs describe the major cost components required to operate a 300-person hotel/camp. The process is divided into six tasks. Each task description includes information on the types and quantities of labor employed, as well as the numbers and types of equipment used and any materials required.

Task A: Food Service

On a weekly basis, four tractor-trailer trucks, from Fairbanks and Anchorage, service most of the camps/hotels on the North Slope. Two major vendors involved are Food Services of America and Anchorage Cold Storage. The raw cost of food per person per day is $12. It is estimated by study engineering staff that one-third of this cost is for transportation costs. The food is then prepared on-site and billed at the rate of $30 to $35 per person.

Task B: Commercial Laundry

Laundry is hauled back and forth to Fairbanks where it is processed once a week, along with housekeeping supplies, for a raw cost of $1 a day per person. Personal laundry is done in laundry rooms located at the camp. It is estimated by study engineering staff that one-half of this cost is for transportation and that 75 percent of the remaining cost is for laundry and the balance for housekeeping supplies.

Task C: Power Generation and Co-generation

The hotel/camp used to develop this profile has its own generators that run on diesel fuel. Two generators are maintained to provide backup in case one fails. In addition, the camp is tied into the local power grid and provides or takes electricity when necessary. A few camps rely solely on power from the local grid, but these camps are an exception to the rule. The raw costs for operating the generators are 7.5 cents/KW/hr. It is estimated by study engineering staff that the generators would cost about $375 per hour to operate with $175 of this cost for capital, $150 for fuel, and $50 for miscellaneous material inputs including oil, antifreeze, “clean sweep” and other inputs including rags.

Task D: Water Treatment

The hotel/camp used to develop this profile has its own water treatment plant. Typically, lake or river water is hauled or pumped to the water treatment plant where it is filtered, chlorinated and treated with iodine and other chemicals. Eco-flush toilets and shower nozzles are used to conserve water. A total of 20,000 to 25000 gallons per day (75-100 gallons per day per person) is used at approximately four cents per gallon. It is estimated by study engineering staff that the $900 daily cost is made up of $350 for hauling, $200 for capital, $150 for chemicals, $100 for fuel (mostly electric) and $100 for filters.

Task E: Sewage Treatment

The hotel/camp used to develop this profile has a grandfathered sewage plant with an evaporative pond, and can process the 20,000 to 25,000 gallons per day of wastewater at a rate of 2 cents per gallon. In some areas of the NSB, commercial processing and hauling of sewerage is required. Where this is the case, this cost can go as high as 19 cents per gallon. Most of the existing camps, however, have their own sewage treatment. It is estimated by study engineering staff that the $450 daily cost is made up of $150 for capital, $100 for chemicals, $100 for incinerator equipment and $100 for fuel (mostly electric).

Task F: Building and Equipment Maintenance

Building and equipment maintenance is performed by two of the skilled staff. Office, shop, and storage areas are required to keep records, repair appliances and equipment, and store spare parts. A cost of $25,000 a month (not including labor) is average. Maintenance personnel must be "jacks of all trades" and operate the generators, water and sewer plant, repair any camp system, keep records, and maintain an inventory of spare parts. Maintenance items include light bulbs, windows, roofing materials, cabinets, doors, and appliances and parts.

4.3 GENERAL PASSENGER TRANSPORT

The manpower and input vector estimates were developed for one day of general passenger transport. For this activity it is assumed that the operation will consist of a small transit type operation with one forty passenger bus and three large 15 passenger vans.

This type of operation is of crucial importance on the North Slope. Work crews are constantly rotating on and off duty whether from day to night shift or from two to four weeks on to two weeks off. Since none of these workers live in the area, there are no personal passenger vehicles to transport them between the airport, the hotel/camp and the work site. Transport in the North Slope area for OCS projects during the period ice roads can be used, is described in this section. In other periods of the year, helicopter transport is used, as discussed in another section of this chapter.

No overall estimate of the cost of this operation is available. Total revenue for this operation will, therefore, be estimated from the bottom up by summing estimates of labor, material, capital and purchased services. It is estimated from interviews with several contractors, as reported in Section 4-1, that the average cost of this service per North Slope based production employee is $15 per day.

The analysis of the general personnel transport support activity is based primarily on the experience of project staff and their familiarity with this type of operation in the North Slope.

The remainder of this section provides the engineering information that was collected from the interviews and other sources. Included is general information on the activity and as well as more specific information on capital, labor and material inputs.

Capital Cost

In order to efficiently shuttle workforces primarily over ice roads between the airport, the hotel/camp and the work site, a variety of buses, vans and pickups are used. For this hypothetical operation, it is assumed there will be one bus and three vans. The bus has a capacity of 40 people and is equipped for the arctic environment with extra heaters and insulation at a cost of $75,000. The van has a capacity of 15 people and is equipped for the arctic environment with extra heaters and insulation at a cost of $50,000. During the summer transport to the islands is generally via helicopters with 12-passenger capacity.

Manpower and Cost

According to project staff, this hypothetical general passenger transport operation would be staffed by four drivers, a two member maintenance crew, and a dispatcher/supervisor. According to the engineering project staff, personnel of this type would generally work two weeks on and two weeks off. The employees would work a 12 to 14 hour day. There are no Native employees in this operation. This is primarily because this function is integrated with a security function and contracted out.

Fuel Use

It is estimated that the bus will consume 40 gallons of fuel per day and that the van will consume 30 gallons of fuel per day.

4.4 ICE ROADS AND ICE ISLANDS

The manpower and input vector estimates were developed for a ten-mile ice road and a 500 foot diameter ice island. The estimates assume that the road is built to a minimum of five feet of depth. This is the minimum depth to which ice roads are normally constructed and is an adequate depth to support normal operations. However, if heavy equipment, such as drill rigs, need to be transported the road will either have to be built to a thicker depth of 10 to 20 feet, or grounded. In the IMPAK model, depths with a five foot minimum and twenty foot maximum are specified by the user.

The average contract price for minimum size five-foot thick floating ice road, according to the contractors interviewed for this study, is about $50,000 to $55,000 per mile. The high end of the range was used here. By way of comparison, onshore tundra ice roads cost about $35,000 per mile to construct. These are actual construction costs. It is assumed, based on interviews with industry personnel conducted for this study that, by including costs of oil company personnel, permits, leases, royalties purchased services and all other resources, the total dollar cost would be double to $110,000 per mile.

Costs for ice roads are estimated to increase more than proportionally to depth. For example a 10-foot deep road would cost four times more than a 5 foot deep road, a 20-foot deep road sixteen times as much. The costs of various size and depth roads can be estimated using these relationships through the use of a simple algorithm.

The technology for construction of an ice island is nearly the same as for ice roads. The construction costs for the ice island are developed by applying ratios of the relative surface areas or relative volumes to the task level estimates of labor, capital and materials. Relative surface areas are used to adjust work tasks that involve surface areas while relative volumes are used for tasks that involve volumes. It is assumed the ice island is built to a depth of 20 feet.

The relative surface area of the island is 62 percent of one mile of ice road or 6.2 percent of a ten mile portion of ice road. The island has a 500 foot diameter or a 250 foot radius. The estimated surface area of the island is estimated by applying the formula for the area of a circle (Πr2). The resulting estimated surface area is 196,350 square feet. One mile (5,280 feet) of ice road at 60 feet wide has a total area of 316,800 square feet.

The relative volume of the island is estimated to be almost 10 times greater than a mile of ice road or approximately equal to ten miles of ice road. The ice road is to be built to five feet of depth, while the island is to be built to 20 feet of depth. As mentioned above, costs increase more than proportionally to depth, such that an ice road of 20 feet depth is estimated to cost 16 times an ice road of 5 foot depth. Multiplying the factor of 16 for depth times the factor of 62 percent for relative surface area results in a factor of 9.9, which is a measure of relative volume between an ice island and a mile of ice road.

Reliable data on the cost to construct an ice island were not provided in the interviews. The best guess available was that one would cost in the $500,000 range.

The analysis of ice road and island construction costs were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff. Interviews were conducted with the owners of two construction firms that build ice roads.

Overview of the Activity

Ice road construction takes approximately a 50-man crew, a small grader, and snow blower equipped with floats (capable of operation on 8" of ocean ice), four Rollagon pumpers, three water trucks, two dump trucks, one ice mill mounted on a grader, one large grader, nine pickup trucks and a survival shed. The first step is to travel out onto about 8" of ice with the small grader and snow blower, removing the snow from the ice road path. This can normally start around the last half of December. The snow removal process is ongoing through construction and the end of ice road service life which is about the first of May.

Next, the Rollagon pumpers are placed in service. They drill and pump in the same operation. They relay around each other, up and down the ice road, until the ice is thick enough for other vehicles. The road is then staked with reflectors to identify the profiled road edges. Fresh water and milled ice chips are used to make ramps from shore to the ice and supplement the saltwater drill-pump operation. The ice chips are hauled with dump trucks, and the fresh water is hauled with water trucks equipped with fan spray nozzles. Any cracks that appear are repaired with fresh water to keep the road from separating and drifting. The construction process continues until the road is thick enough or grounded to handle the loads it will be employed for, including drilling rigs.

The following paragraphs describe the process of building an ice road on a task-by-task basis. The process is divided into six tasks. Each task description includes information on the types and quantities of labor that are employed, the numbers and types of equipment used and any materials required. Differences between ice road and ice island construction, were applicable, are noted.

Task A: Remove Snow with Small Grader and Snow Blower Equipped with Floats

Two operators and one supervisor, for each 12-hour shift, venture out on the ice when it is eight inches thick and remove the snow. This process takes about two days for the initial snow removal on a 10-mile road. This equipment will be used as necessary until a large grader can be used for snow removal. For the ice island, with a much smaller surface area, this task is assumed to be completed in only one shift on one day.

The small grader used by the contractor interviewed is a Future 700 that weighs 5,000 pounds, is equipped with Rollagon bags for floats, and has an escape hatch in the roof. It was a previously used machine that was reconditioned, equipped, and purchased from a Fairbanks dealer for $50,000.

The snow blower is a Rolba R/200 purchased in Switzerland through an Anchorage-based dealer for $150,000, fully equipped and delivered to the North Slope.

Task B: Flood with Pumper-Augers on Small Rollagons

Two supervisors, two snow removal operators, and six pumper operators (each 12-hour shift) drill, pump and move back and forth on the ice road with small Rollagons for 10 to 12 days until the ice is thick enough for larger equipment. For 10 miles of ice road this task is assumed to be completed in 11 days. For an ice island, with a much smaller surface area, this task is assumed to be completed in only one day.

Small Rollagons were purchased in Louisiana, at a base price of $25,000 each, and equipped for ice road operation by Houston Rollagon on the North Slope for a final cost of $120,000 each, including shipping to the North Slope.

Task C: Flood with Water Trucks and Fresh Water

Once the road is thick enough for larger equipment, the road is flooded with fresh water. The 100-barrel trucks and fresh water are used on the floating portion of the road and the 300-barrel truck is used on anchored portion of the road for eight to ten days. For 10 miles of ice road this task is assumed to be completed in nine days. For an ice island, with a slightly smaller volume of material to be added, but a greater travel distance for moving the fresh water, this task is assumed to be completed in ten days.

Two 100-barrel and one 300-barrel water trucks are used. The heavy-duty trucks were purchased from an Anchorage based Kenworth dealer at $100,000 each. The tanks were purchased from Petro Steel in Idaho for $50,000 and $100,000. The trucks were assembled, and pumps added by an equipment dealer in Fairbanks, for a final delivered cost of $175,000 each for the 100-barrel trucks and $300,000 for the 300-barrel truck.

Task D: Reinforce with Ice Chips

Ice chips are milled from a fresh water lake and then loaded and hauled to the ice road to reinforce shore banks and the surface of the road. The ice chips are spread with the grader and watered with the water trucks. This process will finish the road rapidly and is used for the last five to ten days of road construction. The four to six operators are the pumper operators, as the pumpers likely will not be used during this process. For 10 miles of ice road this task is assumed to be completed in eight days. For an ice island, with a slightly smaller volume of material to be added, but a greater travel distance for moving the fresh water and ice chips, this task is assumed to be completed in ten days.

The ice mill is a state, surplus, concrete Roto-Trimmer; it was modified, reconditioned, and a large power pack added, for about $250,000. It is mounted on a loader or grader that was purchased at an Anchorage based dealer for $200,000 each. Dump trucks are heavy-duty trucks purchased from in-state dealers at $50,000 to $100,000 each. The large grader was purchased from a local dealer at $200,000.

Task E: Stake the Road

At about five days into Task A, pickups can safely be driven on the ice roads. Supervisors, support personnel, and staking crews will then move on to the road. Reflector stakes are installed at the roadsides to keep equipment on the road during periods of poor visibility. Stakes are installed by drilling a small hole in the ice and freezing them in place. Four men and two pickups per 12-hour shift stake for four to five days. For 10 miles of ice road this task is assumed to be completed in four days. For an ice island, with a much smaller surface area, this task is assumed to be completed in only one shift on one day.

The nine pickup trucks are heavy-duty crew cab fleet trucks and are purchased from a local dealer who purchased them from a Washington State based fleet dealer for about $25,000 each.

Task F: Road Maintenance

The road is graded as needed by the large grader. Most winters this is continuous. Crews and equipment are called back as necessary to repair the road and seal cracks. Stakes are replaced as needed. For 10 miles of ice road this task is assumed to require a full-time grader operator on each shift and a staker for one shift each week. For an ice island, with a much smaller surface area, this task is assumed to require a grader operator for one shift each week.

4.5 DRILL SHIPS, BOTTOM FOUNDED PLATFORMS AND SUB-SEA WELLS

The drill ship and bottom founded platforms and sub-sea wells modeled in this study represent very similar technologies. In fact, the bottom-founded platform is essentially a drill ship that is welded on the top of a large barge. The bottom-founded platform is more expensive to construct, owing to the need to purchase a salvaged barge and to attach it to the bottom of the drill ship. It has the advantage, however, that it can be placed on the sea floor and used as a longer-term structure for exploration and production purposes.

The mobile exploration platform and the bottom-founded production platform are also based on the same set of technologies. Both begin with the drill ship welded on top of a salvaged barge. To convert the platform from a mobile exploration use to a permanent production use requires a retrofitting that is identical to equipping a gravel production island.

The sub-sea well is also a related technology. The sub-sea well is similar to any well, except that it is drilled from a drill ship and tied back to the production island with a combination sea-floor and buried pipeline.

In each case, the drill ships and bottom-founded platforms are supported by a group of vessels including an icebreakers, work boats, ocean-going tugs and fuel barges. The size and make-up of this auxiliary fleet will depend on the season and whether the operation takes place in an area of calm or rough waters. These activities are also supported by secondary activities including helicopters and barges.

Data for this task was collected from several individuals. These included:

- An interview with an individual who worked as a geophysical data collector and on a drill ship.

- An individual who worked as a crane operator on a Sinkable Island Drill Ship (SIDS), as well as working for an ice road construction firm, an ice road maintenance contractor and as a ship Engineer aboard a support barge.

- An individual who was an owner of a variety of arctic support firms including an ice road and island construction company, a barge support company, a Prudhoe Bay hotel. He also served as an equipment consultant.

The following sections provide information on the various technologies.

Drill Ships

Drill ships can be used for drilling in the summer months and when water depths are over 20 meters. They are used for drilling exploration wells and in conjunction with sub-sea wells. The drill ship modeled in this study was based on the Canmar Drill Ship Explorer III. Canadian Marine Drilling LTD or "CANMAR" has been instrumental in the development of most of the Arctic drilling technologies.

An interview with an individual who worked as a geophysical data collector and on the Canmar drill ship as a sample collector provided some background information. In this instance, the Canmar drill ship was in operation about 200 miles west of Barrow, Alaska approximately 10 miles from Russian waters.

The drill ship had a 33-man crew, including the drilling crew, ship crew, and camp support. The drilling rig was a top drive located in the center of the boat. It had a hydraulic system that allowed the boat to move up and down, about 20 feet, with the drilling equipment staying fixed to the bottom. The ship was held in position by eight anchor lines that were set by the three support work boats with 6-man crews per boat. There was a class-4 ice breaker with a 16-man crew to clear the way to and from the site, and intercept large ice flows that could compromise the drill ships position. If the seas became higher then the 20 foot limit of the drilling system, the well will be shut off at the ocean floor and the ship moved off the well and held in place by an ocean going tug with a 4-man crew. A large fuel barge supplied fuel to all of the on-site equipment. There was also a 4-man diving crew for under water support.

Two 412 helicopters provide 2-hour trips daily to and from the Canmar to Barrow. A total of 6 men flew and supported the helicopters. On shore support required another 33 personal at Barrow.

The permanent ship crew included the following personnel:

- 1 Captain
- 2 Mates
- 2 Engineers
- 4 Able bodied Seamen
- 1 Navigator

In addition, the crew sizes for the additional support activities are as follows.

- Class 4 Ice Breaker (33 crew)
- Support from Three Work Boats (16 crew)
- Ocean Going Tug (18 crew)
- Fuel Barge (4 crew)
- Two Helicopters for Support (8 crew).
- Support from Divers (6 crew)
- Onshore Support (4 crew)
- Maintenance Support (15 crew)
- Camp Services Support (6 crew)
- Seal and Cap Well(s) with a Locator (12 crew)
- M.W.D.'s (2 crew)
- Sample Takers (2 crew)
- Observer (whale watch)
- Wire Line (2 crew)

It is assumed that standard drilling crews will be used in addition to the ships crews.

The average crew wage is about $7,200 per month with about 35 percent overhead for FICA, taxes etc. Ship's cost per man is about $45 per day for food, water, laundry, sewer processing, etc. The crews work 12 hours on and 12 hours off and rotate crews every two weeks.

The amount of use of each of the support vessels and personnel were allowed to vary based on the task under consideration. Note that separate scenarios of support vessel and crew needs were modeled for rough and calm waters. For sub-sea development wells, it was assumed that the rough water scenario would be most likely due to the water depths. The full crews were used to move the equipment or to operate the drill ship in rough water. In calm water, none of the support vessels were included with the exception of one fuel barge which was assumed to double as a work boat. In addition, the drill ship crew was cut in half, except for the captain who was retained and the navigator who was not.

Fuel consumption for the full group of vessels was estimated at 1.6 million gallons of fuel for 30 days under power. Fuel consumption for the workboats was estimated at 180 gallons per hour based on data collected for the sub-arctic model. Fuel for the other vessels was estimated based on vessel size. The estimates were double the work boat rate for the drill ship, sea-going tug and fuel barge and the triple the rate for the ice breaker. The resulting fuel use roughly equals the original estimate. These fuel use rates were also assumed to vary based on the activity. Fuel use for rough seas operations were assumed to be half of the use when underway. Calm seas use was assumed to be a quarter.

Mobile Exploration Platform and Bottom-Founded Production Platform

Data for this task was collected from several individuals. One of these individuals worked as a crane operator on a Sinkable Island Drill Ship (SIDS) as well as working for an ice road construction firm, an ice road maintenance contractor and as a ship Engineer aboard a support barge. Another individual was an owner of a variety of arctic support firms including an ice road and an island construction company, a barge support company, a Prudhoe Bay hotel. He also served as an equipment consultant.

The SIDS is a very large barge equipped with a drilling rig. The ship is loaded with drill stem, casing, drilling mud and all other major supplies necessary to drill several wells. It is then towed to a drilling site that has been prepared by a barge with a large crane to assure the bottom is free of large rocks and is fairly level. The SIDS is then positioned over the drill site and sunk to the bottom (approximately 30 to 40 ft).

"Flex-a-barges" deliver day-to-day supplies. These barges are constructed with individual sections that can be added or subtracted to change the barge size to meet the needs of the day. Power drive sections can also be added or subtracted. The barges have a three- to four-man crew and can be used from mid-July to the first part of October. Ice road support can begin in January and continues until May. From October to January and May to mid-July only helicopter support can be used. The main difference between the SIDS and the Canmar is that the SIDS is bottom based and most of the support vessels are not needed once it is set. The SIDS operates in 30 to 40 feet of water and the Canmar drill ship can operate in open seas up to 600-feet deep.

As discussed in Chapter One, there are a variety of mobile bottom founded structures that have been used or suggested for use in the arctic off-shore environment. These include:

- The Caisson Retained Island (CRI)
- The Concrete Caisson Island (Tarsiut)
- The Concrete Island Drilling Structure (CIDS)
- The Mobile Arctic Caisson (Molikpaq)
- Single Steel Drilling Caisson (SSDS)
- Sinkable Island Drill Ship

For the most part these structures are similar in design and economic impact. They consist of salvaged steel structures, sometimes supplemented with concrete for ice protection, that are towed or self propelled to the site and then ballasted with water or gravel. Ballasting with gravel is less likely because if the gravel becomes contaminated with oil, disposal of the material becomes problematic as the gravel may be considered hazardous material. Depending on water depth, these production structures may be placed on a gravel berm.

These structures become practical when water depths make the use of gravel islands prohibitively expensive due to the required slopes.

These structures can be left in place permanently and equipped as production islands following the same procedures and costs as for gravel islands.

A bottom-founded drilling platform that will be used in the 2002 and 2003 drilling season is the AEC Oil and Gas (USA) Inc. SDC/MAT. This platform is used to model both the mobile gravity exploration platform and the bottom-founded production platform. As stated above, the Arctic Mobile Caisson platforms (Molikpaq) and other mobile platforms will model the same, differing only in size and shape from the Sinkable Island Drilling Structure (SIDS).

The AEC SDC/MAT has been stored and modified in a western Alaska port since 1990. It is now at the McCovey exploration site north of Prudhoe Bay in the Beaufort Sea. If exploration is successful it will be used as a production platform. The MAT is a slope-sided barge permanently mated to the bottom of a Steel Drilling Caisson (SDC), which is a modified "very large crude carrier." The SDC/MAT floats in 23 feet of water when at its lightest weight and in 68 feet of water when loaded with normal fuel and provisions. The SDC/MAT gravity ballasts over the site to a depth of 30 to 75 feet. As with most bottom-founded drilling platforms, bottom depths below 75 feet require a sub-surface gravel island or dredged gravel berm.

Once this SDC is in place, service barges bring drilling and service supplies, including a pile driver to drive 30 feet casings into the ocean floor through four available drilling slots. There are quarters for 104 crewmembers. Crews are moved back and forth to Prudhoe Bay by helicopter.

It will take about $120 million dollars each to modify the SIDS, CIDS, or the Molikpaq so they could be used for exploration and production. These types of bottom-founded platforms have proven the ability to take the winter ice movement and summer wind and waves fairly well; however, just how much maintenance will be required over the long term is unknown at this time.

As discussed above the SDC/MAT is a combination of a salvaged very large crude oil tanker (The Liberia) that is welded on top of a barge. The Liberia has a weight of 82,859 tons. Based on reported salvage values estimated at 23 cents per pound, the vessel would cost approximately $38 million. The MAT constructed barge has an estimated weight of 60,144 tons. At an estimated 23 cents per pound, the vessel would cost approximately $28 million. In addition, the costs of moving this equipment to Port Clarence, Alaska which is at Tellar in Seward Peninsula was estimated to be $20 million. Construction modifications were estimated to cost $130 million, while administration support was estimated to cost $20 million.

Sub-Sea Development Wells

Sub-sea development wells with trenched production lines were modeled. This technology would most likely be used in multiple well, sub-surface caissons. Ice roads or drill ships would access these caissons when necessary. A very high risk, due to access only part of the year, has prevented this technology from being used and may prevent its use in the future.

The cost information is based on sub-sea well completions developed for Saklian Island. In this particular scenario, off shore crude was flowed to shore about 4.5 miles. The off shore water temperature was 27 degrees F. The pipe was wrapped with a protective coating that provided a small insulation R-value. Wax build up from the crude closes the annular area of the pipe creating an insulation R-value. Crude flows in the remaining annular area of the pipe; consequently, the pipe is oversized to provide needed flow rates. Concrete donuts, cathodic protection, and any control or instrumentation lines are installed and lowered as a unit to the ocean floor. The donuts are installed every ten feet. This technology is recommended with high volume fast flowing wells only. Water temperature, crude composition, flow rates and pressure contribute to the pipe size and distance crude will flow and how fast it will cool. In this scenario the crude is at ambient temperature in about 1 and 1/2 miles.

If the pipe comes ashore, the area of pipe subject to ice gouging or keeling (ice being pushed on shore) must be buried up to 21 feet deep depending on the soils, wind and ice conditions.

The buried pipeline costs and installation are the same as for the standard buried pipelines that service the production islands. This technology is described later in this chapter.

The sea-floor portion of the pipeline will be constructed using the same technology as was modeled in the sub-arctic. The sub-arctic pipeline lay barge will have to be used to lay the under-sea portion on the sea floor with a multiplier of 2.2 for deep sea, such as the Chukchi Sea or Hope Basin.

4.6 HELICOPTER SUPPORT

The manpower and input vector estimates were developed for one day of helicopter support. For this activity it is assumed that the helicopter will be staged at the airport at Prudoe Bay. In the IMPAK model the distance of the project from Prudoe Bay is entered. Based on the distance the time per trip is calculated. The number of trips is based on estimates of the number of trips required per activity.

The budget rate for a helicopter and crew is $100,000 per month. This rate is for a long term project requiring year-round support. For Northstar, the first offshore production project in the Beaufort Sea, under construction in 2000, two helicopters and two crews are required. In addition to the monthly fixed cost, there is a fixed fee of $950 per hour plus a federal transportation tax of 10 percent for passengers or six percent for cargo. This cost includes fuel. Ninety percent of the flights are primarily for passengers.

The base daily cost for the helicopter, based on 12 months and 365 days would be $3,288 per day. Based on information provided in the interviews and personal experience on the North Slope, the project engineering staff estimate the helicopters average three round trips per day at 1.5 hours per round trip or 4.5 hours a day. Note that this estimate of 1.5 hours per round trip assumes a maximum trip length of 50 miles one way and that trip times can be adjusted by distance using an assumed line-haul speed of 100 miles per hour.

The estimate of 4.5 hours of use per day would add an additional $4,275 per day to cover the hourly fee. In addition, the weighted average passenger and cargo tax is calculated by multiplying the $2,275 estimate by the tax rate of 9.6 percent. The result is a tax estimate of $410. An overall daily revenue estimate of $7,973 is found by summing the three estimates together. Note that if all twelve seats were filled on all three flights, the one-way cost would be $111 per flight.

The analysis of the helicopter support activity is based on a series of interviews supplemented by the engineering and economic analysis experience of project staff. Interviews were conducted with the following source:

- An employee of a larger helicopter service company in Alaska that was recently awarded the contract to provide helicopter support to Northstar an offshore production island.

Overview of the Activity

The helicopter used for this operation is a Bell 212 that will be staged at the airport at Prudoe Bay. The Bell 212 can carry 12 passengers. From April to December, the season when the ice roads are not functional, the helicopters are busier than from January to March when the ice roads are functional. These helicopters can fly using instruments (IFR) which allows them to be used during inclement weather and at night. They can also be used for med-evac.

As discussed above, the helicopter would make more trips in the summer and less in the winter. In the summer, the helicopter would typically make one trip daily for crew change, one for cargo and a scheduled flight that is part of a sweep that will make stops at designated locations such as other islands or exploration sites.

The remainder of this section provides information on manpower, capital and material costs.

Manpower and Cost

According to the interviews, the helicopter support contract includes a full time hanger manager, a two member maintenance crew and two pilots that are on call 24 hours a day. The pilots can fly 10 hours in a 24 hour day. If they need more coverage than that then they will need another crew. The charge out rate for a pilot is $500 per day. No wage rates were provided for the other personnel. According to the engineering project staff, the helicopter support staff and pilots work two weeks on and two weeks off. All of the employees are Alaskan but there are no Native employees.

Capital Cost

The 15-place Bell 212 is the twin-engine civilian version of the highly successful U.S. Army "Huey" helicopter. This helicopter provides the additional safety of twin engines for offshore or remote area work. With the increased horsepower available, heavy payloads may be carried under difficult climatic conditions.

The Bell 212 engines are twin Pratt and Whitney turbines rated at 1,025 horsepower for a single engine. The craft has a fuel capacity of 220 gallons with an auxiliary tank capacity of 180 gallons.

The helicopter is estimated to cost $5 million, not including delivery to the North Slope.

Fuel Use

A Bell 212 helicopter burns 100 gallons of fuel per hour. Based on the estimate of 4.5 hours of flying time per day, total fuel consumption per helicopter is estimated at 450 gallons per day.

4.7 LOCAL BARGE TRANSPORTATION

The manpower and input vector estimates were developed for one trip by a support barge. Generally, the Beaufort Sea will allow use of barges for four months from the first of June to the first of October, limiting survey work to those months. Surveys can also be conducted on water, but this is generally not the case.

The average lease price per day for barge service, including crew, is $12,000 per day according to the contractors interviewed for this study. These are actual operating costs and include all applicable contractors overhead. It is assumed that no additional oil company or general industry overhead is assigned to this activity.

It is assumed, for purposes of calculation, that a barge trip takes one day so that the daily cost and the per trip cost are the same. However, loading and transit times vary considerably, so it this assumption should be critically reviewed for each project or activity under consideration. According to the sources interviewed, if the island is close and the items that were being hauled could be loaded and unloaded quickly, such as gravel, then the barge might be able to make two trips a day. However, if the items were more difficult to load, such as piping that needs to be cribbed, it would take most of a day to load and another day to unload so would take almost 3 days per trip. If the island is farther away, such as Northstar, then it will take about two days just to travel one way to the island. For this reason, barge support is best calculated as a cost per day.

In addition to barges, several other types of waterborne craft are potentially used on the Beaufort Sea. For example, in the previous manpower model supply boats and tugboats are both included. According to the interviews conducted for this study, however, neither is used for local transportation on the Beaufort Sea. There used to be a supply or support boat a few years ago but most of the islands or sites where located in shallow water 6 to 10 feet deep and the boat would become grounded. As production activities move farther from shore, into Federal waters, then there might be a use for them in the future. In addition, there are currently, no tugs staged at

Prudoe Bay. Tugs are used for the big barges from Anchorage. Only the smaller self-propelled barges are used locally.

The analysis of the local barge activity is based on an interviews supplemented by the engineering and economic experience of project staff. Interviews were conducted with the following sources:

- An owner of a marine firm
- A partner in a marine industry Limited Liability Corporation (LLC)

Overview of the Activity

The remainder of this section provides the engineering information that was collected from the interviews and other sources. Included is general information on the activity and as well as more specific information on capital, labor and material inputs.

The support barges that were modeled are Robaushaw Flex-I floats made in Louisiana. They are made of individual float sections that are pinned together and can vary in configuration. As a model, costs were developed for a 40' by 120' barge with two self-propelled power units and self-contained crew quarters. The barges are shallow draft and haul 400-tons. The original purchase price was $1.2 million. The barge is occasionally refurbished and updated as necessary. It is estimated that total capital costs are on the order of $100,000 per year.

There is also generally some additional capital equipment that is staged at the dock. For example, there might be a 966 Cat loader. On an island, if special equipment is needed such as a crane then it will be included in the contract. If pallets of drilling mud are being moved, for example, then a forklift will be needed. Other than the loader, it is assumed that no specialized loading or unloading equipment or employees are used as part of this activity. Instead, specialized tasks are assumed to be performed using the equipment and labor for the activity that is being assisted by the barge.

The two power units use diesel fuel at the rate of 3 gallons per hour each or 6 gallons in total. The barges are assumed to be in motion 12 to 16 hours a day. At 16 hours per day, which would cover some lesser fuel use while not in motion, fuel use would be 96 gallons per day. The cat is assumed to use 150 gallons per hour and to be used an average of eight hours per day.

The crew for such a vessel is estimated to consist of four individuals. These include a captain, a ship engineer and two laborers. The captain and engineer are paid approximately $400 per day while the laborers are paid $300 per day.

The barge is assumed to operate 24 hours a day and to make two trips a day. Operating 24 hour is made possible due to the summer season and 24 hour day light in the arctic. According to our sources the captain sleeps while the barge is being loaded and unloaded, the laborers sleep while the barge is underway and the engineer sleeps whenever he can. Given the 24 hour operating schedule the barge is able to make a round trip per day. As the unit of analysis for this activity is a round-trip, costs are on a daily basis.

4.8 WELL DRILLING

The development of oil and gas resources require a variety of well drilling activities including the drilling of exploration wells, delineation wells, production wells, service wells and waste wells. In addition, well workovers, which are a maintenance activity performed every five years or so, are required to maintain optimal flow. For the purpose of this study, well drilling is divided into three activities with separate manpower and input vector estimates developed for an exploration well activity, a production well activity and a well workover activity. This is similar to the previous manpower model, except the former model did not include a well workover activity.

The MMS E&D scenarios use a somewhat different categorization scheme. The first difference is that exploration wells are divided between exploration and delineation wells. Also, the E&D scenarios refer to production wells as production and service wells. A final difference is that no explicit mention is made of well workovers. The E&D scenarios also do not mention waste wells.

In this study, no separate estimates are provided for waste, spoils or tailings disposal wells. A separate activity for spoil disposal was contemplated, but was later dropped. According to the interviews conducted for this study, spoils (drilling tailings) are usually ground up and injected back into the well under high pressure as part of the driving force used to bring the crude oil up to the surface. As spoil disposal is part of the production process it is included in the daily cost of well drilling (it is a function of the drilling rig). Where spoils refer to waste disposal such as sewage waste, then this is injected into a separate well. The waste well may only take 4 to 5 days to drill. Since this activity is so small and takes a similar amount of time as a well workover, the model will assume that for every production island constructed, a well workover is immediately performed.

The costs for well drilling activities are based on a quoted cost of $107,000 per day for the drilling of production wells. Per well estimates are then derived by multiplying the daily estimate by the number of days required to drill each type of well. The development of the estimates for exploration wells and well workovers required adjustments in the amount of labor and materials and equipment purchased. For example, well workovers require less materials, more specialized personnel and are sometimes conducted with a smaller more portable drill rig often mounted to a truck. As adjustments were made to the costs for exploration wells and well workovers, the costs per day of these activities were allowed to vary from the rate quoted for production wells.

The analysis of the well drilling activities is based on a series of interviews supplemented by the engineering and economic analysis experience of project staff. Interviews were conducted with the following sources:

- An employee of a well drilling company currently working on the North Slope
- A former sales representative for a well drilling equipment supply company

Overview of the Activity

During the life of an exploration or production project, a number of drilling contractors may be used. Each one uses their own drill rigs and crews. The drilling company provides the drill rig and personnel to operate the drill rig. The oil company provides what goes in the well.

The cost to run a drilling camp is $107,000 per day. Of this total, approximately $75,000 per day is for the labor and drilling and $32,000 per day is the cost of tangible materials, which includes expenditures for casings, tubing and well heads. It does not include the costs of other materials that go into the well such as mud, cement and drilling fluids, which are customarily supplied by the well owner.

Usually a given drill rig is kept on site during the entire construction of the facility. A waste well and about half the production wells and gas injection wells are drilled prior to the start of production and then wells are continually drilled and repaired (worked over) during the remaining production phase.

Typically it takes 3 to 4 weeks to drill a production well and one day to move from one well to another one on the same island. It takes approximately 4 to 5 days to move a new rig onto an island and set it up using an ice road and an equal amount of time to remove an existing rig off an island. To move drilling rigs is usually bid by lump sum. The same crew that operates the drill rig moves the rig from well to well and from site to site. For the purpose of this study, it is assumed that it takes 30 days to drill the average production well. This estimate is assumed to cover the time required for both transportation and drilling.

An exploration well will take at least 2 months and up to 4 months to drill depending on the conditions that they encounter. The midpoint of this range of 3 months (90 days) was assumed in this study. However, there is a great deal of variability in the cost and time spent drilling exploration wells. At $107,000 per day an exploration well would cost only $9.6 million, however, according to the interviews conducted for this study, a dry hole can cost up to $28 million and a potential hole that has extensive testing performed and can go up to $40 million

The test holes are abandoned in place at a depth of 20 feet below sea level. The rig is already in place, so it becomes a matter of removing the production tubing and setting plugs as required on the way out. It is assumed the time required for abandonment is included in the ninety days.

A well work over usually takes 4 to 5 days and often uses a smaller drill rig, but a more specialized crew. A well work over will almost never require replacing the casing, but usually replaces or repairs production tubing, packing, etc. (the "jewelry"). Due to the variability of activities and problems addressed by workovers it was difficult to obtain a reliable estimate of the average cost for a workover, but staff engineers believe that it would be reasonable to assume the same daily rate as a new well.

Assuming four days for a workover and the same daily cost as for other well activities of $107,000, results in a cost estimate of $430,000. Another interviewee that worked up on the North Slope a few years ago quoted a range of $200,000 to $500,000. For this study, the estimate of $107,000 per day was used as a starting point, but reduced as necessary to reflect reductions in material requirements. Capital costs were kept the same based under the assumption that the smaller rig would cost less, but have a lower utilization rate. Labor requirements were also left the same assuming the reductions in costs for crew size would be offset by the cost of more specialized crew.

According to the sources interviewed, every well will get at least one workover during its lifetime. Typically, a well may be worked over 3 to 4 times in its 20-year life. For modeling purposes, it will be assumed that each well receives three workovers, one every five years after initial construction. These well workovers are in addition to the initial proxy for a waste well.

Manpower and Cost

A typical drill camp would require 30 to 35 people to run the drill rig and 10 to 15 service and support personnel. A larger camp may have 50 people to run the drill rig and 20 to 25 service and support personnel. Two work crews stay on the island for two weeks and work 12-hour shifts then two new crews replace them for two weeks. Typically a drilling crew will have 85 percent Alaskan employees with 2 to 4 percent Natives. There is one drilling company that is a Native company that uses about 50 percent Native hires.

For study purposes, an average of 22 workers per shift, two shifts per day, replaced every two weeks is assumed, including 14 service and support and 30 operators. The occupations and costs per day for each worker are described below. Each occupation is required on each shift, so if the drilling supervisor is required and receives $800/day then there is a counterpart on the next shift who also receives $800 for another shift on the same day.

The service and support people each shift and their pay rates include:

- Drilling supervisor ($680/day)
- Directional driller ($580/day)
- Electronics ($580/day)
- Mudder/cementer ($480/day)
- Casing worker ($480/day)
- Spill technician ($530/day)

- Medic ($580/day)

Drill Rig Operators each shift and their pay rates include:

- Pusher ($680/day)
- Motorman ($580/day)
- Derrick hands (2) ($530/day)
- Mechanic ($530/day)
- Welder ($530/day)
- Electrician ($530/day)
- Roustabout (8) ($480/day)

The Roustabout is either an apprentice for an above position or general laborer. Total direct labor costs are $12,100 per shift or $24,200 per day.

Capital Equipment and Cost

A new rig costs about $20 million and may last 10 to 15 years and may be refurbished 3 or 4 times during its life. The costs of refurbishing over the lifetime of a rig was not available from the interviews, but were estimated by engineering staff to total approximately half of the original purchase price. The cost of the rig does not include transportation to the North Slope, so the cost of transportation had to be estimated.

Besides the drill rig, other equipment required to support the drilling operations would include a front-end loader, forklift, two pickups and a van to move equipment and people. The van was not included in the capital estimates for this activity as it is assumed to be purchased by the general personnel transport activity and is included here as a labor-related cost.

The front end loader and the forklift are assumed to be 966 Cats. As estimated in the seismic survey chapter, these vehicles each cost $260,000 in Anchorage with an additional $10,000 for arctic preparation and $3,000 for shipping to the Slope. This equipment lasts about 10 years and then has to be replaced or rebuilt. The pickup trucks are the same variety as those examined for ice roads. Those pickup trucks were heavy-duty crew cab fleet truck and were purchased from an Anchorage dealer from a Washington State based fleet dealer for about $25,000. This equipment is estimated to have a four year life.

Material Cost and Consumption

There are two major groups of material costs. The first are the materials that become part of the well such as the well head casing and production tubing. The second are the materials used in the drilling of the well such as the drilling fluids, drilling muds, cement and fuel.

The first group of materials which include the well head, casing and production tubing cost approximately $960,000 for a production well. The well head (a series of valves to connect or

isolate the well from the flow line) costs approximately $50,000. The casing and production tubing cost $910,000. The casing is standard grade steel pipe and the production tubing is higher strength and more corrosion resistant. The degree of strength and corrosion resistance required depends on the chemical composition of the crude and pressure required to extract the product. Casings and production tubing are not reused, but are usually abandoned in place.
The relative cost of the casing and production tubing were not available from the interviews, but the cost of the casing per foot was estimated by sales representative to be significantly more than the cost of the tubing. This greater cost is due to the larger diameter of the casing. This greater weight also adds to the shipping cost.

According to the interviews conducted, casing and tubing is generally used in exploration wells in order to test flow and to retrieve samples. However, there were some unresolved inconsistencies among interviewees as to the relative costs and amounts of casing and tubing materials used versus a production well. As a rough estimate it is assumed that casing and tubing costs for exploration wells are equal to those for production wells on an aggregate basis, but only one-third the cost on a daily basis.

For well workovers the casing and tubing is already in place. In some instances the workovers will require repair or replacement of the tubing. However, as the replacement rate is thought to be quite low, no costs for casing and tubing are assigned to this activity.

The other major materials consumed are drilling fluids, muds, cements and fuel. The cost of the drilling fluids, muds and cements were estimated by the interviewees to be in the range of $2,000 to $5,000 per day. At the recommendation of the study engineers, the midpoint cost of $3,500 per day was used.

Estimates of fuel consumption were based on the numbers of each type of equipment and their fuel consumption. There are two types of drill rigs, electric and mechanical. Both types are powered by diesel fuel. In the case of the mechanical rig, all pieces of equipment, including generators, pumps etc., are run directly on diesel fuel. In the case of an electric rig, diesel fuel is used to run 2 to 3 turbines that provide electric power to run the various pieces of equipment. According to study engineers, the electric type drills are no longer used extensively on the North Slope. The turbines each use about 70 gallons of fuel per hour at full load, but on average load use about 94 gallons per hour in total. In contrast, the mechanical drill rigs use about 47 gallons per hour for exploration and production and about 27 gallons per hour for workovers. Based on a 24 hour day, estimated daily fuel use is approximately 1128 gallons for exploration and production rigs and 648 gallons for workover rigs.

The loader and forklift (966 Cats), as described in the seismic survey chapter, each consume 150 gallons of fuel per day. The pickup trucks, as described in the ice road chapter, each consume 30 gallons of fuel per day. All of the equipment is assumed to be used for exploration and production activities. With the exception of the rig, no capital equipment is assumed for workovers.

Based on the above assumptions, daily fuel use is estimated at 1488 gallons for exploration or production and 828 gallons for workovers. Total fuel use would be 133,920 for drilling an exploration well, 37,200 gallons for drilling a production well and 2,592 gallons for a well workover.

4.9 GRAVEL PRODUCTION ISLAND

The manpower and input vector estimates were developed for the construction of an offshore gravel production island. Separate vectors were developed for the placement of the gravel and for the placement of the erosion protection and other systems. This was done to allow the depth of water in which the island is constructed to vary.

A large production island will have a working surface of approximately 450 feet by 450 feet that is 16 feet above low water. For the sand and gravel placement activity, it is assumed that the island will be built by enlarging an existing exploration island. This was the case for Northstar, and for cost reasons, making use of existing islands or natural features is a preferred course of action. In 40 feet of water, 1.2 million cubic yards of gravel will be required for the island. Assuming that 400,000 cubic yards are in place at the existing island then an additional 800,000 cubic yards will be required. By way of comparison, Northstar required 700,000 cubic yards on top of a former exploration island that had been abandoned six years earlier. In the IMPAK model, alternative water depths can be entered. The model calculates the amount of sand and gravel required. The ratio of this volume to the volume required in 40 feet of water depth is used to scale the input vector.

The construction of this type of island can be performed during the winter construction period (December to May) using ice roads or by barge during open water. Winter construction is the preferred method and is modeled in this chapter.

To build the gravel island will require an average of 60 personnel. The gravel will be mined from a gravel pit using conventional earth moving equipment and moved to the edge of the sea. When the offshore ice road is completed the gravel will be trucked to the island, spread and compacted. These tasks are modeled in the first activity.

The island will have erosion protection consisting of filter fabric and pre-cast concrete mats. Also, sheet piling will be installed on four sides of the island with tail walls that tie-in to provide support. Finally, concrete foundations for the modules will be added as will a concrete helipad. These tasks are modeled in the second activity.

The analysis of gravel island construction costs were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff.

Overview of the Activity

The island will be accessed by ice road during the winter construction period. A large production island will have a working surface of approximately 450 feet by 450 feet that is 16 feet above mean lower low water level (MLLW). A submerged gravel berm 75 feet wide at 15 feet below MLLW protects the island from deep ice flows and causes premature breaking of waves. The seabed is approximately 40 feet below MLLW. Storm surges may raise the mean water level 4 feet above the MLLW.

The gravel is mined from a gravel pit (typically within a dry riverbed) using conventional earth moving equipment. The gravel mine site will be prepared by removing snow and waste material using large graders, front end loaders and dozers. Dozers with a ripping tooth will loosen the gravel bed for excavation and blasting may be required. Blasting would require drilling 200 to 300 holes at 10 feet on center 20 feet deep and then simultaneously detonating a charge in each of the holes.

The gravel will be moved from the mine site as soon as the tundra is frozen, and onshore ice road can be built, and stock piled onshore until the offshore ice road to the island is constructed. When the offshore ice road is completed the gravel will be trucked to the island, spread and compacted. The sea ice from around island would be cut and removed as required to place the gravel using standard earthmoving equipment.

Once the gravel is in place erosion protection and sheet piling will be installed around the perimeter of the island. The erosion protection will consist of concrete blocks placed on top of fabric. Finally, concrete footings that will serve as foundations for the production modules will be put in place as will concrete blocks that will serve as a heliport.

The following paragraphs discuss each of these major activities (gravel work, concrete work, fabric placement and sheet piling) in detail. Estimates of labor, capital and materials are provided for each.

Gravel Mining, Hauling and Placing

Information was collected on the equipment that is used in constructing a gravel island and the costs of purchasing, retrofitting, refurbishing and shipping the equipment to the North Slope. Information that was not available from the field data collection effort was estimated as described in the capital equipment section below. The following information was collected:

At the mine there will be the following equipment:

- Two 988 CAT front end loaders ($520,000 each, $10,000 arctic equipment, $3,000 shipping).
- One 966 CAT front end loader ($260,000 each).
- One D-10 CAT dozer ($720,000 each, $7,000 arctic equipment, $3,000 shipping).

- One D-7 CAT dozer ($360,000 each).

On the island there will be the following additional equipment:

- One 966 CAT front end loader ($260,000 each).
- One D-7 CAT dozer ($360,000 each).
- Two large graders ($200,000 each).
- Two compactors ($250,000 each, $7,000 arctic equipment, $3,000 shipping).

To haul the gravel there will be the following equipment:

- 16 Euclid B-70s (purchased used for $60,000 to $70,000 each and refurbished for $30,000).

The number of Euclid B-70s required was calculated in the following manner. The trucks have a capacity of 60 to 70 cubic yards. They will make 6 to 7 loads per shift or 12 to 14 per day. To move 800,000 cubic yards in 2 months, which equates to 13,000 cubic yards/day and at 65 cubic yards/trip and 13 trips/day (845 cubic yards/truck/day), requires 16 trucks.

To build the gravel island (excluding erosion protection, concrete work, fabric work and piling) will require approximately 60 personnel. These are total labor requirements and the labor force will be split between two 12 hour shifts). Labor would be housed at a hotel/camp facility and bused to the work site. The construction would be continuous 24 hours a day seven days a week. The crews would work two weeks on and two weeks off. The construction period would take 2 to 3 months.

The manpower that would be required each shift for gravel mining, trucking and placement would include:

- Supervisor (3) ($600/shift)
- Equipment operators (24) ($500/shift)
- Maintenance (2) ($500/shift)
- General laborer (2) ($480/shift)

The daily total cost for the 31 person crew would be $15,760. For both shifts, the estimates would double to 62 employees and $31,520. Approximately 85 percent would be Alaskan hire and 10 percent Native hire.

In addition, the state royalty for the gravel is $1 per cubic yard or $800,000. The total estimated cost to mine the gravel, haul and compact is $20 per cubic yard or $16,000,000 per island.

Concrete Work

A variety of concrete work will be required on the production island. All of the concrete will be pre-poured into blocks and other shapes and barged to the island. The concrete work will include blocks for erosion protection, footers to serve as foundations for the production modules and blocks to form a helipad. The cost of North Slope concrete work, based on the past experience of project engineering staff, is $800 per cubic yard finished in place.

Protection of the island will require the installation of erosion protection consisting of filter fabric and pre-cast concrete mats. This will require approximately 27,000 square yards of filter fabric and 15,000 pre-cast concrete blocks (four feet by four feet by nine inches thick). The concrete blocks would be fabricated on the North Slope at Deadhorse, using aggregate from the North Slope's Oxbow mine and cement and additives from Fairbanks and Anchorage. It would require approximately 30 people and 4 months to pre-fabricate the blocks.

The completed concrete blocks would interlock using cable and shackles. A string of blocks would be tied together, stacked and barged to the island. The completed concrete blocks would interlock using cable and shackles. It is estimated that 45 barge trips would be required to move the concrete blocks and 55 people to install. The total cost for this operation would be $5.4 million.

Concrete foundations (spread footings) for the production modules to be placed on will be produced at Deadhorse and installed on the island. The estimated cost of the module foundation concrete work is $500,000. In addition a concrete 55 feet by 55 feet helipad will be constructed at a cost of approximately $90,000.

Summing the $5,400,000 for the concrete blocks, $500,000 for the concrete foundations, and $90,000 for the heliport, results in estimated total of $5,990,000 in concrete work. The following is a breakdown of the costs for materials, labor and capital:

- Material: 7,500 cubic yards at $200 per cubic yard — $1,500,000
- Labor: 55 people for 120 days at $495/day
- Supervisor (4) — ($600/shift) — $ 288,000
- Equipment operators (38) — ($500/shift) — $2,280,000
- Maintenance (4) — ($500/shift) — $ 240,000
- General laborer (8) — ($480/shift) — $ 460,800
- Equipment:

• Mixing plant - $45 per cubic yard	$ 336,500
• Barges - 45 trips, 45 days, $12,000 per day	$ 540,000
• Two 30 ton cranes, 90 days	$ 130,000
• Two front end loaders, CAT 966, 90 days	$ 65,700
• Two back hoes, 450 Hitachi, 90 days	$ 93,000
• Two cement trucks, 45 days	$ 16,000
• Eight pickups, 120 days	$ 40,000
• Total	$5,990,000

Fabric Erosion Protection

The total installed cost of the fabric will be approximately $270,000. The fabric material itself will cost about 30 percent or $81,000. It comes in 20 foot wide rolls and will be installed by the same equipment used for the concrete block installation. A crane or front end loader will be used to lift it up and roll it out, just before laying down the concrete blocks. A breakdown of costs for materials labor and capital is provided below:

• Material:	$81,000
• Labor: 4 people per shift for 30 days	
• Supervisor (2), $600 per day	$36,000
• Operators (4), $500 per day	$82,800
• Laborers (4), $480 per day	$82,800
• Equipment:	
• One 30 ton crane, 30 day lease	$21,950
• One front end loader, CAT 966, 30 day lease	$10,950
• One pickup, 30 day lease	$2,500
• Total	$270,000

Sheet Piling with Tail Walls

Typically, this task will be performed using flat sheets with tail walls. The sheets weigh 31 pounds per square foot. The material and shipping cost (Manufactured in Texas, truck to Seattle, train to Fairbanks, truck to Deadhorse, truck to job site) is $0.45/lb. The installation cost is $43 per square foot.

Sheet piling will be placed on all four sides of the island and the island is 450 feet by 450 feet in size. The sheet piles will be 40 feet in height, (20 feet bury, 10 feet soil backfill, and 10 feet clear). The tail walls tee in to the wall to provide tie-in support and add forty percent to the total square footage.

The quantity of sheet piling required is calculated by multiplying the 450 foot length per side of the island times the 40 feet in height times the four sides of the island and adding on 40 percent for the tail walls. The result is an estimate of 100,800 square feet.

The weight of sheet piling is 31 pounds per square foot. Multiplying the estimate of 100,800 square feet by the 31 pounds per square foot, results in an estimated 3,125,000 pounds. Given material and shipping costs of $0.45 per pound, results in a total delivered material cost of $1.4 million.

The installation cost for 100,800 square feet at $43 per square foot is $4.3 million for a total of $5.7 million.

To install the sheet piles in frozen ground a typical method is to drill 6 inch wide holes 20 feet deep at 18 inch on center intervals. The holes are then filled with 180 degree water. The next morning the ground is thawed enough to drive the piles into the ground using a hammer supported by a crane. It is estimated that the piles will be installed in 90 days; working 7 days a week, two shifts per day, 12 hours each shift. The equipment and labor required is as follows:

Equipment:

- One Crane - Manitowoc 450 $350,000
- One hammer $195,000
- One CAT 966 front end loader $260,000
- Two Drilling machines $200,000
- One hot water truck $175,000
- Two pick-ups $ 25,000
- Two generator sets (lights) $ 5,000
- One mechanics truck $ 50,000
- Two welding machines $ 7,000
- Three templates (guides for piles) $ 15,000

Materials:

- Weld rods ($5 per man hour of welders)

The labor for each shift includes:

- Foreman (1) ($600/shift)
- Crane/pile operator (1) ($500/shift)
- Pile bucks/welders (4) ($430/shift)
- Mechanic (1) ($480/shift)
- Loader operator (1) ($500/shift)
- Drillers (2) ($500/shift)

- Truck driver (1) ($500/shift)

Fuel Use

The following data on fuel use was collected from the interviews for this task and were supplemented by fuel use data collected for other activities.

For the gravel mining task, the following equipment will be used for 60 days:

- Three large Cats (988 and D-10) (8.33 gallons per hour/200 per day)
- Two small Cats (966 and D-7) (6.25 gallons per hour/150 per day)

For the gravel placing task, the following equipment will be used for 60 days:

- Three large Cats (988 and D-10) (8.33 gallons per hour/200 per day)
- Two small Cats (966 and D-7) (6.25 gallons per hour/150 per day)
- Two large graders (6.25 gallons per hour/150 per day)
- Two compactors (6.25 gallons per hour/150 per day)

For the gravel hauling task, the following equipment will be used for 60 days:

- Sixteen trucks (3.75 gallons per hour/90 per day)

For the concrete work, the following equipment will be used for 90 days except as noted:

- Two 30 ton cranes (10 gallons per hour/240 per day)
- Two Cat 966 front end loaders (6.25 gallons per hour/150 per day)
- Two back hoes, 450 Hitachi (10 gallons per hour/240 per day)
- Two cement trucks, 45 days (3.75 gallons per hour/90 per day)
- Eight pick-ups, 120 days (1.25 gallons per hour/30 per day)

For the fabric work, the following equipment will be used for 30 days:

- One 30 ton cranes (10 gallons per hour/240 per day)
- One Cat 966 front end loader (6.25 gallons per hour/150 per day)
- Two pickups (1.25 gallons per hour/30 per day)

For the sheet piling task, the following equipment will be used for 90 days:

- One Manitowoc 450 Crane (10 gallons per hour/240 per day)
- One hammer (25 gallons per hour/600 per day)
- One CAT 966 front end loader (6.25 gallons per hour/150 per day)
- Two Drilling machines (8 gallons per hour/192 per day)

• One hot water truck	(3.75 gallons per hour/90 per day)
• Two pick-ups	(1.25 gallons per hour/30 per day)
• Two generator sets (lights)	(5 gallons per hour/120 per day)
• One mechanics truck	(1.25 gallons per hour/30 per day)
• Two welding machines	(5 gallons per hour/120 per day)

4.10 EQUIP PRODUCTION ISLAND

The manpower and input vector estimates were developed for equipping a single production island. In addition, the estimates developed for the transportation and installation portions of this activity will be used in developing the manpower and input vector estimates for the abandonment activity. According to project engineering staff, the costs of installation will be similar to the costs of removal.

The gravel production island will be equipped with two infrastructure and two process modules. The costs of fabrication and installation of these modules are modeled on those that are currently planned and under construction for the Northstar Island. Northstar has space for 27 wells and water flood and gas re-injection are planned. Northstar oil production facilities will be built in Anchorage at the Port of Anchorage and barged to the North Slope

The infrastructure modules will include a quarters and a utility module. In addition, the infrastructure modules will be supported by 10 conexs, a diesel and a water tank, three flares, 15 pipe racks and 20 well houses.

The process modules include a processing facility and a compressor module. The process modules are supported by a warehouse/shop facility and two tanks for fuel and start up fluids.

Support equipment will be staged on the island prior to arrival of the modules by sea lift. These include cranes, trailers, rig mats and steel plates that will be used to transport the modules over the island gravel. Once the modules arrive, they will be unloaded from the barges, installed on the foundations and hooked up.

The analyses of the costs of equipping the island were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff. Interviews were conducted with the following sources:

- A manager with one of the firms constructing the modules for Northstar.
- The owner of a marine transportation firm.
- Sales representatives for several heavy duty equipment manufacturers.

Overview of the Activity

The process of equipping the production island has two major components. These include:

- Fabricating the modules; and
- Transporting and installing the modules.

The remainder of this section provides information collected on the manpower, capital and material costs for each of these major components.

Module Fabrication

As was the case for Northstar, it is assumed that the modules will be fabricated in Anchorage. The Northstar project represents the first time that the modules were constructed in Alaska, however, absence information to the contrary, it is assumed that this trend will continue. The fabrication will take approximately a 16 month period, using an average manpower of 250 and peak manpower of 350. The workforce will be predominately Alaskan. Assuming 16 months at 30 days per month and an average of 250 employees, results in an estimated 120,000 man-days to fabricate the modules and load them on the barges. At an estimated cost of $300 a man day, fabrication labor costs will be approximately $36 million.

In addition, it is estimated that the Port of Anchorage will be upgraded with (2) 300-ton cranes, (3) 45-ton hydraulic cranes and new offices to support this fabrication effort.

The following specifications were used in costing the materials and purchased equipment required to build the infrastructure modules:

- The permanent quarters are designed to hold 75 personnel including 20 to 25 core operations and 50 for the drilling operation. The quarters are 60 feet long by 60 feet wide by 40 feet high

- The utility module has a capacity of 14,400 gallons per day. The module is 60 feet long by 60 feet wide by 35 feet high. It will house the following functions:

  a. A potable water treatment system for treating 9,360 gallons per day of potable water using a single distillation type desalination process. It will also have equipment for treating a similar amount of wastewater using single fixed-media activated sludge treatment (FAST) with ultraviolet light disinfecting.

  b. A washdown water system capable of partially treating 5,040 gallons per day and injecting it directly in the disposal well.

c. An emergency power system consisting of two 1,230 kilowatt diesel generators for a combined 2.46 megawatts.

- Ten conexs, which are 8 by 8 by 20 foot steel storage boxes similar to a railroad box car or shipping container. Six of the conexs will be used for consumables and tools and four for construction materials.

- Miscellaneous equipment including two tanks to hold diesel fuel and water, three flares, 15 pipe racks and twenty well-houses.

The cost data collected and estimated for the materials and major pieces of purchased equipment needed to construct these modules include the following:

- The permanent quarter's module which is 60 feet by 60 feet and four floors tall will cost approximately $1,800,000 including structural, mechanical, electrical, and furnishings.

- The utility module which is 60 feet by 60 feet will cost $1,200,000 for structural, mechanical, and electrical. In addition it will house a potable water treatment system that will cost $156,000, a washdown water treatment system that will cost $75,000, a wastewater treatment system that will cost $225,000, and an emergency power system consisting of diesel generators that will cost $3,780,000.

- Ten conexs that will cost $8,000 each.

- Two tanks for diesel and water that will cost $30,000 each.

- Three flares, which are a big radio tower type steel structure with a flame at the top, which are used to release pressure. They will cost $200,000 to $300,000 each.

- Fifteen pipe racks that will cost $5,000 each.

- Twenty well houses including the house and trim that will cost $106,000 each.

The following specifications were used in costing the process modules:

- The primary crude processing facility is designed to separate the gas and water from the oil. This module is made from steel construction and is 240 feet long by 80 feet wide by 90 feet high. It is built in two sections and attached in place. It has a total weight of 6,000 tons.

- The compressor module is designed to compress gas for re-injection into the reservoir. It is made with steel construction and is 125 feet long by 80 feet wide by 55 feet high. It has a total weight of 2,500 tons.

- The warehouse/shop facility is 150 feet long by 60 feet wide by 35 feet high.

- In addition, there are two tanks for holding fuel and start-up fluids.

The cost data collected and estimated for the materials and major pieces of purchased equipment needed to construct these modules, includes the following:

- The process module will require approximately $7,680,000 in materials and equipment. This includes $384,000 in steel structural materials, $768,000 in electrical devices and supplies, and $768,000 in mechanical components including heating and ventilation including duct work and insulation, but not including piping. In addition, there will be five major systems. These include: (1) $864,000 for the inlet manifold system including piping and valves; (2) $1,440,000 for the oil and water and gas separator system which is a large vessel; (3) $1,440,000 for the oil treatment system which is also a large vessel; (4) $864,000 for a set of big pumps to push product through the pipeline; and (5) $1,152,000 for miscellaneous piping, instrumentation, chemical injection, small pumps and valves.

- The compressor module will require approximately $11,672,000 in materials and equipment. This includes $192,000 in steel structural materials, $384,000 in electrical devices and supplies, and $384,000 in mechanical components including heating and ventilation including duct work and insulation, but not including piping. In addition, there will be five major systems. These include: (1) $6,680,000 for two 32,000 HP gas injection turbines; (2) $1,440,000 for a dehydrator system; (3) $1,440,000 for a natural gas liquids (NGL) recovery system that separates out butanes, etc. for mixture with the sales oil ; and (5) $1,152,000 for miscellaneous piping, instrumentation, pumps and valves.

- The warehouse/shop that will cost $2,700,000.

- Two tanks for storing fuel and start up fluids that will cost $50,000 each.

Transportation, Installation and Hook up

The modules will travel by barge from Anchorage to the production island. Travel time will be one month in each direction with two weeks for unloading. Three barges will be required at $75,000 per barge or $225,000 in total.

The entire operation of offloading from the barges and then installation and hook up of the modules will take three months with manpower of 140 persons at the peak. Personnel will be mobilized daily via boat or helicopter as the majority of this work will be done during the summer open water season.

Most of the construction equipment required for module offloading will be transported to the island via local barge from Prudhoe Bay. Two barges will be required. Diesel fuel for the construction equipment will come from Prudhoe Bay by local barge and will be transferred to the permanent diesel storage tank facilities on the island. In addition, the support equipment used to move the modules and set them in place, including rig mats and steel plate for transporting the modules over the island gravel, will be staged on the island prior to seal lift arrival.

The off-loading equipment will include one 300 ton crane, two Cat 966 loaders, two 45 ton hydraulic cranes, and a special module transport trailer. This trailer is 16 feet wide by 400 feet long and will have 108 tires. It will either be transported form Anchorage in one piece by barge or in parts on several trucks. Although nearly every year large modules are sea-lifted or trucked from Anchorage to the North Slope, the operators do not keep such a trailer on hand at Prudhoe Bay and reuse it as necessary. According to engineering staff, this is because there is no other use for the large trailer, so it is only brought up when needed. It will be primarily used to transport the compressor module and the process module. The latter is so large it will be in two pieces.

The cost data collected or estimated to offload the modules from the barge includes the following:

- Equipment: As listed above there will be three cranes, two 966 loaders, the large trailer, rig mats, steel plate. In addition four pickups will be on the island for the course of the installation and hookup operation. The cost of all the equipment for the period of time used was estimated by engineering staff to be $360,000.

- A crew of 50 persons, 25 on each shift, will be employed for the offloading portion of the activity. They will work two weeks on and two weeks off.

    - Supervisor (4) ($600/shift)
    - Equipment operators (10) ($500/shift)
    - Equipment maintenance (4) ($500/shift)
    - Technicians, welders, electricians, etc. (20) ($500/shift)
    - General laborer (12) ($480/shift)

The workers for this task will be paid a combined $25,160 per day or $12,580 per shift.

Installation and hookup of the modules will be a labor intensive task involving piping and electrical work along with small structural projects such as installing decking, walkways and passageways. Members of the installation crew will rotate into this crew as well and will be augmented with additional employees that will include specialized personnel to work with the various systems.

- The cost of all the materials and equipment for the 120 days required for installation and hookup was estimated by engineering staff to be $2,600,000. Ten percent of this total was estimated to be for equipment and the remainder for materials. Of the costs for materials, about 30 percent or $ was for piping, and 30 percent for fittings and valves and other piping related materials and supplies. Another 25 percent was for electrical components and systems, materials and supplies. The remaining fifteen percent was for structural shapes, siding and roofing, doors and windows.

- Equipment: The two smaller hydraulic cranes will remain for this task as will the two loaders and four pickups. Also, two small forklifts will be added to the fleet. Eight welders will also be required. The large crane will no longer be needed. The cost of all the equipment for the period of time used was estimated by engineering staff to be $260,000.

- A crew of 120 persons, 60 on each shift, will be employed for the installation and hookup portion of the activity. They will work two weeks on and two weeks off.

    - Supervisor (8) ($600/shift)
    - Equipment operators (12) ($500/shift)
    - Equipment maintenance (8) ($500/shift)
    - Technicians, welders, electricians, etc. (60) ($500/shift)
    - General laborer (32) ($480/shift)

The workers for this task will be paid a combined $56,320 per day or $28,160 per shift.

All major tools and equipment related to construction and installation will be removed from the island upon completion.

4.11 PRODUCTION ISLAND OPERATIONS

The manpower and input vector estimates were developed for the annual costs of day-to-day operation of a production island. Once the island is constructed, the wells drilled and the production modules and other facilities installed, there will still be a need for an ongoing crew to staff the island. Their duties will include operating the systems, maintaining the equipment, and ensuring safety. In addition, the staff performing these functions will be supported by additional staff that will perform housekeeping functions. These housekeeping personnel will staff a complete housing function similar to the onshore hotel/camp facility.

Total manpower for the production island activity will be approximately 62 persons, half on each shift. Materials that will be consumed will include food and housekeeping goods, diesel fuel, natural gas, and materials for maintenance and other functions.

The analysis of production island operation costs were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff.

Overview of the Activity

The majority of the capital equipment needed to operate the island, including production modules, living quarters, heliports and docks are assumed to be put in place during the Island Construction and the Island Equipment Installation activities covered in previous sections of this chapter. Once the island is constructed and equipped, annual expenditures will be required for the next twenty to thirty years in order to operate and maintain the production infrastructure.

While most of the capital equipment is already installed, the exception is several pieces of general construction equipment that will be permanently stationed on the production island. This includes four pickups, two Cat 966 front end loaders, a utility van and a crane.

In addition, the operation of the production island will require daily expenditures for the following items:

- Manpower
- Food and Housekeeping Supplies
- Diesel Fuel
- Natural Gas
- Other Materials and Supplies

The expenditures for these capital, labor and material inputs are discussed in more detail in the following paragraphs.

Capital Equipment and Cost

Eight pieces of capital equipment are assumed to be permanently stationed on the production island. These include the following:

- Four heavy-duty pickup trucks ($25,000 each as estimated in the ice road chapter)
- Two CAT 966 Front End Loaders ($260,000 each as estimated in the gravel island chapter).
- One utility van ($50,000 as estimated in the general passenger transport chapter)
- One crane ($520,000 base cost plus $7,000 for arctic retrofit and $6,000 for shipping)

Manpower and Cost

Approximately 62 persons, 31 per twelve hour shift, are required for the operation of the production island. The rotation pattern is two weeks on and two weeks off. The occupations of the 31 crew members per shift and their daily pay rates are as follows:

• Cooks/Maids (6)	$380
• Water/Waste treatment (1)	$500
• Maintenance (1)	$500
• Supervisor (1)	$650
• Facility Engineer (1)	$620
• Maintenance Foreman (1)	$600
• Lead Operator (1)	$550
• Expediter (1)	$500
• Operator (3)	$500
• Maintenance (2)	$480
• Roustabout (3)	$430
• Well Operator (1)	$530
• Crane Operator (1)	$500
• Compressor Maintenance (1)	$500
• Welder (1)	$500
• Welder Helper (1)	$430
• Electrician (2)	$500
• Instrumentation (2)	$500
• Safety Officer (1)	$430

Each shift of 31 workers is paid $14,840 in combined wages per day. For both shifts the estimate doubles to $29,680.

Fuel Consumption

Fuel use includes the fuel used for the vehicles, diesel fuel used for a backup generator, and natural gas used to power the main turbines to run the production island modules. The fuel use for the pickup trucks and the van was assumed to be only 25 percent of normal due to the small size of the island, intermittent use, and increased idle time. The fuel use for the Cats and the crane was assumed to be only 50 percent of normal for the same reasons.

The following data on fuel use were collected from the interviews conducted for this task and were supplemented by fuel use data collected for other activities as noted.

- The heavy duty pickups use 30 gallons per day as reported for the ice road activity.
- The Cats use 150 gallons per day as reported for the seismic survey activity.
- The van uses 30 gallons per day as reported for the seismic survey activity.
- The crane uses 120 gallons per day.
- The emergency generator, which is used in the event of an interruption in natural gas supplies, uses 150 gallons per day.

In addition, natural gas is imported through the pipeline system to serve the various natural gas fired turbine generators, compressors and pumps that are part of the modules installed on the island. In the early stages of the life of the production island, the island will import significantly more natural gas than toward the middle and end of operations. On average, it is estimated that $48,000 per day of natural gas will be consumed. In some sense, the expenditure is an accounting practice only, as the natural gas is actually produced and consumed by the same company.

Food and Housekeeping Supplies

Food and housekeeping supplies are assumed to be identical to those consumed at the onshore hotel/camp, with the possible exception of slightly higher transportation costs to transport these items out to the island.

For the hotel/camp, the raw cost of food per person per day was estimated as $12 with one-third of this cost for transportation. The food is then prepared on-site. Laundry is hauled back and forth to Fairbanks where it is processed once a week. The total cost for laundry and housekeeping supplies is $1 a day per person. Personal laundry is done in laundry equipment on the island. It is estimated by study engineering staff, that one-half of the laundry and supplies cost is for transportation and that 75 percent of the remaining cost is for laundry and the balance for housekeeping supplies.

Miscellaneous Materials and Supplies

There are a variety of chemicals, spare parts, tools, small appliances, valves, gauges and miscellaneous materials and supplies consumed on the island each day. It is impossible to estimate either an exact amount expended on these items or an exhaustive list of the items consumed. As a best guess, an estimate of $10,000 per day or $3,650,000 per year was used. A list of potential items was developed along with a rough estimate of costs for each item. As this process only covered about half of the estimated dollars, the estimates for each item were scaled upward on the theory that the items omitted were likely to be similar to the items included, or as least it was likely they might be bought from the same IMPLAN sector.

4.12 LOCAL GAS PRODUCTION

Local gas production in Arctic areas such as the Hope Basin would be a scaled down version of a sub-sea production well and the pipeline to shore scenario. The process would use a smaller drill-ship, smaller diameter piping, a narrower set of trenches, smaller size concrete anchors, less welding and smaller size crews. Engineering staff for this study estimate that the costs, depending on the amount of local gas needed, is approximately 50 percent of an oil production well and gas pipeline to shore. This rule-of thumb estimate is based on the assumption that local use would be about the same as Barrow’s.

In addition, a dedicated gas production facility would be required. The gas production facility cost was based on the cost of the gas module for the sub-arctic oil and gas processing facility. In this case the gas module accounted for one-sixteenth the cost of the facility. As a rule of thumb, one-sixteenth the cost of constructing and operating the facility was used. The facility is assumed to be powered by the gas produced by the facility. During operation the facility is assumed to require the use of one heavy-duty pickup that is operated one-quarter time.

4.13 OFFSHORE AND ONSHORE PIPELINES

The manpower and input vector estimates were developed for ten miles of each type of pipeline. Separate estimates were made for offshore pipeline and onshore pipeline due to differences in the techniques employed, equipment used and the cost of constructing the pipeline. In particular, the offshore pipeline is buried under the sea floor while the onshore pipeline is elevated on steel supports known as vertical support members (VSMs).

Pipeline construction is conducted by contractors hired by the oil companies. The total installed cost for offshore pipelines is about $7 million per mile ($70 million per ten mile segment), while onshore pipelines cost considerably less in the range of $3.4 million per mile ($34 million per ten mile segment). These are actual construction costs.

The ten miles of pipeline is estimated to take two to three months to construct, whether it is offshore or onshore. The midpoint of this range, 75 days, was assumed in developing all of the estimates in this chapter.

In estimating distances and costs for pipeline construction, it is important to consider already existing infrastructure. For example, the onshore pipelines for Northstar will use existing supports and an existing gravel service road for eight of the 11 miles. This will reduce the onshore cost by $10 to $12 million dollars. For the estimates developed in this study, it is assumed that no preexisting infrastructure is used.

The analysis of pipeline construction costs were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff. Interviews were conducted with the following sources:

- A manager with a construction company that holds the pipeline construction contract for Northstar.
- An engineer who served as a consultant to a construction company on several pipeline construction contracts.
- A mechanical engineer familiar with pipeline coating costs.
- Sales representatives for three heavy duty equipment manufacturers.

As discussed above, the construction techniques employed for offshore versus onshore pipeline construction are quite different. The following paragraphs describe the general techniques used to construct each type of pipeline. Additional subsections provide engineering descriptions of the capital, labor and material inputs to the production process.

Overview of the Offshore Pipelines Activity

During the construction of offshore pipelines, a 200 foot wide ice road is used along the pipeline as a work pad. The road is thick enough to support the heavy equipment used to install the pipeline (about 10 feet thick). A Ditch Witch trencher is used to cut a ten-foot wide trench in the ice. Another trencher cross cuts the ice into blocks that can be lifted out of the water with a thumb hoe. The blocks are then moved to edge of the ice road with a bucket loader, so that their weight won't affect the trench. A bridge section is placed across the trench with modified backhoe on it. The backhoe is capable of reaching up to 70 feet down. The bridge, with the hoe on it, is pulled with a D-7 winch tractor. As the hoe excavates the ditch the spoils are loaded on a spoils truck with a bucket loader and hauled to an area where the pipe has been lowered in the trench. Another bucket loader places the spoils back in the trench over the pipelines.

A tie in weld shack is mounted on a D-6 tractor. The tractor contains two welding machines and a generator to run lights, heat and a coating machine. The coating that is used is baked epoxy 25 mil thick or polyethylene. The tractor also has a boom to place the next section of pipe to be welded and coated at the weld section. The other end of the section to be welded on is held with a D-7 side boom tractor. This process is duplicated for the gas pipeline at every section so that the two pipelines can be bundled together. Anodes are installed at the time of bundling. The completed pipeline bundle is then moved to, and lowered in the trench with three D-7 side boom tractors. As stated above the spoils are then placed back in the ditch. The equipment is serviced and supported by a maintenance and survival station, consisting of a generator, mechanics module, lube and fueling module and a survival module. The total installed cost is about $7 million per mile.

Overview of the Onshore Pipelines Activity

The path of the onshore pipeline is covered with a standard 60 foot wide onshore ice road to protect the tundra. A Texoma drill is used to drill 24 by 20 inch deep holes every 50 feet. Ten inch piles are placed in the holes, wedged in place and back filed with slurry mixed in a concrete truck. Cross arm pipe supports are welded on the piles with one cross support member on top of one pile. This completed assembly is called a vertical support member or VSM. The VSMs are subcontracted at $10,000 each installed, or about $1 million per mile. The same D-6 tractor mounted welding shack that is used for the offshore pipeline is used to weld, coat and insulate sections of the pipe together. A D-7 side boom holds the other end of each section. Three D-7 side boom tractors lift the lines onto the VSM's. The installed price of the two pipelines (gas and oil) is $3.4 million per mile.

Pipeline Capital and Equipment Costs

The equipment is dedicated 20 percent to each of the pipeline activities. This level of dedication factor is typical for the Northstar project. Information was collected on the equipment used and, where available, the costs of retrofitting, refurbishing and shipping the equipment to the North Slope. Information that was not available from the field data collection effort was estimated as described in the capital equipment section below. The information collected was as follows:

- Ditch Witch: A model 8020-T trencher has a cost of $160,000 base plus $15,000 arctic upgrade and $3,000 shipping. The ditch witch is used to cut the ice for offshore pipeline construction only. Three are used in total, two on each side of the 10 feet wide trench and one transverse. They are not used for onshore pipeline construction.

- Thumb hoe: The "thumb hoe" is a Hitachi model 450. It is a tracked backhoe with a hydraulic thumb that opposes the bucket and is used to pickup the ice blocks. It cost $370,000 plus $3,500 for arctic upgrade. As an alternative it can be rented for $24,000 per month. One is used for offshore construction, but none are used onshore.

- Texoma drill: This equipment was estimated to cost in the range of $350,000 to 500,000. The Texoma Drill is used onshore only.

- Bucket loader: A Cat 966 has a cost of $260,000 base plus $7,000 arctic upgrade and $3,000 shipping. Three bucket loaders are used offshore and two onshore.

- Bridge section: The bridge section is constructed at Prudhoe from steel and rig mats for $30,000. Two are used for offshore construction, but none are used onshore.

- Cat D-7 winch tractor: The winch tractor is estimated to cost $360,000 base plus $7,000 arctic upgrade and $3,000 shipping. One is used for offshore construction, but none are used onshore.

- Modified backhoe trencher: The "modified backhoe trencher" is a Hitachi model 450, cost $370,000 plus $3,500 arctic upgrade plus $130,000 for the long reach front end. Two are used for offshore construction, but none are used onshore

- Spoils truck: A suitable truck transporting spoils might be purchased used at Prudhoe for a base price of $60,000 and refurbished for an additional $40,000. The spoils truck is used offshore only.

- Concrete slurry truck: The cement truck costs $130,000 plus $10,000 for arctic upgrade ($8,000 for insulated drum and $2,000 for insulated and heated water tank) and $3,000 shipping. The cement truck is used onshore only.

- Cat D-6 mounted weld shack: The cost of the Cat D-6 is $300,000 plus $7,000 for arctic upgrades and $3,000 for shipping. The cost of the weld shack including lighting and heating is $150,000. Two of each are used offshore and one onshore.

- Coating machine: The coating machine costs $25,000. Two are used offshore and one onshore.

- Cat D-7 side boom tractor: The side boom tractor is estimated to cost $370,000 base plus $7,000 arctic upgrade and $3,000 shipping. Five D-7 Side Boom Tractors are used offshore and five onshore.

- Cat XQ 225 self-contained generator unit: The base cost of this unit is $72,000 plus $8,000 for arctic upgrade and $3,000 for shipping. One of these units is used for both offshore and onshore operations.

- Atco skid mounted modules: The modules cost $27,000 each delivered to Prudhoe Bay. One of these units is used for both offshore and onshore operations.

Material Costs

Purchased materials include the pipe, the coating for the pipe, the anodes and the cement. Cost data that were collected from the interviews include:

- Offshore pipe per line: A set of two pipes are installed with the cost per mile for the pipe at $170,000 per mile plus $126,000 per mile for shipping and $30,000 per mile for coating.

- Onshore pipe per line: A set of two pipes are installed with the cost per mile for the pipe at $170,000 per mile plus $126,000 per mile for shipping, $30,000 per mile for coating and $35,000 per mile for insulation.

- Cement: The material cost for cement slurry is $300 per cubic yard or $600 per pile or $60,000 per mile. Cement is used onshore only.

- Anodes: The cost of anodes, assuming one every 50 feet and including the cost of continuous cathodic protection, is $68,000 per mile. Cathodic protection is used both offshore and onshore.

- VSMs: The material cost and margins for VSMs include $3,500 material and $6,500 for labor. The VSM's are used on shore only.

Fuel Use

The following data on fuel use was either collected from the interviews for this task and were supplemented by fuel use data collected for other activities as noted.

- The ditch witch will use five gallons per hour or 120 gallons a day.
- The thumb hoe burns six to 15 gallons of fuel per hour, an average of nine gallons per hour or 216 gallons a day.
- The modified backhoe trencher burns 6 to 15 gallons of fuel per hour, an average of 10 gallons per hour or 240 gallons a day.
- The Texoma drill will use seven gallons per hour or 168 gallons a day
- The CAT XQ-225 self contained generator unit will burn 12 gallons per hour or 288 gallons per day.
- The cats use 150 gallons per day as reported for the seismic survey activity.
- The trucks use 90 gallons per day.

Manpower and Cost

The crews used for offshore and onshore vary significantly with the offshore crew much larger due to the cost of cutting and moving the ice and digging the trench. The offshore crew has approximately 42 employees while the onshore crew has 24 members. There are three crews for each activity, with one crew working, one crew sleeping and one crew on leave. Rotation is four weeks on and two weeks off.

The occupations of the 40 offshore crew members and their pay rates are as follows:

- Project manager (1) ($645/day)
- Environmental Engineer (1) ($645/day)
- Superintendent (1) ($605/day)
- Foreman (1) ($600/day)
- Operators (19) ($500/day)
- Mechanics (2) ($500/day)
- Oiler (1) ($500/day)
- Laborer (2) ($480/day)
- Welder (4) ($500/day)
- Fitter (4) ($500/day)

- Inspector (2) ($500/day)
- Coater (4) ($500/day)

The 42 offshore pipeline crew members per shift are paid $21,455 in combined wages per day. For both shifts, the estimates double to 84 crew members and $42,910 in total daily wages.

The occupations of the 24 onshore crew members and their pay rates are as follows:

- Project manager (1) ($645/day)
- Environmental Engineer (1) ($645/day)
- Superintendent (1) ($605/day)
- Foreman (1) ($600/day)
- Operators (9) ($500/day)
- Mechanics (1) ($500/day)
- Oiler (1) ($500/day)
- Laborer (2) ($480/day)
- Welder (2) ($500/day)
- Fitter (2) ($500/day)
- Inspector (1) ($500/day)
- Coater (2) ($500/day)

The 24 onshore pipeline crew members per shift are paid $12,455 in combined wages per day. For both shifts, the estimates double to 48 crew members and $24,910 in total daily wages.

4.14 SEA FLOOR PIPELINES

This task was developed primarily from an interview with the Alaska Planning Manager for Forrest Oil Corporation. Forrest Oil is drilling the Redoubt Shoals development in the lower Cook Inlet and operates the Osprey platform. The information for this task is based on offshore pipeline construction for that project. It is adjusted to account for the different wage rates and work schedules in the Arctic. In addition, concrete donuts are assumed to be used.

The pipelines to the Osprey will be assembled on shore and pulled with tugs to the platform. OCS deep-water production platforms will require a lay-barge, as the pipe can not be pulled. The cost per unit will be about the same for either method. However, the lay-barge and crews are all from the lower 48 states, as no lay-barges are licensed in Alaska. Cook Inlet pipelines vary in diameter from eight to 16 inches.

Specific installed costs are listed below. Using a chart of weights and dimensions of seamless welded pipe, an estimating formula was developed by project engineering staff for pipeline fabrication. This will cover various coatings, geographic considerations and equipment variations. The formula is as follows:

Installation Cost Per Foot = (pipe weight per foot in pounds @$2.00 per pound) +
($60.00 per foot for fabrication) +
($37.50 per foot for offshore installation)

This activity ignores real estate easement purchases or permitting, as they vary greatly per installation.

Pipeline Installation

According to the estimation formula, pipelines of 8, 10, and 16 inches in diameter can be installed at $140.50, $168.50, and $263.50 per foot.

Onshore Equipment

The onshore fabrication equipment has a ten-year lifetime and therefore costs will be capitalized over a ten-year period and will prorate at about $ 0.32 per foot per $100,000 of original investment or about $29.50 per foot for this example.

Equipment used onshore for pipe fabrication includes the following. One 966 Caterpillar loader with forks and bucket that costs $260,000 for the base model plus $5,000 for Alaska upgrade. Four D6 side boom caterpillars that cost $330,000 each for the base model plus $5,000 for Alaska upgrade. Two pickup trucks at $25,000 each from a local fleet dealer. Two 20 ton cranes at a cost of $260,000 each. Two welding trucks (fully equipped with welders, torches, and tools) at $34,000 each.

Offshore Equipment

Offshore equipment such as tugs, dive boats, and lay-barges are leased by the day for pipeline installation. Some of these boats have been in service for over 30 years, so that calculation of lifetimes and capitalization of costs would be difficult. Each of four tugs has two 55 hundred horse engines and two generators. The fuel consumption is 180 per hour at $1.50 per gallon. This tug leases for $10,000 per day. Each of the two 50 feet by 12 feet dive boats has two 1000 horsepower engines, a generator and an air compressor. The dive boats consume 40 gallons of fuel an hour.

This activity involves “dragging” the pipelines from shore to the platform. A large onshore staging area is prepared where the pipe will come ashore. Four 40-foot pieces of pipe are welded in sections and their joints are coated and wrapped. The 160-foot sections are stacked in the staging area until they are to be dragged off shore. The previously welded sections of pipe are carried to cribs on the beach by the side boom D6 Cats. The 20-ton cranes hold the ends being joined until they are welded and the joints coated and wrapped.

The pipes are then pulled by the tugs towards the platform they will serve. Several platforms may manifold to one that has pipelines going ashore. The divers look for abnormalities in the ocean bottom that could stress the pipe. Each set is 160 feet long and about five sets on each pipeline can be placed in a 12-hour day. The onshore equipment is serviced and fueled before and after work and at lunchtime if necessary. The equipment uses about 600 gallons of fuel per day at $1.50 per gallon.

In addition to the materials used for the sub-arctic pipeline, in the arctic environment concrete donuts are installed around the pipe and lowered as a unit to the ocean floor. The donuts are installed every ten feet. The costs of making the concrete donuts are based on the concrete work for island protection systems discussed above.

Personnel

All personnel work 12 hours a day for 7 days a week. The composition of the pipeline crew includes:

- 1 Construction Manager
- 6 Operators
- 2 Welders
- 2 Pipe fitters/welders helpers
- 2 Laborers
- 4 Divers

Offshore crew that operate and live aboard the tugs work a two week on and two week off schedule averaging 12 hours per day. The crew of the tugs and lay barges include:

- 1 Captain
- 2 Mates
- 1 Engineers
- 1 Helpers
- 2 Seamans
- 1 Cooks

Note that this is the crew for a single shift on a single tug/laybarge. There are four vessels and two shifts.

The crew of the dive boats consists of a Captain, Mate and Engineer. In this case, two divers per boat at $800 per day each will be used. If a lay-barge is used, the onshore crews and equipment will work on the barge. As discussed above, the costs per unit for the two construction techniques are very similar.

The concrete crew includes the following personnel:

- 2 Supervisors
- 19 Equipment operators

- 2 Maintenance personnel
- 4 General laborers

There are two shifts of these employees.

4.15 LAND BASE OPERATIONS

The manpower and input vector estimates were developed for an onshore land base. This land base provides storage of materials, storage and maintenance of vehicles, hauling and logistics. The portion of this operation that is assigned to a given year of a lease development scenario is specified in the E&D scenario.

The North Slope has what has been referred to as a $1 billion warehouse operation that supports all of the oil exploration and production activities. This operation is unlike any in the world, because of the lack of a normal supply chain due to the remote area. BP and Phillips both have large warehouse facilities at Prudhoe Bay and Kuparuk. There are also approximately 12 smaller warehouses and storage areas at the other oil fields.

The E&D scenario for lease 170, which was used extensively in the design and testing of the model and data developed in this study, estimates that the land base will only be used during major construction years in 10 percent increments. However, it is worth noting that since this operation supports all of the ongoing operations, and since North Slope oil production is about 1,250,000 barrels per day, such that an island that produced 25,000 barrels per day would represent two percent of the total production. Project engineering staff has suggested that one could assume that such an island would use two percent of the land based support. During construction the support required by the island may increase to 3.5 percent.

The estimates developed in this chapter assume that capital costs for the construction of the facility are sunk and are therefore not included in the estimates. This provides the most accurate estimate of economic impact, because it is unlikely that the activities to be modeled will require the construction of new land base facilities.

The analysis of land base operation costs were based on a series of interviews supplemented by the engineering and economic analysis experience of project staff.

Overview of the Activity

These North Slope warehouses have everything that is needed. There are no other sources of materials so these warehouses are stocked like a very large hardware store with pumps, valves, pipes, gaskets, tools, clothing, toilet paper, light bulbs, etc. Warehouses in Anchorage would also support the North Slope warehouse system.

There are lots for equipment rentals including front end loaders, graders, trucks, pickups, cranes (10 to 50 ton), bulldozers, etc. They won't have any big cranes (300 ton) that could unload the drilling rigs or process modules. Another company (Kodiak Haulers) also hauls most of the equipment to the remote sites. BP and ARCO won't actually own any heavy equipment on the North Slope; however they will have a large fleet of pickups (pickups, vans, SUVs, i.e. light duty trucks). In addition, there is maintenance operation for the heavy equipment and the light duty trucks.

Other companies have contracts to warehouse and supply the food and fuel for the slopes.

The land base system is assumed to comprise of two main warehouses, one for each major oil company, and approximately 12 smaller warehouses spread out near the various production facilities.

Capital Equipment and Cost

It is very difficult to estimate the amount of money spent to maintain the land base facilities or the amount spent per year to keep them up-to-date. As a rough estimate, it is assumed that on average $2 million is spent each year to add new buildings to the complex and $5 million is spent for maintaining the capital stock.

In terms of equipment, it is assumed that there is a fleet of 40 pickups, SUVs etc. maintained by the oil companies. Each of the large warehouses is assumed to have 5 forklifts and 2 CAT front end loaders while the small warehouses have 2 forklifts and 1 Cat a piece. In addition, it is assumed that there is a fleet of 12 single unit flat bed trucks and 8 tractor trailer flatbeds with half of this fleet at each of the 2 large warehouses.

A summary of the vehicles and their numbers and cost include:

- 16 Cat 966 front end loaders
- 12 flatbed single unit hauling trucks ($80,000 base plus $5,000 for arctic upgrade)
- 8 flatbed combination hauling trucks ($120,000 base for the tractor plus $5,000 for arctic upgrade and $30,000 for the trailer)
- 22 forklifts
- 40 heavy-duty pickup trucks ($25,000)

Manpower and Cost

The large ware houses are assumed to have a staff of 30 each shift and the small warehouse a staff of six each shift. For the large warehouses, on each shift there will be with two supervisors, four mechanics, seventeen operators and six laborers/clerks. For the small warehouses there will be one supervisor, three operators and one mechanic and one laborer/clerk. For all of the warehouses, the total labor on both shifts and the daily pay rates will be as follows:

- 32 Supervisors ($600/shift)
- 40 mechanics ($500/shift)
- 140 operators ($500/shift)
- 48 laborers/clerks ($480/shift)

In total there will be 260 workers earning $132,240 per day.

Heating Fuel Costs

It is assumed that the warehouses will have their own generators that run on diesel fuel. At the large warehouses it is assumed that two generators are maintained to provide backup in case one fails. In addition, the warehouse will be tied into the local power grid and provides or takes electricity when necessary. The smaller warehouses are assumed to have a single generator and to rely solely on power from the local grid if their generator fails.

The raw costs are for operating the generator are 7.5 cents per kilowatt hour. It is estimated by study engineering staff that the two generator sets would cost about $375 per hour to operate with $175 of this cost for capital, $150 for fuel, and $50 for miscellaneous material inputs including oil, antifreeze, "clean sweep" and other inputs including rags. Since a total of sixteen generators are assumed to be used by the 14 warehouses, costs will be eight times these estimates or $3,000 per hour.

Vehicle Fuel Costs

The following data on daily fuel use by vehicle type were collected from the interviews for this task and were supplemented by fuel use data collected for other activities.

- The cats use 150 gallons per day.

- The single-unit trucks use 60 gallons per day.

- The combination tractor trailers use 90 gallons per day.

- The forklifts use 30 gallons per day.

- The heavy-duty pick-up trucks use 30 gallons per day.

4.16 SPILL CONTINGENCY

The manpower and input vector estimates were developed for a typical spill contingency operation. This operation continues year round, but the equipment that is used varies by area protected and the time of year.

Clean Seas, a co-op funded by all of the oil companies involved in North Slope operations, provides the spill protection and cleanup services for spills on land, rivers and offshore. The coop is funded by 13 oil companies that contribute funds in proportion to shares of ownership in oil and gas production. Ninety percent of the expenditures are for maintenance, training and capital. Only 10 percent of expenditures are for the actual cleanup activities which are referred to as oil spill contingency response. Most actual spills are extremely small, often a gallon or less.

The co-op covers about one-third of the North Slope land area and the adjoining Beaufort Sea. It is estimated by project engineering staff to be large enough to provide cleanup capability for potential oil spills for approximately ten production facilities onshore and offshore. Therefore, for modeling purposes, each production island will be assigned one-tenth of the costs of the spill containment co-op developed in this chapter.

These costs assume that OCS oil is brought to shore by a newly constructed pipeline that ties into existing pipeline infrastructure connecting to Pump Station 1 of the Trans-Alaska Pipeline System. A spill could occur at any point between the production facility and Pump Station 1. This includes pipelines crossing land and rivers. OCS oil mixes with non-OCS oil between the production facility and some point onshore. We assume a portion of Clean Seas costs are attributed to the OCS.

The analysis of the spill contingency operation is based on several interviews supplemented by the engineering and economic experience of project staff. One member of the engineering project staff was trained in spill operations while working on the North Slope. Interviews were conducted with the following additional sources:

- An owner of the firm that constructs the new onboard motor river boats that will be used in the operations. This individual also maintains boats currently used in these operations and trains the boat operators.

- An owner of a firm that builds the air boats used in spill contingency operations.

Overview of the Activity

There are three types of spill contingency that include: river protection, open sea water protection and spring and fall freeze and thaw protection. A description of each of these types of spill contingency is provided in the following paragraphs followed by information on manpower, capital and material costs.

River Protection

River protection is relevant to both offshore and onshore activities. They apply to offshore activities because associated production facilities, such as Alpine, are sometimes located on a river delta or because the onshore portion of the pipelines that service offshore activities might cross a river and river protection would be necessary if there were a pipeline leak.

The major equipment for rivers includes eight 24-foot Marion aluminum river boats powered by 200 hp Yamaha outboards. In the case of the Clean Seas Co-op, two are owned by the co-op, while six are owned by the oil companies and assigned to the co-op. The company that produced these boats is out of business and these boats are not as environmentally friendly as newer equipment. They will be replaced by new boats with inboard engines within five years. The new river boats are 22 foot Silver Streak boats with 360 hp inboard jet boat engines.

In spring, when rivers thaw out, the crews drive the boats up to the river and carry booms and anchor them on river banks. Booms are plastic floats filled with air. They contain the oil and prevent it from continuing downstream. Four sets of booms are put in place 400 yards apart. The booms are left in place all summer. If a spill occurs, eight boats and crews are sent to the river (one hour to get there) with eight people per boat. Each boat retrieves one end of a boom and goes to the middle of river and hooks their boom together with the boom from the opposite side of the river. To practice containing the oil spills, the spill contingency teams practice with oranges.

Another important piece of equipment is the oil/water skimmer/separator. These are also staged on the river banks with the booms. There is one skimmer for every two booms. The booms are first used to stop the oil from flowing downstream. The boats then stop to pick-up the skimmers. The skimmers are basically a belt with paddles (like a conveyor belt). It has floats and is powered by gasoline. It also has an oil and water separator that works by pumping the oil off the top and the water off the bottom. The oil is put in barrels or double walled bladders.

Each river or island has its own set of equipment, as it is impractical to go too far for equipment given the importance of quickly containing the oil. If a river has several rigs near it or pipelines crossing it, it will have a set of booms below each.

Open Sea Protection

The major pieces of equipment for open sea protection are two 42 foot ocean going boats. They are staged at a dock in Prudhoe Bay. If a spill occurs they go to the site and hook two booms together and circle the site of spill. Booms generally come in 100 foot lengths and there are 2000 to 4000 feet on each boat. The crews start down wind from the oil spill and spread the booms out to contain the oil spill. They may not close the loop. The boats then disconnect and go inside of the booms to the contained oil and use the same skimmers/separators as are used for the river protection task. The process may be repeated if oil gets over the boom. One difference between the open sea and river operations is that all of the equipment is stored on the boats.

Spring and Fall Protection

During the fall and spring freeze and thaw periods the river and open sea boats cannot operate. As a result, air boats are used. Other than the type of boat, the process is the same as for the other methods. The air boats carry the booms and the skimmers/separators. The air boats can run effectively on ice, snow, or water.

Manpower and Cost

Clean Seas has 108 permanently employed people who maintain the boats and equipment. Half are on duty at any given time and half are on leave. Employees would typically stay at the hotel/camp facilities and use local personnel transport. These employees include:

- Eight (or 16 total) supervisors who are paid $600/day. They work one week on and one week off. They work a ten hour day, but are on standby 24 hours a day.

- 46 (or 92 total) craftsman/spill technicians who are paid $500/day. They work 2 weeks on and two weeks off. They also work a ten hour day, but are on standby 24 hours a day.

- Large cleanup efforts are also supported by trained oil company personnel. These employees participate in training sessions for several hours every two weeks. The cost for these personnel is not included in the co-op budget but rather in general oil company overhead.

Capital Cost

Equipment includes three types of boats, the skimmers and the booms. The life span for the boats is 10 years with 100 percent dedication to task.

At present, the river boats are 24-foot outboards, but the company that produced these boats is out of business. In addition, these boats are less environmentally sound than boats with inboard engines. They will be replaced by new boats with inboard engines. The current 24-foot jet boats cost $15,000 each delivered to the North Slope. Also required was a trailer for each boat at $3,500 per trailer. The boats were built in the in Anchorage and the trailers in the U.S. The equipment is delivered by truck (2 boats per truck). The boats use a 200 hp Yamaha jet outboard engine that cost $12,000. They are Japanese made and are purchased from a local dealer anchorage dealer at an approximate overhead rate or markup of 30 percent.

The new river boats, which will be used in the development of the estimates, are 22-foot Silver Streak boats with 360 hp inboard jetboat engines. They have stainless steel pumps, are safer and more stable, and are more environmentally friendly. They cost $35,000 each. New trailers will be required at $3,500 each. The old boats will be replaced within five years. The engines are

Chevrolet factory machine engines that have a base price of $5,200, but cost up to $10,000 with marine setup.

The two ocean-going 42-foot boats were purchased at a price of $150,000 each. Equipping the vessel for the North Slope costs an additional $50,000 per boat. This included purchase prices and installation for navigational equipment, radar, insulation, and heaters.

The skimmer/separators cost $100,000 each including accessories, pumps, motors, controls. Two inventors in Keni designed them and custom build them. Each section of river to be protected requires four skimmers and the four ocean-going and air boats each carry one skimmer. Assuming four river protection sites results in an estimate of 20 booms. For transport from Southern Alaska, all the skimmers would fit on one truck.

Each section of river to be protected requires eight sets of booms with each set assumed to be 200 feet long for a total of 1,600 feet for each river protection site. Assuming four river protection sites results in an estimate of 6,400 feet for river protection. Each ocean-going boat carries 2,000 to 4,000 feet of boom each. Using an assumed average of 3,000 feet for the two ocean-going boats and an average of 1,000 feet for each of the air boats, results in an estimate of 8,000 feet of booms for these types of protection and 14,400 feet of boom in total.

The most common spill containment boom used on the North Slope is called 8 by 12 Contractor Boom. It has 8" floats and a 12" skirt and is used offshore. The boom comes in 100 foot lengths and costs about $13 per foot wholesale at Anchorage. A bundled 100 foot roll weighs 170 pounds and makes a bundle approximately 40" wide by 30" high by 7.5 feet long. The 14,400 feet of boom to serve the co-op will cost $187,200. This includes wholesale margins but no transportation to the slope.

Fuel Consumption

The out-board river boats consume 18 gallons of fuel per hour and a typical run is about six hours. The boats are estimated to be used two times per week on average for about four months. Multiplying 17 weeks (34 trips), 18 gallons per hour and six hours per trip, and eight boats, results in an estimate of 29,376 gallons per year.

The new river boats consume 11 gallons per hour. Assuming the same typical runs as for the old river boats, results in an estimate of 17,952 gallons of fuel.

The ocean-going boats consume 13 to 17 gallons per hour. Assuming the same typical runs as for the river boats, results in an estimate of 6,120 gallons of fuel.

The air boats consume 20 gallons per hour as air powered boats are less efficient. Assuming the same typical runs as for the other boats, results in an estimate of 8,160 gallons of fuel.

4.17 FACILITY ABANDONMENT

The manpower and input vector estimates were developed for abandonment of a production island. The estimates do not include the costs for abandonment of any of the onshore facilities as it is assumed that these facilities would be used for other production projects.

In reality, abandonment can range from complete removal to a shut down mode with most facilities left intact for future use. Decisions as to the desired course of action will normally be decided when the field is abandoned, because of potential unknown future uses. Possible uses of an island structure include other oil and gas projects, a deepwater port facility, scientific research projects, or a shelter for travelers. A mobile production structure could be relocated for use at another reservoir. Pipelines are likely to be reused only if production continues, or to supply fuel for activities or housing. Housing facilities on an island may be of interest to local government, businesses, or individuals.

If no uses for facilities can be identified, structures may be removed. Removal involves similar activities to construction. Mobile production structures are easiest to remove, with islands and pipelines the most difficult. Some facilities, such as underground offshore pipelines, could be abandoned in place.

For this study, it is assumed that abandonment in place will be the chosen alternative. The production island will have most of the modules and equipment removed, but the island itself will be left intact for possible future uses. All or part of the personnel quarter's module will be left for shelter. The cost of removal is estimated to be similar to the cost of module installation including transportation. Therefore, the manpower and other costs of this portion of the activity were estimated using the vector developed for equipping the production island, with the exception that the costs of the modules and other equipment were not included. A further description of the development of this data is provided in the Equip Island activity.

It is also assumed that wells will be abandoned. This activity will take four to five days and consist of removing the first thousand feet of casing and tubing and plugging the well. The time, equipment and materials required will be very similar to a well workover. Therefore the costs of the well workover activity were used to estimate the cost of well abandonment.

The input vector for a single well abandonment was multiplied by an estimate of the number of wells per Production Island. The Northstar Island is designed to hold up to 27 wells. The E&D scenario for Sale 170 assumes 28 to 29 wells per island depending on the scenario. The E&D scenario for the Beaufort Sea Sale 144 assumes 30 to 34 wells per island depending on the scenario. Based on these data, it is assumed 30 wells per island are abandoned.

Remaining facilities are assumed to be abandoned in place. Offshore pipelines which are already buried under the sea floor are assumed to be left in place. Onshore pipelines are assumed to left for future uses as are hotel/camps and land base operations facilities.

The manpower estimates and input vectors for island abandonment are the sum of the vectors for thirty well workovers and the equipping of a production island (less the actual costs of the equipment itself).

5. LABOR INPUTS

The purpose of this chapter is to provide an overview of the methods used to develop the labor inputs to the various activities that comprise the oil exploration, development and production process in the Alaskan Beaufort Sea. Subsequent chapters provide similar discussions for purchased services, materials, equipment and government. In some sense, this study developed a production function for each activity, where the production function is defined in terms of expenditures for various types of inputs. These inputs can be broadly grouped into the following categories: labor, purchased services, capital, and materials with the latter including raw, intermediate and energy material and inputs.

The data developed in this study were based on information collected in the years 1999 and 2000 and published reports providing data for various years, but mostly for the years 1997 to 1999. As such, the estimates provided in this study should be considered to be reported in 1999 dollars.

The model developed in this study is designed to be stimulated by activity levels contained in the MMS E&D scenarios. These activity levels then activate input vectors for each activity. This chapter and those that follow describe the general methods used to develop the expenditure estimates for each of the major input categories. This chapter provides an overview of the techniques used to develop later inputs as well as describing some common data and data development techniques used in the following chapters.

5.1 OVERVIEW OF THE METHODOGY

Labor inputs include the direct labor used in the construction and operation of the oil and gas facilities as well the overhead or headquarter salaried non-production staff that provide support functions over a range of operations. As a result, estimates of labor inputs not only considered employment in the field, but also local and regional offices and headquarters. In order to allow stimulation of both RAM and IMPLAN, estimates are made for both the man-days of employment and employee compensation, respectively. The information on man-days is also used in estimating lodging and food costs. In addition, the development of estimates both in man-days and employee compensation will facilitate updating of the data in future studies

In calculating estimates of economic impact in cases where workers are commuting, it is necessary to consider both where the employee works and where the employee spends their income and pays their taxes. Therefore, while data is initially developed based on the location of the workplace of the individual, these estimates are then converted to estimates of the location in which the expenditures of wages and payment of taxes are made.

5.2 ESTIMATES OF PRODUCTION EMPLOYMENT AND WAGES

The first step was to estimate the actual labor used in the field. These direct construction labor inputs were estimated through interviews with representatives of construction contractors and oil companies that have experience in constructing or operating the structures under consideration. These estimates are often the most clearly defined, since the work efforts of these types of employees are most easily assignable to a particular activity. These estimates, which were developed separately for each individual activity, are discussed in detail in the previous chapter. In most cases, data was collected, by activity, on the number of employees by trade, wages for employees by trade, task crew size, duration of task, number of shifts, shift duration and rotation pattern.

These data were tabulated and are presented in Exhibit 5-1. For each activity, the crew members are listed by trade. For hourly employees, the wage rate is recorded along with the hours worked per day and days per week to calculate a weekly wage. For salaried employees the hourly wage is found based on hours per day, days per week, and rotation pattern. Weekly wages are converted to total wages based on crew sizes, shift factors, number of crews, rotation patterns and the length of the activity in weeks. Note that for some activities this is simplified as all the crew members work the same schedule, while for other tasks these calculations must be made at the crew member level.

The following paragraphs provide an overview of the data development for each of the activities. The section concludes with a discussion of fringe benefits.

Seismic Survey

As discussed in the engineering description for this task in the previous chapter, about 100 workers are required for the operation of the survey, six operators with the cat train company, and around 94 personnel with the survey company. There is only one shift per day, however, employees commonly work 16-18 hours a day.

The total Native hire for seismic surveys is negligible. Most of the crew works four weeks on and two weeks off, resulting in about a 30 percent over hire. For the permanent employees (about half), there is a $7 per hour benefit package. Sixteen to eighteen hours a day is common; so a lot of overtime, at time and a half, is paid.

In total, it is estimated that it would require 3,000 man-days of labor to conduct one month of seismic survey work based on a 100 person crew for 30 days.

The first step in compiling this data was to convert all wages to a daily wage. For hourly employees, the following procedure was used. First, assuming a 16-hour day on average, hourly employees would work 112 hours a week, and with 72 of those hours at overtime pay, would be paid the equivalent of 148 hours a week. Therefore, the hourly wage was multiplied by 148 to convert to a weekly wage and then divided by seven to convert to a daily wage. For monthly employees, monthly wages were first divided by 20 to account for the fact that with a four weeks on/two weeks off rotation, these employees work 20 days per month on average.

North Slope Support

A resident staff of 20 is required to operate a 300 person hotel/camp. However, total employment is thirty as ten more personnel would normally be on leave (time off). Ninety percent of the staff is unskilled at a cost of $300 per day. Ten percent is skilled at a cost of $400 per day. Ninety percent of the staff is Alaska hire with the remaining ten percent drawn from the other 49 states. Fifteen percent of the total staff is Native hire. In total, it is estimated that it would require 7300 man-days of labor to operate the hotel/camp on an annual basis.

General Personnel Transport

It is estimated that seven workers are required for the operation of the general personnel transportation function including four drivers, a two member maintenance crew, and a dispatcher/supervisor. According to the engineering project staff, personnel of this type would generally work two weeks on and two weeks off.

No wage information was available from the interviews; however, engineering project staff estimated that the drivers and maintenance crew would be paid $300 per day. The management employee, the dispatcher/supervisor, would make about $100 more or $400 per day.

Ice Roads and Ice Islands

A total of 50 men for 21 to 30 days, depending on the weather, work two 12 hour shifts, 24 hours per day, until the ice road, the island, or both, are complete. Forty men are operators, four are supervisors, and six are support fuelers/mechanics. The six support personnel will be used equally on all tasks in this unit. The supervisors are paid $600 per day, while the operators and support staff are paid $500 per day. The total Native hire for ice road and island construction activities is 15 percent with 25 percent residing in the NSB.

In total it is estimated that it would require 710 man-days of labor to construct the 10 miles of ice road and 390 man-days of labor to construct the ice island.

Drill Ships and Mobile Exploration Platforms

As discussed in the engineering description for this set of activities, there are a number of vessels and support functions required for these activities. Each has a specific crew makeup and size. In each of the tasks involving drill ships and exploration platforms, the vessels and support crews in use were assumed to vary based on the requirements of the activity. Exhibit 5-1 provides a listing of the vessels and support activities employed in each activity and the crews that are required for each. In most cases, the crews are identical regardless of the activity. An exception is for the drill ship crew itself, which is assumed to be greatly reduced in calm water activities.

Helicopter Support

About five workers are required for the operation of the helicopter support function including two pilots, a full time hanger manager and a two member maintenance crew. There is only one shift per day; however, employees are on call 24 hours a day. It is further assumed that the helicopter company, headquartered in Anchorage will have overhead type staffing requirements including individuals from the CEO to the mail room clerk. No information was available on the quantity or cost of these overhead employees per helicopter.

As discussed in the engineering description for this task, the helicopter pilots are paid $500 per day each. No wage information was provided for the other employees; however, engineering project staff estimated that each of the two member maintenance crew would be paid $500, the same as the pilot. The management employee, the hanger manager, would make about $100 more or $600 per day.

Barge Support

Approximately four workers are required for the operation of the barge including a captain, a ship engineer and two laborers. There is only one shift per day, however, employees commonly work as needed and are available 24 hours a day. The total Native hire for the construction is estimated to be five percent.

Given the short duration of the task and the fact it takes place in the more desirable summer months, it is assumed the crew works solid for all four months with no days off. It is further assumed that one person per barge will be required to fulfill the manager, owner, bookkeeper, salesperson, dispatcher functions.

Well Drilling

As discussed in the engineering description for this task, approximately 44 workers are required for the well drilling operation. These workers are divided among two twelve hour shifts per day. Typically a drilling crew will have two to four percent Natives. In addition, there is one Native-owned drilling company that uses about 50 percent Native hires. A five percent Native hire for the drilling crew was used as an average. The crew works two weeks on and two weeks off.

Assuming a crew size of 44 workers and 90 days to drill an exploration well, the result is an estimate of 3,960 man-days to drill an exploration well. For production wells with the same size crew and an assumed 30 day drilling period, an estimate of 1,320 man-days is derived. For a well workover, the 44 person crew and four day drilling period assumptions result in an estimate of 176 man-days.

These manpower estimates were then multiplied by estimates of wage rates to develop estimates of employment costs. The cost per day for the various field workers involved in the well drilling activities was provided in detail in the engineering description of the activity.

Gravel Island Construction

For island construction, which consists of separate activities for gravel placement and island protection, the number of workers required varies depending on the stage of island construction. Typically, an island construction crew will have 5 percent Natives. The crews work two weeks on and two weeks off. The cost per day for the various field workers involved in the island construction activities was provided in detail in the engineering description of the activity.

Production Module Installation

For module installation, the number of workers required varies depending on the task underway. For this activity the manpower that was analyzed was limited to the manpower required to offload, install and hookup the modules. The manpower for the fabrication of the modules in Anchorage was not included as the modules are treated as purchased goods. As such no production function for the fabrication of the modules is estimated.

There are assumed to be 50 employees for two weeks for offloading and 120 employees for 120 days for installation and hookup. Typically, an island construction crew will have 5 percent Native employees. The crews work two weeks on and two weeks off.

The cost per day for the various field workers involved in the module installation activities was provided in detail in the engineering description of the activity.

Production Island Operation

Approximately 31 workers are required per shift for the operation of a production island. Typically, a production island operations crew will have 85 percent Alaskan employees with 15 percent Natives. The crews work two weeks on and two weeks off. The cost per day for the various field workers involved in the operation of the production island were provided in detail in the engineering description.

Gas Production Facilities

Labor for these facilities was based on scaled down version of the estimates for the production facility installation and operation. They were based on a rule of thumb that the facility would cost roughly one-sixteenth the cost of the full facility.

Onshore and Offshore Pipelines

As discussed in the engineering description for this task, about 42 workers are required per shift for an offshore pipeline construction crew and about 24 for an onshore pipeline construction crew. Typically a pipeline construction crew will have 5 percent Native employees. The crews work four weeks on and four weeks off. The cost per day for the various field workers involved in the pipeline construction activities was provided in detail in the engineering description provided in the previous chapter.

Subsea Pipelines

Construction of the subsea pipeline requires four sets of crews including one for pipeline construction itself, one for operation of the tugs and lay barges, one for the dive boats and one for constructing the concrete shapes. The size and composition of each of these crews is discussed in the engineering description for this activity and enumerated in detail in Exhibit 5-1.

Land Base Operations

It is estimated that approximately 260 workers will provide warehousing services, vehicle maintenance and hauling services. Typically, a North Slope crew will have 10 percent Natives. The crews work two weeks on and two weeks off. Estimates of production worker wages are developed by averaging the daily pay rates for the various types of employees.

Spill Contingency

As discussed in the engineering description for this task, a staff of 54 is required to operate the spill containment co-op. However, total employment is 108 as half the personnel would normally be on leave (time off). Forty-six (92 total) of the staff are craftsman/technicians at a cost of $500 per day. Eight (16 total) are supervisors at a cost of $600 per day. Five percent of the staff is Native hire.

Abandon Island

Labor estimates for abandoning a production island were based on the assumption that removing the production equipment would entail the same labor as installing the equipment and that shutting down each of an assumed 30 wells would require the same time and labor as a well workover.

Fringe Benefits

Wages were adjusted to include an estimate of the value of fringe benefits. Data for this purpose were taken from the 1997 Census of Mineral Industries. The U.S. Oil and Gas Industry volume contains data on fringe benefits that were used in the analysis. According to data provided in that publication, fringe benefits not included in payroll amounted to 20.4 percent of take home wages for U.S. oil and gas industry employees.

Some fragmentary data on fringe benefits were reported in the industry interviews conducted for this study, such as the per hour information for seismic surveys discussed in the engineering description for that activity. However, these data were incomplete and therefore, the Census data were believed to be more accurate. Note that although the Census data represent an accurate average for the industry as a whole, actual rates may vary among activities.

5.3 ESTIMATES OF NON-PRODUCTION EMPLOYMENT AND WAGES

While data on field or production employees by activity could be estimated directly from primary sources, estimates of office and headquarters personnel attributable to each activity were developed using secondary data sources. These estimates were based on industry-level ratios of total to production employees. Note that these employees are not necessarily associated with an individual activity, but rather represent an allocation of an overhead type function.

The numbers of headquarters and support staff are estimated based on published Census data on the ratio of total workers to production workers. Exhibit 5-2 provides these ratios from the 1997 Census of Mineral Industries for a variety of areas and industries for which data were available. Data are also provided on the ratio of total to production employee wages and average payroll per non-production employee. All data are presented on a NAICS code basis.

Exhibit 5-2: 1997 Census Data on Non-Production Employment and Payroll

Region	NAICS Code	Number of Total Employees	Number of Production, Development, and Exploration Workers	Ratio: Total to Production Employees	Payroll for All Employees ($,1000)	Wages for Production, Development, and Exploration Workers ($,1000)	Ratio: Total to Production Employee Wages	Number of Non-Production Employees	Payroll for Non-Production Employees ($,1000)	Average Payroll Per Non-Production Employee ($,1000)
Alaska	211	2,389	1,715		247,884	173,143				
	213111	1,023	791		54,802	46,364				
	213112	5,071	3,782		284,113	231,417				
	Total	8,483	6,288	1.35	586,799	450,924	1.30	2,195	135,875	61,902
U.S.	211111	100,308	58,289		4,968,722	2,717,588				
	211112	10,549	8,870		541,593	456,083				
	213111	53,865	45,219		1,918,086	1,539,296				
	213112	106,339	80,734		3,628,416	2,821,468				
	Total	271,061	193,112	1.40	11,056,817	7,534,435	1.47	77,949	3,522,382	45,188

The ratios for the sum of the NAICS codes 21111, 213111 and 213112, which combines exploration, drilling and extraction, were selected to be used in this study as comparable data were available for both Alaska and the U.S. Note that non-production employment within Alaska is 35 percent of direct production employment, while non-production employment within the U.S. is 40 percent of the direct production employment. It was assumed that the difference between the 35 and 40 percent ratios are due to Alaska-related non-production work located in other parts of the country, not a difference in the number of employees required to accomplish equivalent tasks. Therefore, it is estimated that for every 100 production workers on an Alaska

OCS project, there would be 35 non-production workers in Alaska and five non-production workers in the other 49 states.

Non-production employment within Alaska is then divided between the NSB and the remainder of Alaska based on data provided by industry sources. Based on these interviews it is estimated that 41.2 percent of Alaskan non-production employment related to NSB activities are located in the NSB, while the remaining 58.8 percent are located elsewhere in Alaska, primarily in Anchorage. Note that NSB employment refers to location of employment only and that location of residence for the vast majority of workers is outside the NSB primarily in South-Central Alaska. This is important because most expenditures of personal income are in South-Central Alaska.

Exhibit 5-3 provides the estimates of non-production workers and their wages. The number of full time equivalent (FTE) production workers is estimated as the product of the task work force and task length. The resulting estimates of non-production workers are then derived for Alaska by applying the 35 percent factor and for the U.S. by applying the five percent factor.

Exhibit 5-3: Numbers and Wages of Non-Production Worker Wages by Activity by Geographic Area

Activity	Total Task Work Force	Total Task Length (weeks)	Number of Production Workers (FTE)	Number of Alaskan Non-Production Workers (FTE)	Wages for Alaskan Non-Production Workers	Fringe Benefits @20.4% of Wages	Alaska Non-Production Wages and Fringe Benefits	Number of U.S. Non-Production Workers (FTE)	Wages for U.S. Non-Production Workers	Fringe Benefits @20.4% of Wages	U.S. Non-Production Wages and Fringe Benefits
1. Geological Survey	134	4	11.16	3.9	241,056	49,175	290,232	0.609	27,508	5,612	33,120
2. North Slope Support	30	52	30.00	10.5	648,259	132,245	780,503	1.637	73,976	15,091	89,068
3. General Personnel Transport	14	0	0.04	0.0	831	170	1,001	0.002	95	19	114
4. Construct Ice Road	150	5	14.01	4.9	302,758	61,763	364,521	0.765	34,549	7,048	41,597
5. Construct Ice Island	150	3	9.07	3.2	195,902	39,964	235,866	0.495	22,355	4,561	26,916
6. Move Drll Ship/Bottom Founded Platform	232	1/7	0.64	0.2	13,773	2,810	16,582	0.035	1,572	321	1,892
7. Operate Drill Ship in Calm Waters	50	1/7	0.14	0.0	2,968	606	3,574	0.007	339	69	408
8. Operate Drill Ship in Rough Seas	232	1/7	0.64	0.2	13,773	2,810	16,582	0.035	1,572	321	1,892
9. Operate Mobile Exploration Platform	48	0	0.13	0.0	2,849	581	3,431	0.007	325	66	392
10. Helicopter Support	10	0	0.03	0.0	594	121	715	0.001	68	14	82
11. Barge Support	4	0	0.01	0.0	237	48	286	0.001	27	6	33
12. Drill Exploration Well	88	13	21.76	7.6	470,166	95,914	566,079	1.187	53,653	10,945	64,598
13. Drill Production Well	88	4	7.25	2.5	156,722	31,971	188,693	0.396	17,884	3,648	21,533
14. Well Workover	88	1	0.97	0.3	20,896	4,263	25,159	0.053	2,385	486	2,871
15. Construct Gravel Island	124	9	20.44	7.1	441,671	90,101	531,772	1.115	50,401	10,282	60,683
16. Protect Gravel Island	172	26	85.05	29.7	1,837,920	374,936	2,212,856	4.641	209,735	42,786	252,521
17. Equip Production Island	340	19	125.16	43.7	2,704,639	551,746	3,256,386	6.830	308,641	62,963	371,604
18. Operate Production Island	124	52	124.00	43.3	2,679,469	546,612	3,226,080	6.767	305,769	62,377	368,146
19. Construct Gas Production Facility	88	26	44.00	15.4	950,779	193,959	1,144,738	2.401	108,499	22,134	130,632
20. Operate Gas Production Facility	12	52	12.00	4.2	259,303	52,898	312,201	0.655	29,591	6,036	35,627
21. Construct Offshore Pipeline	126	11	25.96	9.1	560,993	114,443	675,436	1.417	64,018	13,060	77,078
22. Construct Onshore Pipeline	72	11	14.84	5.2	320,567	65,396	385,963	0.810	36,582	7,463	44,044
23. Lay Sea Floor Pipeline	328	5	29.74	10.4	642,560	131,082	773,642	1.623	73,326	14,959	88,285
24. Land Base Operation	520	52	520.00	181.5	11,236,482	2,292,242	13,528,725	28.376	1,282,257	261,580	1,543,837
25. Spill Contingency	108	52	108.30	37.8	2,340,142	477,389	2,817,531	5.910	267,047	54,477	321,524
26. Abandon Production Island	428	17	141.10	49.3	3,048,952	621,986	3,670,939	7.700	347,933	70,978	418,911

The number of non-production FTE are then multiplied by the Alaskan and U.S. wage rates from Exhibit 5-2. Fringe benefits are then calculated and added to the total for each area.

5.4 WORKERS BY PLACE OF RESIDENCE

Due to the remote location of many E&D activities in Alaska, a large percentage of the workforce commutes to the project area. Because the geographic spending patterns of workers depends heavily on their primary place of residence, an important first step in estimating worker spending by area is to establish the primary place of residence for the components of the workforce.

According to expert project staff and based on their interviews with industry, it was determined that oil and gas industry related workers in existing or new production areas will be primarily drawn from existing pools of workers throughout Alaska, and the lower 49 states. For projects in the Beaufort Sea area, labor will continue to be drawn from the various areas in the current percentages. These percentages were estimated by project staff and are presented in Exhibit 5-4. Percentage estimates are presented for Native employment, non-Natives from the rest of Alaska and other U.S. residents.

Exhibit 5-4: Percent of Production Employees By Ethnicity, Place of Residence and Activity

	Native Workers				Non-Native Workers		All Workers		
Activity	Percent Native	Percent Native Residing in NSB	Percent Residing in NSB	Percent Residing in Other Alaska	Percent Residing in Other Alaska	Percent Residing in Other U.S.	Percent Residing in NSB	Percent Residing in Other Alaska	Percent Residing in Other U.S.
1. Geological Survey	0%	25%	0.00%	0.00%	80%	20%	0.00%	80.00%	20.00%
2. North Slope Support	15%	25%	3.75%	11.25%	70%	15%	3.75%	81.25%	15.00%
3. General Personnel Transport	0%	25%	0.00%	0.00%	70%	30%	0.00%	70.00%	30.00%
4. Construct Ice Road	15%	25%	3.75%	11.25%	65%	20%	3.75%	76.25%	20.00%
5. Construct Ice Island	15%	25%	3.75%	11.25%	65%	20%	3.75%	76.25%	20.00%
6. Move Drll Ship/Bottom Founded Platform	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
7. Operate Drill Ship in Calm Waters	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
8. Operate Drill Ship in Rough Seas	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
9. Operate Mobile Exploration Platform	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
10. Helicopter Support	0%	25%	0.00%	0.00%	90%	10%	0.00%	90.00%	10.00%
11. Barge Support	5%	25%	1.25%	3.75%	80%	15%	1.25%	83.75%	15.00%
12. Drill Exploration Well	5%	25%	1.25%	3.75%	70%	25%	1.25%	73.75%	25.00%
13. Drill Production Well	5%	25%	1.25%	3.75%	70%	25%	1.25%	73.75%	25.00%
14. Well Workover	5%	25%	1.25%	3.75%	70%	25%	1.25%	73.75%	25.00%
15. Construct Gravel Island	5%	25%	1.25%	3.75%	80%	15%	1.25%	83.75%	15.00%
16. Protect Gravel Island	5%	25%	1.25%	3.75%	80%	15%	1.25%	83.75%	15.00%
17. Equip Production Island	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
18. Operate Production Island	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
19. Construct Gas Production Facility	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
20. Operate Gas Production Facility	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
21. Construct Offshore Pipeline	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
22. Construct Onshore Pipeline	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
23. Lay Sea Floor Pipeline	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
24. Land Base Operation	10%	25%	2.50%	7.50%	70%	20%	2.50%	77.50%	20.00%
25. Spill Contingency	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%
26. Abandon Production Island	5%	25%	1.25%	3.75%	75%	20%	1.25%	78.75%	20.00%

Native employment was estimated based on interviews conducted for the study, primarily with owners and employees of contractors, combined with the personal experience of expert project staff members who have worked extensively on the NSB. The estimates were developed by activity and therefore, the total final estimate of the percent of Native workers will depend upon the specific amounts of the different technologies required in the scenario under examination. Note that these are estimates of the number of individuals of Native-Alaskan descent, regardless of where they live while not at work. Expert project staff estimated that, approximately 25 percent of these NSB Natives still live in the NSB. The remaining Natives are assumed to live in the rest of Alaska.

Labor percentages in the Hope Basin are more hypothetical due to the lack of actual examples. However, it is the opinion of expert project staff, that these projects will also draw labor from the existing areas in the same percentages as the Beaufort Sea projects. Native labor, however, will be from the local Borough.

5.5 ESTIMATES OF SPENDING BY GEOGRAPHIC REGION

Where an employee spends his/her income, will depend to a large extent, upon whether they are a resident or nonresident of the NSB. As discussed above, most workers in the oil industry on the North Slope in and near Prudhoe Bay are not permanent residents of the North Slope. They live mostly in South-central Alaska and Fairbanks. Since food, lodging and transportation are part of an employee's total compensation package; it is unlikely that nonresidents will spend much of their disposable income in the NSB. This is especially true given the long hours of work and minimum amount of time for personal leisure. Study team members with extensive experience working in the area estimate that perhaps $5 per day is spent at informal convenience stores or on local crafts brought from their villages by Native oil and gas employees. Since most employees make in the range of $500 per day, it is assumed that one percent of disposable income of all employees stationed in the NSB is spent on locally produced goods.

Full time NSB residents, on the other hand, will be inclined to spend relatively more of their disposable income in the NSB. The extent of those expenditures in the NSB will depend upon cultural factors (e.g., subsistence living) and the availability of goods and services. Since there is little or no manufacturing in the NSB, the impacts of personal consumption there will be felt primarily in the retail, wholesale, transportation, and service sectors. As noted above, expert project staff members have estimated the percent of workers who are Natives and the percent of NSB Natives who still live in the NSB. In addition it was estimated that those who still lived in the NSB spent the majority (80 percent) of their income there, with the remainder spent on the occasional trip outside the NSB to Anchorage or other destinations. NSB Natives who had left their Native village were estimated to spend none of their disposable income in the NSB, other than the one percent spent while working. In addition, it was assumed that all employees in Alaska spent all of their disposable income within Alaska and that all non-Alaska employees spent all of their income in the lower 49.

The percentages spent in each area for workers who reside in each area are provided in Exhibit 5-5.

Exhibit 5-5: Percent of Spending By Place of Full-Time Residence

Place of Full-Time Residence	Place of Spending NSB	Place of Spending Other Alaska	Place of Spending Other U.S.
NSB	80	20	0
Other Alaska	1	99	0
Other U.S.	1	0	99

In stimulating the PCE vectors in IMPLAN it may, be desirable to modify these vectors to take into account the atypical expenditure patterns of these employees. For example, in the state model, the food and lodging expenditures of nonresidents can be adjusted downward to avoid potential double counting of the food and lodging provided as compensation on the NSB.

5.6 ESTIMATES OF TAXES, SAVINGS AND PERSONAL CONSUMPTION EXPENDITURES (PCE)

Once employees are paid wages, they will pay taxes, save a small part of these wages, and then spend the rest on goods and services, generating induced impacts. To capture the induced impacts, the wages will need to be converted into disposable income which can then be used to stimulate IMPLAN's PCE vectors. Note that wages as defined here include fringe benefits, which is compatible with IMPLAN PCE definitions and standard I-O model conventions.

For the purposes of this study, disposable wages are calculated by reducing Total Personal Income by 20.5 percent. Of this, 2 percent reflects savings. This figure was estimated from a trend analysis of personal income data published in the U.S. Statistical Abstract and compiled by the U.S. Bureau of Economic Analysis. Due to the modeling complexities involved and the speed at which financial capital can move across geographic boundaries, IMPAK currently does not provide a way for estimating the regional economic impacts associated with savings. However, the amounts devoted to savings, by residence, are provided on the output screens and can be used along with other resources to develop estimates of such impacts.

The combination of taxes paid to local, state and federal government entities reflects the remaining 18.5 percent. These payments, captured in the model by multiplying tax rate parameters by estimates of total personal income, are used to stimulate the government expenditure vectors (See the "Government" section in 10.3.1 for more details).

As an input into the IMPLAN modeling system, the estimates of PCE can used to estimate the induced impacts that are generated as North Slope employee spend their earnings. The preferred way to estimate such impacts would be to allocate IMPAK's PCE estimates to consumer bundles using IMPLAN's PCE data to develop the allocation ratios. The resulting vectors would then be used to stimulate the outputs of the associated industries in IMPLAN. Note that IMPLAN provides PCE vectors for several different income groups. Therefore, it will be up to the analyst running the IMPLAN model to allocate disposable income to these income groups, or to assume that all employees fall within the same income group.

In addition, the analyst should be aware that IMPAK's PCE estimates reflect where goods are purchased, not where they are produced. As such, the estimates are different than the business expenditure estimates, which do indicate not only where a good is produced but also where the associated margins accrue. This means that the two types of expenditures will have to be handled differently when they are input into IMPLAN. With IMPAK's business expenditures, the user should not use IMPLAN to apply either margins or RPCs to the expenditure inputs. However, just the opposite is the case with IMPAK's PCE estimates, which do need to be converted into margins and further divided into production regions.

In some cases it seems as if we have already allocated PCE to consumer bundles since some of impacted sectors in IMPAK are "consumer oriented". This is only an appearance and is due to the fact that several activities (e.g., seismic surveys, production operations, and camp support) involve house-keeping operations that make purchases similar to those conducted by households. Like all other industry impacts reported on the output screens, these impacts are still direct impacts and will generate indirect impacts if used to stimulate IMPLAN.

5.7 FINAL ESTIMATES OF SPENDING BY AREA

In order to develop the final estimates of spending by area, estimates of wages by production and non-production workers are combined and then place of residence and place of spending percentages are applied and the results summed. In addition, in converting from wages to spending, wages are reduced to account for taxes and savings, as discussed in the previous section. The resulting final estimates are provided in Exhibit 5-6.

Exhibit 5-6: Spending by All Workers by Area

		Production Employee Residence Percentage			Production Wages by Place of Residence			Non-Production Wages		Alaskan Non-Production Employee Residence Percentage	
Activity	Production Wages	NSB	Other Alaska	Other U.S.	NSB	Other Alaska	Other U.S.	Alaska	Other U.S.	NSB	Other Alaska
1. Geological Survey	659,695	0.00%	80.00%	20.00%	-	527,756	131,939	290,232	33,120	41.2%	58.8%
2. North Slope Support	2,717,187	3.75%	81.25%	15.00%	101,895	2,207,715	407,578	780,503	89,068	41.2%	58.8%
3. General Personnel Transport	2,649	0.00%	70.00%	30.00%	-	1,854	795	1,001	114	41.2%	58.8%
4. Construct Ice Road	435,607	3.75%	76.25%	20.00%	16,335	332,150	87,121	364,521	41,597	41.2%	58.8%
5. Construct Ice Island	240,078	3.75%	76.25%	20.00%	9,003	183,059	48,016	235,866	26,916	41.2%	58.8%
6. Move Drll Ship/Bottom Founded Platform	78,573	1.25%	78.75%	20.00%	982	61,876	15,715	16,582	1,892	41.2%	58.8%
7. Operate Drill Ship in Calm Waters	16,760	1.25%	78.75%	20.00%	209	13,198	3,352	3,574	408	41.2%	58.8%
8. Operate Drill Ship in Rough Seas	78,573	1.25%	78.75%	20.00%	982	61,876	15,715	16,582	1,892	41.2%	58.8%
9. Operate Mobile Exploration Platform	16,158	1.25%	78.75%	20.00%	202	12,724	3,232	3,431	392	41.2%	58.8%
10. Helicopter Support	3,130	0.00%	90.00%	10.00%	-	2,817	313	715	82	41.2%	58.8%
11. Barge Support	1,686	1.25%	83.75%	15.00%	21	1,412	253	286	33	41.2%	58.8%
12. Drill Exploration Well	2,581,135	1.25%	73.75%	25.00%	32,264	1,903,587	645,284	566,079	64,598	41.2%	58.8%
13. Drill Production Well	860,378	1.25%	73.75%	25.00%	10,755	634,529	215,095	188,693	21,533	41.2%	58.8%
14. Well Workover	114,717	1.25%	73.75%	25.00%	1,434	84,604	28,679	25,159	2,871	41.2%	58.8%
15. Construct Gravel Island	2,277,005	1.25%	83.75%	15.00%	28,463	1,906,992	341,551	531,772	60,683	41.2%	58.8%
16. Protect Gravel Island	4,503,442	1.25%	83.75%	15.00%	56,293	3,771,632	675,516	2,212,856	252,521	41.2%	58.8%
17. Equip Production Island	9,116,014	1.25%	78.75%	20.00%	113,950	7,178,861	1,823,203	3,256,386	371,604	41.2%	58.8%
18. Operate Production Island	13,007,438	1.25%	78.75%	20.00%	162,593	10,243,357	2,601,488	3,226,080	368,146	41.2%	58.8%
19. Construct Gas Production Facility	5,429,992	1.25%	78.75%	20.00%	67,875	4,276,119	1,085,998	1,144,738	130,632	41.2%	58.8%
20. Operate Gas Production Facility	1,051,814	1.25%	78.75%	20.00%	13,148	828,304	210,363	312,201	35,627	41.2%	58.8%
21. Construct Offshore Pipeline	3,874,773	1.25%	78.75%	20.00%	48,435	3,051,384	774,955	675,436	77,078	41.2%	58.8%
22. Construct Onshore Pipeline	2,249,373	1.25%	78.75%	20.00%	28,117	1,771,381	449,875	385,963	44,044	41.2%	58.8%
23. Lay Sea Floor Pipeline	6,394,829	1.25%	78.75%	20.00%	79,935	5,035,928	1,278,966	773,642	88,285	41.2%	58.8%
24. Land Base Operation	57,954,973	2.50%	77.50%	20.00%	1,448,874	44,915,104	11,590,995	13,528,725	1,543,837	41.2%	58.8%
25. Spill Contingency	12,216,988	1.25%	78.75%	20.00%	152,712	9,620,878	2,443,398	2,817,531	321,524	41.2%	58.8%
26. Abandon Production Island	12,557,527	1.25%	78.75%	20.00%	156,969	9,889,053	2,511,505	3,670,939	418,911	41.2%	58.8%

Exhibit 5-6 (Cont.): Spending by All Workers by Area

	Non-Production Wages by Place of Residence			Total Wages by Place of Residence			Spending by Area		
Activity	NSB	Other Alaska	Other U.S.	NSB	Other Alaska	Other U.S.	NSB	Other Alaska	Other U.S.
1. Geological Survey	119,576	170,656	33,120	119,576	698,413	165,059	82,915	568,698	129,910
2. North Slope Support	321,567	458,936	89,068	423,462	2,666,651	496,646	294,470	2,166,118	390,885
3. General Personnel Transport	412	588	114	412	2,443	909	289	1,988	715
4. Construct Ice Road	150,183	214,338	41,597	166,518	546,489	128,719	111,273	456,590	101,308
5. Construct Ice Island	97,177	138,689	26,916	106,180	321,749	74,932	70,684	270,115	58,975
6. Move Drll Ship/Bottom Founded Platform	6,832	9,750	1,892	7,814	71,627	17,607	5,679	57,616	13,857
7. Operate Drill Ship in Calm Waters	1,472	2,101	408	1,682	15,300	3,760	1,221	12,309	2,959
8. Operate Drill Ship in Rough Seas	6,832	9,750	1,892	7,814	71,627	17,607	5,679	57,616	13,857
9. Operate Mobile Exploration Platform	1,413	2,017	392	1,615	14,741	3,623	1,173	11,859	2,852
10. Helicopter Support	294	420	82	294	3,238	395	216	2,595	311
11. Barge Support	118	168	33	139	1,580	285	103	1,265	225
12. Drill Exploration Well	233,225	332,855	64,598	265,489	2,236,442	709,882	192,274	1,802,404	558,713
13. Drill Production Well	77,742	110,952	21,533	88,496	745,481	236,627	64,091	600,801	186,238
14. Well Workover	10,366	14,794	2,871	11,800	99,397	31,550	8,546	80,107	24,832
15. Construct Gravel Island	219,090	312,682	60,683	247,552	2,219,673	402,234	178,288	1,786,355	316,578
16. Protect Gravel Island	911,697	1,301,159	252,521	967,990	5,072,791	928,037	663,348	4,146,451	730,412
17. Equip Production Island	1,341,631	1,914,755	371,604	1,455,581	9,093,616	2,194,807	1,015,493	7,388,568	1,727,423
18. Operate Production Island	1,329,145	1,896,935	368,146	1,491,738	12,140,293	2,969,633	1,068,869	9,792,204	2,337,250
19. Construct Gas Production Facility	471,632	673,106	130,632	539,507	4,949,225	1,216,631	392,145	3,981,069	957,549
20. Operate Gas Production Facility	128,627	183,574	35,627	141,775	1,011,878	245,990	100,169	818,941	193,606
21. Construct Offshore Pipeline	278,279	397,156	77,078	326,714	3,448,540	852,032	241,980	2,766,121	670,592
22. Construct Onshore Pipeline	159,017	226,946	44,044	187,134	1,998,328	493,919	138,831	1,602,538	388,739
23. Lay Sea Floor Pipeline	318,740	454,901	88,285	398,676	5,490,829	1,367,250	308,080	4,384,947	1,076,094
24. Land Base Operation	5,573,835	7,954,890	1,543,837	7,022,709	52,869,994	13,134,832	4,991,181	42,727,940	10,337,770
25. Spill Contingency	1,160,823	1,656,708	321,524	1,313,535	11,277,586	2,764,922	947,046	9,084,877	2,176,132
26. Abandon Production Island	1,512,427	2,158,512	418,911	1,669,396	12,047,565	2,930,417	1,180,811	9,747,470	2,306,384

In the exhibit production worker wages including fringe benefits are transcribed from Exhibit 5-1 and distributed to place of residence based on percentages from Exhibit 5-4. Non-production wages, which were already distributed by place of residence, are taken from Exhibit 5-3. Production and non-production worker wages are then summed to provide total wages by place of residence. These wages are then converted to spending by area based on the percentages from Exhibit 5-5 and the estimate of the percent diverted to taxes and savings. Taxes and savings are directly calculated in the model by applying the tax and savings percentages to the estimates of total wages by place of residence.

5.8 OTHER EMPLOYEE RELATED COSTS

In addition to direct compensation, several contractors provided estimates of additional employee related costs for airfare to and from the NSB, local transportation, clothing, and housing and meal costs. While these costs are theoretically not part of employee compensation, but rather part of overhead costs, their levels are dependent upon the numbers and of employees and are therefore most accurately estimated along with employee compensation. They are assumed to not be included in Bureau of the Census' estimates of fringe benefits and are coded directly to the appropriate IMPLAN sectors, or used to stimulate secondary activities

Interviews with several contractors conducted for this study revealed employee related costs of up to $120 for employees working on the North Slope. Included in the $120 is an estimated $75 per day for food and lodging, $20 for airfare, $15 for local transportation, and $10 for cold weather gear and other miscellaneous expenses. These overhead costs are assumed to apply to both regular and supervisory production personnel. In addition, supervisory personnel are assumed to be provided with office space and a private bath at an extra $35 per day.

Since these estimates apply to employees housed in an on-shore hotel/camp on a four week rotation, adjustments were required depending on the type of employee and the activity. For airfares, since the $20 per day for airfare was based on a $550 airfare and a 28 day rotation, airfare was doubled to $40 per day for employees who are on a two week rotation. For food and lodging, employees in certain activities such as production island operation or seismic survey cat train are not assumed to live on site rather than at contractor purchased lodging. Instead their food and lodging is assumed to be company provided and the costs of the quarters and food are estimated as part of the production function for that activity. For local travel, employees staying on site such as is the case with the production island or seismic survey cat train, are not assumed to require daily transport. Employees who stay on-site are generally assumed to require only one day of local travel per two week shift (one trip out to the island, platform or mobile structure and one trip back). To reflect this fact, local transportation is reduced to approximately $1 per day. Cat-train employees are assumed to require no local travel.

The following paragraphs summarize the allocations of these costs to each sector in more detail. The estimates of other employee related costs by activity, type of cost are provided in Exhibit 5-7.

Exhibit 5-7: Production Worker Lodging Expenses

Activity	Place of Residence for Employees	Hotel/Camp Percentage	Work Clothes Percentage	Local Travel Percentage	Rotation Pattern: Weeks On/Total Weeks	Daily Air Travel Cost	Days/ Week	Production Worker Man-Weeks	Production Worker Man-Days	Production Worker Percent Supervisor	Non-Production Worker Man-Days
1. Geological Survey	Cat-Train	0%	100%	0%	4/6	1/28	7	387	2,707	4.5%	870
2. North Slope Support	Camp	0%	0%	0%	4/6	1/28	7	1,040	7,280	10.0%	2,340
3. General Personnel Transport	Camp	100%	100%	0%	2/4	1/14	7	1.0	7	14.3%	2
4. Construct Ice Road	Camp	100%	100%	100%	2/4	1/14	7	101	710	9.6%	228
5. Construct Ice Island	Camp	100%	100%	100%	2/4	1/14	7	56	390	11.3%	125
6. Move Drll Ship/Bottom Founded Platform	Platform	0%	100%	0%	2/4	1/14	7	17	116	6.9%	37
7. Operate Drill Ship in Calm Waters	Ship	0%	100%	0%	2/4	1/14	7	4	25	12.0%	8
8. Operate Drill Ship in Rough Seas	Ship	0%	100%	0%	2/4	1/14	7	17	116	6.9%	37
9. Operate Mobile Exploration Platform	Platform	0%	100%	0%	2/4	1/14	7	27	190	1.6%	61
10. Helicopter Support	Camp	100%	100%	100%	2/4	1/14	7	0.7	5	20.0%	2
11. Barge Support	Camp	100%	100%	100%	16/16	1/112	7	0.6	4	25.0%	1
12. Drill Exploration Well	Camp	100%	100%	100%	2/4	1/14	7	566	3,960	4.5%	1,273
13. Drill Production Well	Camp	100%	100%	100%	2/4	1/14	7	189	1,320	4.5%	424
14. Well Workover	Island	0%	100%	7%	2/4	1/14	7	25	176	4.5%	57
15. Construct Gravel Island	Camp	100%	100%	100%	2/4	1/14	7	531	3,720	9.7%	1,195
16. Protect Gravel Island	Camp	100%	100%	100%	2/4	1/14	7	1,063	7,440	8.1%	2,391
17. Equip Production Island	Camp	100%	100%	100%	2/4	1/14	7	2,157	15,100	6.7%	4,853
18. Operate Production Island	Island	0%	100%	7%	2/4	1/14	7	3,224	22,568	6.5%	7,252
19. Construct Gas Production Facility	Camp	100%	100%	100%	2/4	1/14	7	1,144	8,008	6.8%	2,573
20. Operate Gas Production Facility	Camp	100%	100%	100%	2/4	1/14	7	312	2,184	33.3%	702
21. Construct Offshore Pipeline	Camp	100%	100%	100%	4/6	1/28	7	900	6,300	9.5%	2,025
22. Construct Onshore Pipeline	Camp	100%	100%	100%	4/6	1/28	7	514	3,600	16.7%	1,157
23. Lay Sea Floor Pipeline	Camp	100%	100%	100%	2/4	1/14	7	1436.6	10,056	9.3%	3,232
24. Land Base Operation	Camp	100%	50%	100%	2/4	1/14	7	13,520	94,640	12.3%	30,414
25. Spill Contingency	Camp	100%	100%	100%	2/4	1/14	7	2,816	19,710	14.8%	6,334
26. Abandon Production Island	Camp	100%	100%	100%	2/4	1/14	7	2,911	20,380	6.2%	6,549

Activity	Production Non-Supervisor Worker Lodging @$45/day	Production Supervisor Worker Lodging @$80/day	Non- Production Worker Lodging @$80/day	Total Lodging Cost	Food Service @$30/day	Work Clothing @$10/day	Local Travel @$15/day	Air Travel @$550 Per Round Trip
1. Geological Survey	-	-	69,596	69,596	26,098	27,071	-	87,351
2. North Slope Support	-	-	187,160	187,160	70,185	-	-	234,909
3. General Personnel Transport	270	80	180	530	277	70	-	363
4. Construct Ice Road	28,890	5,440	18,253	52,583	28,145	7,100	10,650	36,857
5. Construct Ice Island	15,570	3,520	10,026	29,116	15,460	3,900	5,850	20,245
6. Move Drll Ship/Bottom Founded Platform	-	-	2,982	2,982	1,118	1,160	-	6,022
7. Operate Drill Ship in Calm Waters	-	-	643	643	241	250	-	1,298
8. Operate Drill Ship in Rough Seas	-	-	2,982	2,982	1,118	1,160	-	6,022
9. Operate Mobile Exploration Platform	-	-	4,885	4,885	1,832	1,900	-	9,863
10. Helicopter Support	180	80	129	389	198	50	75	260
11. Barge Support	135	80	103	318	159	40	60	70
12. Drill Exploration Well	170,100	14,400	101,807	286,307	156,978	39,600	59,400	205,566
13. Drill Production Well	56,700	4,800	33,936	95,436	52,326	13,200	19,800	68,522
14. Well Workover	-	-	4,525	4,525	1,697	1,760	189	9,136
15. Construct Gravel Island	151,200	28,800	95,637	275,637	147,464	37,200	55,800	193,107
16. Protect Gravel Island	307,800	48,000	191,273	547,073	294,928	74,400	111,600	386,215
17. Equip Production Island	633,780	81,280	388,203	1,103,263	598,576	151,000	226,500	783,850
18. Operate Production Island	-	-	580,196	580,196	217,574	225,680	24,180	1,171,518
19. Construct Gas Production Facility	335,790	43,680	205,876	585,346	317,444	80,080	120,120	415,700
20. Operate Gas Production Facility	65,520	58,240	56,148	179,908	86,576	21,840	32,760	113,373
21. Construct Offshore Pipeline	256,500	48,000	161,965	466,465	249,737	63,000	94,500	203,287
22. Construct Onshore Pipeline	135,000	48,000	92,552	275,552	142,707	36,000	54,000	116,164
23. Lay Sea Floor Pipeline	410,310	75,040	258,528	743,878	398,628	100,560	150,840	522,013
24. Land Base Operation	3,734,640	931,840	2,433,081	7,099,561	3,751,605	473,200	1,419,600	4,912,816
25. Spill Contingency	755,550	233,600	506,720	1,495,870	781,320	197,100	295,650	1,023,157
26. Abandon Production Island	860,580	100,480	523,945	1,485,005	807,880	203,800	305,700	1,057,937

Seismic survey production employees were assumed to receive food and lodging in the cat train camp and as they are away from camp do not require local travel. Therefore only air travel and work gear were assigned to these employees. Since these employees work for four weeks at a time, they require only a twenty-eighth of an airfare per day.

The hotel/camp employees were assumed to be provided room and board at no cost, require minimal ground transport and none of the specialized outdoor work gear. Since these employees work for four weeks at a time, they require only a twenty-eighth of an airfare per day.

General personnel transport employees were assumed to stay at the hotel/camp. The $15 for local transportation was assumed to not apply to these employees, as they work in this sector.

Employees working in ice roads and islands were assumed to stay at hotel camps and require work clothes and daily ground transport.

Employees involved with drill ships and mobile platforms were assumed to stay onboard ship and as such do not require use of the hotel camp or daily ground transport.

Helicopter employees were assumed to stay at hotel/camps and require clothing and ground transport.

Barge workers were assumed to stay at the hotel/camps and to use local transport. However, they only require one round-trip air flight per year as they work all summer.

Adjustments were made to employee-related costs for well drilling employees based on the type of well. Well workover employees were assumed to receive company provided food and lodging on the production island and as such these employees were not charged for food and lodging. Since these employees stay at the work site, they only require one day of local travel per two week shift (one trip out to the island and one trip back). All of the employee-related costs were assumed to apply to exploratory and production well drilling employees as they will stay at the hotel/camp and commute to the drilling site.

Gravel production island construction employees were assumed to stay at hotel/camps, require a fourteenth of an airfare per day as they work a two-week shift, and require daily ground transport and work clothing.

The workers for production module installation and gas production facility installation were assumed to stay at hotel/camps, require a fourteenth of an airfare per day as they work a two-week shift, and require daily ground transport and work clothing.

Employees operating equipment on the production island were assumed to receive company provided food and lodging on the production island and as such these employees were not charged for food and lodging. Since these employees stay at the work site, they only require one day of local travel per two week shift (one trip out to the island and one trip back).

The workers constructing pipelines were assumed to stay at hotel/camps, require a fourteenth of an airfare per day as they work a two-week shift, and require daily ground transport and work clothing.

Land base operation employees were assumed to stay at hotel/camps, require a fourteenth of an airfare per day as they work a two-week shift, and require daily ground transport. However, since approximately half work indoors in warehouses, on average they are assumed to require only 50 percent of the cost for the specialized cold weather work clothing.

The spill contingency workers were assumed to stay at hotel/camps, require a fourteenth of an airfare per day as they work a two-week shift, and require daily ground transport and work clothing.

Finally, North Slope salaried employees were assumed to receive the same food, lodging and airfare as the supervisory production employees. They were not assigned costs for local travel and work gear.

6. PURCHASED SERVICES INPUTS

Purchases from service sectors represent overhead types of costs that are usually not separately specified in the type of engineering cost estimates used in this study. If they are considered, they are generally lumped together in a common overhead category. Moreover, while these purchases are part of the real costs of doing business, no data is available to directly allocate them to the different activities. Part of the problem is that these costs represent common overhead components. The amount of advertising that is purchased by a large oil company, for example, is probably fairly independent of the miles of pipelines constructed, but is probably somewhat related to gallons of oil produced. On the other hand, a smaller company specializing in pipeline construction, although likely to have a small advertising budget, is likely to have spending fairly related to the miles of pipelines it constructs in a year.

The assignment of these costs by area is also problematic. The oil and gas industry is an amalgamation of a large number of companies, not just the big oil companies. For example, the 1992 Census of Mineral Industries estimates that almost 17,000 companies were involved in the Crude Petroleum and Natural Gas and Oil and Gas Field Services industries. Therefore, one can not simply ask the large oil companies where they spend their overhead dollar, even assuming they would be willing to provide an answer. Instead, estimates must be made of where the aggregate of all companies make their expenditures.

6.1 NATIONAL INPUT/OUTPUT DATA

As discussed above, most major inputs to the IMPAK model were estimated based on information on cost and quantity gathered in the industry interviews or based on the expert engineering knowledge of project staff. However, in order to determine what purchased services are utilized in quantities that are significant enough to warrant estimation, data from the latest national-level input-output table of the U.S. economy were tabulated and analyzed. The latest table available is for the year 1992, as developed by the Bureau of Economic Analysis, and published in September 1998. Data from this table is tabulated and presented in Exhibits 6-1 and 6-2.

As shown in Exhibit 6-1, the various activities that comprise the oil and gas industry are subsumed within four sectors in the national I-O table. The largest of these sectors is mining Sector 8.0001, Crude Petroleum and Natural Gas. The three smaller sectors are all construction industries. These include Sector 11.0601 (Petroleum and Natural Gas Well Drilling), Sector 11.0602 (Petroleum, Natural Gas, and Solid Mineral Exploration), and Sector 12.0215 (Maintenance and Repair of Petroleum and Natural Gas Wells).

Exhibit 6-1: Selected Oil and Gas Industry Input Data From the 1992 BEA National Input-Output Table (Millions of Dollars)

BEA I-O Industry Number	BEA I-O Industry Name	BEA #8.0001 Mining: Crude Petroleum and Natural Gas	BEA #11.0601 Construction: Petroleum and Natural Gas Well Drilling	BEA #11.0602 Construction: Petroleum, Natural Gas, and Solid Mineral Exploration	BEA #12.0215 Construction: Maintenance and Repair of Petroleum and Natural Gas Wells
	MAJOR INTERMEDIATE INPUTS				
27.0100	Industrial inorganic and organic chemicals	853	394	7	25
27.0406	Chemicals and chemical preparations, n.e.c.	321	62	1	4
29.0203	Polishes and sanitation goods	5	0	0	27
31.0101	Petroleum refining	386	254	25	14
31.0102	Lubricating oils and greases	244	81	1	0
31.0200	Asphalt paving mixtures and blocks	0	0	0	23
36.0100	Cement, hydraulic	187	88	0	33
36.1100	Concrete products, except block and brick	0	0	0	14
36.1900	Minerals, ground or treated	0	108	0	3
37.0101	Blast furnaces and steel mills	1079	221	16	21
37.0103	Steel wiredrawing and steel nails and spikes	112	14	1	0
40.0400	Fabricated structural metal	19	138	7	9
42.0800	Pipe, valves, and pipe fittings	434	15	0	24
45.0100	Construction machinery and equipment	200	139	10	0
46.0300	Hoists, cranes, and monorails	0	0	0	16
50.0400	Industrial and commercial machinery and equipment, n.e.c.	157	127	0	0
53.0500	Relays and industrial controls	66	0	0	0
62.0200	Mechanical measuring devices	1	22	7	0
65.0100	Railroads and related services	99	76	0	7
65.0200	Local and suburban transit and interurban highway passenger transportation	61	6	1	1
65.0301	Trucking and courier services, except air	251	101	1	31
65.0400	Water transportation	264	32	0	1
65.0500	Air transportation	246	29	5	6
66.0100	Telephone and telegraph communications, and communications sevices, n.e.c.	196	45	11	4
68.0100	Electric services (utilities)	1626	55	12	8
68.0201	Natural gas transportation	2303	0	0	0
68.0202	Natural gas distribution	518	103	10	0
68.0301	Water supply and sewerage systems	82	5	0	0
69.0100	Wholesale trade	935	301	10	40
69.0200	Retail trade, except eating and drinking	126	15	1	1
70.0100	Banking	567	64	9	12
70.0400	Insurance carriers	113	11	3	3
71.0201	Real estate agents, managers, operators, and lessors	521	85	24	11
71.0202	Royalties	16661	5	152	1
72.0101	Hotels	264	30	5	5
73.0103	Personnel supply services	154	18	3	3
73.0104	Computer and data processing	115	16	1	4
73.0111	Management and consulting services	135	17	3	3
73.0200	Advertising	128	25	5	4
73.0301	Legal services	980	93	9	4
73.0302	Engineering, architectural, and surveying services	874	0	0	0
73.0303	Accounting, auditing, and bookeeping, and miscellaneous services, n.e.c.	28	5	0	15
74.0000	Eating and drinking places	312	35	6	7
75.0001	Automotive rental and leasing, without drivers	96	12	1	2
77.0501	Business associations and professional membership organizations	62	6	1	1
Total		31781	2853	348	387
INTRA-INDUSTRY PURCHASES					
8.0001	Crude petroleum and natural gas	20296	0	0	0
11.0601	Petroleum and natural gas well drilling	0	107	0	0
11.0602	Petroleum, natural gas and solid mineral exploration	0	0	63	0
12.0215	Maintenance and repair of petroleum and natural gas wells	1719	0	0	0
Total		22015	107	63	0
OTHER COMPONENTS OF OUTPUT					
80.0000	Noncomparable imports	1033	0	0	0
88.0000	Compensation of employees	14127	6529	1042	1019
89.0000	Indirect business tax and nontax liability	4729	515	56	37
90.0000	Other value added	30457	1337	143	201
Total		50346	8381	1241	1257
TOTAL OUTPUT		105369	11633	1673	1719
Percentage of all Inputs Accounted for		98.84%	97.49%	98.74%	95.64%
Percentage of all Intermediate Inputs Accounted for		96.28%	90.72%	94.31%	83.77%

Exhibit 6-1 provides the dollars of purchases for all input sectors that accounted for at least one half of one percent of industry output for any of the four sectors. In total, there were 53 sectors that met this criterion. Note that as shown at the bottom of Exhibit 6-1, the purchases from these 53 sectors account for 96 to 99 percent of the total purchases of the four oil and gas sectors.

Exhibit 6-2: Selected Miscellaneous Sector Input Data From the 1992 BEA National Input-Output Table
(Millions of Dollars)

BEA I-O Industry Number	BEA I-O Industry Name	BEA # 65.0200 Local Transport	BEA # 65.0400 Water Transport	BEA # 65.0500 Air Transport	BEA # 72.0101 Hotels
MAJOR INTERMEDIATE INPUTS					
12.0300	Other maintenance and repair	-	-	-	1,390
19.0200	Housefurnishings, n.e.c.	-	-	-	483
31.0101	Petroleum refining	1,352	727	9,432	-
32.0100	Tires and inner tubes	135	-	-	-
32.0500	Rubber and plastics hose and belting	103	-	-	-
42.0800	Pipe, valves, and pipe fittings	151	-	-	-
43.0200	Internal combustion engines, n.e.c.	191	217	-	-
49.0200	Ball and roller bearings	177	184	-	-
59.0302	Motor Vehicle parts and accessories	374	-	-	-
60.0200	Aircraft and missile engines and engine parts	-	-	1,375	-
60.0400	Aircraft and missile equipment, n.e.c.	-	-	921	-
61.0100	Ship building and repairing	-	585	-	-
65.0301	Trucking and courier services, except air	269	-	-	279
65.0701	Freight forwarders and other transportation services	-	873	734	-
65.0702	Arrangement of passenger transportation	-	525	6,967	793
66.0100	Telephone and telegraph communications, and communications sevices, n.e.c.	346	-	1,204	363
66.0200	Cable and other pay television services	-	-	-	369
68.0100	Electric services (utilities)	-	-	-	1,830
68.0202	Natural gas distribution	-	-	-	318
68.0302	Sanitary services, steam supply, and irrigation systems	-	-	-	621
69.0100	Wholesale trade	1,120	505	1,462	402
69.0200	Retail trade, except eating and drinking	162	-	-	-
70.0100	Banking	169	469	601	1,670
70.0200	Credit agencies other than banks	-	526	784	1,335
70.0400	Insurance carriers	158	-	-	-
71.0201	Real estate agents, managers, operators, and lessors	301	877	1,425	1,353
73.0102	Services to dwellings and other buildings	-	-	-	619
73.0103	Personnel supply services	430	-	-	504
73.0104	Computer and data processing	-	280	2,224	341
73.0106	Detective and protective services	-	-	-	406
73.0107	Miscellaneous equipment rental and leasing	-	186	675	-
73.0109	Other business services	-	198	-	941
73.0111	Management and consulting services	-	911	-	971
73.0112	Testing and research labs	-	743	-	-
73.0200	Advertising	-	1,244	1,389	974
73.0301	Legal services	189	164	944	289
73.0302	Engineering, architectural, and surveying services	-	302	-	-
73.0303	Accounting, auditing, and bookkeeping, and miscellaneous services, n.e.c.	-	217	-	-
74.0000	Eating and drinking places	-	-	1,832	298
75.0001	Automotive rental and leasing, without drivers	325	-	-	-
78.0100	U.S. Postal Service	-	-	-	264
Total		5,952	9,733	31,969	16,813
INTRA-INDUSTRY PURCHASES					
65.0200	Local transportation	-	-	-	-
65.0400	Water transportation	-	4,282	-	-
65.0500	Air transportation	-	-	6,064	-
72.0101	Hotels	-	-	-	-
Total		0	4282	6064	0
OTHER COMPONENTS OF OUTPUT					
80.0000	Noncomparable imports	-	2,954	8,827	-
88.0000	Compensation of employees	8,704	7,140	32,761	19,934
89.0000	Indirect business tax and nontax liability	169	583	5,696	4,999
90.0000	Other value added	3,515	5,073	3,709	6,159
Total		12388	15750	50993	31092
TOTAL OUTPUT		20166	32440	94141	52407
Percentage of all Inputs Accounted for		90.95%	91.75%	94.57%	91.41%
Percentage of all Intermediate Inputs Accounted for		76.52%	78.44%	86.21%	78.88%

Many of these sectors were not of interest in the analysis of purchased services and were therefore dropped from the analysis. These sectors can be classified into six groups. One such group of sectors is those that represent intra-industry purchases, such as the purchases the Crude Petroleum and Natural sector makes from itself and the other three oil and gas sectors listed in the table.

A second group of sectors includes those that represent other components of output such as compensation of employees, and non-comparable imports. Estimates for these sectors were made from primary sources. Non-comparable imports are estimated as foreign purchased equipment.

A third set of industries that are not important in the analysis of purchased services are those that are often referred to as margin industries. In input-output analysis, the value of a purchase is divided between the amount paid for the actual good and the amount paid others to transport, wholesale and retail the good. While the values of purchases from these sectors are estimated as part of this study, these estimates are derived and subtracted from the estimates made for purchases of capital and materials.

A fourth set of sectors are selected utility sectors such as electricity, natural gas, and water and sewer. Since the oil and gas production in Alaska is so isolated, the production process normally generates its own power and waste disposal and does not separately purchase these inputs.

A fifth set of industries are those that supply or are related to the capital goods that are purchased. Capital goods purchases from these sectors are derived from primary data sources and are discussed in Chapter 7.

A sixth set of industries are those that provide material inputs. These include the following sectors:

- 27.0100 Industrial inorganic and organic chemicals
- 27.0406 Chemicals and chemical preparations, n.e.c.
- 29.0203 Polishes and sanitation goods
- 31.0101 Petroleum refining
- 31.0102 Lubricating oils and greases
- 31.0200 Asphalt paving mixtures and blocks
- 36.0100 Cement, hydraulic
- 36.1100 Concrete products, except block and brick
- 36.1900 Minerals, ground or treated

These inputs are also derived from primary sources and are discussed in Chapter 8.

After eliminating these six types of sectors, the 18 sectors that remain are considered to be the types of sectors supplying the purchased services that are of interest here. These include the following BEA I-O codes and sectors:

- 66.0100 Telephone and telegraph communications, and communications services, n.e.c.
- 70.0100 Banking
- 70.0400 Insurance carriers
- 71.0201 Real estate agents, managers, operators, and lessors
- 71.0202 Royalties
- 72.0101 Hotels
- 73.0103 Personnel supply services
- 73.0104 Computer and data processing
- 73.0111 Management and consulting services
- 73.0200 Advertising
- 73.0301 Legal services
- 73.0302 Engineering, architectural, and surveying services
- 73.0303 Accounting, auditing, and bookkeeping, and miscellaneous services, n.e.c.
- 74.0000 Eating and drinking places
- 75.0001 Automotive rental and leasing, without drivers
- 77.0501 Business associations and professional membership organizations
- 90.0000 Other value added.

The data for the oil and gas industry, provided in Exhibit 6-1 are used for all of the activities except for camp support, helicopter support and boat support. These activities are secondary support activities that are not part of the oil and gas industry as traditionally defined by input-output models. As a result, purchased services data for these activities were based on the input-output data for hotels, air transport, and water transport, respectively. These data are shown in Exhibit 6-2.

As was the case with the oil and gas input-output sectors, Exhibit 6-2 provides information for inputs that accounted for at least one half of one percent. The list of included sectors is slightly different than for Exhibit 6-1. Once again, sectors that were not considered purchased services were eliminated from consideration.

6.2 THE CALCULATION OF TOTAL PURCHASED SERVICES

The calculation of total overhead or purchased services expenditures is based on the ratio of these expenditures to labor compensation. The choice of labor compensation is based on the relative quality of the labor data and the availability of labor data for all of the activities including the secondary, non oil and gas industry sectors.

Exhibits 6-3 and 6-4 list the purchased services sectors and their ratio to labor compensation from the national input-output tables. The BEA I-O sector number and name is provided along with the corresponding IMPLAN sector number. Exhibit 6-3 provides this data for oil and gas industries, while Exhibit 6-4 provides this data for the hotel, air and water sectors. The ratios provided in these exhibits are multiplied by the total labor compensation for each of the activities to generate estimates of purchased services inputs.

Exhibit 6-3: Percentage Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities

BEA I-O Sector	Sector Name	IMPLAN Sector	Percent of Labor	Percent of Purchased Services NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	1.13	20	60	20
70.0100	Banking	456	2.87	5	60	35
70.0400	Insurance carriers	459	0.57	0	60	40
71.0201	Real estate agents	462	2.82	10	50	40
72.0101	Hotels	463	1.34	5	50	45
73.0103	Personnel supply	474	0.78	15	50	35
73.0104	Computers & data processing	475	0.60	25	40	35
73.0111	Management & consulting	508	0.70	10	50	40
73.0200	Advertising	469	0.71	0	40	60
73.0301	Legal services	494	4.78	0	40	60
73.0302	Engineering, architectural & surveying	506	3.85	15	45	40
73.0303	Accounting, auditing & bookeeping	507	0.21	10	60	30
74.0000	Eating & drinking places	454	1.58	5	50	45
75.0001	Automotive rental & leasing	477	0.49	20	50	30
77.0501	Associations & professional org.	503	0.31	0	40	60
90.0000	Other value added	n.a.	70.74	0	20	80
88.0000	Compensation of Employees	n.a.		n.a.	n.a.	n.a.

Exhibit 6-4: Percentage Estimates of Purchased Services by Sector and Geographic Area For Support Activities

BEA I-O Sector	Sector Name	IMPLAN Sector	Percent of Labor Compensation 65.0200 Local Transport	65.0400 Water Transport	65.0500 Air Transport	72.0101 Hotels	Percent of Purchased Services NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	3.98	-	3.68	1.82	20%	60%	20%
66.0200	Cable TV	441	-	-	-	1.85	20%	60%	20%
70.0100	Banking	456	1.94	6.57	1.83	8.38	5%	60%	35%
70.0200	Credit agencies	457	-	7.37	2.39	6.70	5%	60%	35%
70.0400	Insurance carriers	459	1.82	-	-	-	0%	60%	40%
71.0201	Real estate agents	462	3.46	12.28	4.35	6.79	10%	50%	40%
73.0102	Services to dwellings/buildings	472	-	-	-	3.11	10%	60%	30%
73.0103	Personnel supply	474	4.94	-	-	2.53	15%	50%	35%
73.0104	Computers & data processing	475	-	3.92	6.79	1.71	25%	40%	35%
73.0106	Detective services	476	-	-	-	2.04	10%	60%	30%
73.0107	Equipment rental & leasing	473	-	2.61	2.06	-	10%	60%	30%
73.0109	Other business services	470	-	2.77	-	4.72	10%	50%	40%
73.0111	Management & consulting	508	-	12.76	-	4.87	10%	50%	40%
73.0112	Testing and research labs	509	-	10.41	-	-	0%	20%	80%
73.0200	Advertising	469	-	17.42	4.24	4.89	0%	40%	60%
73.0301	Legal services	494	2.17	2.30	2.88	1.45	0%	60%	40%
73.0302	Engineering, architectural & surveying	506	-	4.23	-	-	15%	45%	40%
73.0303	Accounting, auditing & bookeeping	507	-	3.04	-	-	10%	60%	30%
74.0000	Eating & drinking places	454	-	-	5.59	1.49	5%	50%	45%
75.0001	Automotive rental & leasing	477	3.73	-	-	-	20%	50%	30%
78.0100	U.S. Postal Service	513	-	-	-	1.32	10%	60%	30%
90.0000	Other value added	n.a.	40.38	71.05	11.32	30.90	0%	20%	80%
88.0000	Compensation of Employees	n.a.					n.a.	n.a.	n.a.

Investment Finance Charges

Note that one BEA sector, "Other Value Added", is not assigned directly to an IMPLAN sector. This category is comprised of capital depreciation and finance charges. Mining industries are different from other production oriented industries (e.g., manufacturing) in that they are very capital intensive and a large percentage of their total expenditures falls under research and development (R&D), which can be capitalized. As a result, mining industries incur relative high finance charges to cover these capital and R&D expenditures. In the National Input-Output

Accounts, these types of finance charges are grouped with depreciation charges under the category called "Other Value Added."

In Chapter Seven, we explicitly addressed capital depreciation by spreading equipment expenditures over the lives of the assets and taking into account usage rates. To account for finance charges, we started by calculating total other value added for each activity. This was accomplished by multiplying each activity's employee compensation estimate by a corresponding ratio of Other Value Added to Employee Compensation (calculated using the National Input-Output tables). The results were then divided in half to eliminate the depreciation charges (this is based on the assumption that finance charges are paid monthly over a 20 year period at an 8 percent interest rate). The resulting interest payments were further divided and assigned to the sources of the funds. Some of the charges reflect a return to personal savings and were assigned to PCE accordingly. The remaining charges represent returns to financial service industries and were distributed between the banking industry (IMPLAN sector 456), credit agencies (IMPLAN Sector 457) and security/commodity brokers (IMPLAN sector 458).

It should be noted that some of the finance charges occur only in one time period whereas others span a number of years. This is to be expected and reflects the different nature of capital investments being financed. The first case is generally associated with the use of equipment to carry out a specific project: for example, using a bulldozer to help build an ice road. In this example, a small fraction of the total finance charges the contractor incurred when he purchased the bulldozer are expensed to the project based upon how much the machine is used. Finance charges paid over multiple years include not only equipment usage, but also the capitalization of labor, materials and installed equipment needed to conduct research and development. In IMPAK, such charges are tied to oil production operations.

6.3 PURCHASED SERVICES BY GEOGRAPHIC AREA

The estimates of purchased services by activity and IMPLAN sector are then split among the local area, the rest of Alaska and the 49 states. This disaggregation is based on percentage distributions developed by engineering study staff, based on their familiarity with the area and the production process. These percentages are provided in Exhibits 6-3 and 6-4. The percentage estimates provided in Exhibit 6-3 are for the oil and gas sectors, while those in Exhibit 6-4 are used for the hotel, air and water sectors. In each exhibit, separate percentages are provided for projects located in the Cook Inlet, remote locations and remote location near areas of labor availability.

6.4 FINAL ESTIMATES OF PURCHASED SERVICES

The final estimates of purchased services inputs by activity, input sector and geographic area are found by multiplying the national input-output ratios by the labor compensation calculated for sub-arctic Alaska and the percentages for geographic areas. These final estimates are provided in Exhibit 6-5. Exhibit 6-5 includes a specific table of results for each of the 26 activities included in the IMPAK model.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 1. Geological Survey

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	11,078	2,216	6,647	2,216
70.0100	Banking	456	28,214	1,411	16,929	9,875
70.0400	Insurance carriers	459	5,626	-	3,375	2,250
71.0201	Real estate agents	462	27,738	2,774	13,869	11,095
72.0101	Hotels	463	13,155	658	6,578	5,920
73.0103	Personnel supply	474	7,703	1,155	3,851	2,696
73.0104	Computers & data processing	475	5,885	1,471	2,354	2,060
73.0111	Management & consulting	508	6,837	684	3,419	2,735
73.0200	Advertising	469	7,010	-	2,804	4,206
73.0301	Legal services	494	46,995	-	18,798	28,197
73.0302	Engineering, architectural & surveying	506	37,821	5,673	17,020	15,128
73.0303	Accounting, auditing & bookeeping	507	2,077	208	1,246	623
74.0000	Eating & drinking places	454	15,579	779	7,789	7,010
75.0001	Automotive rental & leasing	477	4,803	961	2,402	1,441
77.0501	Associations & professional org.	503	3,029	-	1,212	1,817
90.0000	Other value added	n.a.	695,364	-	139,073	556,291
88.0000	Compensation of Employees	n.a.	983,047	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 2. North Slope Support

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	65,315	130.63	391.89	130.63
66.0200	Cable TV	441	66,395	132.79	398.37	132.79
70.0100	Banking	456	300,486	150.24	1,802.92	1,051.70
70.0200	Credit agencies	457	240,209	120.10	1,441.25	840.73
70.0400	Insurance carriers	459	0	-	-	-
71.0201	Real estate agents	462	243,448	243.45	1,217.24	973.79
73.0102	Services to dwellings/buildings	472	111,378	111.38	668.27	334.13
73.0103	Personnel supply	474	90,686	136.03	453.43	317.40
73.0104	Computers & data processing	475	61,357	153.39	245.43	214.75
73.0106	Detective services	476	73,052	73.05	438.31	219.16
73.0107	Equipment rental & leasing	473	0	-	-	-
73.0109	Other business services	470	169,316	-	-	-
73.0111	Management & consulting	508	174,714	174.71	873.57	698.85
73.0112	Testing and research labs	509	0	-	-	-
73.0200	Advertising	469	175,253	-	701.01	1,051.52
73.0301	Legal services	494	52,000	-	312.00	208.00
73.0302	Engineering, architectural & surveying	506	0	-	-	-
73.0303	Accounting, auditing & bookeeping	507	0	-	-	-
74.0000	Eating & drinking places	454	53,620	26.81	268.10	241.29
75.0001	Automotive rental & leasing	477	0	-	-	-
78.0100	U.S. Postal Service	513	47,502	47.50	285.01	142.51
90.0000	Other value added	n.a.	1,108,199	-	2,216.40	8,865.59
88.0000	Compensation of Employees	n.a.	3,586,758			

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 3. General Personnel Transport

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	150	0.3	0.9	0.3
66.0200	Cable TV	441	-	-	-	-
70.0100	Banking	456	73	0.0	0.4	0.3
70.0200	Credit agencies	457	-	-	-	-
70.0400	Insurance carriers	459	68	-	0.4	0.3
71.0201	Real estate agents	462	130	0.1	0.7	0.5
73.0102	Services to dwellings/buildings	472	-	-	-	-
73.0103	Personnel supply	474	186	0.3	0.9	0.7
73.0104	Computers & data processing	475	-	-	-	-
73.0106	Detective services	476	-	-	-	-
73.0107	Equipment rental & leasing	473	-	-	-	-
73.0109	Other business services	470	-	-	-	-
73.0111	Management & consulting	508	-	-	-	-
73.0112	Testing and research labs	509	-	-	-	-
73.0200	Advertising	469	-	-	-	-
73.0301	Legal services	494	82	-	0.5	0.3
73.0302	Engineering, architectural & surveying	506	-	-	-	-
73.0303	Accounting, auditing & bookeeping	507	-	-	-	-
74.0000	Eating & drinking places	454	-	-	-	-
75.0001	Automotive rental & leasing	477	141	0.3	0.7	0.4
78.0100	U.S. Postal Service	513	-	-	-	-
90.0000	Other value added	n.a.	1,520	-	3.0	12.2
88.0000	Compensation of Employees	n.a.	3,764			

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 4. Construct Ice Road

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	9,485	1,897	5,691	1,897
70.0100	Banking	456	24,158	1,208	14,495	8,455
70.0400	Insurance carriers	459	4,817	-	2,890	1,927
71.0201	Real estate agents	462	23,751	2,375	11,875	9,500
72.0101	Hotels	463	11,264	563	5,632	5,069
73.0103	Personnel supply	474	6,595	989	3,298	2,308
73.0104	Computers & data processing	475	5,039	1,260	2,016	1,764
73.0111	Management & consulting	508	5,854	585	2,927	2,342
73.0200	Advertising	469	6,003	-	2,401	3,602
73.0301	Legal services	494	40,239	-	16,096	24,144
73.0302	Engineering, architectural & surveying	506	32,384	4,858	14,573	12,954
73.0303	Accounting, auditing & bookeeping	507	1,779	178	1,067	534
74.0000	Eating & drinking places	454	13,339	667	6,669	6,003
75.0001	Automotive rental & leasing	477	4,113	823	2,056	1,234
77.0501	Associations & professional org.	503	2,594	-	1,037	1,556
90.0000	Other value added	n.a.	595,399	-	119,080	476,319
88.0000	Compensation of Employees	n.a.	841,725	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 5. Construct Ice Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	5,667	1,133	3,400	1,133
70.0100	Banking	456	14,433	722	8,660	5,051
70.0400	Insurance carriers	459	2,878	-	1,727	1,151
71.0201	Real estate agents	462	14,189	1,419	7,095	5,676
72.0101	Hotels	463	6,729	336	3,365	3,028
73.0103	Personnel supply	474	3,940	591	1,970	1,379
73.0104	Computers & data processing	475	3,010	753	1,204	1,054
73.0111	Management & consulting	508	3,497	350	1,749	1,399
73.0200	Advertising	469	3,586	-	1,434	2,152
73.0301	Legal services	494	24,040	-	9,616	14,424
73.0302	Engineering, architectural & surveying	506	19,347	2,902	8,706	7,739
73.0303	Accounting, auditing & bookeeping	507	1,063	106	638	319
74.0000	Eating & drinking places	454	7,969	398	3,984	3,586
75.0001	Automotive rental & leasing	477	2,457	491	1,229	737
77.0501	Associations & professional org.	503	1,550	-	620	930
90.0000	Other value added	n.a.	355,701	-	71,140	284,561
88.0000	Compensation of Employees	n.a.	502,860	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 6. Move Drll Ship/Bottom Founded Platform

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	1,094	219	656	219
70.0100	Banking	456	2,785	139	1,671	975
70.0400	Insurance carriers	459	555	-	333	222
71.0201	Real estate agents	462	2,738	274	1,369	1,095
72.0101	Hotels	463	1,299	65	649	584
73.0103	Personnel supply	474	760	114	380	266
73.0104	Computers & data processing	475	581	145	232	203
73.0111	Management & consulting	508	675	67	337	270
73.0200	Advertising	469	692	-	277	415
73.0301	Legal services	494	4,639	-	1,856	2,784
73.0302	Engineering, architectural & surveying	506	3,734	560	1,680	1,493
73.0303	Accounting, auditing & bookeeping	507	205	21	123	62
74.0000	Eating & drinking places	454	1,538	77	769	692
75.0001	Automotive rental & leasing	477	474	95	237	142
77.0501	Associations & professional org.	503	299	-	120	179
90.0000	Other value added	n.a.	68,647	-	13,729	54,918
88.0000	Compensation of Employees	n.a.	97,047	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 7. Operate Drill Ship in Calm Waters

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	234	47	140	47
70.0100	Banking	456	595	30	357	208
70.0400	Insurance carriers	459	119	-	71	47
71.0201	Real estate agents	462	585	59	293	234
72.0101	Hotels	463	278	14	139	125
73.0103	Personnel supply	474	163	24	81	57
73.0104	Computers & data processing	475	124	31	50	43
73.0111	Management & consulting	508	144	14	72	58
73.0200	Advertising	469	148	-	59	89
73.0301	Legal services	494	992	-	397	595
73.0302	Engineering, architectural & surveying	506	798	120	359	319
73.0303	Accounting, auditing & bookeeping	507	44	4	26	13
74.0000	Eating & drinking places	454	329	16	164	148
75.0001	Automotive rental & leasing	477	101	20	51	30
77.0501	Associations & professional org.	503	64	-	26	38
90.0000	Other value added	n.a.	14,671	-	2,934	11,737
88.0000	Compensation of Employees	n.a.	20,741	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 8. Operate Drill Ship in Rough Seas

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	1,094	219	656	219
70.0100	Banking	456	2,785	139	1,671	975
70.0400	Insurance carriers	459	555	-	333	222
71.0201	Real estate agents	462	2,738	274	1,369	1,095
72.0101	Hotels	463	1,299	65	649	584
73.0103	Personnel supply	474	760	114	380	266
73.0104	Computers & data processing	475	581	145	232	203
73.0111	Management & consulting	508	675	67	337	270
73.0200	Advertising	469	692	-	277	415
73.0301	Legal services	494	4,639	-	1,856	2,784
73.0302	Engineering, architectural & surveying	506	3,734	560	1,680	1,493
73.0303	Accounting, auditing & bookeeping	507	205	21	123	62
74.0000	Eating & drinking places	454	1,538	77	769	692
75.0001	Automotive rental & leasing	477	474	95	237	142
77.0501	Associations & professional org.	503	299	-	120	179
90.0000	Other value added	n.a.	68,647	-	13,729	54,918
88.0000	Compensation of Employees	n.a.	97,047	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 9. Operate Mobile Exploration Platform

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	225	45	135	45
70.0100	Banking	456	573	29	344	201
70.0400	Insurance carriers	459	114	-	69	46
71.0201	Real estate agents	462	564	56	282	226
72.0101	Hotels	463	267	13	134	120
73.0103	Personnel supply	474	157	23	78	55
73.0104	Computers & data processing	475	120	30	48	42
73.0111	Management & consulting	508	139	14	69	56
73.0200	Advertising	469	142	-	57	85
73.0301	Legal services	494	955	-	382	573
73.0302	Engineering, architectural & surveying	506	769	115	346	307
73.0303	Accounting, auditing & bookeeping	507	42	4	25	13
74.0000	Eating & drinking places	454	317	16	158	142
75.0001	Automotive rental & leasing	477	98	20	49	29
77.0501	Associations & professional org.	503	62	-	25	37
90.0000	Other value added	n.a.	14,133	-	2,827	11,306
88.0000	Compensation of Employees	n.a.	19,980	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 10. Helicopter Support

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	144	0.3	0.9	0.3
66.0200	Cable TV	441	-	-	-	-
70.0100	Banking	456	72	0.0	0.4	0.3
70.0200	Credit agencies	457	94	0.0	0.6	0.3
70.0400	Insurance carriers	459	-	-	-	-
71.0201	Real estate agents	462	171	0.2	0.9	0.7
73.0102	Services to dwellings/buildings	472	-	-	-	-
73.0103	Personnel supply	474	-	-	-	-
73.0104	Computers & data processing	475	267	0.7	1.1	0.9
73.0106	Detective services	476	-	-	-	-
73.0107	Equipment rental & leasing	473	81	0.1	0.5	0.2
73.0109	Other business services	470	-	-	-	-
73.0111	Management & consulting	508	-	-	-	-
73.0112	Testing and research labs	509	-	-	-	-
73.0200	Advertising	469	166	-	0.7	1.0
73.0301	Legal services	494	113	-	0.7	0.5
73.0302	Engineering, architectural & surveying	506	-	-	-	-
73.0303	Accounting, auditing & bookeeping	507	-	-	-	-
74.0000	Eating & drinking places	454	220	0.1	1.1	1.0
75.0001	Automotive rental & leasing	477	-	-	-	-
78.0100	U.S. Postal Service	513	-	-	-	-
90.0000	Other value added	n.a.	445	-	0.9	3.6
88.0000	Compensation of Employees	n.a.	3,927			

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 11. Barge Support

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	-	-	-	-
66.0200	Cable TV	441	-	-	-	-
70.0100	Banking	456	132	0.1	0.8	0.5
70.0200	Credit agencies	457	148	0.1	0.9	0.5
70.0400	Insurance carriers	459	-	-	-	-
71.0201	Real estate agents	462	246	0.2	1.2	1.0
73.0102	Services to dwellings/buildings	472	-	-	-	-
73.0103	Personnel supply	474	-	-	-	-
73.0104	Computers & data processing	475	79	0.2	0.3	0.3
73.0106	Detective services	476	-	-	-	-
73.0107	Equipment rental & leasing	473	52	0.1	0.3	0.2
73.0109	Other business services	470	56	-	-	-
73.0111	Management & consulting	508	256	0.3	1.3	1.0
73.0112	Testing and research labs	509	209	-	0.4	1.7
73.0200	Advertising	469	349	-	1.4	2.1
73.0301	Legal services	494	46	-	0.3	0.2
73.0302	Engineering, architectural & surveying	506	85	0.1	0.4	0.3
73.0303	Accounting, auditing & bookeeping	507	61	0.1	0.4	0.2
74.0000	Eating & drinking places	454	-	-	-	-
75.0001	Automotive rental & leasing	477	-	-	-	-
78.0100	U.S. Postal Service	513	-	-	-	-
90.0000	Other value added	n.a.	1,424	-	2.8	11.4
88.0000	Compensation of Employees	n.a.	2,004			

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 12. Drill Exploration Well

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	36,194	7,239	21,717	7,239
70.0100	Banking	456	92,182	4,609	55,309	32,264
70.0400	Insurance carriers	459	18,380	-	11,028	7,352
71.0201	Real estate agents	462	90,627	9,063	45,313	36,251
72.0101	Hotels	463	42,981	2,149	21,490	19,341
73.0103	Personnel supply	474	25,166	3,775	12,583	8,808
73.0104	Computers & data processing	475	19,228	4,807	7,691	6,730
73.0111	Management & consulting	508	22,339	2,234	11,169	8,935
73.0200	Advertising	469	22,904	-	9,162	13,742
73.0301	Legal services	494	153,543	-	61,417	92,126
73.0302	Engineering, architectural & surveying	506	123,569	18,535	55,606	49,428
73.0303	Accounting, auditing & bookeeping	507	6,786	679	4,072	2,036
74.0000	Eating & drinking places	454	50,898	2,545	25,449	22,904
75.0001	Automotive rental & leasing	477	15,694	3,139	7,847	4,708
77.0501	Associations & professional org.	503	9,897	-	3,959	5,938
90.0000	Other value added	n.a.	2,271,894	-	454,379	1,817,515
88.0000	Compensation of Employees	n.a.	3,211,813	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 13. Drill Production Well

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	12,065	2,413	7,239	2,413
70.0100	Banking	456	30,727	1,536	18,436	10,755
70.0400	Insurance carriers	459	6,127	-	3,676	2,451
71.0201	Real estate agents	462	30,209	3,021	15,104	12,084
72.0101	Hotels	463	14,327	716	7,163	6,447
73.0103	Personnel supply	474	8,389	1,258	4,194	2,936
73.0104	Computers & data processing	475	6,409	1,602	2,564	2,243
73.0111	Management & consulting	508	7,446	745	3,723	2,978
73.0200	Advertising	469	7,635	-	3,054	4,581
73.0301	Legal services	494	51,181	-	20,472	30,709
73.0302	Engineering, architectural & surveying	506	41,190	6,178	18,535	16,476
73.0303	Accounting, auditing & bookeeping	507	2,262	226	1,357	679
74.0000	Eating & drinking places	454	16,966	848	8,483	7,635
75.0001	Automotive rental & leasing	477	5,231	1,046	2,616	1,569
77.0501	Associations & professional org.	503	3,299	-	1,320	1,979
90.0000	Other value added	n.a.	757,298	-	151,460	605,838
88.0000	Compensation of Employees	n.a.	1,070,604	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 14. Well Workover

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	1,609	322	965	322
70.0100	Banking	456	4,097	205	2,458	1,434
70.0400	Insurance carriers	459	817	-	490	327
71.0201	Real estate agents	462	4,028	403	2,014	1,611
72.0101	Hotels	463	1,910	96	955	860
73.0103	Personnel supply	474	1,119	168	559	391
73.0104	Computers & data processing	475	855	214	342	299
73.0111	Management & consulting	508	993	99	496	397
73.0200	Advertising	469	1,018	-	407	611
73.0301	Legal services	494	6,824	-	2,730	4,094
73.0302	Engineering, architectural & surveying	506	5,492	824	2,471	2,197
73.0303	Accounting, auditing & bookeeping	507	302	30	181	90
74.0000	Eating & drinking places	454	2,262	113	1,131	1,018
75.0001	Automotive rental & leasing	477	697	139	349	209
77.0501	Associations & professional org.	503	440	-	176	264
90.0000	Other value added	n.a.	100,973	-	20,195	80,778
88.0000	Compensation of Employees	n.a.	142,747	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 15. Construct Gravel Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	32,336	6,467	19,402	6,467
70.0100	Banking	456	82,356	4,118	49,414	28,825
70.0400	Insurance carriers	459	16,421	-	9,852	6,568
71.0201	Real estate agents	462	80,967	8,097	40,483	32,387
72.0101	Hotels	463	38,399	1,920	19,200	17,280
73.0103	Personnel supply	474	22,484	3,373	11,242	7,869
73.0104	Computers & data processing	475	17,179	4,295	6,871	6,013
73.0111	Management & consulting	508	19,958	1,996	9,979	7,983
73.0200	Advertising	469	20,463	-	8,185	12,278
73.0301	Legal services	494	137,176	-	54,871	82,306
73.0302	Engineering, architectural & surveying	506	110,398	16,560	49,679	44,159
73.0303	Accounting, auditing & bookeeping	507	6,063	606	3,638	1,819
74.0000	Eating & drinking places	454	45,473	2,274	22,736	20,463
75.0001	Automotive rental & leasing	477	14,021	2,804	7,010	4,206
77.0501	Associations & professional org.	503	8,842	-	3,537	5,305
90.0000	Other value added	n.a.	2,029,729	-	405,946	1,623,783
88.0000	Compensation of Employees	n.a.	2,869,460	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 16. Protect Gravel Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	78,532	15,706	47,119	15,706
70.0100	Banking	456	200,012	10,001	120,007	70,004
70.0400	Insurance carriers	459	39,880	-	23,928	15,952
71.0201	Real estate agents	462	196,637	19,664	98,319	78,655
72.0101	Hotels	463	93,257	4,663	46,629	41,966
73.0103	Personnel supply	474	54,604	8,191	27,302	19,112
73.0104	Computers & data processing	475	41,720	10,430	16,688	14,602
73.0111	Management & consulting	508	48,469	4,847	24,235	19,388
73.0200	Advertising	469	49,696	-	19,878	29,818
73.0301	Legal services	494	333,149	-	133,259	199,889
73.0302	Engineering, architectural & surveying	506	268,114	40,217	120,651	107,246
73.0303	Accounting, auditing & bookeeping	507	14,725	1,472	8,835	4,417
74.0000	Eating & drinking places	454	110,436	5,522	55,218	49,696
75.0001	Automotive rental & leasing	477	34,051	6,810	17,026	10,215
77.0501	Associations & professional org.	503	21,474	-	8,589	12,884
90.0000	Other value added	n.a.	4,929,434	-	985,887	3,943,547
88.0000	Compensation of Employees	n.a.	6,968,818	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 17. Equip Production Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	143,613	28,723	86,168	28,723
70.0100	Banking	456	365,765	18,288	219,459	128,018
70.0400	Insurance carriers	459	72,929	-	43,757	29,171
71.0201	Real estate agents	462	359,594	35,959	179,797	143,838
72.0101	Hotels	463	170,541	8,527	85,270	76,743
73.0103	Personnel supply	474	99,856	14,978	49,928	34,950
73.0104	Computers & data processing	475	76,295	19,074	30,518	26,703
73.0111	Management & consulting	508	88,636	8,864	44,318	35,455
73.0200	Advertising	469	90,880	-	36,352	54,528
73.0301	Legal services	494	609,235	-	243,694	365,541
73.0302	Engineering, architectural & surveying	506	490,305	73,546	220,637	196,122
73.0303	Accounting, auditing & bookeeping	507	26,928	2,693	16,157	8,078
74.0000	Eating & drinking places	454	201,956	10,098	100,978	90,880
75.0001	Automotive rental & leasing	477	62,270	12,454	31,135	18,681
77.0501	Associations & professional org.	503	39,269	-	15,708	23,562
90.0000	Other value added	n.a.	9,014,544	-	1,802,909	7,211,635
88.0000	Compensation of Employees	n.a.	12,744,004	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 18. Operate Production Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	187,086	37,417	112,251	37,417
70.0100	Banking	456	476,484	23,824	285,890	166,769
70.0400	Insurance carriers	459	95,004	-	57,003	38,002
71.0201	Real estate agents	462	468,445	46,845	234,223	187,378
72.0101	Hotels	463	222,164	11,108	111,082	99,974
73.0103	Personnel supply	474	130,083	19,512	65,042	45,529
73.0104	Computers & data processing	475	99,389	24,847	39,756	34,786
73.0111	Management & consulting	508	115,467	11,547	57,733	46,187
73.0200	Advertising	469	118,390	-	47,356	71,034
73.0301	Legal services	494	793,653	-	317,461	476,192
73.0302	Engineering, architectural & surveying	506	638,722	95,808	287,425	255,489
73.0303	Accounting, auditing & bookeeping	507	35,079	3,508	21,047	10,524
74.0000	Eating & drinking places	454	263,089	13,154	131,545	118,390
75.0001	Automotive rental & leasing	477	81,119	16,224	40,560	24,336
77.0501	Associations & professional org.	503	51,156	-	20,462	30,694
90.0000	Other value added	n.a.	11,743,282	-	2,348,656	9,394,626
88.0000	Compensation of Employees	n.a.	16,601,664	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 19. Construct Gas Production Facility

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	75,563	15,113	45,338	15,113
70.0100	Banking	456	192,450	9,623	115,470	67,358
70.0400	Insurance carriers	459	38,372	-	23,023	15,349
71.0201	Real estate agents	462	189,204	18,920	94,602	75,681
72.0101	Hotels	463	89,731	4,487	44,866	40,379
73.0103	Personnel supply	474	52,540	7,881	26,270	18,389
73.0104	Computers & data processing	475	40,143	10,036	16,057	14,050
73.0111	Management & consulting	508	46,637	4,664	23,318	18,655
73.0200	Advertising	469	47,817	-	19,127	28,690
73.0301	Legal services	494	320,554	-	128,222	192,332
73.0302	Engineering, architectural & surveying	506	257,978	38,697	116,090	103,191
73.0303	Accounting, auditing & bookeeping	507	14,168	1,417	8,501	4,250
74.0000	Eating & drinking places	454	106,261	5,313	53,130	47,817
75.0001	Automotive rental & leasing	477	32,764	6,553	16,382	9,829
77.0501	Associations & professional org.	503	20,662	-	8,265	12,397
90.0000	Other value added	n.a.	4,743,077	-	948,615	3,794,461
88.0000	Compensation of Employees	n.a.	6,705,362	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 20. Operate Gas Production Facility

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	15,773	3,155	9,464	3,155
70.0100	Banking	456	40,171	2,009	24,103	14,060
70.0400	Insurance carriers	459	8,010	-	4,806	3,204
71.0201	Real estate agents	462	39,493	3,949	19,747	15,797
72.0101	Hotels	463	18,730	937	9,365	8,429
73.0103	Personnel supply	474	10,967	1,645	5,483	3,838
73.0104	Computers & data processing	475	8,379	2,095	3,352	2,933
73.0111	Management & consulting	508	9,735	973	4,867	3,894
73.0200	Advertising	469	9,981	-	3,992	5,989
73.0301	Legal services	494	66,911	-	26,764	40,146
73.0302	Engineering, architectural & surveying	506	53,849	8,077	24,232	21,540
73.0303	Accounting, auditing & bookeeping	507	2,957	296	1,774	887
74.0000	Eating & drinking places	454	22,180	1,109	11,090	9,981
75.0001	Automotive rental & leasing	477	6,839	1,368	3,419	2,052
77.0501	Associations & professional org.	503	4,313	-	1,725	2,588
90.0000	Other value added	n.a.	990,045	-	198,009	792,036
88.0000	Compensation of Employees	n.a.	1,399,643	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 21. Construct Offshore Pipeline

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	52,145	10,429	31,287	10,429
70.0100	Banking	456	132,808	6,640	79,685	46,483
70.0400	Insurance carriers	459	26,480	-	15,888	10,592
71.0201	Real estate agents	462	130,567	13,057	65,283	52,227
72.0101	Hotels	463	61,923	3,096	30,961	27,865
73.0103	Personnel supply	474	36,257	5,439	18,129	12,690
73.0104	Computers & data processing	475	27,702	6,926	11,081	9,696
73.0111	Management & consulting	508	32,183	3,218	16,092	12,873
73.0200	Advertising	469	32,998	-	13,199	19,799
73.0301	Legal services	494	221,210	-	88,484	132,726
73.0302	Engineering, architectural & surveying	506	178,027	26,704	80,112	71,211
73.0303	Accounting, auditing & bookeeping	507	9,777	978	5,866	2,933
74.0000	Eating & drinking places	454	73,329	3,666	36,665	32,998
75.0001	Automotive rental & leasing	477	22,610	4,522	11,305	6,783
77.0501	Associations & professional org.	503	14,258	-	5,703	8,555
90.0000	Other value added	n.a.	3,273,137	-	654,627	2,618,510
88.0000	Compensation of Employees	n.a.	4,627,286	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 22. Construct Onshore Pipeline

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	30,194	6,039	18,117	6,039
70.0100	Banking	456	76,901	3,845	46,140	26,915
70.0400	Insurance carriers	459	15,333	-	9,200	6,133
71.0201	Real estate agents	462	75,603	7,560	37,802	30,241
72.0101	Hotels	463	35,856	1,793	17,928	16,135
73.0103	Personnel supply	474	20,994	3,149	10,497	7,348
73.0104	Computers & data processing	475	16,041	4,010	6,416	5,614
73.0111	Management & consulting	508	18,635	1,864	9,318	7,454
73.0200	Advertising	469	19,107	-	7,643	11,464
73.0301	Legal services	494	128,089	-	51,236	76,854
73.0302	Engineering, architectural & surveying	506	103,085	15,463	46,388	41,234
73.0303	Accounting, auditing & bookeeping	507	5,661	566	3,397	1,698
74.0000	Eating & drinking places	454	42,461	2,123	21,230	19,107
75.0001	Automotive rental & leasing	477	13,092	2,618	6,546	3,928
77.0501	Associations & professional org.	503	8,256	-	3,302	4,954
90.0000	Other value added	n.a.	1,895,275	-	379,055	1,516,220
88.0000	Compensation of Employees	n.a.	2,679,381	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 23. Lay Sea Floor Pipeline

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	81,777	16,355	49,066	16,355
70.0100	Banking	456	208,276	10,414	124,966	72,897
70.0400	Insurance carriers	459	41,527	-	24,916	16,611
71.0201	Real estate agents	462	204,762	20,476	102,381	81,905
72.0101	Hotels	463	97,110	4,856	48,555	43,700
73.0103	Personnel supply	474	56,861	8,529	28,430	19,901
73.0104	Computers & data processing	475	43,444	10,861	17,378	15,205
73.0111	Management & consulting	508	50,472	5,047	25,236	20,189
73.0200	Advertising	469	51,750	-	20,700	31,050
73.0301	Legal services	494	346,914	-	138,765	208,148
73.0302	Engineering, architectural & surveying	506	279,192	41,879	125,636	111,677
73.0303	Accounting, auditing & bookeeping	507	15,333	1,533	9,200	4,600
74.0000	Eating & drinking places	454	114,999	5,750	57,499	51,750
75.0001	Automotive rental & leasing	477	35,458	7,092	17,729	10,637
77.0501	Associations & professional org.	503	22,361	-	8,944	13,417
90.0000	Other value added	n.a.	5,133,108	-	1,026,622	4,106,486
88.0000	Compensation of Employees	n.a.	7,256,756	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 24. Land Base Operation

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	822,954	164,591	493,772	164,591
70.0100	Banking	456	2,095,961	104,798	1,257,577	733,586
70.0400	Insurance carriers	459	417,906	-	250,744	167,163
71.0201	Real estate agents	462	2,060,600	206,060	1,030,300	824,240
72.0101	Hotels	463	977,258	48,863	488,629	439,766
73.0103	Personnel supply	474	572,210	85,832	286,105	200,274
73.0104	Computers & data processing	475	437,194	109,299	174,878	153,018
73.0111	Management & consulting	508	507,917	50,792	253,959	203,167
73.0200	Advertising	469	520,776	-	208,310	312,465
73.0301	Legal services	494	3,491,126	-	1,396,450	2,094,675
73.0302	Engineering, architectural & surveying	506	2,809,617	421,443	1,264,328	1,123,847
73.0303	Accounting, auditing & bookeeping	507	154,304	15,430	92,582	46,291
74.0000	Eating & drinking places	454	1,157,279	57,864	578,640	520,776
75.0001	Automotive rental & leasing	477	356,828	71,366	178,414	107,048
77.0501	Associations & professional org.	503	225,027	-	90,011	135,016
90.0000	Other value added	n.a.	51,656,445	-	10,331,289	41,325,156
88.0000	Compensation of Employees	n.a.	73,027,535	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 25. Spill Contingency

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	173,049	34,610	103,829	34,610
70.0100	Banking	456	440,733	22,037	264,440	154,257
70.0400	Insurance carriers	459	87,876	-	52,726	35,151
71.0201	Real estate agents	462	433,298	43,330	216,649	173,319
72.0101	Hotels	463	205,495	10,275	102,748	92,473
73.0103	Personnel supply	474	120,323	18,048	60,161	42,113
73.0104	Computers & data processing	475	91,932	22,983	36,773	32,176
73.0111	Management & consulting	508	106,803	10,680	53,402	42,721
73.0200	Advertising	469	109,507	-	43,803	65,704
73.0301	Legal services	494	734,105	-	293,642	440,463
73.0302	Engineering, architectural & surveying	506	590,799	88,620	265,860	236,320
73.0303	Accounting, auditing & bookeeping	507	32,447	3,245	19,468	9,734
74.0000	Eating & drinking places	454	243,350	12,167	121,675	109,507
75.0001	Automotive rental & leasing	477	75,033	15,007	37,516	22,510
77.0501	Associations & professional org.	503	47,318	-	18,927	28,391
90.0000	Other value added	n.a.	10,862,185	-	2,172,437	8,689,748
88.0000	Compensation of Employees	n.a.	15,356,043	n.a.	n.a.	n.a.

Exhibit 6-5: Estimates of Purchased Services by Sector and Geographic Area For Oil and Gas Related Activities
Activity # 26. Abandon Production Island

BEA I-O Sector	Sector Name	IMPLAN Sector	Service Purchases	NSB	Other Alaska	Other U.S.
66.0100	Telephone communications	441	187,601	37,520	112,561	37,520
70.0100	Banking	456	477,796	23,890	286,678	167,229
70.0400	Insurance carriers	459	95,266	-	57,160	38,106
71.0201	Real estate agents	462	469,735	46,973	234,867	187,894
72.0101	Hotels	463	222,776	11,139	111,388	100,249
73.0103	Personnel supply	474	130,441	19,566	65,221	45,654
73.0104	Computers & data processing	475	99,663	24,916	39,865	34,882
73.0111	Management & consulting	508	115,785	11,578	57,892	46,314
73.0200	Advertising	469	118,716	-	47,486	71,230
73.0301	Legal services	494	795,838	-	318,335	477,503
73.0302	Engineering, architectural & surveying	506	640,481	96,072	288,216	256,192
73.0303	Accounting, auditing & bookeping	507	35,175	3,518	21,105	10,553
74.0000	Eating & drinking places	454	263,814	13,191	131,907	118,716
75.0001	Automotive rental & leasing	477	81,343	16,269	40,671	24,403
77.0501	Associations & professional org.	503	51,297	-	20,519	30,778
90.0000	Other value added	n.a.	11,775,618	-	2,355,124	9,420,494
88.0000	Compensation of Employees	n.a.	16,647,377	n.a.	n.a.	n.a.

Activity Units

Activity	*Units*	*Activity*	*Units*
Barge Support	1 Day	Mobile Bottom Founded Structure	1 Day
Camp Support	1 Year	Move Platform	1 Day
Drill Ship – Calm Water	1 Day	Offshore Pipeline	1 Mile
Drill Ship – Rough Water	1 Day	Onshore Pipeline	1 Mile
Equip Production Island	1 Island	Personnel Transport	1 Day
Exploration Well	1 Well	Production Operations	1 Year
Gravel Island	1 Island	Production Well	1 Well
Helicopter Support 1 Day		Seafloor Tieback Pipeline	10 Miles
Ice Island	1 Island	Seismic Survey	1 Month
Ice Road	10-Miles	Spill Contingency	1 Year
Land Base Operations	1 Year	Well Work-over	1 Well

7 CAPITAL INPUTS

Unlike most labor and material inputs which are entirely and immediately consumed in the production process, capital inputs are used up gradually over time. This defining aspect of capital requires special attention when utilizing an input-output (I-O) framework to estimate economic impacts. Capital expenditures are not included in the use coefficients of an industry, which only account for inputs that are immediately consumed for current production. In an I-O model, annualized capital expenditures are included with value added. Unfortunately, these expenses are frequently aggregated and, without a capital flow matrix, it is not possible to isolate specific types of investments or trace the secondary impacts associated with such investments. For this reason, exogenous estimates of capital investment are often developed outside of the I-O model, and then used as model catalysts along with other direct expenditures.

Capital investments represent a substantial portion of mineral exploration and development (E&D) expenditures. Due to the harsh environment, this is especially true on Alaska's North Slope, where many of the machines only last four years and are often operated for long periods of time without even being turned off. E&D activities require transportation and earth moving equipment, drilling equipment, et cetera.

This section describes how expenditures for these items were developed and should be used to stimulate the IMPLAN input-output model. Please note that separate data are not provided for the two activities specific to the local gas scenario (Construct Gas Production Facility and Operate Gas Production Facility); capital expenditures for these activities are “rule-of-thumb” estimates based on scaled vectors of other activities in the model (Equip Production Island and Operate Production Island, respectively).

7.1 OVERVIEW

Capital expenditures were estimated by activity, IMPLAN sector and geographic region. The estimates were developed for the levels of E&D activities comprising the base scenario and identified in Exhibit 2-2.

The numbers are based upon estimated expenditures for the different assets needed to carry out each activity. Each capital expenditure is based upon the total delivered price of the asset. This cost is annualized (based upon the average life of the machine), converted into a "per unit" basis, and then divided into its various cost components: i.e., manufacturing, transportation and wholesale trade, and retrofitting. Each cost category is assigned to an associated IMPLAN sector.

Finally, regional purchase coefficients (See Glossary and Chapter 3 were used to allocate expenditures to impacted geographic regions. This allocation is performed for each cost component. For example, the manufacturing cost of a particular asset may have been assigned to the contiguous 48-states whereas part of the cost of delivering it to the North Slope may have been assigned to the NSB.

Information on capital usage and costs were obtained from the engineering reports presented in Chapter 4. These data were compiled through surveys of construction and mining contractors and supplemented with professional judgment. Data were gathered on the types of equipment used, the percentage of equipment purchases that were new versus used, the percentage of time equipment were devoted to a particular activities, where equipment were obtained, prices at the factory gate, shipping methods and costs, how much retrofitting was performed and where it was done, and wholesale trade margins. Such information was not available for every piece of machinery and much of it had to be estimated by JFA staff.

7.2 INVENTORY OF ASSETS USED IN EACH E&D ACTIVITY

The first step in the process was to identify the capital assets used in each E&D activity. It should be noted that much of the equipment has to be retrofitted with special accessories before it can be used in the harsh conditions found on the North Slope. These accessories include insulation, special engine lubricants, and hardware attachments. The accessories associated with each primary piece of capital were also identified in this first step.

Developing the capital cost vectors also required dividing the assets into new and used equipment categories. There is a considerable amount of salvaged equipment that is used on the North Slope. Since used equipment is not manufactured, the main economic impacts associated with the sale of such equipment results from retrofitting, reconditioning, and margin activities. These activities, as well as their associated regional purchase coefficients (See Glossary and Chapter 3), are not the same for new and used equipment. The estimated percentages of assets that are new and used are based on subjective judgments and take into account relevant professional experience.

The number of assets required to carry out one unit of each activity were then estimated.

7.3 COST ESTIMATES BY ASSET

This step entailed developing a cost estimate for each asset per activity unit. To develop the cost estimates, it was necessary to make some assumptions regarding the average life of the machine and the amount of time that it is devoted to the particular activity in question. Average life was used to capitalize the investment in the machine. Dedication to task was needed since some machinery can be used on multiple projects simultaneously during a given time period. Both of these numbers are based on professional engineering judgment.

Total delivery cost was the final information needed to develop the cost estimates. This information was gathered primarily in contractor surveys. Some of the information had to be supplemented with additional estimates based upon professional judgment.

For each activity and asset, a cost estimate was developed using the above information. The total delivery cost was multiplied by the number of assets needed, adjusted for the amount of time it was devoted to the activity, and then divided by the average life of the machine. For each asset type, this last step means that we are assuming that the age distribution of the current population is uniform. We felt that it would be too difficult and too costly to compute this distribution through survey work. We also had to assume that each asset adheres to a straight line depreciation schedule. Again, we felt that it would be too costly and would make the model unnecessarily complicated to develop different depreciation schedules by asset type. We also didn't feel comfortable using established depreciation schedules at the national level given the North Slope's harsh environment.

Finally, the cost estimates were converted into a per unit basis by dividing them by the number of activity units per year.

Table A-1 in Appendix A presents an inventory of the capital assets and per unit costs for each E&D activity in IMPAK.

7.3.1 Seismic Survey

In Appendix Table A-1, the asset requirements for conducting and supporting seismic ice surveys reflect the annualized capital cost to complete one month of survey work supported by a 100 man camp. It is assumed that much of the equipment will not be refurbished. Due to economic competition, contractors are required to use the latest innovations which are being introduced rapidly in some of the seismic and survey technologies.

Asset lifetimes range from 7 to 10 years depending on the type of asset. Equipment dedication ranges from a low of 50 percent for general equipment such as loaders to 100 percent for the more specialized seismic and survey equipment. To put the costs estimates on a per unit basis, it was assumed that each piece of equipment could be used four months out of the year for the survey work.

Information regarding the equipment used for ice surveys was gathered from contractors engaged in conducting ice surveys as well as those who provide camp support for the survey crews.

7.3.2 North Slope Camp Support

In Appendix A, Table A-1, the asset requirements and annual capital costs are provided for North Slope Camp Support. Some of the assumed lifetimes are somewhat shorter than might be expected to take into account major overhauls and refurbishments: i.e., these activities are treated similar to the purchase of a used piece of machinery. All of the equipment is 100 percent dedicated to camp support.

As can be seen, most of the capital assets are large expensive pieces of equipment with relatively long lifetimes. Purchases of smaller assets such as sewage and water pipe were captured in the annual maintenance expenditures. Included in the itemized expenditures are charges for installation/construction and finance. It should be noted that the economic impacts of the installation and actual equipment costs (net of finance) will occur in the year in which the equipment was acquired; they will not be felt over the life of the asset. However, for these large types of assets, replacement investment (beyond that captured in maintenance charges) will take place over their lifetimes. Secondary data sources have indicated that annual replacement investment is roughly equal to depreciation charges, so depreciation is used as a proxy for replacement investment.

Information regarding the equipment used to provide food, lodging and other related activities were gathered from contractors engaged in providing camp support.

7.3.3 General Personnel Transport (GPT)

As shown in Table A-1 in Appendix A, the assets needed for one operation that provides GPT services was estimated to be three vans and one bus.

A large percentage of the capital expenditures are accounted for by refurbishments. Lifetimes for the vehicles were assumed to be 9 years, with major overhauls conducted every three years.

The vehicles are assumed to be 100 percent dedicated to providing personnel transportation support for oil exploration and development operations. Dividing the annual capital cost by 365 yields the daily capital cost for each vehicle.

Information regarding the equipment used to transport personnel to/from the location of E&D activities were gathered from contractors engaged in providing these activities, as well as equipment manufactures and suppliers

7.3.4 Ice Roads and Ice Islands

The same type of machinery is used to build both ice islands and ice roads and includes a variety of construction vehicles: e.g., snow blowers, graders, dump trucks and water trucks. For each asset, Table A-1 in Appendix A provides the capital cost to complete a 10-mile ice road that is five feet deep or one ice island.

For the most part, lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year.

Information regarding the equipment used to build ice roads and ice islands were gathered from several construction contractors who provide these services.

7.3.5 Move Platform

Shown in Appendix Table A-1 are the assets required to move drill ships and mobile bottom founded structures into their operating locations. In addition to the ships and structures themselves, which move under their own power, other types of vessels are needed to assist in this effort. Among these are ice breakers, tugs, workboats and fuel barges. For each asset, the exhibit provides the annualized capital cost involved in one day of moving operations.

Asset lifetimes range from 10 to 20 years with all assets assumed to be used. Equipment dedication was assumed to be 100% once operations are underway. To put the annual costs estimates on a per day basis, it was assumed that these operations could be conducted 270 days per year.

7.3.6 Operate Drill Ship for Exploration

The asset requirements for operating drill ships used for exploration purposes are provided in Appendix Table A-1. For each asset, the exhibit provides the annualized capital cost involved in operating the drill ship for one day. Such operations do not include actual drilling activities, which are addressed separately in Section 7.3.10.

Asset lifetimes range from 10 to 20 years with all assets assumed to be used. Equipment dedication was assumed to be 100% once operations are underway. To put the annual costs estimates on a per day basis, it was assumed that the drill ships could operate 270 days per year.

7.3.7 Mobile Bottom Founded Structure (MBFS) for Exploration

The asset requirements for operating an MBFS used for exploration purposes are provided in Appendix Table A-1. For each asset, the exhibit provides the annualized capital cost involved in operating the structure for one day. Such operations do not include actual drilling activities, which are addressed separately in Section 7.3.10.

Asset lifetimes range from 10 to 20 years with all assets assumed to be used. Equipment dedication was assumed to be 100% once operations are underway. To put the annual costs estimates on a per day basis, it was assumed that the structures could operate 270 days per year.

7.3.8 Helicopter Support

The only asset considered for helicopter support is the actual helicopter. Platform helipads are taken into account in the chapter dealing with the construction of the platforms. While hangars, fuel trucks, and other related assets are utilized by helicopter services, this equipment typically belongs to the airport where the helicopters are staged.

Lifetimes for the helicopters were assumed to be 15 years, with major overhauls conducted every three years. A large percentage of the capital replacements are accounted for by refurbishments.

The helicopters are assumed to be 100 percent dedicated to providing support for oil exploration and development operations. However, it is also assumed that the one helicopter can be used to support multiple platforms and different types of operations (e.g., ice road construction). Dividing the annual capital cost by 365 yields the capital cost per day for the helicopter.

Information regarding the equipment used for helicopter support services was gathered from contractors engaged in providing these activities, as well as equipment manufactures and suppliers.

7.3.9 Barge Support

The asset requirements for conducting and supporting barge support are provided in Appendix Table A-1. For each asset, the exhibit provides the annualized capital cost for one day of barge support.

Asset lifetimes ranged from 3 to 5 years depending on whether the asset was new or used. Equipment dedication ranges from a low of 35 percent for general equipment such as loaders to 100 percent for the actual barges. To put the annual costs estimates on a per unit basis, it was assumed that each piece of equipment could be used four months out of the year.

Information regarding the equipment used for barge support was gathered from contractors engaged in providing barge support activities.

7.3.10 Well Drilling

The assets needed to drill production and exploration wells, as well as perform well work-overs, are provided in Appendix A, Table A-1. For each asset, the exhibit provides the annual capital cost to drill one well or perform one well work-over.

A large percentage of the capital replacements are accounted for by refurbishment and the purchase of used machinery. Lifetimes for the drill rigs were assumed to be 15 years, with major overhauls conducted every three years.

The rigs are assumed to be 100 percent dedicated to a given task: i.e., they can't be used on more than one task at any give time. However, it is assumed that the same rigs are used to drill both exploration and production wells, and that one rig can drill one exploration well and six production wells per year. Taking into account the amount of time it takes to drill each type of well and to move the rig between wells, it is assumed that the rigs are utilized 270 days per year. Dividing the annual capital cost by 270 yields the daily capital cost for the rig. To put the cost on a per-well basis, this figure is then multiplied by the number of days it takes to drill a well. It is assumed that each work-over rig, which are considerably smaller than the production rigs, is utilized 120 days per year and that an average work-over takes four days.

All of the equipment was assumed to be manufactured outside of Alaska. Unlike most of the other heavy equipment, the drill rigs are sometimes transported by Hercules aircraft; therefore, part of the freight transportation margins were assigned to the air sector.

Information regarding the equipment used for drilling operations was gathered from contractors engaged in providing these activities, as well as equipment manufactures and suppliers.

7.3.11 Gravel Island Construction

As shown in Appendix Table A-1, the asset requirements to build one gravel island included pile drivers, cranes, welding equipment, and other machinery needed to mine, haul and move sand, gravel and concrete blocks.

Acquisition costs reflect the total delivered cost to the North Slope. To keep the methodology on a consistent basis, in some instances acquisition costs had to be estimated using equipment lease rates. This was accomplished by using the ratio of owner capital charges (depreciation plus interest) per day to daily lease rates for equipment where both data were available.

Most lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year. Note that some of the equipment is listed more than once. In these cases, the equipment is used at different rates (e.g., 30 days vs. 90 days) in more than one task (e.g., gravel mining and installation of concrete module foundations).

Information regarding the equipment used to construct gravel islands were gathered from several construction contractors who provide these services.

7.3.12 Production Module Installation

Shown in Appendix Table A-1 are the asset requirements to completely outfit one island with all of the equipment needed for production. The assets used for these installation and logistic activities include cranes, loaders, welding machines, and trailers and steel mats needed to move the modules across the gravel islands.

Acquisition costs reflect the total delivered cost to the North Slope. To keep the methodology on a consistent basis, in some instances acquisition costs had to be estimated using equipment lease rates. This was accomplished by using the ratio of owner capital charges (depreciation plus interest) per day to daily lease rates for equipment where both data were available. Note that capital costs for barges and other transportation equipment are not included as those charges are included in the transportation margins detailed elsewhere.

Most lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year. . Note that some of the equipment is listed more than once. In these cases, the equipment is used at different rates (e.g., 30 days vs. 90 days) in more than one task (e.g., offloading the modules from barges and installing the modules).

The modules themselves are treated as purchased equipment and cost detail for them is provided separately in Exhibit 7-1. The modules are designed to facilitate transportation and installation and consist of large pieces of machinery housed in metal buildings. In the table, the major pieces of equipment are itemized separately. In addition to this detail, the table provides information on the cost of fabricating the modules, transportation costs from point of origin to the North Slope, wholesale trade margins, and finance charges (In the model, finance charges will be assigned to production operations to ensure they span the life of the equipment). Note that the expenditures have been assigned to IMPLAN sectors and allocated to regions where the impacts are expected to accrue.

Information regarding the production modules and the equipment used to install the modules were gathered from oil company executives and contractors who provide these services.

Exhibit 7-1 Expenditures for Fabrication and Transportation of Production Modules to Equip One Production Island								
Cost Component	Item	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Other US	Foreign	Total
Process Module	Inlet Manifold	303	Pipe, Valves, Pipe Fittings	-	43,200	648,000	172,800	864,000
	Separator	338	General Industrial Machinery, N.E.C.	-	72,000	1,080,000	288,000	1,440,000
	Oil Treatment	331	Special Industrial Machinery, N.E.C.	-	72,000	1,080,000	288,000	1,440,000
	Pumps	332	Pumps and Compressors	-	43,200	648,000	172,800	864,000
	Instruments	403	Mechanical Measuring Devices	-	57,600	864,000	230,400	1,152,000
Compressor Module	Turbines	307	Steam Engines and Turbines	-	383,000	5,745,000	1,532,000	7,660,000
	Dehydrator	338	General Industrial Machinery, N.E.C.	-	72,000	1,080,000	288,000	1,440,000
	NGL Recovery	338	General Industrial Machinery, N.E.C.	-	72,000	1,080,000	288,000	1,440,000
	Manifold	303	Pipe, Valves, Pipe Fittings	-	30,000	450,000	120,000	600,000
	Pumps	332	Pumps and Compressors	-	30,000	450,000	120,000	600,000
Utility Module	Building	287	Prefabricated Metal Buildings	-	480,000	720,000	-	1,200,000
	Water Treatment	331	Special Industrial Machinery, N.E.C.	-	22,800	342,000	91,200	456,000
	Generator	357	Motors and Generators	-	189,000	2,835,000	756,000	3,780,000
Warehouse Module	Building	287	Prefabricated Metal Buildings	-	1,080,000	1,620,000	-	2,700,000
Fuel Tanks	Fuel Tanks	284	Fabricated Plate Work	-	6,500	97,500	26,000	130,000
Water Tank	Water Tank	284	Fabricated Plate Work	-	1,500	22,500	6,000	30,000
Living Quarters	Building	287	Prefabricated Metal Buildings	-	720,000	1,080,000	-	1,800,000
Conex	Building	287	Prefabricated Metal Buildings	-	32,000	48,000	-	80,000
Well Houses	Building	287	Prefabricated Metal Buildings	-	848,000	1,272,000	-	2,120,000
Fabrication	Capital	392	Shipbuilding and Repairing	-	8,008,800	2,669,600	2,669,600	13,348,000
	Labor	392	Shipbuilding and Repairing	-	21,600,000	7,200,000	7,200,000	36,000,000
	Materials	392	Shipbuilding and Repairing	-	1,968,000	656,000	656,000	3,280,000
	Overhead	392	Shipbuilding and Repairing	-	8,208,000	2,736,000	2,736,000	13,680,000
Transportation	Rail	433	Railroads and Related Services	-	33,750	100,000	-	133,750
	Truck	435	Motor Freight Transportation	8,435	25,315	100,000	-	133,750
	Water	436	Water Transportation	-	185,000	25,000	25,000	235,000
	Air	437	Air Transportation	5,625	66,875	25,000	25,000	122,500
Wholesale Trade	Wholesale Trade	447	Wholesale Trade	74,490	715,104	700,206	-	1,489,800
TOTAL				88,550	45,065,644	35,373,806	17,690,800	**98,218,800**

7.3.13 Production Island Operations

The asset requirements to operate a production operation are relatively minor and include a few pieces of construction machinery. The large production modules are treated as installed equipment and considered above under "Equip Production Island". For each asset, Table A-1 in Appendix A provides the capital cost to operate a production facility for one year.

Most lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year. It was assumed that all of the equipment would be 100 percent dedicated to this task.

Information regarding the equipment needed for production operations was gathered from oil company officials.

7.3.14 Pipelines

Shown in Table A1 in Appendix A are the asset requirements to construct a 10-mile buried offshore pipeline, a 10-mile onshore pipeline, and a 10-mile seafloor tie-back pipeline. Although the equipment includes welding and pipeline coating equipment as well as a variety of construction vehicles, it can be seen that the types and quantity of machinery utilized varies depending on the type of pipeline being constructed.

For the most part, lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year.

Information regarding the equipment used to construct the pipelines were gathered from several construction contractors who provide these services.

7.3.15 Land Base Operations

The asset requirements to operate a warehousing facility operation for one year include trucks and machinery used to move supplies and equipment in and out of inventory.

Most lifetimes were assumed to be 12 years, with major overhauls conducted once every three years. Equipment dedication rates were calculated by dividing the number of days the machine is used for a given activity by an estimate of the total number of days the machine is used each year. It was assumed that all of equipment would be 100 percent dedicated to this task.

It should be noted that maintenance and repair of building capital were treated somewhat differently. It was estimated that approximately seven million dollars per year would be spent on such services. This amount was assigned to IMPLAN sector 56 (Maintenance and Repair of Nonresidential Facilities).

Information regarding the equipment needed for warehouse operations was gathered from oil company officials and contractors who provide these services.

7.3.16 Spill Contingency

Appendix Table A-1 shows the assets needed to operate a spill containment operation for one year.

Asset lifetimes ranged from 8 to 10 years and all equipment is assumed to be 100 percent dedicated to spill containment. Given the more stringent spill contingency mandates that were implemented after the *Exxon Valdez* oil spill, it is assumed that all depreciated capital will be replaced with new equipment.

Information regarding the equipment used for spill contingency efforts was gathered from a co-op engaged in providing these activities, as well as equipment manufactures and suppliers.

7.3.17 Mobile Bottom Founded Structure (MBFS) for Production

Occasionally, an MBFS being used for exploration purposes is converted into a permanent production platform. When this happens, the full cost of the structure must be assigned to the project, which is the same way the production modules were treated in Section 7.3.12 above.

The acquisition cost of an MBFS was estimated to be $236 million. This value was assigned to IMPLAN's shipbuilding industry (Sector 392), with 71% allocated to Other Alaska, 19% allocated to Other US, and 10% allocated to Foreign.

7.4 MARGINS

The cost estimates developed above reflect the total delivered price of the asset. This price includes not only the manufacturing price but also trade and transportation margins as well as additional labor for retrofitting. To be used in the I-O model, it was necessary to break out these expenditures from the total delivery price. This was accomplished by developing a margin matrix (See definition of margin rates in Glossary). For each asset, the margin matrix (Table A-2 and Table A-3 in Appendix A) shows the percentage of the delivery price that can be attributed to the following categories:

- Production
  Transportation to Alaska
    - Rail
    - Water
    - Truck
    - Air

  Transportation Within Alaska
    - Rail
    - Water
    - Truck
    - Air
- Wholesale Trade
- Retrofitting

During the contractor interviews conducted for the study, data was gathered on production costs, transportation costs to Alaska, transportation costs within Alaska, wholesale trade, and retrofitting. Secondary data sources were used to develop the modal detail for the transportation cost categories; these include the 1993 Commodity Flow Survey and other sources available from the U.S. Department of Commerce (e.g., the economic censuses, county business patterns, etc.). Data are extremely sparse in this area and in some instances we had to rely upon IMPLAN data or professional judgment.

7.5 REGIONAL PURCHASE COEFFICIENTS (RPC)

After each asset's total delivered price had been split into the above expenditure categories, it was necessary to assign the expenditures to geographic locales. This was accomplished through a regional purchase coefficient (See Glossary for definition) matrix, which allocates the expenditures to four geographic areas: the North Slope Borough, Other Alaska, Other US, and Foreign. The geographic definitions were determined in part by MMS's need for equitable sharing analysis.

By associating the expenditures with the areas in which they take place, this step helps to ensure that both the direct and indirect regional impacts of an investment are accurately gauged. For example, most of the heavy equipment utilized on the North Slope is manufactured in the contiguous 48-states or overseas. Therefore, there won't be any direct manufacturing employment generated on the North Slope as a result of a North Slope firm investing in one of these assets. Those impacts will occur where the product is manufactured. On the other hand, employment in the NSB may be generated as a result of transportation and wholesale activities associated with a heavy equipment purchase. Once these direct impacts have been estimated, they can be used in an I-O model of the NSB to estimate the secondary impacts.

The regional purchase coefficients are based upon information gathered during the contractor interviews, internet searches to identify production locations for brand name equipment and secondary data sources such as the Survey of Manufactures, and professional judgment.

Appendix Table A-4 presents the regional purchase coefficients used for E&D assets used on Alaska's North Slope.

7.6 ASSIGNMENT OF EXPENDITURES TO IMPLAN SECTORS

At this point, capital expenditure estimates by asset and activity unit have been divided into production and margin categories and allocated to geographic regions. Each asset and margin was then assigned to an IMPLAN sector. In Appendix A, Table A-5 shows the concordance between the assets and IMPLAN sectors.

7.7 CAPITAL EXPENDITURES BY IMPLAN SECTOR AND REGION

Capital expenditures were then summed across IMPLAN sectors to produce the matrix shown in Table A-6 in Appendix A. These values are later combined with expenditures on labor, materials and purchased services to produce the final vectors used in the model (See Appendix B).

8. MATERIAL INPUTS

Most major material inputs such as fuel were estimated based on information on cost and quantity gathered in the industry interviews or based on the expert engineering knowledge of project staff. Separate sections of this chapter provide summaries of the quantities, prices and total costs of various groups of material purchases including:

- Equipment Fuel Use
- Camp Material Uses
- Well Drilling Materials
- Gravel Island Materials
- Production Module Installation Materials
- Production Island Operation
- Pipeline Construction Materials
- Materials for Land Base Operations

8.1 OVERVIEW OF MATERIAL PURCHASES

In order to determine what materials and purchased services are utilized in quantities that are significant enough to warrant estimation, data from the latest national-level input-output table of the U.S. economy was tabulated and analyzed. The latest table available is for the year 1992, as developed by the Bureau of Economic Analysis, and published in September 1998. This tabulation was presented earlier in Exhibit 6-1.

As shown in Exhibit 6-1 and discussed in Chapter 6, the various activities that comprise the oil and gas industry are subsumed within four sectors in the national I-O table. The largest of these sectors is mining Sector 8.0001, Crude Petroleum and Natural Gas. The three smaller sectors are all construction industries. These include Sector 11.0601 (Petroleum and Natural Gas Well Drilling), Sector 11.0602 (Petroleum, Natural Gas, and Solid Mineral Exploration), and Sector 12.0215 (Maintenance and Repair of Petroleum and Natural Gas Wells).

Of these four sectors, the mining sector, Crude Petroleum and Natural Gas, is far larger than the others with output of over $100 billion compared to just over $10 billion for Petroleum and Natural Gas Well Drilling and between $1 and $2 billion for the other two sectors.

Exhibit 6-1 provides the dollars of purchases for all input sectors that accounted for at least one half of one percent of industry output for any of the four sectors. In total, there were 53 sectors that met this criterion. Note that as shown at the bottom of Exhibit 6-1, the purchases from these 53 sectors account for 96 to 99 percent of the total purchases of the four oil and gas sectors. The other sectors, which combined accounted for only one to four percent of intermediate purchases, were considered too small to be relevant to the analysis.

Many of the 53 sectors listed in Exhibit 6-1 were not producers of materials. They include purchases of services, trade margins, payments of taxes and capital type purchases. These purchases are discussed in Chapters 6, 7 and 9.

Of the remaining sectors, nine, which happen to be the first nine sectors listed in Exhibit 6-1, were considered to be material inputs. These include the following sectors:

- 27.0100 Industrial inorganic and organic chemicals
- 27.0406 Chemicals and chemical preparations, not elsewhere classified
- 29.0203 Polishes and sanitation goods
- 31.0101 Petroleum refining
- 31.0102 Lubricating oils and greases
- 31.0200 Asphalt paving mixtures and blocks
- 36.0100 Cement, hydraulic
- 36.1100 Concrete products, except block and brick
- 36.1900 Minerals, ground or treated

In summary, material inputs to the oil and gas production process are made up of four main types of commodities. The first, represented by the first three sectors on the list, are chemicals. The second, corresponding to the fourth and fifth sectors on the list are the products of petroleum refining such as gasoline as well as lubricating oils and greases. The third, corresponding to the sixth through eighth sectors on the list, are the various paving and building compounds, asphalt, concrete and cement. The fourth and final group of major material inputs, corresponding to the final sector on the list, is specialty minerals used in well drilling operations.

The type of products for each of these sectors and their associated SIC codes were useful input to the interviewing process. Estimates were solicited on the usage of these various inputs for the particular activity under consideration. These estimates were often based on usage rates for particular pieces of equipment that were then multiplied by the number of units in use, the hours or days of use per piece of equipment and the cost per unit of the input. An example would be the gallons of fuel used per day for a pickup truck. This estimate would then be multiplied by the product of the number of pickup trucks and the number of days they were employed in the task. Total usage would then be multiplied by the cost of fuel. Since the products were already defined by SIC code and input-output sector it was a simple matter to code them to IMPLAN sector. As the estimates were in purchasers prices, rough estimates of shipping costs by mode and wholesale and retail margins (if applicable) had to be made prior to assignment to sectors. Finally, the area of production for each of the inputs was specified, so that the resulting values could be divided among the local community, the KPB, Anchorage, and the 49 States.

8.2 EQUIPMENT FUEL USE

Fuel use by vehicle or equipment type was estimated by multiplying daily, or in the case of helicopters hourly, fuel use estimates by the numbers of each type of vehicle and the number of days required for the task they are engaged in. Estimates of the types and numbers of equipment are provided in the engineering description. Estimates of daily fuel use per piece of equipment are based on a combination of engineering staff expertise and interviews. A listing of the number of pieces of equipment, hours used, daily or hourly fuel use, and total gallons consumed is provided in Exhibit 8-1.

Fuel cost was then derived by multiplying by a price of $1.50 per gallon, which was developed based on the industry interviews. This is the price for diesel fuel and gasoline produced by the Phillips crude oil topping plant located at Prudhoe Bay. One-third of this cost is assumed to be for local truck transportation. The final dollar cost estimates are provided in Exhibit 8-1

In some cases, the information collected in the industry interviews was further adjusted or enhanced by expert staff. Discussions of these adjustments for particular activities are discussed in the following paragraphs.

Seismic Survey

The only major material purchase for seismic surveys is the consumption of fuel for vehicle and arctic camp use. Fuel use estimates were provided in the interviews as a daily range for the entire operation. Although information was provided on the cost of flying in fuel from Fairbanks, it is assumed that all fuel is trucked in from Prudhoe Bay, as this is a far more common practice. The midrange of the daily estimates was used and multiplied by 30 to convert to a monthly estimate.

North Slope Support

Fuel use for equipment in this activity was developed as part of a more specific procedure and is discussed in Section 8.2, below.

General Personnel Transport

Fuel use for this activity was based on the numbers of pieces of equipment and engineering estimates of fuel use per day. Detailed data on these pieces of equipment are provided in the engineering descriptions for this activity and are summarized in Exhibit 8-1.

Ice Road and Ice Island Construction

Fuel use for these activities was based on the numbers of pieces of equipment and engineering estimates of fuel use per day. Detailed data on these pieces of equipment are provided in the engineering descriptions for these activities and are summarized in Exhibit 8-1.

Exhibit 8-1: Estimates of Fuel Consumption by Activity

Equipment Type	Number	Days Used	Daily Fuel Use	Total Fuel Use	Fuel Cost	Transport Cost
1. Geological Survey (One Month)						
All		30	4,050	121,500	$121,500	$60,750
2. General Personnel Transport (One Day)						
Bus	1	1	40	40	$40	$20
Van	3	1	30	90	$90	$45
Total				130	$130	$65
4. Ice Road Construction (Ten Miles)						
Small Grader	1	26	30	780	$780	$390
Snow Blower	1	26	60	1,560	$1,560	$780
Small Rollagons	6	22	30	3,960	$3,960	$1,980
100-bbl Water Truck	2	68	60	8,160	$8,160	$4,080
300-bbl Water Truck	1	34	60	2,040	$2,040	$1,020
Ice Mill	1	16	150	2,400	$2,400	$1,200
Ice Mill Loader/Grader	1	16	150	2,400	$2,400	$1,200
Loader	1	16	150	2,400	$2,400	$1,200
Dump Truck	4	64	60	15,360	$15,360	$7,680
Large Grader	1	156	150	23,400	$23,400	$11,700
Heavy Duty Pick-up	9	72	30	19,440	$19,440	$9,720
Survival Shed Generator	1	25	150	3,750	$3,750	$1,875
Total				85,650	$85,650	$42,825
5. Ice Island Construction (Per Island)						
Small Grader	1	4	30	120	$120	$60
Snow Blower	1	2	60	120	$120	$60
Small Rollagons	6	12	30	2,160	$2,160	$1,080
100-bbl Water Truck	2	80	60	9,600	$9,600	$4,800
300-bbl Water Truck	1	40	60	2,400	$2,400	$1,200
Ice Mill	1	20	150	3,000	$3,000	$1,500
Ice Mill Loader/Grader	1	20	150	3,000	$3,000	$1,500
Loader	1	20	150	3,000	$3,000	$1,500
Dump Truck	4	80	60	19,200	$19,200	$9,600
Large Grader	1	60	150	9,000	$9,000	$4,500
Heavy Duty Pick-up	9	72	30	19,440	$19,440	$9,720
Survival Shed Generator	1	25	150	3,750	$3,750	$1,875
Total				74,790	$74,790	$37,395
6. Move Drill Ship or Bottom Founded Structure (One Day)						
Drill Ship	1	1	8,640	8,640	$8,640	$4,320
Ice Breaker	1	1	12,960	12,960	$12,960	$6,480
Work Boat	3	1	4,320	12,960	$12,960	$6,480
Fuel Barge	1	1	4,320	4,320	$4,320	$2,160
Ocean Going Tug	1	1	8,640	8,640	$8,640	$4,320
Total				47,520	$47,520	$23,760
7. Operate Drill Ship in Calm Waters (One Day)						
Drill Ship	1	1	2,160	2,160	$2,160	$1,080
Fuel Barge	1	1	1,080	1,080	$1,080	$540
Total				3,240	$3,240	$1,620
8. Operate Drill Ship in Rough Waters (One Day)						
Drill Ship	1	1	4,320	4,320	$4,320	$2,160
Ice Breaker	1	1	6,480	6,480	$6,480	$3,240
Work Boat	3	1	2,160	6,480	$6,480	$3,240
Fuel Barge	1	1	2,160	2,160	$2,160	$1,080
Ocean Going Tug	1	1	4,320	4,320	$4,320	$2,160
Total				23,760	$23,760	$11,880
9. Operate Mobile Exploration Platform (One Day)						
Fuel Barge	1	1	1080	1,080	$1,080	$540
Total				1,080	$1,080	$540

Exhibit 8-1: Estimates of Fuel Consumption by Activity (continued)

Equipment Type	Number	Days Used	Daily Fuel Use	Total Fuel Use	Fuel Cost	Transport Cost
10. Helicopter Support (One Day)						
Helicopter	1	4.5 hours	100/hour	450	$450	$225
11. Barge Support (One Day)						
All Equipment		1	96	96	$96	$48
Cat Loader	1/3	1	150	50	$50	$25
Total				146	$146	$73
12. Drill Exploration Well (One Well)						
Drill Rig	1	90	1128	101,520	$101,520	$50,760
Front-end loader	1	90	150	13,500	$13,500	$6,750
Forklift	1	90	150	13,500	$13,500	$6,750
Heavy Duty Pick-up	2	90	30	5,400	$5,400	$2,700
Total				133,920	$133,920	$66,960
13. Drill Production Well (One Well)						
Drill Rig	1	25	1128	28,200	$28,200	$14,100
Front-end loader	1	25	150	3,750	$3,750	$1,875
Forklift	1	25	150	3,750	$3,750	$1,875
Heavy Duty Pick-up	2	25	30	1,500	$1,500	$750
Total				37,200	$37,200	$18,600
14. Well Workover (One Well)						
Drill Rig	1	4	648	2,592	$2,592	$1,296
15. Construct Gravel Production Island (Per Island)						
Gravel Mining						
Large Cats	3	60	200	36,000	$36,000	$18,000
Small Cats	2	60	150	18,000	$18,000	$9,000
Gravel Placing						
Large Cats	3	60	200	36,000	$36,000	$18,000
Small Cats	2	60	150	18,000	$18,000	$9,000
Large Graders	2	60	150	18,000	$18,000	$9,000
Compactors	2	60	150	18,000	$18,000	$9,000
Gravel Hauling						
Trucks	16	60	90	86,400	$86,400	$43,200
				230,400	$230,400	$115,200
16. Protect Gravel Production Island (Per Island)						
Concrete Work						
Cranes	2	90	240	43,200	$43,200	$21,600
Small Cats	2	90	150	27,000	$27,000	$13,500
Back Hoes	2	90	240	43,200	$43,200	$21,600
Cement Trucks	2	45	90	8,100	$8,100	$4,050
Heavy Duty Pick-up	8	120	30	28,800	$28,800	$14,400
Fabric Placement						
Cranes	1	30	240	7,200	$7,200	$3,600
Small Cats	1	30	150	4,500	$4,500	$2,250
Heavy Duty Pick-up	2	30	30	1,800	$1,800	$900
Sheet Piling						
Cranes	1	90	240	21,600	$21,600	$10,800
Hammer	1	90	600	54,000	$54,000	$27,000
Small Cats	1	90	150	13,500	$13,500	$6,750
Drilling Machines	2	90	192	34,560	$34,560	$17,280
Hot Water Truck	1	90	90	8,100	$8,100	$4,050
Heavy Duty Pick-up	2	90	30	5,400	$5,400	$2,700
Generator Sets	2	90	120	21,600	$21,600	$10,800
Mechanics Truck	1	90	30	2,700	$2,700	$1,350
Welding Machines	2	90	120	21,600	$21,600	$10,800
Total				346,860	346,860	173,430

Exhibit 8-1: Estimates of Fuel Consumption by Activity (continued)

Equipment Type	Number	Days Used	Daily Fuel Use	Total Fuel Use	Fuel Cost	Transport Cost
17. Production Module Installation (Per Island)						
Offloading						
Cranes	3	14	240	10,080	$10,080	$5,040
Small Cats	2	14	150	4,200	$4,200	$2,100
Heavy Duty Pick-up	4	14	30	1,680	$1,680	$840
Installation and Hookup						
Cranes	2	120	240	57,600	$57,600	$28,800
Small Cats	2	120	150	36,000	$36,000	$18,000
Small Fork Lift	2	120	30	7,200	$7,200	$3,600
Heavy Duty Pick-up	4	120	30	14,400	$14,400	$7,200
Welding Machines	8	120	120	115,200	$115,200	$57,600
Total				246,360	$246,360	$123,180
18. Production Island Operation (Per Year)						
Heavy Duty Pick-up	4	365/4	30	10,950	$10,950	$5,475
Small Cats	2	365/2	150	54,750	$54,750	$27,375
Van	1	365/4	30	2,738	$2,738	$1,369
Cranes	1	365/2	120	21,900	$21,900	$10,950
Generator Sets	1	365	150	54,750	$54,750	$27,375
Production Equipment	1	365	48,000	17,520,000	$17,520,000	$0
Total				17,665,088	$17,665,088	$72,544
19. Onshore Gas Production Installation (Per Facility)						
Offloading						
Cranes	1	7	240	1,680	$1,680	$840
Small Cats	1	7	150	1,050	$1,050	$525
Heavy Duty Pick-up	2	7	30	420	$420	$210
Installation and Hookup						
Cranes	1	21	240	5,040	$5,040	$2,520
Small Cats	1	21	150	3,150	$3,150	$1,575
Small Fork Lift	1	21	30	630	$630	$315
Heavy Duty Pick-up	2	21	30	1,260	$1,260	$630
Welding Machines	2	21	120	5,040	$5,040	$2,520
Total				18,270	$18,270	$9,135
20. Gas Production Facility Operation (Per Year)						
Heavy Duty Pick-up	1	365/4	30	2,738	$2,738	$1,369
Total				2,738	$2,738	$1,369
21. Offshore Pipeline Construction (10 Miles)						
Ditch Witch	3	75	120	27,000	$27,000	$13,500
Thumb Hoe	1	75	216	16,200	$16,200	$8,100
Small Cats	11	75	150	123,750	$123,750	$61,875
Modified Backhoe Trencher	2	75	240	36,000	$36,000	$18,000
Spoils Truck	2	75	90	13,500	$13,500	$6,750
Generator	1	75	288	21,600	$21,600	$10,800
Heavy Duty Pick-up	7	75	30	15,750	$15,750	$7,875
Total				253,800	$253,800	$126,900
22. Onshore Pipeline Construction (10 Miles)						
Texoma Drill	1	75	168	12,600	$12,600	$6,300
Small Cats	8	75	150	90,000	$90,000	$45,000
Concrete Slurry Truck	1	75	90	6,750	$6,750	$3,375
Generator	1	75	288	21,600	$21,600	$10,800
Heavy Duty Pick-up	6	75	30	13,500	$13,500	$6,750
Total				144,450	$144,450	$72,225

Exhibit 8-1: Estimates of Fuel Consumption by Activity (continued)

Equipment Type	Number	Days Used	Daily Fuel Use	Total Fuel Use	Fuel Cost	Transport Cost
23. Sea Floor Pipeline Construction (10 Miles)						
Lay Pipe						
Tug Boats (for Lay Barges)	4	33	4320	570,240	$570,240	$285,120
Dive Boats	2	33	960	63,360	$63,360	$31,680
Cranes	2	33	240	15,840	$15,840	$7,920
Loader Cats	1	33	150	4,950	$4,950	$2,475
Side Boom Cats	4	33	150	19,800	$19,800	$9,900
Heavy Duty Pick-up	2	33	30	1,980	$1,980	$990
Welding Trucks	2	33	30	1,980	$1,980	$990
Concrete Work						
Cranes	2	84	240	40,320	$40,320	$20,160
Small Cats	2	102	150	30,600	$30,600	$15,300
Back Hoes	2	69	240	33,120	$33,120	$16,560
Cement Trucks	2	87	90	15,660	$15,660	$7,830
Heavy Duty Pick-up	8	59	30	14,160	$14,160	$7,080
				812,010	$812,010	$406,005
24. Land Base Operation						
Small Cats	16	365	150	876,000	$876,000	$438,000
Single-unit Flatbed	12	365	60	262,800	$262,800	$131,400
Combination Flatbed	8	365	90	262,800	$262,800	$131,400
Forklift	22	365	30	240,900	$240,900	$120,450
Heavy Duty Pick-up	40	365	30	438,000	$438,000	$219,000
Total				2,080,500	$2,080,500	$1,040,250
25. Spill Containment (Per Year)						
River Boat	8	34	66	17,952	$17,952	$8,976
Ocean Boat	2	34	90	6,120	$6,120	$3,060
Air Boat	2	34	120	8,160	$8,160	$4,080
Total				32,232	$32,232	$16,116
26. Abandon Island						
Install/Remove Production Modules	1	n.a.	246,360	246,360	$246,360	$123,180
Well Workover/Removal	30	n.a.	2,592	77,760	$77,760	$38,880
Total				324,120	$324,120	$162,060

Drill Ships and Mobile Exploration Platforms

As discussed in the engineering description for this set of activities, fuel consumption for the full group of vessels was estimated at 1.6 million gallons of fuel for 30 days under power. Fuel consumption for the workboats was estimated at 180 gallons per hour based on data collected for the sub-arctic model. Fuel for the other vessels was estimated based on vessel size. The estimates were double the work boat rate for the drill ship, sea-going tug and fuel barge and the triple the rate for the ice breaker. The resulting fuel use roughly equals the original estimate of 1.6 million gallons. These fuel use rates were also assumed to vary based on the activity as the amount of time under power would also vary. Fuel use for rough seas operations were assumed to be half of the use when underway. Calm seas use was assumed to be a quarter. Estimates for each activity were then developed by multiplying fuel use for the vessels used in the activity and the daily fuel use estimate. The results are provided in Exhibit 8-1.

Helicopter Support

The only major material purchase for helicopter support is the consumption of fuel for the helicopter. Fuel use estimates were provided in terms of use per hour and multiplied by hours of operation. According to the interviews, the helicopter consumes 100 gallons per hour. Project engineering staff estimates three trips per day at 1.5 hours round trip or 4.5 hours. Fuel use is, therefore, assumed to be 450 gallons per day.

Barge Support

The only major material purchase for barge support is the consumption of fuel for the onboard motors and the cat. Fuel use estimates were provided in terms of use per hour and multiplied by hours of operation. The two power units use diesel fuel at the rate of 3 gallons per hour each or 6 gallons in total. The barges are assumed to be in motion 12 to 16 hours a day. At 16 hours per day, which would cover some lesser fuel use while not in motion, fuel use would be 96 gallons per day.

Well Drilling

Equipment fuel use in the well drilling sectors includes estimates for the drill rig itself along with miscellaneous equipment including a loader, a forklift and two pickups. The estimated fuel use is based upon the assumed number of days of duration for the task and the fuel use per piece of equipment. The drill rig is assumed to use 1128 gallons of fuel per day. For well workovers, none of the miscellaneous equipment is required.

Gravel Island Construction, Protection and Equipment Installation

Fuel use for these activities was based on the numbers of pieces of equipment and engineering estimates of fuel use per day. Detailed data on these pieces of equipment are provided in the engineering descriptions for these activities and are summarized in Exhibit 8-1.

Production Island Operation

While vehicles used on the island are available 365 days per year the number of days for the island vehicles was adjusted downward by two to four times to account for the small size of the island and the intermittent use of the equipment.

Also shown are expenditures for natural gas to power the generators, compressors and pumps that are part of the modules installed on the island. On average, it is estimated that $48,000 per day of natural gas will be consumed. While the figure is shown in the above table, we have eliminated it from the vectors used in the model. As noted in Chapter 4, the expenditure is based on an oil industry accounting practice. Based upon the results from two other approaches that we used to corroborate the figure, it is assumed that the expenditure includes both labor and capital used for gas extraction/processing. Note that such costs are already included in our estimates of labor and capital for this activity. In addition, the value of the raw material itself is assumed to be negligible since it is primarily a by-product that is readily available from oil production activities.

Pipeline Construction

Fuel use for these activities was based on the numbers of pieces of equipment and engineering estimates of fuel use per day. Detailed data on these pieces of equipment are provided in the engineering descriptions for these activities and are summarized in Exhibit 8-1.

Gas Production Facilities

Fuel use for these facilities were based on scaled down version of the estimates for the production facility installation and operation. They were based on a rule of thumb that the facility would cost roughly one-sixteenth the cost of the full facility.

Land Base

Fuel use for this activity is based on the numbers of pieces of equipment, and engineering estimates of fuel use per day. Detailed data on these pieces of equipment are provided in the engineering descriptions for this activity and are summarized in Exhibit 8-1.

Spill Containment

The only major material purchase for the spill co-op is the consumption of fuel for vehicle and arctic camp use. Fuel use estimates were provided in the interviews as a daily range per hour of boat usage and was converted to yearly estimates based on estimates of the number of trips per week, the operating season for each type of craft and the length of each trip in hours.

Abandon Island

Fuel use estimates for abandoning a production island were based on the assumption that removing the production equipment would entail the same fuel use as installing the equipment and that shutting down each of an assumed 30 wells would require the same time and fuel use as a well workover.

8.3 MATERIAL USES AT EMPLOYEE CAMPS AND QUARTERS

A number of materials are required at the employee hotel/camps and at the employee quarters on the production island. The development of these estimates is described in the following two subsections.

North Slope Support Camps

There are a number of major material purchases for the North Slope support activity. These materials are detailed in the engineering task description for this activity and include food and laundry as well as fuel, chemicals, filters and other inputs to the electric generators and water and sewer systems.

Developing the final estimates for materials required four steps. First, estimates on a per person per day basis were converted to daily basis using an average occupancy of 80 percent or 240 persons. Second, each of the estimates was assigned to an IMPLAN sector. In some cases the estimate had to be further divided prior to coding by IMPLAN sector. Third, the purchases were divided once again to separate the margins from the actual cost of the good. Finally, each estimate was divided yet again by geographic area.

Items that were further divided included estimates for food, housekeeping supplies, generator inputs, and water system chemicals. Food was divided based on PCE food purchases in the NSB. Housekeeping supplies were divided equally among soaps, polishes, surface active agents and toilet preparations. Miscellaneous generator inputs were divided equally between oil (petroleum products), antifreeze (chemicals preparations n.e.c.), and other. As the only information on other inputs is that it includes rags, these costs were assigned to textile goods n.e.c. Two-thirds of water system chemicals were assigned to chorine (alkalies & chlorine) and one-third to iodine (inorganic chemicals n.e.c.). Sewerage chemicals were assigned to biological products which are part of the drug sector in the IMPLAN model. The costs for electricity for water and sewer treatment were dropped as the cost of generation is already covered. The remaining assignments are reasonably self-evident.

Due to the lack of detailed data a few simplifying assumptions were used in separating the cost of the actual good from transportation margins. First, only transportation margins were estimated with no allocation to wholesale trade. Since some of the largest purchases are for North Slope produced petroleum products the inaccuracies caused by this assumption are less important. A second assumption is that all of the transportation margins are assigned to truck transportation. Since, most of the goods would almost certainly move by truck, especially the movements from Southern Alaska and the intra-North Slope petroleum movements; this assumption will also cause minimal distortion. Finally, it is assumed that either one-third or one half of movements were assigned to transportation. The one-third assumption for petroleum products is based on data, provided through the interviews, that fuel on the North Slope is priced at cost $1.50 per gallon with one-third of that cost for transportation. The assumptions for other goods are based on the general expertise of project staff.

Divisions among areas were based on the expertise of project staff. Consumption of North Slope petroleum products was straight forward. Goods that were likely to be at least partially produced in the Other Alaska area were assigned 50 percent to Other Alaska and 50 percent to other U.S. This included food and housekeeping supplies. All other goods were assigned to other U.S.

including chemicals, filters and other generator inputs. The total dollar cost of these items, the amount attributable to margins and the purchase location for each of these items is provided in Exhibit 8-2.

EXHIBIT 8-2: MATERIAL CONSUMPTION ESTIMATES FOR A 300 PERSON HOTEL/CAMP

Description	Days Used	Cost Per Day	Annual Cost	NSB Purchases	Other AK Purchases	Other US Purchases	IMPLAN Sector
Food	365	1920	$700,800		$350,400	$350,400	PCE Dist.
Truck Transport (For Food)	365	960	$350,400	$87,600	$175,200	$87,600	435
Laundry	365	90	$32,850		$32,850		464
Soaps (Supplies)	365	7.5	$2,738		$1,369	$1,369	196
Polishes (Supplies)	365	7.5	$2,738		$1,369	$1,369	197
Surface Actives (Supplies)	365	7.5	$2,738		$1,369	$1,369	198
Toilet Preparations (Supplies)	365	7.5	$2,738		$1,369	$1,369	199
Truck Transport (For Laundry etc.)	365	120	$43,800	$19,163	$21,901	$2,738	435
Diesel Fuel (For Generator)	365	2400	$876,000	$876,000			210
Truck Transport (For Diesel Fuel)	365	1200	$438,000	$438,000			435
Oil (For Generator)	365	300	$109,500	$109,500			210
Truck Transport (For Oil)	365	100	$36,500	$36,500			435
Antifreeze/Cleanup (For Generator)	365	200	$73,000			$73,000	209
Truck Transport (For Antifreeze etc.)	365	200	$73,000	$18,250	$36,500	$18,250	435
Other Inputs (For Generator)	365	200	$73,000			$73,000	123
Truck Transport (For Rags)	365	200	$73,000	$18,250	$36,500	$18,250	435
Truck Transport (For Water System)	365	350	$127,750	$127,750			435
Chlorine (For Water System)	365	50	$18,250			$18,250	186
Iodine (For Water System)	365	25	$9,125			$9,125	189
Truck Transport (For Chemicals)	365	75	$27,375	$6,844	$13,687	$6,844	435
Filters (For Water System)	365	50	$18,250			$18,250	338
Truck Transport (For Filters)	365	50	$18,250	$4,563	$9,125	$4,563	435
Chemicals (For Sewage System)	365	50	$18,250			$18,250	195
Truck Transport (For Chemicals)	365	50	$18,250	$4,563	$9,125	$4,563	435
Total			$3,146,302				

Other Camp Operations

There are three major categories of material purchases for the production island operation activity. These purchases and their associated quantities and costs, which are discussed in detail in the engineering description, include: (1) food and housekeeping supplies; (2) miscellaneous materials and supplies; and (3) fuel.

The costs for food laundry and housekeeping supplies for camp-like quarters in other activities were taken directly from the hotel/camp and adjusted to reflect the smaller number of personnel. The camp has a capacity of 300, but on average is assumed to be 80 percent full and thus serve 240 persons. The production island is estimated to have 62 full time staff members, but it is assumed that additional personnel will require food and lodging on a short-term basis. These include employees conducting well workovers, non-production staff such as engineers and draftsman, and consultants and other experts brought in for specific duties. It is estimated that an additional ten personnel will be staying on the island at any one time raising total average occupancy to 72 persons or 30 percent of that for the hotel/camp. The estimates for the hotel camp were therefore multiplied by 30 percent to derive estimates for the production island. The numbers of employees used for each of the activities using camp operations are provided in Exhibit 8-3.

EXHIBIT 8-3: NUMBER OF EMPLOYEES USED TO ESTIMATE FOOD AND HOUSEKEEPING SUPPLIES

Activity	Number of Employees
1. Geological Survey	100
3. North Slope Support Camp	240
6. Move Drill Ship or Bottom Founded Structure	116
7. Operate Drill Ship in Calm Waters	25
8. Operate Drill Ship in Rough Waters	116
9. Operate Mobile Exploration Platform	24
18. Production Island Operation	72

8.4 WELL DRILLING MATERIALS

There are three major categories of material purchases for the well drilling activities. These purchases, which are discussed in detail above in the engineering description, include: (1) the casing, tubing and wellhead; (2) the drilling fluids, muds, and cements; and (3) the fuel.

Estimates of the costs of each of these components, as collected from industry interviews, were provided in the engineering description. The casing, tubing and wellhead are expected to cost approximately $32,000 per day for a production well or a total of $960,000. Of this total, $50,000 is for the wellhead and the remainder is for casing and tubing. To distribute these costs to production, transportation and wholesale margins, it was necessary to make some assumptions about the average well depth (13,000 feet) as well as the weight and cost of the casing and tubing used. The casing was assumed to weigh 40 pounds per foot and cost $8.00 per foot f.o.b. plant. The tubing was assumed to weigh 10 pounds per foot and to cost $4.75 per foot f.o.b. plant. It was assumed that each well would need 13,000 feet of casing and 52,000 feet of tubing (four strings): i.e., 520,000 pounds of casing and 520,000 pounds of tubing. Transportation costs are based upon an average freight rate of $0.45 per pound. Pipe is sourced from the 48 contiguous states, Canada, and Japan.

The production and margin costs were then assigned to appropriate IMPLAN sectors. Exhibit 8-4 provides these estimates separately for wellhead, casing, and tubing.

Exhibit 8-4
Expenditures by Margins for Casing, Tubing and Well Head

Commodity	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Other US	Foreign	Total
Casing	Total		13,473	148,204	106,940	106,940	375,556
	258	Steel Pipe and Tubes	-	-	52,015	52,015	104,029
	433	Railroads and Related Services	-	38,316	11,384	11,384	61,084
	435	Motor Freight Transportation	8,422	48,034	11,384	11,384	79,224
	436	Water Transportation	1,296	46,832	22,768	22,768	93,664
	447	Wholesale Trade	3,756	15,022	9,389	9,389	37,556
Tubing	Total		15,065	154,621	182,379	182,379	534,444
	258	Steel Pipe and Tubes	-	-	123,457	123,457	246,913
	433	Railroads and Related Services	-	38,333	11,390	11,390	61,114
	435	Motor Freight Transportation	8,424	48,053	11,390	11,390	79,258
	436	Water Transportation	1,296	46,857	22,781	22,781	93,715
	447	Wholesale Trade	5,344	21,378	13,361	13,361	53,444
Well Head	Total		1,422	9,203	29,219	10,156	50,000
	313	Oil Field Machinery	-	-	26,250	8,750	35,000
	433	Railroads and Related Services	-	2,656	586	195	3,438
	435	Motor Freight Transportation	1,016	3,828	586	195	5,625
	436	Water Transportation	156	1,719	1,172	391	3,438
	447	Wholesale Trade	250	1,000	625	625	2,500
TOTAL			**29,960**	**312,028**	**318,537**	**299,475**	**960,000**

Exploration and production wells are assumed to have the identical costs for these items. However, no wellhead, casing or tubing is assumed for well workovers, although there is some evidence that workovers occasionally require a small amount of repair to casing or even more rarely to the tubing.

The drilling fluids, muds and cements are estimated to cost $3,500 per day or $315,000 for a exploration well, and $105,000 for a production well. Each of these estimates was in delivered prices, so wholesale and transportation margins had to be divided out and assigned to the appropriate sectors. These margins were developed in aggregate assuming these were mostly lower value goods such as mud and cement moved in break bulk.

The remaining manufacturing costs were disaggregated among IMPLAN sectors using data on the relative purchases of these items by the well drilling sector as calculated from the 1992 BEA I-O table as shown in Exhibit 8-5.

Exhibit 8-5: Selected Oil and Gas Industry Input Data From the 1992 BEA Input-Output Table

BEA I-O Industry Number	BEA I-O Industry Name	IMPLAN Sector	BEA 11.0601 Construction: Petroleum & Natural Gas Well Drilling ($, Millions)	Exploration Well ($)	Production Well ($)	BEA 12.0215 Construction: Maintenance and Repair of Petroleum & Natural Gas Wells ($, Millions)	Well Workover ($)
27.0100	Industrial inorganic and organic chemicals	189	394	136,180	45,393	25	2,880
27.0406	Chemicals and chemical preparations, n.e.c.	209	62	21,429	7,143	4	461
29.0203	Polishes and sanitation goods	198	0	-	-	27	3,111
31.0102	Lubricating oils and greases	213	81	27,996	9,332	0	-
31.0200	Asphalt paving mixtures and blocks	211	0	-	-	23	2,650
36.0100	Cement, hydraulic	232	88	30,416	10,139	33	3,802
36.1100	Concrete products, except block and brick	243	0	-	-	14	1,613
36.1900	Minerals, ground or treated	250	108	37,329	12,443	3	346
Total			**733**	**253,350**	**84,450**	**129**	**14,862**

For well maintenance, the relative costs of these materials over the life of the well were estimated by comparing the sum of the dollar purchases for these inputs between the well drilling and well maintenance sectors in the 1992 BEA I-O table. This ratio was applied to the estimates for production wells to estimate the costs for these inputs for well maintenance for the life of a well.

This result was then divided by three to approximate the cost of these inputs for a single workover. This factor of three is based on an estimate of a twenty year well lifetime and a workover every five years. Workovers therefore are assumed to occur after the fifth, tenth and fifteen year of a wells operation.

This per workover estimate was then disaggregated among IMPLAN sectors using data on the relative purchases of these inputs by the well maintenance sector as calculated from the 1992 BEA I-O table.

The final step was to estimate margins on the well workover inputs, which was accomplished by assuming the same ratio of margins to manufacturing cost as for production wells.

The resulting estimates for the manufacturing component are provided in Exhibit 8-5. The final estimates for margins are provided in Exhibit 8-6.

Exhibit 8-6: Expenditures by Margins for Drilling Fluids, Mud and Cement

Activity	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Total
Exploration Wells	n.a.	Manufacturing	-	253,350	253,350
	435	Motor Freight Transportation	7,538	22,612	30,150
	447	Wholesale Trade	7,875	23,625	31,500
	Total		15,413	299,587	315,000
Production Wells	n.a.	Manufacturing	-	84,450	84,450
	435	Motor Freight Transportation	2,513	7,537	10,050
	447	Wholesale Trade	2,625	7,875	10,500
	Total		5,138	99,862	105,000
Well Workovers	n.a.	Manufacturing	-	14,862	14,862
	435	Motor Freight Transportation	442	1,326	1,769
	447	Wholesale Trade	462	1,386	1,848
	Total		904	17,575	18,479

8.5 GRAVEL ISLAND MATERIALS

There are four major categories of material purchases that are consumed in the construction of a gravel production island. These purchases, which are discussed in detail above in the engineering description, include: (1) the components of the concrete blocks; (2) the state royalties for gravel; (3) the weld rods; (4) the erosion protection fabric; (5) the sheet piling; and (6) the fuel. Note that there is no cost for the gravel that is mined, however, a $1 per cubic yard royalty is paid to the state. The cost of this royalty is included as a material. While strictly speaking this is not a cost of the material itself, it is considered a material-related cost.

Estimates of the costs of each of these components, as collected from the industry interviews, are provided in the engineering description. The costs for each of the components except for fuel are summarized in Exhibit 8-7**.** Information on the inputs to the cement making process was provided only as a total. This total was divided amongst: (1) the cement and cement additives; (2) the sand and gravel materials used in the concrete; and (3) the cable and shackles used to join the concrete. The proportions were 50 percent to the cement and cement additives and 25 percent to the other two items. These assignments were made based on an examination of the BEA national-level I-O table.

To distribute the costs for each item amongst production, and transportation and wholesale margins, it was necessary to make some assumptions about where these items were purchased and how they were transported to the North Slope and the construction site. The production and margin costs were then assigned to the appropriate IMPLAN sectors. The results are provided in Exhibit 8-8.

EXHIBIT 8-7: MATERIAL ESTIMATES FOR GRAVEL PRODUCTION ISLAND CONSTRUCTION			
Material Type	Number of Units	Cost Per Unit	Total Cost
CONCRETE COMPONENTS			
Cement and cement additives			$750,000
Sand, gravel and aggregates			$375,000
Cable and Shackles			$375,000
Total	7,500 cubic yards	$200 per cubic yard	1,500,000
OTHER MATERIALS			
State Royalties for Mined Gravel Materials for Island	800,000 cubic yards	$1 per cubic yard	$800,000
Erosion Protection Fabric	27,000 square yards	$0.30 per square yard	$81,000
Sheet Piling	3,125,000 pounds	$0.45 per pound	$1,400,000
Welding Rods	8,640 hours	$5 per hour	$43,200
TOTAL			
Total			$3,824,200

8.6 PRODUCTION MODULE INSTALLATION MATERIALS

There are four major categories of material purchases that are consumed in the construction of a gravel production island. These purchases, which are discussed in detail above in the engineering description, include: (1) piping; (2) fittings and valves and other piping related materials; (3) electrical components and systems, materials and supplies; (4) structural shapes, siding and roofing, doors and windows; and (5) the fuel.

The cost of all the materials, except fuel, was estimated by engineering staff to be 90 percent of the $2,600,000 expended for equipment and materials or $2,340,000. The costs for each of the components except for fuel are summarized in Exhibit 8-9.

To distribute the costs for each item amongst production, and transportation and wholesale margins, it was necessary to make some assumptions about where these items were purchased and how they were transported to the North Slope and the construction site. The production and margin costs were then assigned to the appropriate IMPLAN sectors. The results are provided in Exhibit 8-10.

Exhibit 8-8
Expenditures for Materials Used in Gravel Island Construction

Commodity	Sector	Description	North Slope	Other Alaska	Other US	Total
Cement	Total		61,875	688,125	-	**750,000**
	232	Cement, Hydraulic	-	375,000	-	375,000
	435	Motor Freight Transportation	61,875	185,625	-	247,500
	447	Wholesale Trade	-	127,500	-	127,500
Aggregates	Total		375,000	-	-	**375,000**
	041	Sand and Gravel	187,500	-	-	187,500
	435	Motor Freight Transportation	187,500	-	-	187,500
Cables and Shackles	Total		7,184	71,726	296,095	**375,005**
	256	Steel Wire and Related Products	-	10,313	195,938	206,251
	433	Railroads and Related Services	-	11,331	22,419	33,750
	435	Motor Freight Transportation	3,994	11,981	40,275	56,250
	436	Water Transportation	-	7,500	7,500	15,000
	447	Wholesale Trade	3,190	30,601	29,963	63,754
Erosion Protection Fabric	Total		2,617	19,991	58,393	**81,001**
	128	Canvas Products	-	1,053	20,007	21,060
	433	Railroads and Related Services	-	6,059	11,988	18,047
	435	Motor Freight Transportation	1,928	5,783	19,440	27,151
	436	Water Transportation	-	486	486	972
	447	Wholesale Trade	689	6,610	6,472	13,771
Sheet Pilings	Total		42,000	322,000	1,036,000	**1,400,000**
	282	Fabricated Structural Metal	-	-	224,000	224,000
	433	Railroads and Related Services	-	154,000	308,000	462,000
	435	Motor Freight Transportation	42,000	154,000	490,000	686,000
	436	Water Transportation	-	14,000	14,000	28,000
	447	Wholesale Trade	-	-	-	-
Welding Rods	Total		1,296	9,936	31,968	**43,200**
	266	Nonferrous Rolling and Drawing	-	-	6,912	6,912
	433	Railroads and Related Services	-	4,752	9,504	14,256
	435	Motor Freight Transportation	1,296	4,752	15,120	21,168
	436	Water Transportation	-	432	432	864
	447	Wholesale Trade	-	-	-	-

EXHIBIT 8-9: MATERIAL ESTIMATES FOR PRODUCTION MODULE INSTALLATION

Material Type	Percent of Material Costs	Total Cost
Piping	30 percent	$702,000
Fittings and valves and other piping related materials	30 percent	$702,000
Electrical components and systems, materials and supplies	25 percent	$585,000
Structural shapes, siding and roofing, doors and windows	15 percent	$351,000
Total		$2,340,000

Exhibit 8-10
Expenditures for Materials Used During Installation of Modules to Equip One Production Island

Commodity	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Other US	Foreign	Total
Piping and Related Materials	Total		24,570	232,362	936,468	210,600	**1,404,000**
	303	Pipe, Valves, Pipe Fittings	-	49,140	737,100	196,560	982,800
	433	Railroads and Related Services	-	49,140	49,140	-	98,280
	435	Motor Freight Transportation	17,550	52,650	70,200	-	140,400
	436	Water Transportation	-	14,040	14,040	14,040	42,120
	447	Wholesale Trade	7,020	67,392	65,988	-	140,400
Electrical Systems	Total		10,238	96,818	390,195	87,750	**585,000**
	355	Transformers	-	2,048	30,713	8,190	40,950
	356	Switchgear	-	2,048	30,713	8,190	40,950
	359	Relays and Industrial Controls	-	2,048	30,713	8,190	40,950
	360	Electrical Industrial Apparatus, NEC	-	2,048	30,713	8,190	40,950
	368	Wiring Devices	-	10,238	153,563	40,950	204,750
	369	Lighting Fixtures and Equipment	-	2,048	30,713	8,190	40,950
	433	Railroads and Related Services	-	20,475	20,475	-	40,950
	435	Motor Freight Transportation	7,313	21,938	29,250	-	58,500
	436	Water Transportation	-	5,850	5,850	5,850	17,550
	447	Wholesale Trade	2,925	28,080	27,495	-	58,500
Structural Shapes, Siding, Roofing, Doors and Windows	Total		6,143	144,086	197,262	3,510	**351,000**
	282	Fabricated Structural Metal	-	33,415	50,123	-	83,538
	283	Metal Doors, Sash, and Trim	-	32,432	48,649	-	81,081
	285	Sheet Metal Work	-	32,432	48,649	-	81,081
	433	Railroads and Related Services	-	12,285	12,285	-	24,570
	435	Motor Freight Transportation	4,388	13,163	17,550	-	35,100
	436	Water Transportation	-	3,510	3,510	3,510	10,530
	447	Wholesale Trade	1,755	16,848	16,497	-	35,100
GRAND TOTAL			**40,950**	**473,265**	**1,523,925**	**301,860**	**2,340,000**

8.7 PRODUCTION ISLAND OPERATION

As discussed in the engineering description of this task, miscellaneous materials were difficult to estimate. As a result, an average of $10,000 per day is assumed, and distributed among items that could be identified in proportion to rough estimates of their costs. Due to the large number of items, the same percentages were used to distribute all delivered values among production costs, transportation costs and wholesale margins. In total 77 percent of costs are assumed to be for production. Five percent of all goods are assumed to be produced in Alaska and the remainder in the U.S. The production and margin costs were then assigned to the appropriate IMPLAN sectors. Exhibit 8-11 provides the initial and final estimates of costs for the various items, the percentages used to divide delivered costs among production and margins, the final results and the IMPLAN sector assignments.

Exhibit 8-11: Miscellaneous Materials and Supplies for Production Island Operation

Item	IMPLAN Sector	Initial Estimate of Daily Cost	Scaled Estimate of Yearly Cost	Production		Wholesale Trade			Water Transportation to Alaska		Rail Tranportation to AK	Truck Tranportation to AK	Truck Transportation Within Alaska		Total
				AK	US	NSB	AK	US	AK	US	US	US	NSB	AK	
Percentage of Delivered Cost				73.15%	3.85%	0.85%	8.13%	7.99%	1.13%	1.13%	1.13%	1.13%	0.38%	1.13%	100.00%
Glycol	195	500	948	693	36	8	77	76	11	11	11	11	4	11	948
Calcium Hypoclorite	189	50	95	69	4	1	8	8	1	1	1	1	0	1	95
Defoamer	198	50	95	69	4	1	8	8	1	1	1	1	0	1	95
Scale inhibitor	198	100	190	139	7	2	15	15	2	2	2	2	1	2	190
Pipefitings	303	200	379	277	15	3	31	30	4	4	4	4	1	4	379
Valves	303	250	474	347	18	4	39	38	5	5	5	5	2	5	474
Pipe	258	100	190	139	7	2	15	15	2	2	2	2	1	2	190
Oil filters	313	1,500	2,844	2,080	109	24	231	227	32	32	32	32	11	32	2,844
Oil & grease	198	1,500	2,844	2,080	109	24	231	227	32	32	32	32	11	32	2,844
Halon	209	50	95	69	4	1	8	8	1	1	1	1	0	1	95
Tools	276	100	190	139	7	2	15	15	2	2	2	2	1	2	190
Presssure/temperature guages	403	200	379	277	15	3	31	30	4	4	4	4	1	4	379
Rags	123	100	190	139	7	2	15	15	2	2	2	2	1	2	190
light bulbs	367	25	47	35	2	0	4	4	1	1	1	1	0	1	47
Washers & other fittings	289	25	47	35	2	0	4	4	1	1	1	1	0	1	47
Small household appliances	364	25	47	35	2	0	4	4	1	1	1	1	0	1	47
Bearings & bushings	333	500	948	693	36	8	77	76	11	11	11	11	4	11	948
Total		5,275	10,000	7,315	385	85	813	799	113	113	113	113	38	113	10,000

8.8 PIPELINE CONSTRUCTION MATERIALS

There are seven major categories of material purchases for pipeline construction activities. These purchases, which are discussed in detail above in the engineering description, include: (1) the piping; (2) the shipping for the pipe; the coating for the pipe; (3) the insulation for the pipe; (4) the cement to hold the VSMs; (5) the anodes; (6) the vertical support members or VSMs; and (7) the fuel.

Estimates of the costs of each of these components, as collected from industry interviews, were provided in the engineering description on a per mile basis. The costs for all of these items except fuel are summarized in Exhibit 8-12. Note that the costs for cement include expenditures for the cement truck and an operator which were already estimated and included in the manpower and capital estimates. As a result, the estimate for materials was adjusted downward by one-third to reflect only the purchased materials.

To distribute material costs to production, transportation and wholesale margins, it was necessary to make some assumptions about where these items were purchased and how they were transported to the North Slope and the construction site. The production and margin costs were then assigned to the appropriate IMPLAN sectors. Exhibit 8-13 provides these estimates separately for offshore and onshore pipeline construction.

EXHIBIT 8-12: MATERIAL ESTIMATES FOR OFFSHORE AND ONSHORE PIPELINE CONSTRUCTION (PER TEN MILES)			
Material Type	Number of Sets [3]	Cost Per Mile	Total Cost
OFFSHORE PIPELINE CONSTRUCTION			
Pipe	2	170,000	3,400,000
Shipping	2	126,000	2,520,000
Coating	2	30,000	600,000
Anodes	2	68,000	1,360,000
Total Material Cost			7,880,000
ONSHORE PIPELINE CONSTRUCTION			
Pipe	2	170,000	3,400,000
Shipping	2	126,000	2,520,000
Coating	2	30,000	600,000
Insulation	2	35,000	700,000
Cement	1	60,000	600,000
Anodes	2	68,000	1,360,000
Vertical Support Members (VSMs)	1	290,000	2,900,000
Total Material Cost			12,080,000

8.9 MATERIALS FOR LAND BASE OPERATIONS

There are two major categories of material purchases that are consumed in the land base operation. These purchases, which are discussed in detail above in the engineering description, include: (1) fuel and other generator inputs; and (2) fuel for vehicle operation.

Estimates of total cost for operation of a set of two diesel generators were described in detail in the North Slope Support activity, as were the methods used to distribute the costs for each item amongst production, and transportation and wholesale margins, by geographic area. The estimates from that activity are simply multiplied by the number of generator sets for this activity (eight) to develop the required estimates. The results are provided in Exhibit 8-14.

3 One pipe is used for oil and one pipe is used for gas

Exhibit 8-13
Expenditures for Materials Used in 10 miles of Pipeline Construction

Commodity	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Other US	Foreign	Total
Offshore Pipeline Construction							
Pipe	Total		98,900	1,413,500	3,604,100	803,500	**5,920,000**
	258	Steel Pipe and Tubes	-	-	2,116,500	705,500	2,822,000
	433	Railroads and Related Services	-	280,000	490,000	-	770,000
	435	Motor Freight Transportation	70,000	210,000	490,000	-	770,000
	436	Water Transportation	-	490,000	392,000	98,000	980,000
	447	Wholesale Trade	28,900	433,500	115,600	-	578,000
Cathodic Protection	Total		25,000	274,000	846,100	214,900	**1,360,000**
	331	Special Industry Machinery, NEC	-	49,000	735,000	196,000	980,000
	433	Railroads and Related Services	-	-	23,700	6,300	30,000
	435	Motor Freight Transportation	15,000	45,000	23,700	6,300	90,000
	436	Water Transportation	-	30,000	23,700	6,300	60,000
	447	Wholesale Trade	10,000	150,000	40,000	-	200,000
Wrapping	Total		6,350	106,900	388,575	98,175	**600,000**
	220	Miscellaneous Plastic Products	-	24,150	362,250	96,600	483,000
	433	Railroads and Related Services	-	-	1,975	525	2,500
	435	Motor Freight Transportation	1,250	3,750	1,975	525	7,500
	436	Water Transportation	-	2,500	1,975	525	5,000
	447	Wholesale Trade	5,100	76,500	20,400	-	102,000
Onshore Pipeline Construction							
Pipe	Total		98,900	1,413,500	3,604,100	803,500	**5,920,000**
	258	Steel Pipe and Tubes	-	-	2,116,500	705,500	2,822,000
	433	Railroads and Related Services	-	280,000	490,000	-	770,000
	435	Motor Freight Transportation	70,000	210,000	490,000	-	770,000
	436	Water Transportation	-	490,000	392,000	98,000	980,000
	447	Wholesale Trade	28,900	433,500	115,600	-	578,000
VSM	Total		370,000	2,930,000	200,000	-	**3,500,000**
	282	Fabricated Structural Metal	-	2,220,000	-	-	2,220,000
	41	Sand and Gravel	200,000	-	-	-	200,000
	232	Cement, Hydraulic	-	100,000	100,000	-	200,000
	435	Motor Freight Transportation	145,000	235,000	-	-	380,000
	447	Wholesale Trade	25,000	375,000	100,000	-	500,000
Cathodic Protection	Total		25,000	274,000	846,100	214,900	**1,360,000**
	331	Special Industry Machinery, NEC	-	49,000	735,000	196,000	980,000
	433	Railroads and Related Services	-	-	23,700	6,300	30,000
	435	Motor Freight Transportation	15,000	45,000	23,700	6,300	90,000
	436	Water Transportation	-	30,000	23,700	6,300	60,000
	447	Wholesale Trade	10,000	150,000	40,000	-	200,000
Wrapping	Total		6,350	106,900	388,575	98,175	**600,000**
	220	Miscellaneous Plastic Products	-	24,150	362,250	96,600	483,000
	433	Railroads and Related Services	-	-	1,975	525	2,500
	435	Motor Freight Transportation	1,250	3,750	1,975	525	7,500
	436	Water Transportation	-	2,500	1,975	525	5,000
	447	Wholesale Trade	5,100	76,500	20,400	-	102,000
Insulation	Total		7,200	123,800	454,225	114,775	**700,000**
	249	Asbestos Products	-	28,300	424,500	113,200	566,000
	433	Railroads and Related Services	-	-	1,975	525	2,500
	435	Motor Freight Transportation	1,250	3,750	1,975	525	7,500
	436	Water Transportation	-	2,500	1,975	525	5,000
	447	Wholesale Trade	5,950	89,250	23,800	-	119,000

Exhibit 8-14: Material Consumption Estimates For Generators at Land Base Operations

Description	Days Used	Cost Per Day	Number of Generator Sets	Annual Cost	NSB Purchases	Other AK Purchases	Other US Purchases	IMPLAN Sector
Diesel Fuel (Generator)	365	2,400	8	$7,008,000	$7,008,000			210
Truck Transport (Diesel Fuel)	365	1,200	8	$3,504,000	$3,504,000			435
Oil (Generator)	365	300	8	$876,000	$876,000			210
Truck Transport (Oil)	365	100	8	$292,000	$292,000			435
Antifreeze/Cleanup (Generator)	365	200	8	$584,000			$584,000	209
Truck Transport (Antifreeze)	365	200	8	$584,000	$146,000	$292,000	$146,000	435
Other Inputs (Generator)	365	200	8	$584,000			$584,000	123
Truck Transport (Other inputs)	365	200	8	$584,000	$146,000	$292,000	$146,000	435
Total				$14,016,000	$11,972,000	$584,000	$1,460,000	

8.10 DRILL SHIPS AND MOBILE BOTTOM FOUNDED STRUCTURES

For these activities, materials other than fuel were divided into two categories: boat operations and E&D operations. For boat operations, each large vessel involved in the activity was assumed to consume $150 per day of materials. This estimate is based on IMPLAN data for Alaska's water transportation sector: specifically the ratio between materials and fuel purchases. This ratio was multiplied by average fuel consumption per day to estimate expenditures on materials. Note average fuel consumption per day depends upon the number of vessels involved in the activity. Exhibit 8-15 below shows the allocation of intermediate expenditures for vessel operations. For E&D operations, it was assumed that the activities would require the same type of materials needed to operate a production island (excluding well drilling operations which are addressed separately). These expenditures, shown above in Exhibit 8-11, were first scaled to a daily basis.

Exhibit 8-15: Intermediate Purchases for Vessel Operations							
Activity	**Description**	**IMPLAN**	**NSB**	**Other AK**	**Other US**	**Foreign**	**Total**
Daily Purchases Per Vessel	Maintenance and Repair Other Facilities	056	10.00	1.77	0.00	0.00	11.77
	Cordage and Twine	122	0.00	0.00	6.02	2.58	8.59
	Canvas Products	128	0.00	4.00	11.30	2.69	17.99
	Fabricated Rubber Products, N.E.C.	219	0.00	0.39	14.29	4.63	19.31
	Hardware, N.E.C.	278	0.00	0.00	7.81	2.60	10.41
	Miscellaneous Fabricated Wire Products	304	0.00	0.00	11.03	2.42	13.45
	Pumps and Compressors	332	0.00	0.00	5.60	2.40	8.00
	Boat Building and Repairing	393	4.48	13.45	0.00	0.00	17.93
	Wholesale Trade	447	2.95	8.98	7.46	1.50	20.89
	Service Stations	451	8.34	0.00	0.00	0.00	8.34
	Miscellaneous Repair Shops	482	9.99	3.33	0.00	0.00	13.32
	Total		35.76	31.91	63.50	18.83	150.00
Move Drill Ship or Mobile Bottom Founded Structure	Maintenance and Repair Other Facilities	056	40.00	7.07	0.00	0.00	47.07
	Cordage and Twine	122	0.00	0.00	24.07	10.31	34.38
	Canvas Products	128	0.00	16.00	45.19	10.76	71.95
	Fabricated Rubber Products, N.E.C.	219	0.00	1.54	57.16	18.54	77.24
	Hardware, N.E.C.	278	0.00	0.00	31.24	10.41	41.65
	Miscellaneous Fabricated Wire Products	304	0.00	0.00	44.12	9.68	53.80
	Pumps and Compressors	332	0.00	0.00	22.39	9.60	31.99
	Boat Building and Repairing	393	17.92	53.80	0.00	0.00	71.72
	Wholesale Trade	447	11.80	35.92	29.82	6.01	83.55
	Service Stations	451	33.34	0.00	0.00	0.00	33.34
	Miscellaneous Repair Shops	482	39.97	13.32	0.00	0.00	53.30
	Total		143.04	127.66	253.98	75.31	599.99
Operate Drill Ship in Calm Waters	Maintenance and Repair Other Facilities	056	10.00	1.77	0.00	0.00	11.77
	Cordage and Twine	122	0.00	0.00	6.02	2.58	8.59
	Canvas Products	128	0.00	4.00	11.30	2.69	17.99
	Fabricated Rubber Products, N.E.C.	219	0.00	0.39	14.29	4.63	19.31
	Hardware, N.E.C.	278	0.00	0.00	7.81	2.60	10.41
	Miscellaneous Fabricated Wire Products	304	0.00	0.00	11.03	2.42	13.45
	Pumps and Compressors	332	0.00	0.00	5.60	2.40	8.00
	Boat Building and Repairing	393	4.48	13.45	0.00	0.00	17.93
	Wholesale Trade	447	2.95	8.98	7.46	1.50	20.89
	Service Stations	451	8.34	0.00	0.00	0.00	8.34
	Miscellaneous Repair Shops	482	9.99	3.33	0.00	0.00	13.32
	Total		35.76	31.91	63.50	18.83	150.00
Operate Drill Ship in Rough Waters	Maintenance and Repair Other Facilities	056	40.00	7.07	0.00	0.00	47.07
	Cordage and Twine	122	0.00	0.00	24.07	10.31	34.38
	Canvas Products	128	0.00	16.00	45.19	10.76	71.95
	Fabricated Rubber Products, N.E.C.	219	0.00	1.54	57.16	18.54	77.24
	Hardware, N.E.C.	278	0.00	0.00	31.24	10.41	41.65
	Miscellaneous Fabricated Wire Products	304	0.00	0.00	44.12	9.68	53.80
	Pumps and Compressors	332	0.00	0.00	22.39	9.60	31.99
	Boat Building and Repairing	393	17.92	53.80	0.00	0.00	71.72
	Wholesale Trade	447	11.80	35.92	29.82	6.01	83.55
	Service Stations	451	33.34	0.00	0.00	0.00	33.34
	Miscellaneous Repair Shops	482	39.97	13.32	0.00	0.00	53.30
	Total		143.04	127.66	253.98	75.31	599.99
Operate Mobile Bottom Founded Structure	Maintenance and Repair Other Facilities	056	10.00	1.77	0.00	0.00	11.77
	Cordage and Twine	122	0.00	0.00	6.02	2.58	8.59
	Canvas Products	128	0.00	4.00	11.30	2.69	17.99
	Fabricated Rubber Products, N.E.C.	219	0.00	0.39	14.29	4.63	19.31
	Hardware, N.E.C.	278	0.00	0.00	7.81	2.60	10.41
	Miscellaneous Fabricated Wire Products	304	0.00	0.00	11.03	2.42	13.45
	Pumps and Compressors	332	0.00	0.00	5.60	2.40	8.00
	Boat Building and Repairing	393	4.48	13.45	0.00	0.00	17.93
	Wholesale Trade	447	2.95	8.98	7.46	1.50	20.89
	Service Stations	451	8.34	0.00	0.00	0.00	8.34
	Miscellaneous Repair Shops	482	9.99	3.33	0.00	0.00	13.32
	Total		35.76	31.91	63.50	18.83	150.00

8.11 MATERIALS FOR LAYING SEAFLOOR TIE-BACK PIPELINES

There are several categories of non-fuel material purchases need to lay seafloor tie-back pipelines. These purchases include piping, welding rods, anodes, coating for the pipe, concrete structural supports to hold the pipe off the seafloor bottom, and materials used by vessels laying the pipelines. Costs for several these categories area based upon estimates found in exhibits 8-12 and 8-13.

Costs for the concrete structural supports are based on the assumptions that one support will be used every 10 feet and that each support costs $2,400 to fabricate (Three yards per support @ $800 per yard). Total fabrication costs were adjusted downward to eliminate capital and labor expenses, which are captured elsewhere. The resulting material purchases were then distributed to IMPLAN sectors using IO coefficients for the concrete products industry.

Costs for materials for vessel operations are based upon the estimates of daily material purchases per vessel shown in Exhibit 8-15. To convert these estimates into the costs associated with laying ten miles of seafloor tie-back pipelines, it was assumed that the operation would entail 5 vessels that together could place 1800 feet of pipe per day.

Exhibit 8-16 summarizes these material cost expenditures by the different cost categories mentioned above.

Exhibit 8-16
Expenditures for Non-Fuel Materials Used in Laying Seafloor Tie-back Pipelines

Commodity	IMPLAN Sector	Description	North Slope Burrough	Other Alaska	Other US	Foreign	Total
Pipe	Total		98,900	1,413,500	3,604,100	803,500	**5,920,000**
	258	Steel Pipe and Tubes	-	-	2,116,500	705,500	2,822,000
	433	Railroads and Related Services	-	280,000	490,000	-	770,000
	435	Motor Freight Transportation	70,000	210,000	490,000	-	770,000
	436	Water Transportation	-	490,000	392,000	98,000	980,000
	447	Wholesale Trade	28,900	433,500	115,600	-	578,000
Weldind Rods	Total		549	775	2,000	195	**3,519**
	266	Nonferrous Rolling and Drawing	-	-	362	195	558
	433	Railroads and Related Services	-	209	836	-	1,045
	435	Motor Freight Transportation	549	392	627	-	1,568
	436	Water Transportation	-	174	174	-	348
			-	-	-	-	-
Cathodic Protection	Total		25,000	274,000	846,100	214,900	**1,360,000**
	331	Special Industry Machinery, NEC	-	49,000	735,000	196,000	980,000
	433	Railroads and Related Services	-	-	23,700	6,300	30,000
	435	Motor Freight Transportation	15,000	45,000	23,700	6,300	90,000
	436	Water Transportation	-	30,000	23,700	6,300	60,000
	447	Wholesale Trade	10,000	150,000	40,000	-	200,000
Wrapping	Total		6,350	106,900	388,575	98,175	**600,000**
	220	Miscellaneous Plastic Products	-	24,150	362,250	96,600	483,000
	433	Railroads and Related Services	-	-	1,975	525	2,500
	435	Motor Freight Transportation	1,250	3,750	1,975	525	7,500
	436	Water Transportation	-	2,500	1,975	525	5,000
	447	Wholesale Trade	5,100	76,500	20,400	-	102,000
Concrete Structural Supports	Total		2,439,360	1,726,560	-	-	**4,165,920**
	041	Sand and Gravel	823,680	-	-	-	823,680
	232	Cement, Hydraulic	-	1,393,920	-	-	1,393,920
	435	Motor Freight Transportation	1,615,680	332,640	-	-	1,948,320
Vessel Operations	Total		5,244	4,680	9,312	2,761	**21,997**
	056	Maintenance Other Facilities	1,467	259	0	0	1,726
	122	Cordage and Twine	0	0	882	378	1,260
	128	Canvas Products	0	587	1,657	394	2,638
	219	Fabricated Rubber Products, NE(	0	57	2,096	680	2,832
	278	Hardware, NEC	0	0	1,145	382	1,527
	304	Misc. Fabricated Wire Products	0	0	1,617	355	1,972
	332	Pumps and Compressors	0	0	821	352	1,173
	393	Boat Building and Repairing	657	1,972	0	0	2,629
	447	Wholesale Trade	433	1,317	1,093	220	3,063
	451	Service Stations	1,222	0	0	0	1,222
	482	Miscellaneous Repair Shops	1,466	489	0	0	1,954

9. GOVERNMENT, TAPS AND LOCAL GAS ACTIVITY VECTORS

In addition to the E&D activities listed in Exhibit 2-4, IMPAK estimates direct economic impacts associated with government expenditures, transportation of Arctic OCS oil via the Trans-Alaska Pipeline System (TAPS), and development of gas reservoirs for local consumption. Below, we describe the methods used to develop the cost vectors for these three activities; as you will see, these are somewhat different than the overall approach that was used to develop the other vectors in the model. For information on how IMPAK estimates the activity levels used to stimulate the government, TAPS and local gas vectors, see the appropriate sections in 10.3.1.

9.1 GOVERNMENT

Government revenues, as described below in the "Government" section in 10.3.1, are distributed to a number of IMPLAN sectors. To carry out the allocation, separate input-output vectors were developed for local, state and federal governments. Each cell in the vectors represents a percentage of the respective total government expenditures. For the most part, it is assumed that all expenditures will take place in the region in which the government is located. Finance expenditures are the exception; these are all assumed to take place in the continental U.S. regardless of the government entity.

Vectors for state and local government expenditures were developed using data provided by MMS. The MMS data was developed using location-specific State and local budget data from the U.S. Census Bureau's Census of Governments and data from the national input-output accounts published by the U.S. Bureau of Economic Analysis. Table C provides the commodity composition of Federal Government consumption and investment expenditures. To minimize the number of industries added to the model, we recalibrated the commodity expenditure shares using 95 percent of the value of commodity purchases. Expenditures in National Income and Products Accounts (NIPA) industry 82, reflecting government value added, were adjusted for taxes and savings and assigned to PCE. The proportion of the expenditures assigned to PCE was based on data from the Census of Governments and from published budgets of the relevant State and local governments.

9.2 TRANS-ALASKA PIPELINE SYSTEM

TAPS expenditures, described below in the TAPS section 10.3.1, are assigned to IMPLAN sector 438 (Pipelines, Except Natural Gas) and are divided between the North Slope Borough and Other Alaska. The regional allocation is based on the NSBTAPSPercent parameter, which is currently set at 10%. In IMPAK, the cell associated with sector 438 in the TAPS NSB coefficient vector (on the NSBMatrix worksheet) is set equal to the NSBTAPSPercent parameter. All other cells in the vector are set equal to zero. In a similar fashion, the cell associated with sector 438 in the TAPS Other Alaska coefficient vector (on the AKMatrix worksheet) is set equal to the OtherAKTAPSPercent parameter (which is equal to 1 minus the NSBTAPSPercent parameter). Again, all other cells in the vector are set equal to zero. In the future, it will be possible to upgrade the model by developing a specific vector for the TAPS. In the meantime, it should be noted that all TAPS revenues are assumed to be expended on current operations: i.e., new and replacement investment expenditures are not captured in the vector.

9.3 LOCAL GAS

Section 10.4 details how IMPAK estimates the total expenditures needed to develop natural gas reservoirs to supply local Arctic communities. These expenditures are then distributed across a number of already existing activities in the model and their associated vectors. The assignments are first adjusted to take into account differences in scale.

10. MODEL DOCUMENTATION

This chapter provides an overview of the model and describes how to use it to forecast manpower and expenditures needed to carry out oil exploration and development (E&D) operations on Alaska's North Slope.

The main purpose of the model is to forecast the direct manpower and expenditures needed to conduct oil exploration and development (E&D) operations on Alaska's North Slope. These first round estimates are categorized in such a way that the IMPLAN economic impact model can be used to estimate the secondary economic repercussions associated with these E&D activities.

IMPAK is organized around a comprehensive set of activities which characterize oil exploration and development in the Arctic. These activities are shown in Exhibit 10-1. For each activity, the model houses a cost vector of labor and commodity input requirements on a per unit basis. The commodities are defined according to IMPLAN's 1995 commodity/industry sector scheme. Costs are provided in 1999 dollars.

Beginning with the 2001 IMPLAN data (expected to be available near the end of the 2003), IMPLAN's sectors will be based on the new North American Industry Classification System (NAICs), a new sectoring scheme to be used for all Federal economic statistics. After that time, the Arctic IMPAK: First-Step model described in this documentation will remain a valid stand alone model. However, some adjustments may be necessary to use it to provide inputs to the IMPAK: Second-Step model files that MMS has developed to estimate employment, personal income, total value added etc.

The user is required to input some general data that describe a particular E&D scenario being evaluated. To make things easy for the user, most of these data can be obtained from MMS' E&D reports. These reports are prepared by MMS staff and describe any given proposed lease sale.

The model translates these user inputs into IMPAK activity levels and then multiplies the results by the cost vectors described above. The product and primary output of the model is a vector of the estimated expenditures by IMPLAN sector. The model produces separate vectors for each year in the forecast horizon. The model can handle up to 50 years in the forecast horizon.

The model also breaks down and assigns the cost estimates to geographic regions where the associated economic impacts accrue. Four regions are utilized: the North Slope Borough, the NSB native village, the rest of Alaska, and the continental United States. The output is organized according to these geographic definitions and is presented on separate worksheet tabs accordingly.

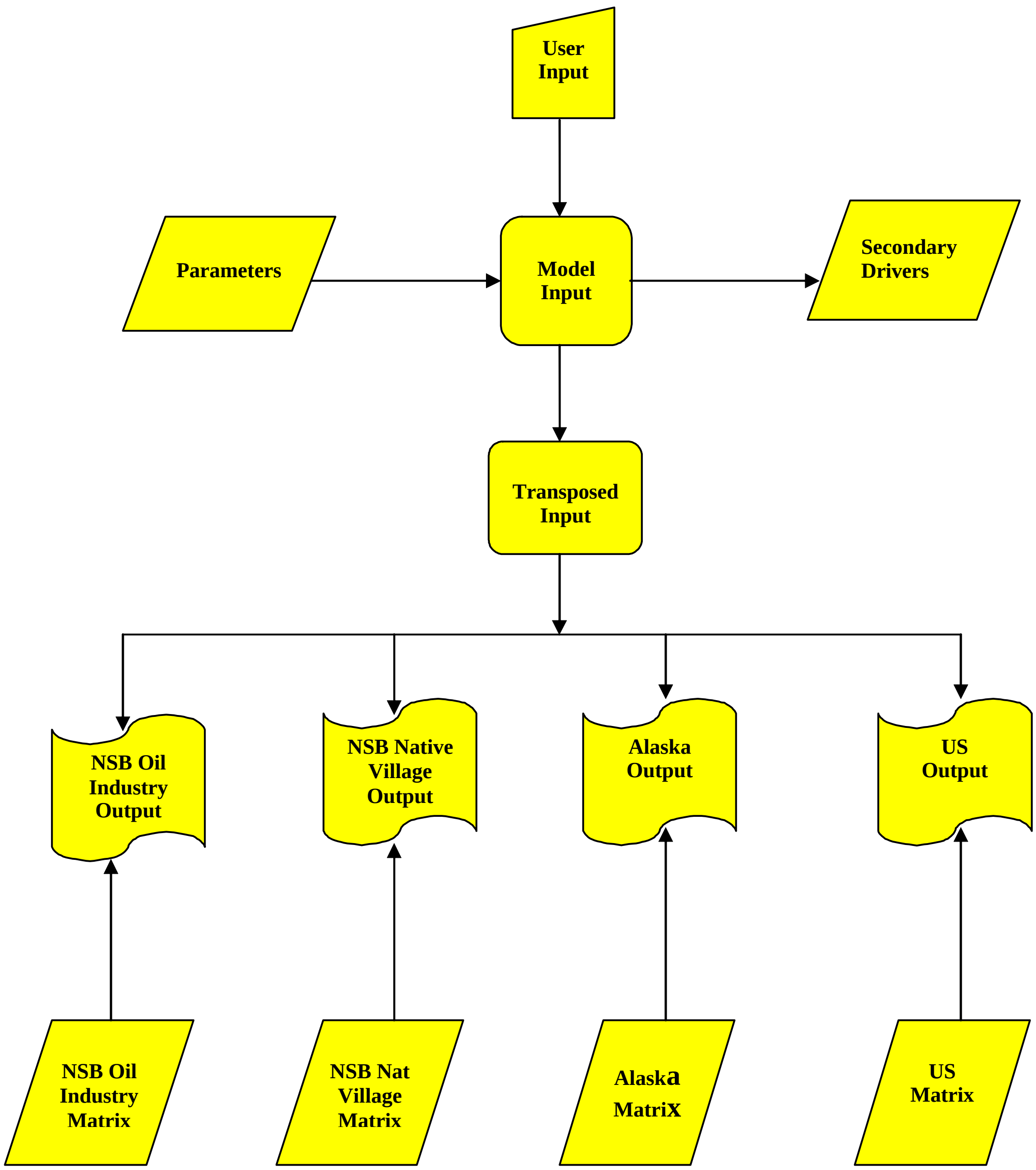
A broad schematic of the model is presented in Exhibit 10-2.

Exhibit 10-1: IMPAK Activities and Respective Units

Activity	***Unit***
Seismic Survey	1 Month
Construct Ice Island	1 Island
Move Platform	1 Day
Calm Water Exploration Drill Ship	1 Day
Rough Water Exploration Drill Ship	1 Day
Drill Exploration Well	1 Well
MBFS for Exploration	1 Day
Place Gravel (Gravel Island)	786,000 cubic yards
Protect Gravel (Gravel Island)	1 Island
Purchase MBFS for Production	Total Cost Per Unit
Equip Production Island	1 Island
Drill l Production Well	1 Well
Operate Production Island	1 Island Per Year
Lay Offshore Pipeline	10 Miles
Lay Onshore Pipeline	10 Miles
Lay Seafloor Tie-back Pipeline	10 Miles
Perform Well Work-over	1 Well
Land-base Operations	1 Year
Spill Contingency Operations	Annual Cost Per Ten Platforms
Abandonment	1 Island
Construct Ice Roads	10 Miles
Helicopter Support	1 Day
Barge Support	1 Trip
General Personnel Transport	1 Day
Camp Support	1 Year

Exhibit 10-2

Broad Schematic of Arctic IMPAK Model



10.1 INSTALLATION

The application consists of an Excel spreadsheet file with supporting documentation activated through hyperlinks to PDF files. In order for the hyperlinks to work properly, the documentation and spreadsheet files should be copied to the same directory. The links will not work with shortcuts. The list of files that should be copied include:

Arctic_IMPAK.xls (MS Excel spreadsheet application)

IMPAK Model Description.pdf (model documentation)

Arctic IMPAK Final Report.pdf (final report)

Arctic IMPAK Journal Article.pdf (journal article)

To maintain the documentation in a different directory, use Excel's Properties option to set the default address for hyperlinks in the file:

1.) On the File menu, click Properties.
2.) Click the Summary tab.
3.) In the Hyperlink base box, type the path you want to use.

When opening the file, the user may be prompted with a caution and a choice about enabling the macros contained in the file. The application will not work properly if the macros are disabled.

Whether or not the user sees the message will depend upon the security level set for macros in the user's version of Excel (see the Security Level tab in the Security dialog box (Tools menu, Macro submenu). Under all settings, if antivirus software that works with Microsoft Office XP is installed and the file contains macros, the file is scanned for known viruses before it is opened. For information on how to change the security settings and/or verify trusted file sources using digital signatures, see Excel's help files on the topic.

10.2 USER INTERFACE

IMPAK is a Microsoft Excel workbook consisting of numerous worksheets or pages. Most of these pages are designated by labeled tabs at the bottom of the screen and which the user can select with the mouse. The main screens are described in more detail below.

10.2.1 Documentation Screen

This screen contains hyperlinks to this help file, the final report, and a journal article about IMPAK presented at the 24th Annual International Association for Energy Economics International Conference and 2002 National IMPLAN User's Conference. These files are in PDF file format so the user must have a version of Adobe's Acrobat Reader in order to view the files.

10.2.2 Model Setup Screen

This screen provides an avenue for altering most of the default settings used in the model.

<u>Calculation</u>

Under this option the user can choose how formulas in the model are updated when the user input data and/or parameters are changed.

- *Automatic* calculation: each time a cell value changes, all other cells linked to it through formulas are immediately updated to reflect the new value. With large spreadsheets, the updating process can be somewhat slow, especially if the user's computer has limited memory and/or a relatively slow processor.
- *Manual* calculation: even though linked cell values change, formulas are not updated until the user presses F9. When the updating process is slow due to limited computer resources, this option allows the user to minimize the amount of time spent waiting for formulas to update.

<u>Initialize Forecast Horizon</u>

Here the user specifies the first year in the forecast horizon. The model automatically replace the default year with whatever is typed in. The user does not have to click on the box or highlight the default year before typing the first year scenario. Subsequent years that are printed on the data entry screen, the output screens, and the manpower graph are determined by this initial year.

<u>Edit Model Parameters</u>

The options under this label allow the user to modify the parameters used to estimate the activity levels for a given scenario. Unlike the variable inputs entered by the user on the Data Entry screen, parameters remain constant throughout the forecasts horizon. Each parameter can be restored to its original values by clicking the appropriate "Restore Default" button.

- *Barge Support*: These parameters are used to estimate the total number of days of barge support required under the given scenario.

Parameter	Description
Number of Barge Trips to Construct 1 Gravel Island	This parameter is multiplied by the number of gravel islands constructed each year to estimate the number of barge-related support trips.
Number of Barge Trips to Equip 1 Production Island	This parameter is multiplied by the number of production islands equipped each year to estimate the number of barge-related support trips.
Number of Barge Trips to Operate 1 Production Island	This parameter is multiplied by the number of operating production islands each year to estimate the number of barge-related support trips.
Number of Barge Trips to Abandon 1 Production Island	This parameter is multiplied by the number of production islands abandoned each year to estimate the number of barge-related support trips.
Number of Barge Trips Per Day of Drill Ship Operations	This parameter is multiplied by the number of days of drill ship/MFBS operations (rough water + calm water + MBFS for exploration) to estimate the number of barge related support trips.
Number of Barge Trips to Lay 10 Miles of Seafloor Pipe.	This parameter is multiplied by the number of 10-mile units of seafloor pipe laid to estimate the number of barge related support trips. The default value (53) was calculated by assuming that each barge trip could carry 100 concrete supports out of a total of 5280 needed per 10 miles of pipeline.
Average Miles Per Day Traveled by Barge	Total barge trips generated in the scenario are converted to total barge mileage based upon the distance from base (a user input) and the circuitry factor (see below). Total mileage is then converted into the number of support days by dividing by average miles per day.
Adjustment in Miles Added to Straight-line Distance	A figure added to the distance from base user input to take into account the fact that most trips are not "as the crow flies".

- *Helicopter Support*: These parameters are used to estimate the total number of days of helicopter support required under the given scenario.

Parameter	Description
Number of Helicopter Trips Per Month of Seismic Survey	This parameter is multiplied by the number of months of seismic survey work each year to estimate the number of helicopter-related support trips.
Number of Helicopter Trips to Construct 1 Gravel Island	This parameter is multiplied by the number of gravel islands constructed each year to estimate the number of helicopter-related support trips.
Number of Helicopter Trips to Equip 1 Production Island	This parameter is multiplied by the number of production islands equipped each year to estimate the number of helicopter-related support trips.
Number of Helicopter Trips to Operate 1 Production Island	This parameter is multiplied by the number of operating production islands each year to estimate the number of helicopter-related support trips.
Number of Helicopter Trips to Abandon 1 Production Island	This parameter is multiplied by the number of production islands abandoned each year to estimate the number of helicopter-related support trips.
Average Number of Helicopter Trips Per Day	The total number of helicopter trips generated in the E&D scenario is divided by this parameter to estimate the number of days of helicopter support required.
Daily Fixed Cost for Helicopter Service	This cost is added to a variable cost calculation to estimate the total cost for 1 day of helicopter support. The variable cost estimate is roughly equal to $28.50 per mile (input by the user in the average distance from shore column).
Total Daily Cost of Helicopter Service in the Base Scenario.	This cost estimated for the base scenario is used in conjunction with the total cost estimate for the current scenario (see above) to create an adjustment factor which is applied to the total days of helicopter support required. The adjustment is necessary to take into account differences in the number of islands served in the base case and the current scenario.
Number of Helicopter Trips Per Day of Drill Ship/MBFS Operations	This parameter is multiplied by the number of days of drill ship/MFBS operations (rough water + calm water + MBFS for exploration) to estimate the number of helicopter-related support trips.
Number of Helicopter Trips to Lay 10 Miles of Seafloor Pipe	This parameter is multiplied by the number of 10-mile units of seafloor pipe laid to estimate the number of helicopter related support trips. The default value (56) was estimated by assuming that the typical operation could lay 1880 feet per day and that two helicopter trips per day would be needed.

- *Ice Roads*: These parameters are used to estimate the miles of ice roads needed to support the level of activities under the given scenario.

Parameter	Description
Adjustment for Doubling Ice Road Depth	This parameter is applied to specific portions of the ice road network that have to be thicker in order to support the movement of heavy equipment. The default factor is based on the assumption that associated cost increases are greater than proportional increases in thickness.
Factor to Estimate Length of Trunk-line for Ice Road Network	This parameter (a percentage) is multiplied by the total length of the ice road network to estimate the length of the ice road trunk line. The length of the trunk line is then subtracted from the total length to estimate the mileage attributed to network spurs.
Ice Road Unit Conversion Factor	The ice road cost vectors were developed on a "10-mile" basis so this factor is used to put the cost vectors and the activity levels on a comparable basis.
Ice Road Width Factor for Offshore Pipeline Construction	Ice roads used to support offshore pipeline construction have to be wider than typical ice roads. This factor makes the appropriate adjustment where needed.
Adjustment for Building Ice Road Onshore	Ice Roads built on shore (e.g., to support the construction of onshore pipelines) do not have to be as deep as typical ice roads built offshore. This factor makes the appropriate adjustments and is based on the assumption that associated cost increases are greater than proportional increases in thickness.

- *Gravel Island Construction*: These parameters are used to estimate the volume (cubic yards) of gravel needed to construct the gravel production islands in the scenario. These islands are assumed to be truncated pyramids with four sides and rectangular-shaped surfaces.

Parameter	Description
Width of Gravel Island – First Side	The width of one side of the rectangular shaped surface
Width of Gravel Island – Second Side	The width of the second side of the rectangular shaped surface
Average Height of Gravel Island Above Water	Total volume is first estimated for a complete pyramid based upon the slope, height of the pyramid and the width of its sides. The top of the pyramid is then truncated and its volume reduced accordingly. The parameter is used in both calculations.
Average Width of Island Divided by Height of Island (Slope)	Total volume is first estimated for a complete pyramid based upon the slope, height of the pyramid and the width of its sides. The top of the pyramid is then truncated and its volume reduced accordingly. The parameter is used in both calculations.
Percentage of Gravel in Place	This parameter is used to reduce the amount of gravel required if the scenario calls for the use of an existing gravel island.

- *Underwater Berm*: These parameters are used to estimate the volume (cubic yards) of gravel needed to construct an underwater gravel berm to support the use of Mobile Bottom Founded Structures (MBFS). Like the gravel islands, these berms are assumed to be truncated pyramids with four sides and rectangular-shaped surfaces.

Parameter	Description
Width of the Top of the Berm – First Side	The width of one side of the rectangular shaped surface
Width of the Top of the Berm – Second Side	The width of the second side of the rectangular shaped surface
Maximum Operating Water Depth of MBFS	This parameter is subtracted from the water depth value input by the user on the Data Entry screen to estimate the height of the berm if one is needed. The height is then used to calculate the volume of gravel needed.
Average Width of Island Divided by Height of Island (Slope)	Total volume is first estimated for a complete pyramid based upon the slope, height of the pyramid and the width of its sides. The top of the pyramid is then truncated and its volume reduced accordingly. The parameter is used in both calculations.

- *Platform*: These parameters are used to estimate the number of days that drill ships and MBFS are used for exploration purposes in the scenario. In addition to the number of days used on site, the screen includes parameters used to estimate the number of days in transit as well as parameters associated with the completion of sub-sea wells.

Parameter	Description
Average Number of Drill Ship Operating Days Per Calm Water Exploration Site	This parameter is multiplied by the Average Number of Drill Ship Exploration Sites Per Year to estimate the average annual working days per drill ship operating in calm waters in the region.
Average Number of Drill Ship Operating Days Per Rough Water Exploration Site	This parameter is multiplied by the Average Number of Drill Ship Exploration Sites Per Year to estimate the average annual working days per drill ship operating in rough waters in the region.
Average Number of Drill Ship Exploration Sites Per Year	This parameter is multiplied by the average number of drill ship operating days per exploration site to estimate the average annual working days per drill ship operating in the region.
Average Number of MBFS Operating Days Per Exploration Site	This parameter is multiplied by the Average Number of MBFS Exploration Sites Per Year to estimate the average annual working days per MBFS operating in the region.
Average Number of MBFS Exploration Sites Per Year	This parameter is multiplied by the average number of MBFS operating days per exploration site to estimate the average annual working days per MBFS operating in the region.
Average Distance (miles) from Winter Port to E&D Region	This parameter is divided by the Drill Ship In-Transit Speed to estimate the number of days required to move the rig from its port to the region.
Average Distance (miles) from Sub-Sea Well to Tie-back Location	This parameter is multiplied by the number of tie-back lines required to support the sub-sea wells developed.
Average Number of Drill Ship Operating Days Per Sub-Sea Well Completion	This parameter is multiplied by the number of sub-sea well completions (entered by the user) to estimate the level of drill ship support needed for the operation.
Average Number of Sub-Sea Wells Per Tie-back Line	This parameter is divided into the number of sub-sea well completions to estimate the number of tie-back pipelines required.
Drill Ship In-Transit Speed (Average Miles Per Day)	This parameter is divided into the Average Distance from Winter Port to E&D Region to estimate the number of days required to move the drill ship from its port to the region.
MFBS In-Transit Speed (Average Miles Per Day)	This parameter is divided into the Average Distance from Winter Port to E&D Region to estimate the number of days required to move the MBFS from its port to the region.
Average Transit Time Between Exploration Sites (Days)	This parameter is used in conjunction with the average number of exploration sites per year to estimate the number of days spent moving rigs between exploration sites.

- *Government Revenue and Taxes*: These parameters are used to estimate government revenues for the local NSB government, the State of Alaska, and the Federal government.

Parameter	Description
Royalty Paid to State for Gravel Mining Operations	This parameter is multiplied by the volume of gravel mined to produce gravel islands and underwater berms; the product is added to state government revenues and used to stimulate the government vectors in the model.
Royalty Paid for Oil Production	This parameter is multiplied by the value of oil production to estimate royalty revenues to the Federal government.
Fee Paid to Lease Land During E&D	This parameter is multiplied by leased acreage to estimate acreage rental payments to the Federal government.
Percent of 8(g) Revenues Returned to Alaska	This parameter is multiplied by total 8(g) revenues to estimate the amounts that contribute to Federal government revenues and state government revenues.
Percent of 8(g) Revenues Allocated to General Fund	This parameter is used to estimate the amount of the state's 8(g) revenues that are allocated to the state's general fund.
Percent of 8(g) Revenues Allocated to Permanent Fund	This parameter is used to estimate the amount of the state's 8(g) revenues that are allocated to the Alaska Permanent Fund.
Percent of AK Tax and 8(g) Revenues Distributed to the NSB	This parameter is used to estimate the amount of state government revenues that are distributed to the local NSB government.
Percent of Permanent Fund Balance Distributed to the Populace	This parameter is used to estimate Permanent Fund dividends that can be attributed to the oil industry activity in the given scenario.
Percent of Permanent Fund Dividend Allocated to the NSB	This parameter is used to distribute Permanent Fund dividends between NSB residents and Other Alaska residents.
Percent of NSB Permanent Fund Dividend Spent in the NSB	This parameter is used to determine where NSB residents spend their Permanent Fund dividends. The amounts are added to PCE estimates in the various regions.
Local Tax Revenues as a Percent of Total Income	This parameter is multiplied by the amount of personal income generated to estimate the amount of local government revenues generated from taxes.
State Tax Revenues as a Percent of Total Income	This parameter is multiplied by the amount of personal income generated to estimate the amount of state government revenues generated from taxes.
Federal Tax Revenues as a Percent of Total Income	This parameter is multiplied by the amount of personal income generated to estimate the amount of federal government revenues generated from taxes.

- *Workforce:* These parameters are used to estimate the number of native workers who are employed in the scenario.

- *Other Parameters*: These miscellaneous parameters are used to produce a variety of estimates used in the model.

Parameter	Description
Number of Platforms Supported by Each Spill Operation	This parameter is used to determine the level of spill containment operations required in the given scenario.
Total Camp Expenditures for 1 Camp Operation	This parameter is used to determine the level of camp support operations required in the given scenario.
Total Daily Expenditures for 1 General Personnel Transport (GPT) Operation	This parameter is used to determine the level of GPT operations required in the given scenario.
Offshore Pipeline Unit Conversion Factor	Expenditure vectors for offshore pipelines were developed on a 10-mile basis. This parameter converts user input on a one mile basis into the appropriate 10-mile units.
Onshore Pipeline Unit Conversion Factor	Expenditure vectors for onshore pipelines were developed on a 10-mile basis. This parameter converts user input on a one mile basis into the appropriate 10-mile units.
Percent of TAPS Revenue Distributed to the NSB	The parameter is multiplied by total TAPS revenues to estimate impacts on the NSB associated with transporting oil from the Arctic OCS to Valdez.
PCE as a Percent of Disposable Income	This parameter is used to determine the amount of Permanent Fund income that is spent on consumption and allocated to PCE.
Personal Savings as a Percent of Total Income	This parameter is multiplied by the amount of personal income generated to estimate personal savings.

Review I-O Coefficients

The options under this label allow the user to view the input-output vectors associated with each IMPAK activity and geographic region. Note that clicking on any one of the links will bring up all of the vectors for all of the regions; the region selected will be shown first but the user will then be able to tab to the vectors associated with the other geographic areas.

10.2.3 Data Entry

The Data Entry screen presents the user with a table organized by year and E&D activity. Shown below in Exhibit 10-3, most of these activities can be obtained from MMS's E&D Scenario/Schedule. Note that these activities are somewhat different than the ones presented above in Exhibit 10-1. Through a number of formulas, the data entered by the user are converted into quantities that correspond to the activities defined in Exhibit 10-1.

To develop an accurate analysis, the user should enter as much information as possible. The temporal profile of the data that is entered should also reflect the actual timeline that MMS expects to see for a given scenario: for example, aggregating the inputs and entering them into a single year may lead to anomalous results since many of the formulas have temporal components.

Once the data has been entered, the user should be able to review the results almost immediately simply by clicking on the appropriate tab. If calculation is set to "manual", you will need to first press F9 so that the formulas are updated; otherwise the results will not correspond to the most recent data inputs. The password to unprotect the sheet is MMS.

Exhibit 10-3: E&D Data Entry Requirements and Respective Units

Variable	***Unit***
Water Depth	(Feet)
Distance from Base	(Miles)
Exploration Wells	(Number)
Delineation Wells	(Number)
Exploration Ice Islands	(Number)
Drill Ships for Calm Water Exploration	(Number)
Drill Ship for Rough Water Exploration	(Number)
Moveable Bottom Founded Structures for Exploration	(Number)
Moveable Bottom Founded Structures for Production	(Number)
Gravel Production Islands	(Number)
Production Wells	(Number)
Sub-Sea Production Well Completions	(Number)
Offshore Pipeline	(Miles)
Onshore Pipeline	(Miles)
Landbase Operations[4]	(Proportion of All Operations at Local Landbase)
Geo-Survey	(Months)
Total Oil Production	(MMBLS)
8(g) Oil Production	(MMBLS)
Price	($ Per Barrel)
TAPS Surcharge	($ Per Barrel)
Total Lease Acreage	(000 Acres)
8(g) Lease Acreage	(000 Acres)
Total Bonus Bid	(Millions $)
8(g) Bonus Bid	(Millions of $)

10.2.4 Output Screens

4 Landbase operations entries should be expressed as decimals no greater than 1.0

Output for a scenario is provided in tabular form on four different screens. The NSBOutput screen presents industry expenditures (by IMPLAN sector) and direct manpower that take place within and are provided by the NSB oil economy.

The NSBLocalOutput screen displays the impacts that E&D activity has on the local economy in the NSB. These impacts include expenditures and employment by the local NSB government, personal consumption expenditures (PCE) that take place within the NSB, and personal income that is generated for NSB residents.

The AKOutput screen presents industry expenditures (by IMPLAN sector), personal consumption expenditures (PCE), and personal income that is generated or takes within Alaska but outside of the NSB.

The USOutput screen presents industry expenditures (by IMPLAN sector), personal consumption expenditures (PCE), and personal income that is generated or takes place in the continental US.

Please note that personal consumption expenditures reflect household purchases of commodities and services in an area and should be used to estimate the induced impacts in a region. The figures are derived from estimates of disposable income (total income minus taxes and savings) and take into account differences between where income is earned and where it is spent.

10.2.5 Manpower Graph

The Manpower Graph screen graphically depicts the amount of manpower (days) needed to conduct the scenario under consideration. The data used to populate the graph are taken from the NSBOutput screen and refer to labor directly involved in oil exploration, development and production activities. Two trends are presented: direct manpower provided by NSB resident natives and total direct manpower. Management and overhead personnel who are not directly involved in the activities are not included in the totals. The figures also do not include local government employment that is stimulated by the E&D activity; these data, however, are provided at the bottom of the NSBLocalOutput screen.

10.3 MODEL PROCESSING ENGINE

10.3.1 Conversion of Data Entry Input into IMPAK Activity Levels

Since the activities listed in the E&D reports are not identical to those used in IMPAK, the model has to convert the E&D data entry input into corresponding IMPAK activity levels. This translation takes place in columns AD - DF on the Data Entry worksheet. The conversion is a function of model equations, model parameters, and Secondary Activity drivers. Details of the process are provided below.

Geo-Survey: Currently, there are no E&D data that can be used to estimate this activity level and the user will have to enter the total number of months of geo-surveys required for all activities in the E&D scenario.

Construct Ice Island: The number of ice islands constructed is assumed to be equal to the number of exploration and delineation rigs entered by the user on the Data Entry screen..

Move Platforms: The level of activity needed to move drill ships and mobile bottom founded structures into the E&D region and transition them between sites is driven by the corresponding number of vessels entered by the user on the Data Entry screen. The calculations utilize a number of parameters that can be changed on the PlatformParameter screen. These include the distance between the E&D region and the vessel's winter port, the average speed of the vessels during transit, and the average number of sites in the region serviced by each vessel (used to determine the number of moves between sites).

Drill Ship Exploration in Calm Water: The level of drill ship activity in calm waters is based on the number of calm water drill ships entered by the user on the Data Entry screen. These values are then multiplied by the average annual number of calm water exploration sites and the average number of working days per site. Both of these parameters can be changed on the PlatformParameters screen. The resulting product reflects the total number of working days spent on site. Days spent in transit are estimated separately below.

Drill Ship Exploration in Rough Water: The level of drill ship activity in rough waters is based on the number of rough water drill ships entered by the user on the Data Entry screen. These values are then multiplied by the average annual number of rough water exploration sites and the average number of working days per site. Both of these parameters can be changed on the PlatformParameters screen. It is also assumed that a drill ship is required to drill sub-sea wells. The number of sub-sea wells entered by the user, therefore, is multiplied by the average number of days required to drill a sub-sea well, a parameter that be altered on the PlatformParameters screen. In both cases, the resulting product reflects the total number of working days spent on site. Days spent in transit are estimated separately below.

Mobile Bottom Founded Structure (MBFS) for Exploration: The level of MBFS exploration activity is based on the number of MBFSs used for exploration and entered by the user on the Data Entry screen. These values are then multiplied by the average annual number of exploration sites and the average number of working days per site. Both of these parameters can be changed on the PlatformParameters screen. The resulting product reflects the total number of working days spent on site. Days spent in transit are estimated separately below.

<u>Drill Exploration Well</u>: The number of exploration wells drilled is equal to the number of exploration and delineation wells entered by the user on the Data Entry screen.

<u>Place Gravel (Island)</u>: Due to significant differences in size and the amount of gravel required, the number of gravel islands is based upon estimates of the volume of gravel needed support the E&D operations. The model derives these estimates from several data fields entered by the user on the Data Entry screen. These include water depth, the number of gravel production islands, and the number of mobile bottom-founded structures. Water depth is used to determine the height of both a gravel island and underwater berms used to support mobile bottom founded structures.

Expenditures for this activity were developed for a prototype island requiring approximately 786,000 cubic yards of gravel. It was assumed that the island was situated in 40 feet of water, had a surface that was 16 feet above water level, and had sloped sides.

Based upon user input, the model calculates the amount of gravel required to build a hypothetical island for a given model run. The volume of the hypothetical island(s) is divided by the volume of the prototype island to produce a scalar which can then be applied to the cost vector.

The volume of the hypothetical island is a function of several variables which can be modified by the user. These include the percentage of gravel already in place if an existing island is used, height of the surface above water level, width and length of the surface, the slope of the island, and water depth. The first four variables can be modified on the parameter screen and are assumed to be the same for all islands constructed in the scenario. Water depth can be specified for each year on the user input screen.

The user should be aware of several issues in specifying water depths. First, although the model does not limit the user-specified water depth, it is unlikely that gravel islands would be built in depths greater than fifty feet. Second, the relevant E&D input is the number of production islands in a given year. If more than 1 production island is constructed in a year, the water depth for that year will reflect the average depth of the islands. Given that gravel volume increases exponentially with water depth, the calculation using the average depth will be lower than the value that would be calculated using specific water depths for each island. The extent of the difference between the two approaches depends upon the variance in the water depths. In cases where the islands are constructed in very different water depths, the average approach may significantly underestimate the volume of gravel needed. Only a minor bias will result when the islands are constructed in similar depths.

<u>Protect Gravel Island</u>: The number of gravel islands protected is equal to the number of production islands plus twenty-five percent of the number of the mobile bottom founded structures, both entered by the user on the Data Entry screen. The number of mobile

bottom-founded structures is reduced because they don't need the same level of protection operations as required by the gravel islands.

Mobile Bottom Founded Structure (MBFS) for Production: The level of MBFS production activity is based on the number of MBFSs used for production and entered by the user on the Data Entry screen. The treatment of this activity is somewhat different than MBFSs used for exploration. Because the latter can be re-used over a long period of time and in different areas, the MBFS used for exploration is capitalized and an annual capital cost based on use is assigned to operations. On the other hand, when an MBFS is permanently installed for production, it becomes totally dedicated to the scenario; in this case, therefore, it is treated as purchased equipment and its total cost is assigned to the project. When the user enters an MBFS for production, the production operations vector and the equip production island vector are also stimulated as the costs of these activities are assumed to be similar to those associated with production from a gravel island.

Equip Production Island: The number of islands equipped with production modules is equal to the number of gravel islands and mobile bottom founded structures installed in the previous year and entered by the user on the Data Entry screen.

Drill Production Well:The number of production wells drilled is equal to the number of production wells entered by the user on the Data Entry screen.

Operate Production Island: The number of operating production islands is equal to zero if oil production is equal to zero as specified by the user on the Data Entry screen; otherwise, it is equal to the total number of islands equipped with production modules since the inception date (See Equip Production Island above).

Lay Offshore Pipeline: The number of 10 mile pipeline sections is based on the number of offshore pipeline miles and the number of sub-sea well completions entered by the user on the Data Entry screen. The two values are summed and then divided by 10 to convert them into the appropriate units. It is assumed that each sub-sea well completion will require 1 mile of trenched offshore pipe.

Lay Onshore Pipeline:The number of 10 mile pipeline sections is equal to onshore pipeline miles, entered by the user on the Data Entry screen, divided by 10.

Sea Floor Tie-Back Pipeline: The amount of sea floor pipeline required to connect sub-sea well completions to existing platforms is driven by the number of sub-sea well completions in the scenario, which the user must enter on the Data Entry screen. This value is divided by the average number of wells per tieback line and then converted to an integer using a ceiling function: in other words, this conversion results in the number of tie-back lines that have to be installed. Finally, the number of lines is multiplied by the average distance of the line, a parameter on the PlatformParameters screen. It is assumed that 1 mile of the total distance between the platform/island is trenched so the average distance is adjusted accordingly.

Perform Well Workover: The number of well workovers is based on the assumption that each production well specified on the Data Entry screen will need maintenance every 6 years.

Landbase Operations: The percent of landbase operations that can be attributed to the project is based on the corresponding value entered by the user on the Data Entry screen. Landbase operations entries should be expressed as decimals no greater than 1.0.

Spill Contingency Operations: The required number of spill contingency response operations is based on the number of platforms in operation, which the model derives from the number of production islands entered by the user on the Data Entry screen. To be consistent with the expenditure vector, this figure is calibrated by dividing it by the average number of platforms supported by a spill containment operation.

Abandonment: The number of islands abandoned is derived from the total number of production islands entered by the user on the Data Entry screen. All islands are assumed to be abandoned at the same time.

Construct Ice Roads: The extent of ice roads is derived from several variables entered by the user on the Data Entry screen; these include the number of ice exploration islands, the number of gravel production islands, and the amount of offshore and onshore pipelines installed.

To estimate the miles of ice road constructed each year, it was necessary to make some assumptions about the configuration of the road network. We started by assuming that the network would consist of 1 main trunk line with spurs leading to the various operations. We also made two assumptions about the network in the latter years of the project when only production activities are occurring: (1) the total length of the network is equal to the total number of offshore pipeline miles, and (2) the trunk line comprises 50% of the total length of the network. By dividing the length of the non-trunk portion of the network by the number of production islands, we were then able to estimate the average length of each spur. We then assumed that the trunk length and average spur length would remain constant throughout the project.

For each year, the number of activities requiring an ice road is multiplied by the average spur length; the result is then added to the length of the trunk line to yield an estimate of the total length of the road network. This length is then adjusted to take into account the fact that portions of the network will consist of ice roads that are 10 feet thick in contrast to the standard ice road which is only 5 feet thick. To make the adjustment, we quadruple the length of the thicker sections since they cost four times more to build than sections of the same length that are standard thickness.

Finally, special ice roads are built to aid in the construction of the pipelines. The roads used for the offshore pipelines are generally three times wider than normal ice roads so we multiply their length by 3. The roads built onshore do not have to be as thick as the standard offshore ice road and are adjusted accordingly.

Helicopter Support: The level of helicopter support required for the scenario is based upon several variables entered by the user on the Data Entry screen. These include the average distance from base, water depth (used to determine the scale of gravel placement operations), the amount of time spent for geo-surveys, the number of production islands, the level of oil production, and the number of drill ships and mobile bottom founded structures.

For each activity requiring helicopter support, we calculate the following product: the number of helicopter trips per activity unit multiplied by the number of activity units. These results are then summed and converted into days of helicopter support. It is assumed that each helicopter operation makes an average of 3 trips per day.

A final adjustment was made to account for the fact that the average distance/time of a trip is one determinant of the price of helicopter service. The helicopter expenditure vector was developed under the assumption that the helicopter would be serving a group of five islands, situated five miles apart from each other and located approximately twenty miles from the shore base. As noted earlier, the helicopters make an average of three trips per day: two sweeps of the islands and a dedicated trip to one of the islands. Under these assumptions, it was estimated that helicopter services provide approximately 4.5 hours of support per day.

This daily amount of time is obviously a function of how far the group of islands is located from the shore base. To develop the function between distance and total daily service time, we divided the helicopter service time into four components: take-off/landing time, loading/unloading time, travel time between the islands during sweeps, and travel time between the shore base and the group of islands. The first three components are held constant; only the travel time to get to the islands is assumed to vary with distance. To estimate that time, we first subtract 1 from the round-trip distance to remove the effect of landing/takeoff time. Regardless of the distance, we assume that all helicopters will travel 0.25 miles at a reduced speed after takeoff and prior to landing. To estimate the travel time, we then divide this distance by the average speed which is assumed to be 100 mph. Finally, the travel time is multiplied by 3 to reflect the three daily trips that are made.

This travel time variable is then multiplied by $950 to put it on a cost basis. We then add this variable cost to fixed cost to compute total daily revenues for helicopter service. Fixed cost include the base contract fee ($3,288), taxes ($410), and the fixed hourly charges ($3,734) such as take-off/landing time, loading/unloading time, and travel time between the islands during sweeps.

This total cost is then divided by the total helicopter charges for the base scenario ($7,973). We then apply the resulting factor to the estimated days of helicopter service, which produces the desired adjustment.

Barge Support: The level of barge support required for the scenario is based upon several variables entered by the user on the Data Entry screen. These include the average distance from base, water depth (used to determine the scale of gravel placement operations), and the number of production islands, the level of oil production.

For each activity requiring barge support, we calculate the following product: the number of barge trips per activity unit multiplied by the number of activity units. The results are then summed to compute the total number of barge trips generated by the activities. This figure is then multiplied by the average round-trip distance of each trip, yielding total number of barge miles traveled. Finally, the number of barge miles is divided by the average barge miles traveled per day to estimate the number of days of barge service required. It is assumed that barges travel an average of 60 miles per day.

General Personnel Transport: Expenditures for personnel transportation were estimated for every activity except camp support are therefore based on all of the data entered by the user on the Data Entry screen. These expenditures, presented on the "SecondaryDrivers" worksheet, are normalized by the total cost of a personnel transportation operation, multiplied by the corresponding activity levels, and then summed. When the sum is multiplied by the personnel transportation input vector, the result will be the same as if the personnel transportation expenditures had been allocated to input sectors based upon each commodity's share of the total cost of the transportation operation.

Camp Support: Expenditures for food and lodging were estimated for every activity except general personnel transportation and are therefore based on all of the data entered by the user on the Data Entry screen. These expenditures, presented on the "SecondaryDrivers" worksheet, are normalized by the total cost of running a camp, multiplied by the corresponding activity levels, and then summed. When the sum is multiplied by the camp support input vector, the result will be the same as if the food and lodging expenditures had been allocated to input sectors based upon each commodity's share of the total cost of a camp operation.

Government

The model uses various government revenue functions to stimulate three government expenditure vectors: the NSB local government, the Alaska State government, and the US

Federal government. In all three cases, government expenditures in the current period are assumed to be equal to revenues generated in the previous year.

The revenue function for a specific jurisdiction can be modeled by trying to imitate each revenue instrument or by using proxies. For many revenue sources, the former approach would be extremely time-consuming to implement, fraught with the potential of compounding errors in estimation, and difficult to adapt for changing fiscal regimes. In addition, the means by which State and local governments obtain revenues will vary over time and, certainly, from jurisdiction to jurisdiction. IMPAK instead uses a combination of the two approaches to estimate revenues resulting from new OCS activities. It directly estimates State (and local shares of) revenues from the Federal Government and from gravel royalties but uses proxies to estimate tax revenues.

State and Local Government

State and local government expenditures are a function of two primary revenue sources: (1) state and local tax revenues and (2) state revenues obtained from 8(g) funds and gravel royalties.

Estimates of tax revenues by jurisdiction are based on ratios of total tax revenues to total personal income developed from data in the *Statistical Abstract of the United States*. To produce the revenue estimates, the ratios are multiplied by the amount of total personal income generated from the E&D activities in an IMPAK scenario. Total Personal Income is used as a proxy for the general level of economic activity, reflecting changes in infrastructure investment, production, property assessments, and government tax revenues. By using the relationship between Total Personal Income and government tax revenues, IMPAK can be adapted to changing fiscal regimes or for use with other local government entities, such as the Northwest Arctic Borough or individual villages. However, given the small size of these jurisdictions, and the difficulty of obtaining good data, the user should be careful to seek independent confirmation of the revenue estimates.

Neither the State of Alaska nor the NSB has a broad-based income tax or a general sales tax, so state and local tax revenues are collected through property taxes, indirect business taxes (IBT), licenses (hunting, motor vehicle, etc.), and selective sales taxes (alcohol, insurance, motor fuel, and utility). In the NSB, property taxes represented about 80 percent of NSB operating revenues in FY99. The average ratio between total state tax revenues and total personal income in Alaska was calculated to be 1.6% between 1995 and 1997. The average ratio between total local tax revenues and total personal income in the state was calculated to be 5.17% over the same period. This average local tax ratio was applied to all Alaska residents. It should be noted that both the state and local tax parameters can be changed on the Government Parameters screen.

OCS oil activities provide income for Alaska residents through worker earnings and increases in the annual Permanent Fund dividends. Estimates of local earnings are obtained by summing, across activities, the product of earnings per unit and number of units. To estimate PF dividends, the model maintains a running PF balance based upon annual disbursements and additions generated by the level of E&D activities specified in the scenario. It should be emphasized that IMPAK's PF account only deals with funds related to the scenario under consideration; its balance and dividends, therefore, do not correspond to the actual values associated with the fund itself. Total dividends to Alaska residents are calculated by multiplying the dividend rate (a parameter) by the balance in the previous year. A parameter is then used to assign a portion of the total dividends to NSB residents; the remainder is assigned to Other Alaska residents.

As noted above, revenues are also derived from 8(g) funds. Under section 8(g) of the OCS Lands Act, as amended, the Federal Government must pay to the State 27 percent of all revenues (bids to obtain leases, annual lease rental payments, and royalties on production) for leases within 3 miles of State waters. In IMPAK, 8(g) revenues are directly estimated based upon projected 8(g) bids, leases and oil production. Estimated royalties are the product of the royalty rate (a parameter,) 8(g) oil production, and price per barrel; production and price are both user inputs. Lease revenues are the product of 8(g) lease acreage (a user input) and the acreage rental rate (a parameter). Bonus bids are input by the user. Twenty-seven percent of the total 8(g) revenue is then allocated to Alaska, where it is divided equally between the State budget and the Alaska Permanent Fund. Through the Government Parameters Worksheet, the user can change the default for any of the relevant rates: the Federal royalty rate, the 8(g) payment rate, the percentage of 8(g) revenues going into the Permanent Fund, etc.

The State of Alaska also receives royalties for any sand or gravel mined for E&D construction activities on the Arctic OCS. These revenues are estimated directly from the projected amounts of sand and gravel needed under a given scenario. The current royalty is $1 per cubic yard. This fee is multiplied by the total cubic yards of gravel required each year to estimate the total revenues obtained.

The NSB receives none of these payments directly. However, a small portion of State funds is distributed to the NSB government as intergovernmental revenues. The proportion of the revenues going to the NSB (through the State) can be changed on the Government Parameters Worksheet.

Federal Government

Federal government expenditures are a function of two primary revenue sources: (1) federal tax revenues generated from earnings, and (2) federal revenues obtained from royalties, lease revenues, and bonus bids. Government expenditures in the current period are assumed to be equal to revenues generated in the previous year.

Tax revenues are estimated by applying a federal tax rate to earnings that can be attributed to E&D activities (including government) in the scenario. Earnings are obtained by summing, across activities, the product of earnings per unit and number of units. These results are provided on the USOutput screen. The federal tax rate, a parameter, was estimated to be 11.7%. This was calculated as the average ratio between 1996 federal individual income tax returns of Alaska residents and personal income in the state in 1996 (The data were obtained from the Statistical Abstract of the United States.). Tax revenues were estimated for all US residents involved in the scenario. These include production workers directly involved in the E&D activities as well as overhead support personnel such as oil company employees serving engineering or administrative functions.

Other Federal revenues were estimated from total royalties, lease rental revenues, and bonus (auction) bids, less the portion of these amounts paid to Alaska under section 8(g) of the OCS Lands Act (see above). Royalties are the product of the royalty rate (a parameter,) total oil production, and price per barrel; production and price are both user inputs. Lease revenues are the product of total lease acreage (a user input) and the acreage rental rate (a parameter). Bonus bids are input by the user.

Trans-Alaska Pipeline System (TAPS)

It is assumed that TAPS expenditures in a given year are equal to TAPS revenues generated in the previous year. These revenues are estimated by multiplying total oil production by a TAPS surcharge which is defined in terms of dollars per barrel. Both variables are input by the user. It is assumed that all oil produced from the Arctic OCS is transported via TAPS to Valdez.

10.3.2 Generation of Model Output

The model inputs are first transposed into a matrix compatible with the regional input-output matrices. An Excel array function (transpose) is used to accomplish the task. The transposed input is then multiplied by each region's input-output matrix to yield the total direct impacts by region and IMPLAN sector. Again, an Excel array function is used to accomplish the matrix multiplication (mmult). Note that each year in the forecast horizon requires a separate formula.

It should be noted that annual Permanent Fund (PF) disbursements arising from E&D activities in the scenario are converted and added to PCE at this time. As noted above, the dividends are estimated for both the NSB and "Other Alaska" residents. The disbursements are adjusted for savings and taxes and then allocated to local spending areas. For example, after the tax and savings adjustment, PF disbursements to NSB residents are then divided between the North Slope Borough and Other Alaska. The adjustment for taxes is based upon the tax rate parameters found on the Government Parameters worksheet. The PCERate parameter is used to adjust for savings and specify the percentage of disposable income assigned to personal consumption expenditures (PCE). The parameter is currently set at 95% with the remaining 5% going to savings. A location parameter (NSBPFExpenditurePercent) is used to divide the PCE into the areas where it is spent. The parameter is currently set at 10%, meaning that NSB residents spend 10% of their PF dividend, after adjustments for taxes and savings, in the NSB; the remainder is assumed to be spent in "Other Alaska". Estimated PF expenditures in "Other Alaska" are based upon the dividends to all Alaska residents. PF expenditures by "Other Alaska" residents are assumed to take place entirely in "Other Alaska". Added to these expenditures are purchases by NSB residents. As implied above, it is assumed that 90% of NSB PF expenditures are made in "Other Alaska".

10.4 LOCAL GAS PROCESSING

The local gas module is designed to estimate the economic impacts associated with developing off-shore gas reservoirs for consumption by local communities lining the Hope Basin. The model is based on a scaled down version of an Arctic oil production scenario and assumes that development takes place through sub-sea wells bored by drill-ships operating in calm water.

The module utilizes the framework of Arctic IMPAK and provides the same type of parameter screens, data entry screen, and output screens. Many of the equations and activities are also the same. Among these are the barge, helicopter and government activities. However, some of the activities in Arctic IMPAK are not relevant to the gas scenario and were eliminated; these include the construction of ice islands and gravel islands, the use of mobile bottom founded structures for exploration or production, the use of drill ships in rough waters, and the Trans-Alaska Pipeline System.

Other activities were borrowed from Arctic IMPAK but were modified in some way to fit the local gas scenario. In some cases, the estimated activity levels were reduced by 50% to reflect lower expenditures required to carry out the corresponding operation in the gas scenario. These activities include the geo-survey, all well drilling activities, and the construction of on-shore pipelines. Expenditures for offshore trenched pipeline, ice road construction, calm water drill ship operations, and placing of seafloor pipeline were also reduced by 50%; however in these cases additional modifications were incorporated. Trenched offshore pipeline was limited to 1 mile, with seafloor pipeline constituting any remaining offshore pipeline. Ice roads are only used to support pipeline construction. Finally, it is assumed that only 1 drill ship is used for exploration and the development of the sub-sea wells.

The assumption of 1 drill-ship also affected the Move Platform activity level; however, the expenditures were not otherwise reduced since the cost of moving a drill ship in to place should be fairly similar.

In Arctic IMPAK, the level of spill contingency operations is based on the number of production islands. In the gas module, the spill contingency activity level is based on the number of wells drilled (exploration and sub-sea production well) and drill-ship operating days. Drill ship operating days is converted into the number of drill-ships required by assuming that they can operate in the Hope Basin 270 days per year. This value is then scaled by the number of platforms that can be supported by the spill contingency operation vector developed for Arctic IMPAK.

In Arctic IMPAK, land base operations for a 25,000 barrel per day island were assumed to account for 2% of the cost of a $1 billion warehouse operation that supports all E&D activities on the North Slope. For the gas module, this value was reduced using the following procedure. First, we used 1999 historical production data for the North Slope to develop a ratio between gas production and oil production of 8.5 billion cubic feet of gas per 1 million barrels of oil production. Multiplying this ratio by 8.25 million barrels (the annual equivalent of 25,000 barrels per day) results in 70.125 billion cubic feet of gas per year. We then divided this value into 1.5 billion cubic feet per year (the gas production volumes assumed for the scenario) to develop a scalar that is then multiplied by the 2% value above.

We utilized the Equip Island vector from Arctic IMPAK as a proxy for the Construct Gas Production Facility vector, assuming that this would mostly entail equipment installation. The vector represents the total costs to install all of the oil production equipment on a gravel island. To take into account differences in the scale of operations, we developed a total construction cost estimate for the gas production facility and then divided that estimate by the total cost of equipping one gravel island. The remaining percentage is used to stimulate the Equip Island vector and scales the expenditures appropriately. The construction cost is based upon an 1999 engineering estimate of the cost of developing a Gas-to-Liquid (GTL) plant on the Alaskan North Slope5. The cost of a GTL facility designed to handle approximately 180 billion cubic feet of natural gas per year was estimated at $1.8 billion. This amounts to $10 million dollars per 1 billion cubic feet of gas processed. This factor is multiplied by the maximum gas production volume entered by the user in the model to produce the construction cost estimate.

Finally, we also used the Operation Production Island vector from Arctic IMPAK as a proxy for the Operation Gas Facility in the local gas module. To take into differences in the scale of operations, we developed a total operating cost estimate for the gas facility and then divided that by the total cost of operating an oil production island in the Arctic. The total operating cost estimate of the gas facility is based on a $2/Mcf gas acquisition price, which is multiplied by gas production levels entered by the user on the Data Entry screen.

5 *Options for Gas-to-Liquids Technology in Alaska*, December 1999 (DOE Study DE-AC07-99ID13727). Prepared by E.P. Robertson for the U.S. Department of Energy, Office of Fossil Energy, Idaho Operations Office, Idaho City, Idaho.

APPENDIX A: CAPITAL TABLES

APPENDIX TABLE A-1

Capital Costs Per Activity Unit† by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit†	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases: Total Delivered Cost (Per Asset)	New Equipment Purchases: Expected Life (Years)	New Equipment Purchases: Cost Per Activity Unit	Used Equipment Purchases/Refurbishments: Total Delivered Cost (Per Asset)	Used Equipment Purchases/Refurbishments: Expected Life (Years)	Used Equipment Purchases/Refurbishments: Cost Per Activity Unit
Seismic Survey	D7 CAT	311	4	75%	60%	363,000	5	32,670	250,000	3	12,500
	Heater	386	4	75%	60%	5,000	5	450	3,000	3	150
	Insulation	251	4	100%	60%	2,250	5	270	–	–	–
	CAT Challenger	311	1	75%	60%	193,000	5	4,343	150,000	3	1,875
	Angle Blade	311	1	100%	60%	20,000	5	600	–	–	–
	Heater	386	1	75%	60%	5,000	5	113	3,000	3	38
	Insulation	251	1	100%	60%	2,250	5	68	–	–	–
	966 CAT Loader	311	1	75%	50%	263,000	5	4,931	185,000	3	1,927
	Heater	386	1	75%	50%	5,000	5	94	3,000	3	31
	Insulation	251	1	100%	50%	2,250	5	56	–	–	–
	Shaker Truck	312	10	100%	100%	444,000	5	222,000	–	–	–
	Heater	386	10	75%	100%	3,500	5	1,313	3,000	3	625
	Insulation	251	10	100%	100%	2,250	5	1,125	–	–	–
	Nodwell	311	9	75%	100%	222,222	5	75,000	150,000	3	28,125
	Seismic Equipment	403	1	100%	100%	6,000,000	5	300,000	–	–	–
	Survey Equipment	400	1	100%	100%	300,000	5	15,000	–	–	–
	60 Foot Sleigh	399	17	60%	100%	25,000	10	6,375	16,000	5	5,440
	Generator	357	4	90%	100%	150,000	5	27,000	100,000	3	3,333
	Incinerator	337	1	90%	100%	125,000	7	4,018	80,000	5	400
	Snow Melter	281	1	90%	100%	125,000	7	4,018	80,000	5	400
	500 Gallon Fuel Tank	284	3	100%	100%	2,000	7	214	–	–	–
	3000 Gallon Fuel Tank	284	9	100%	100%	10,000	7	3,214	–	–	–
	Prefabricated Modules	287	14	100%	100%	60,000	7	30,000	–	–	–
Camp Support	Power Generator	357	2	100%	100%	1,205,189	10	241,038	–	–	–
	Transformers	355	1	100%	100%	482,076	10	48,208	–	–	–
	Switchgear	356	1	100%	100%	482,076	10	48,208	–	–	–
	Relays	359	1	100%	100%	482,076	10	48,208	–	–	–
	Electrical Apparatus, NEC	360	1	100%	100%	482,076	10	48,208	–	–	–
	Wiring Devices	368	1	100%	100%	482,076	10	48,208	–	–	–
	Power Facility Construction	050	1	100%	100%	4,820,755	10	482,076	–	–	–
	Water Treatment Equipment	349	1	100%	100%	229,560	10	22,956	–	–	–
	Water Treatment Construction	050	1	100%	100%	229,560	10	22,956	–	–	–
	Sewage Treatment Equipment	349	1	100%	100%	172,170	10	17,217	–	–	–
	Sewage Treatment Construction	050	1	100%	100%	172,170	10	17,217	–	–	–
	Interest	456	1	100%	100%	6,162,531	10	616,253	–	–	–
Personnel Transport	Van	384	3	34%	100%	50,000	9	16	25,000	3	45
	Bus	384	1	34%	100%	75,000	9	8	37,500	3	23

APPENDIX TABLE A-1

Capital Costs Per Activity Unit† by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit†	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases: Total Delivered Cost (Per Asset)	New Equipment Purchases: Expected Life (Years)	New Equipment Purchases: Cost Per Activity Unit	Used Equipment Purchases/Refurbishments: Total Delivered Cost (Per Asset)	Used Equipment Purchases/Refurbishments: Expected Life (Years)	Used Equipment Purchases/Refurbishments: Cost Per Activity Unit
Ice Road	Small Rollagon	311	6	60%	63%	39,157	12	7,401	7,000	3	3,528
	Heater	386	6	40%	63%	3,267	4	1,235	2,135	3	1,614
	Auger	312	6	63%	63%	45,361	12	9,002	3,302	3	1,539
	Hydraulic Pump	352	6	53%	63%	30,018	12	5,012	6,623	3	3,922
	Insulation	251	6	100%	63%	2,250	6	1,418	–	–	–
	Small Grader	311	1	60%	12%	94,554	12	567	15,759	3	252
	Heater	386	1	40%	12%	3,267	4	39	2,135	3	51
	Tires	215	1	100%	12%	2,566	6	51	–	–	–
	Motor Vehicle Parts	386	1	60%	12%	8,422	6	101	6,120	3	98
	Insulation	251	1	100%	12%	2,250	6	45	–	–	–
	Snowblower	311	1	60%	35%	150,000	12	2,625	25,000	3	1,167
	Small Water Truck	317	2	60%	76%	100,000	12	7,600	16,667	3	3,378
	100 Barrel Water Tank	284	2	60%	76%	49,916	12	3,794	8,333	3	1,689
	Water Pumps	332	2	75%	76%	23,404	6	4,447	12,380	3	1,568
	Insulation	251	2	100%	76%	2,250	6	570	–	–	–
	Large Water Truck	317	1	57%	76%	138,554	12	5,002	26,104	3	2,844
	300 Barrel Water Tank	284	1	60%	76%	110,060	12	4,182	18,313	3	1,856
	Water Pumps	332	1	75%	76%	46,807	6	4,447	24,759	3	1,568
	Insulation	251	1	100%	76%	4,500	6	570	–	–	–
	Ice Mill	311	1	53%	13%	366,054	12	2,102	2,584	3	53
	Engine	308	1	53%	13%				10,201	3	208
	Hydraulics	352	1	53%	13%				14,900	3	303
	Large Grader	311	1	62%	13%	195,181	12	1,311	30,120	3	496
	Heater	386	1	40%	13%	3,267	4	42	2,135	3	56
	Insulation	251	1	100%	13%	2,250	6	49	–	–	–
	Large Grader	311	1	62%	75%	195,181	12	7,563	30,120	3	2,861
	Heater	386	1	40%	75%	3,267	4	245	2,135	3	320
	Insulation	251	1	100%	75%	2,250	6	281	–	–	–
	Large Loader	311	1	60%	8%	175,000	12	656	29,167	3	292
	Heater	386	1	40%	8%	3,267	4	25	2,135	3	32
	Insulation	251	1	100%	8%	2,250	6	28	–	–	–
	Dump Truck	317	4	60%	30%	96,386	12	5,783	16,064	3	2,570
	Heater	386	4	40%	30%	3,267	4	392	2,135	3	512
	Insulation	251	4	100%	30%	2,250	6	450	–	–	–
	Pickup Truck	384	9	58%	25%	25,000	9	3,625	6,125	3	1,929
	Prefabricated Modules	287	1	100%	21%	30,000	7	900	–	–	–
	Generator	357	1	60%	21%	75,000	12	788	12,000	3	336
	60 Foot Sleigh	399	1	60%	21%	25,000	10	315	16,000	5	269

APPENDIX TABLE A-1

Capital Costs Per Activity Unit† by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit†	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases			Used Equipment Purchases/Refurbishments		
						Total Delivered Cost (Per Asset)	Expected Life (Years)	Cost Per Activity Unit	Total Delivered Cost (Per Asset)	Expected Life (Years)	Cost Per Activity Unit
Ice Island	Small Rollagon	311	6	60%	6%	39,157	12	705	7,000	3	336
	Heater	386	6	40%	6%	3,267	4	118	2,135	3	154
	Auger	312	6	63%	6%	45,361	12	857	3,302	3	147
	Hydraulic Pump	352	6	53%	6%	30,018	12	477	6,623	3	374
	Insulation	251	6	100%	6%	2,250	6	135	–	–	–
	Small Grader	311	1	60%	2%	94,554	12	95	15,759	3	42
	Heater	386	1	40%	2%	3,267	4	7	2,135	3	9
	Tires	215	1	100%	2%	2,566	6	9	–	–	–
	Motor Vehicle Parts	386	1	60%	2%	8,422	6	17	6,120	3	16
	Insulation	251	1	100%	2%	2,250	6	8	–	–	–
	Snowblower	311	1	60%	3%	150,000	12	225	25,000	3	100
	Small Water Truck	317	2	60%	89%	100,000	12	8,900	16,667	3	3,956
	100 Barrel Water Tank	284	2	60%	89%	49,916	12	4,443	8,333	3	1,978
	Water Pumps	332	2	75%	89%	23,404	6	5,207	12,380	3	1,836
	Insulation	251	2	100%	89%	2,250	6	668	–	–	–
	Large Water Truck	317	1	57%	89%	138,554	12	5,857	26,104	3	3,330
	300 Barrel Water Tank	284	1	60%	89%	110,060	12	4,898	18,313	3	2,173
	Water Pumps	332	1	75%	89%	46,807	6	5,207	24,759	3	1,836
	Insulation	251	1	100%	89%	4,500	6	668	–	–	–
	Ice Mill	311	1	53%	17%	366,054	12	2,748	2,584	3	69
	Engine	308	1	53%	17%				10,201	3	272
	Hydraulics	352	1	53%	17%				14,900	3	397
	Large Grader	311	1	62%	17%	195,181	12	1,714	30,120	3	649
	Heater	386	1	40%	17%	3,267	4	56	2,135	3	73
	Insulation	251	1	100%	17%	2,250	6	64	–	–	–
	Large Grader	311	1	62%	29%	195,181	12	2,924	30,120	3	1,106
	Heater	386	1	40%	29%	3,267	4	95	2,135	3	124
	Insulation	251	1	100%	29%	2,250	6	109	–	–	–
	Large Loader	311	1	60%	10%	175,000	12	875	29,167	3	389
	Heater	386	1	40%	10%	3,267	4	33	2,135	3	43
	Insulation	251	1	100%	10%	2,250	6	38	–	–	–
	Dump Truck	317	4	60%	38%	96,386	12	7,325	16,064	3	3,256
	Heater	386	4	40%	38%	3,267	4	497	2,135	3	649
	Insulation	251	4	100%	38%	2,250	6	570	–	–	–
	Pickup Truck	384	9	58%	10%	25,000	9	1,450	6,125	3	772
	Prefabricated Modules	287	1	100%	21%	30,000	7	900	–	–	–
	Generator	357	1	60%	21%	75,000	12	788	12,000	3	336
	60 Foot Sleigh	399	1	60%	21%	25,000	10	315	16,000	5	269
Move Platform	Fuel Barge	393	1	0%	100%	–	–	–	20,000,000	10	7,407
	Ice Breaker	392	1	0%	100%	–	–	–	162,000,000	20	30,000
	Workboat	392	3	0%	100%	–	–	–	55,000,000	20	30,556
	Tug	392	1	0%	100%	–	–	–	110,000,000	20	20,370
Drill Ship – Calm Water	Drill Ship	392	1	0%	100%	–	–	–	168,000,000	20	31,111
	Fuel Barge	393	1	0%	100%	–	–	–	20,000,000	10	7,407

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Drill Ship - Rough Water	Drill Ship	392	1	0%	100%	–	–	–	168,000,000	20	31,111
	Fuel Barge	393	1	0%	100%	–	–	–	20,000,000	10	7,407
	Ice Breaker	392	1	0%	100%	–	–	–	162,000,000	20	30,000
	Workboat	392	3	0%	100%	–	–	–	55,000,000	20	30,556
	Tug	392	1	0%	100%	–	–	–	110,000,000	20	20,370
MBFS - Operate	MBFS	392	1	0%	100%	–	–	–	236,000,000	20	65,556
	Fuel Barge	393	1	0%	100%	–	–	–	20,000,000	10	11,111
Helicopter Support	Hellicopter	389	1	20%	100%	5,340,526	15	195	667,566	3	488
	Interest	456	1	20%	100%	4,989,595	15	182	107,891	3	79
Barge Support	Self Propelled Barge	392	1	75%	100%	1,600,000	5	2,000	750,000	3	521
	966 CAT Loader	311	1	75%	35%	263,000	5	115	185,000	3	45
	Heater	386	1	75%	35%	5,000	5	2	3,000	3	1
	Insulation	251	1	100%	35%	2,250	5	1	–	–	–
Exploration Well	Drill Rig	313	1	20%	100%	30,000,000	15	133,333	2,500,000	3	222,222
	Front-end Loader	311	1	75%	50%	175,000	5	4,375	85,000	3	1,181
	Forklift	317	1	75%	50%	100,000	5	2,500	50,000	3	694
	Pickup Truck	384	2	75%	35%	25,000	5	875	12,050	3	234
Production Well	Drill Rig	313	1	20%	100%	30,000,000	15	44,444	2,500,000	3	74,074
	Front-end Loader	311	1	75%	50%	175,000	5	1,458	85,000	3	394
	Forklift	317	1	75%	50%	100,000	5	833	50,000	3	231
	Pickup Truck	384	2	75%	35%	25,000	5	292	12,050	3	78
Well Workover	Drill Rig	313	1	20%	100%	7,000,000	8	5,833	850,000	4	5,667
Gravel Island (Place Gravel)	988 CAT Loader	311	2	60%	40%	535,000	12	21,400	89,167	3	9,511
	Heater	386	2	40%	40%	3,267	4	261	2,135	3	342
	Insulation	251	2	100%	40%	2,250	6	300	–	–	–
	D10 CAT	311	1	60%	40%	735,000	12	14,700	122,500	3	6,533
	Heater	386	1	40%	40%	3,267	4	131	2,135	3	171
	Insulation	251	1	100%	40%	2,250	6	150	–	–	–
	966 CAT Loader	311	2	60%	29%	263,000	12	7,627	43,833	3	3,390
	Heater	386	2	40%	29%	3,267	4	189	2,135	3	248
	Insulation	251	2	100%	29%	2,250	6	218	–	–	–
	D7 CAT	311	2	60%	29%	363,000	12	10,527	60,500	3	4,679
	Heater	386	2	40%	29%	3,267	4	189	2,135	3	248
	Insulation	251	2	100%	29%	2,250	6	218	–	–	–
	Large Grader	311	2	60%	40%	200,000	12	8,000	33,333	3	3,556
	Heater	386	2	40%	40%	3,267	4	261	2,135	3	342
	Insulation	251	2	100%	40%	2,250	6	300	–	–	–
	Compactor	311	2	60%	40%	265,000	12	10,600	44,167	3	4,711
	Heater	386	2	40%	40%	3,267	4	261	2,135	3	342
	Insulation	251	2	100%	40%	2,250	6	300	–	–	–
	Dump Truck	317	16	60%	40%	200,000	12	64,000	33,333	3	28,444
	Heater	386	16	40%	40%	3,267	4	2,091	2,135	3	2,733
	Insulation	251	16	100%	40%	2,250	6	2,400	–	–	–

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Gravel Island (Protect Islandl)	Crane	311	2	60%	50%	550,000	12	27,500	91,667	3	12,222
	Heater	386	2	40%	50%	3,267	4	327	2,135	3	427
	Insulation	251	2	100%	50%	2,250	6	375	–	–	–
	966 CAT Loader	311	3	60%	43%	263,000	12	16,964	43,833	3	7,539
	Heater	386	3	40%	43%	3,267	4	421	2,135	3	551
	Insulation	251	3	100%	43%	2,250	6	484	–	–	–
	Backhoe	311	2	60%	43%	380,000	12	16,340	63,333	3	7,262
	Heater	386	2	40%	43%	3,267	4	281	2,135	3	367
	Insulation	251	2	100%	43%	2,250	6	323	–	–	–
	Concrete Truck	317	2	60%	21%	150,000	12	3,150	25,000	3	1,400
	Heater	386	2	40%	21%	3,267	4	137	2,135	3	179
	Insulation	251	2	100%	21%	2,250	6	158	–	–	–
	Insulated Drum	317	2	100%	21%	10,000	12	350	–	–	–
	Pickup Truck	384	8	58%	33%	25,000	9	4,253	6,125	3	2,264
	Crane	311	1	60%	17%	550,000	12	4,675	91,667	3	2,078
	Heater	386	1	40%	17%	3,267	4	56	2,135	3	73
	Insulation	251	1	100%	17%	2,250	6	64	–	–	–
	966 CAT Loader	311	1	60%	14%	263,000	12	1,841	43,833	3	818
	Heater	386	1	40%	14%	3,267	4	46	2,135	3	60
	Insulation	251	1	100%	14%	2,250	6	53	–	–	–
	Pickup Truck	384	2	58%	10%	25,000	9	322	6,125	3	172
	Crane	311	1	60%	50%	400,000	12	10,000	66,667	3	4,444
	Heater	386	1	40%	50%	3,267	4	163	2,135	3	214
	Insulation	251	1	100%	50%	2,250	6	188	–	–	–
	Hammer	311	1	57%	75%	210,000	9	9,975	52,500	3	5,644
	Drilling Machine	312	2	57%	75%	215,000	9	20,425	53,750	3	11,556
	Pickup Truck	384	2	58%	25%	25,000	9	806	6,125	3	429
	Small Water Truck	317	1	60%	76%	100,000	12	3,800	16,667	3	1,689
	100 Barrel Water Tank	284	1	60%	76%	49,916	12	1,897	8,333	3	844
	Water Pumps	332	1	75%	76%	23,404	6	2,223	12,380	3	784
	Insulation	251	1	100%	76%	2,250	6	285	–	–	–
	Heater	386	1	40%	76%	3,267	4	248	2,135	3	325
	Van	384	1	57%	25%	50,000	9	792	12,500	3	448
	Welding Machine	324	2	100%	43%	10,000	6	1,433	–	–	–
	Generator	357	2	100%	43%	10,000	5	1,720	–	–	–
	Cement Mixing Plant	311	1	60%	35%	2,000,000	12	35,000	333,333	3	15,556
	Pile Driving Template	311	3	100%	35%	15,000	12	1,313	–	–	–

APPENDIX TABLE A-1

Capital Costs Per Activity Unit[†] by Asset and Activity

						New Equipment Purchases			Used Equipment Purchases/Refurbishments		
Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit[†]	Percent of Equipment Purchases that are New	Percent Dedication to Task	Total Delivered Cost (Per Asset)	Expected Life (Years)	Cost Per Activity Unit	Total Delivered Cost (Per Asset)	Expected Life (Years)	Cost Per Activity Unit
Equip Production Island	966 CAT Loader	311	2	60%	7%	263,000	12	1,841	43,833	3	818
	Heater	386	2	40%	7%	3,267	4	46	2,135	3	60
	Insulation	251	2	100%	7%	2,250	6	53	–	–	–
	966 CAT Loader	311	2	60%	43%	263,000	12	11,309	43,833	3	5,026
	Heater	386	2	40%	43%	3,267	4	281	2,135	3	367
	Insulation	251	2	100%	43%	2,250	6	323	–	–	–
	Crane	311	2	60%	8%	550,000	12	4,400	91,667	3	1,956
	Heater	386	2	40%	8%	3,267	4	52	2,135	3	68
	Insulation	251	2	100%	8%	2,250	6	60	–	–	–
	Crane	311	1	60%	23%	5,000,000	12	57,500	833,333	3	25,556
	Heater	386	1	40%	23%	3,267	4	75	2,135	3	98
	Insulation	251	1	100%	23%	2,250	6	86	–	–	–
	Crane	311	2	60%	50%	550,000	12	27,500	91,667	3	12,222
	Heater	386	2	40%	50%	3,267	4	327	2,135	3	427
	Insulation	251	2	100%	50%	2,250	6	375	–	–	–
	Transport Trailer	317	4	60%	23%	135,000	9	33,750	33,750	3	4,140
	Pickup Truck	384	4	58%	4%	25,000	9	258	6,125	3	137
	Pickup Truck	384	4	58%	25%	25,000	9	1,611	6,125	3	858
	Forklift	317	2	75%	50%	40,000	9	3,333	10,000	3	833
	Welding Machine	324	8	100%	43%	10,000	6	5,733	–	–	–
	Rig Mats	282	1	0%	23%	–	–	–	250,000	5	11,500
Production Operations	966 CAT Loader	311	2	60%	100%	263,000	12	26,300	43,833	3	11,689
	Heater	386	2	40%	100%	3,267	4	653	2,135	3	854
	Insulation	251	2	100%	100%	2,250	6	750	–	–	–
	Pickup Truck	384	4	58%	100%	25,000	9	6,444	6,125	3	3,430
	Van	384	1	57%	100%	50,000	9	3,167	12,500	3	1,792
	Crane	311	1	60%	100%	550,000	12	27,500	91,667	3	12,222
	Heater	386	1	40%	100%	3,267	4	327	2,135	3	427
	Insulation	251	1	100%	100%	2,250	6	375	–	–	–

APPENDIX TABLE A-1

Capital Costs Per Activity Unit[†] by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit[†]	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases: Total Delivered Cost (Per Asset)	New Equipment Purchases: Expected Life (Years)	New Equipment Purchases: Cost Per Activity Unit	Used Equipment Purchases/Refurbishments: Total Delivered Cost (Per Asset)	Used Equipment Purchases/Refurbishments: Expected Life (Years)	Used Equipment Purchases/Refurbishments: Cost Per Activity Unit
Offshore Pipeline	Ditch Witch	311	3	60%	35%	200,000	12	10,500	33,333	3	4,667
	Heater	386	3	40%	35%	3,267	4	343	2,135	3	448
	Insulation	251	3	100%	35%	2,250	6	394	–	–	–
	Backhoe	311	2	60%	35%	380,000	12	13,300	63,333	3	5,911
	Heater	386	2	40%	35%	3,267	4	229	2,135	3	299
	Insulation	251	2	100%	35%	2,250	6	263	–	–	–
	Long Reach Attachment	311	1	60%	35%	136,000	12	2,380	22,667	3	1,058
	D7 CAT	311	6	60%	35%	363,000	12	38,115	60,500	3	16,940
	Heater	386	6	40%	35%	3,267	4	686	2,135	3	897
	Insulation	251	6	100%	35%	2,250	6	788	–	–	–
	966 CAT Loader	311	3	60%	35%	263,000	12	13,808	43,833	3	6,137
	Heater	386	3	40%	35%	3,267	4	343	2,135	3	448
	Insulation	251	3	100%	35%	2,250	6	394	–	–	–
	D6 CAT	311	2	60%	35%	300,000	12	10,500	50,000	3	4,667
	Heater	386	2	40%	35%	3,267	4	229	2,135	3	299
	Insulation	251	2	100%	35%	2,250	6	263	–	–	–
	Dump Truck	317	2	60%	35%	150,000	12	5,250	25,000	3	2,333
	Heater	386	2	40%	35%	3,267	4	229	2,135	3	299
	Insulation	251	2	100%	35%	2,250	6	263	–	–	–
	Prefabricated Modules	287	2	100%	63%	30,000	7	5,400	–	–	–
	60 Foot Sleigh	399	1	60%	63%	25,000	10	945	16,000	5	806
	Generator	357	1	60%	50%	90,000	9	3,000	15,000	3	1,000
	3000 Gallon Fuel Tank	284	2	100%	35%	10,000	7	1,000	–	–	–
	Welding Machine	324	4	100%	35%	105,000	6	24,500	–	–	–
	Pipeline Heating Machine	331	2	100%	35%	35,000	6	4,083	–	–	–
	Pipeline Coating Machine	331	2	100%	35%	35,000	6	4,083	–	–	–
	Industrial Lights	369	2	100%	35%	10,000	6	1,167	–	–	–
	Pickup Truck	384	7	58%	10%	25,000	9	1,128	6,125	3	600
	Bridge Section	282	2	0%	35%	–	–	–	30,000	4	5,250

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Capital Costs Per Activity Unit[†] by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit[†]	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases: Total Delivered Cost (Per Asset)	New Equipment Purchases: Expected Life (Years)	New Equipment Purchases: Cost Per Activity Unit	Used Equipment Purchases/Refurbishments: Total Delivered Cost (Per Asset)	Used Equipment Purchases/Refurbishments: Expected Life (Years)	Used Equipment Purchases/Refurbishments: Cost Per Activity Unit
Onshore Pipeline	D7 CAT	311	5	60%	35%	363,000	12	31,763	60,500	3	14,117
	Heater	386	5	40%	35%	3,267	4	572	2,135	3	747
	Insulation	251	5	100%	35%	2,250	6	656	–	–	–
	966 CAT Loader	311	2	60%	35%	263,000	12	9,205	43,833	3	4,091
	Heater	386	2	40%	35%	3,267	4	229	2,135	3	299
	Insulation	251	2	100%	35%	2,250	6	263	–	–	–
	D6 CAT	311	1	60%	35%	300,000	12	5,250	50,000	3	2,333
	Heater	386	1	40%	35%	3,267	4	114	2,135	3	149
	Insulation	251	1	100%	35%	2,250	6	131	–	–	–
	Concrete Truck	317	1	60%	35%	150,000	12	2,625	25,000	3	1,167
	Heater	386	1	40%	35%	3,267	4	114	2,135	3	149
	Insulation	251	1	100%	35%	2,250	6	131	–	–	–
	Insulated Drum	317	1	100%	35%	10,000	12	292	–	–	–
	Texoma Drill	312	1	60%	35%	425,000	12	7,438	70,833	3	3,306
	Prefabricated Modules	287	2	100%	63%	30,000	7	5,400	–	–	–
	60 Foot Sleigh	399	1	60%	63%	25,000	10	945	16,000	5	806
	Generator	357	1	60%	50%	90,000	9	3,000	15,000	3	1,000
	3000 Gallon Fuel Tank	284	2	100%	35%	10,000	7	1,000	–	–	–
	Welding Machine	324	2	100%	35%	105,000	6	12,250	–	–	–
	Pipeline Heating Machine	331	1	100%	35%	35,000	6	2,042	–	–	–
	Pipeline Coating Machine	331	1	100%	35%	35,000	6	2,042	–	–	–
	Industrial Lights	369	1	100%	35%	10,000	6	583	–	–	–
	Pickup Truck	384	6	58%	10%	25,000	9	967	6,125	3	515
Sea Floor Pipe	Crane	311	2	60%	28%	550,000	12	15,400	91,667	3	6,844
	Heater	386	2	40%	28%	3,267	4	183	2,135	3	239
	Insulation	251	2	100%	28%	2,250	6	210	–	–	–
	966 CAT Loader	311	3	60%	23%	263,000	12	9,074	43,833	3	4,033
	Heater	386	3	40%	23%	3,267	4	225	2,135	3	295
	Insulation	251	3	100%	23%	2,250	6	259	–	–	–
	Backhoe	311	2	60%	23%	380,000	12	8,740	63,333	3	3,884
	Heater	386	2	40%	23%	3,267	4	150	2,135	3	196
	Insulation	251	2	100%	23%	2,250	6	173	–	–	–
	Concrete Truck	317	2	60%	9%	150,000	12	1,350	25,000	3	600
	Heater	386	2	40%	9%	3,267	4	59	2,135	3	77
	Insulation	251	2	100%	9%	2,250	6	68	–	–	–
	Insulated Drum	317	2	100%	9%	10,000	12	150	–	–	–
	Pickup Truck	384	8	58%	18%	25,000	9	2,320	6,125	3	1,235
	Cement Mixing Plant	311	1	60%	92%	2,000,000	12	92,000	333,333	3	40,889
	Tug	392	4	0%	100%	–	–	–	110,000,000	20	10,476
	Dive Boat	393	2	0%	100%	–	–	–	25,000	20	2,500

APPENDIX TABLE A-1

Capital Costs Per Activity Unit† by Asset and Activity

Activity	Asset	IMPLAN Sector	Quantity Per Activity Unit†	Percent of Equipment Purchases that are New	Percent Dedication to Task	New Equipment Purchases: Total Delivered Cost (Per Asset)	New Equipment Purchases: Expected Life (Years)	New Equipment Purchases: Cost Per Activity Unit	Used Equipment Purchases/Refurbishments: Total Delivered Cost (Per Asset)	Used Equipment Purchases/Refurbishments: Expected Life (Years)	Used Equipment Purchases/Refurbishments: Cost Per Activity Unit
Land Base Operations	966 CAT Loader	311	16	60%	100%	263,000	12	210,400	43,833	3	93,510
	Heater	386	16	40%	100%	3,267	4	5,227	2,135	3	6,832
	Insulation	251	16	100%	100%	2,250	6	6,000	–	–	–
	Small Flatbed Truck	384	12	60%	100%	85,000	12	51,000	14,167	3	22,667
	Heater	386	12	40%	100%	3,267	4	3,920	2,135	3	5,124
	Insulation	251	12	100%	100%	2,250	6	4,500	–	–	–
	Truck Tractor	384	8	60%	100%	130,000	12	52,000	21,667	3	23,111
	Heater	386	8	40%	100%	3,267	4	2,614	2,135	3	3,416
	Insulation	251	8	100%	100%	2,250	6	3,000	–	–	–
	Truck Trailer	387	8	60%	100%	32,000	12	12,800	5,333	3	5,689
	Forklift	317	22	75%	100%	40,000	9	73,333	10,000	3	18,333
	Pickup Truck	384	40	58%	100%	25,000	9	64,444	6,125	3	34,300
	Hoists	316	4	60%	100%	250,000	12	50,000	41,667	3	22,222
	Conveyors	315	4	60%	100%	125,000	12	25,000	20,833	3	11,111
	Loading Ramps	317	22	0%	100%	–	–	–	10,000	9	24,444
Spill Contingency	River Boat	393	8	100%	100%	40,000	8	40,000	–	–	–
	Ocean Vessel	392	2	100%	100%	250,000	10	50,000	–	–	–
	Air Boat	393	2	100%	100%	45,000	10	9,000	–	–	–
	Skimmer/Separators	338	20	100%	100%	100,000	10	200,000	–	–	–
	Booms	219	72	100%	100%	2,685	10	19,332	–	–	–

†***Activity Units***

Activity	*Units*	*Units Per Year*
Barge Support	1 Day	120
Camp Support	1 Year	1
Drill Ship – Calm Water	1 Day	270
Drill Ship – Rough Water	1 Day	270
Equip Production Island	1 Island	1
Exploration Well	1 Well	3
Gravel Island	1 Island	1
Helicopter Support	1 Day	365
Ice Island	1 Island	1
Ice Road	10-Miles	1
Land Base Operations	1 Year	1

Activity	*Units*	*Units Per Year*
Mobile Bottom Founded Structure	1 Day	270
Move Platform	1 Day	270
Offshore Pipeline	1 Mile	1
Onshore Pipeline	1 Mile	1
Personnel Transport	1 Day	365
Production Operations	1 Year	1
Production Well	1 Well	9
Seafloor Tieback Pipeline	10 Miles	1
Seismic Survey	1 Month	4
Spill Contingency	1 Year	1
Well Work-over	1 Well	30

APPENDIX TABLE A-2

New Equipment Margin Matrix
Percent of Total Delivered Price

	Producer	Transportation to Alaska					Transportation Within Alaska					Wholesale	Retrofit
Asset	**Price**	**Rail**	**Water**	**Truck**	**Air**	**Total**	**Rail**	**Water**	**Truck**	**Air**	**Total**	**Trade**	**Labor**
100 Barrel Water Tank	42.0%	0.5%	1.0%	0.5%	0.0%	2.0%	3.0%	0.0%	1.0%	0.0%	4.0%	10.0%	42.0%
300 Barrel Water Tank	40.9%	0.6%	1.3%	0.6%	0.2%	2.7%	2.0%	1.0%	2.0%	0.5%	5.5%	10.0%	40.9%
3000 Gallon Fuel Tank	30.3%	3.0%	15.2%	2.0%	0.0%	20.2%	3.0%	5.0%	22.3%	0.0%	30.3%	16.6%	2.6%
500 Gallon Fuel Tank	35.1%	2.0%	8.5%	2.0%	0.0%	12.5%	2.0%	3.0%	18.0%	2.0%	25.0%	14.9%	12.5%
60 Foot Sleigh	29.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.8%	3.0%	0.0%	4.0%	6.9%	59.4%
966 CAT Loader	71.4%	2.2%	5.0%	2.2%	0.0%	9.4%	0.3%	0.7%	1.3%	0.0%	2.3%	16.9%	0.0%
988 CAT Loader	80.2%	0.5%	1.1%	0.5%	0.0%	2.1%	0.1%	0.2%	0.4%	0.0%	0.7%	17.0%	0.0%
Air Boat	88.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%	0.0%	6.7%	5.0%	0.0%
Angle Blade	31.7%	5.0%	15.0%	5.0%	0.0%	25.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.6%	31.7%
Auger	44.1%	0.2%	0.3%	0.2%	0.0%	0.8%	0.5%	0.5%	0.5%	0.0%	1.5%	9.5%	44.1%
Backhoe	72.9%	2.0%	4.3%	1.9%	0.0%	8.2%	0.4%	0.4%	1.2%	0.0%	2.0%	16.9%	0.0%
Booms	91.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%	0.8%	3.2%	5.0%	0.0%
Bridge Section	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bus	60.0%	1.5%	2.5%	1.5%	0.5%	6.0%	3.0%	1.5%	6.0%	1.5%	12.0%	16.0%	6.0%
CAT Challenger	70.9%	2.2%	4.6%	2.1%	0.0%	8.9%	0.4%	0.8%	2.0%	0.0%	3.2%	17.0%	0.0%
Cement Mixing Plant	76.8%	1.2%	2.4%	1.2%	0.0%	4.8%	0.3%	0.3%	0.8%	0.0%	1.4%	17.0%	0.0%
Compactor	77.3%	1.0%	2.2%	1.0%	0.0%	4.2%	0.3%	0.2%	1.0%	0.0%	1.5%	17.0%	0.0%
Concrete Truck	77.0%	1.2%	2.3%	1.2%	0.0%	4.7%	0.4%	0.4%	0.5%	0.0%	1.3%	17.0%	0.0%
Conveyors	77.0%	1.2%	2.5%	1.3%	0.0%	5.0%	0.3%	0.4%	0.3%	0.0%	1.0%	17.0%	0.0%
Crane	77.0%	1.2%	2.5%	1.3%	0.0%	5.0%	0.3%	0.4%	0.3%	0.0%	1.0%	17.0%	0.0%
D10 CAT	81.0%	0.3%	0.8%	0.4%	0.0%	1.5%	0.2%	0.1%	0.2%	0.0%	0.5%	17.0%	0.0%
D6 CAT	72.9%	2.0%	4.3%	1.9%	0.0%	8.2%	0.4%	0.4%	1.2%	0.0%	2.0%	16.9%	0.0%
D7 CAT	74.4%	1.7%	3.6%	1.6%	0.0%	6.9%	0.3%	0.4%	1.0%	0.0%	1.7%	17.0%	0.0%
Ditch Witch	72.9%	2.0%	4.3%	1.9%	0.0%	8.2%	0.4%	0.4%	1.2%	0.0%	2.0%	16.9%	0.0%
Dive Boat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Drill Rig	70.8%	0.9%	2.0%	0.9%	1.5%	5.3%	1.0%	1.5%	2.5%	0.3%	5.3%	0.9%	17.7%
Drill Ship	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Drilling Machine	76.8%	1.2%	2.4%	1.2%	0.0%	4.8%	0.3%	0.3%	0.8%	0.0%	1.4%	17.0%	0.0%
Dump Truck	68.0%	2.7%	6.0%	2.7%	0.0%	11.4%	0.8%	0.8%	2.0%	0.0%	3.6%	17.0%	0.0%
Electrical Apparatus, NEC	77.2%	0.2%	0.2%	0.2%	0.2%	0.8%	0.1%	0.1%	0.3%	0.3%	0.8%	16.1%	5.1%
Engine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Forklift	73.0%	0.5%	1.2%	0.5%	0.1%	2.3%	1.6%	1.5%	1.6%	0.0%	4.7%	15.0%	5.0%
Front-end Loader	73.0%	0.5%	1.2%	0.5%	0.1%	2.3%	1.6%	1.5%	1.6%	0.0%	4.7%	15.0%	5.0%
Fuel Barge	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Generator	72.9%	0.6%	1.5%	0.4%	0.1%	2.6%	0.2%	0.2%	1.5%	0.1%	2.0%	15.9%	6.6%
Hammer	76.8%	1.2%	2.4%	1.2%	0.0%	4.8%	0.3%	0.3%	0.8%	0.0%	1.4%	17.0%	0.0%
Heater	41.9%	0.5%	0.6%	0.5%	0.5%	2.1%	0.5%	0.5%	2.0%	1.2%	4.2%	9.9%	41.9%
Helicopter	93.6%	0.1%	0.1%	0.1%	0.1%	0.4%	0.0%	0.0%	0.1%	0.0%	0.1%	5.0%	0.9%
Hoists	77.0%	1.2%	2.5%	1.3%	0.0%	5.0%	0.3%	0.4%	0.3%	0.0%	1.0%	17.0%	0.0%
Hydraulic Pump	43.3%	0.3%	0.5%	0.3%	0.1%	1.2%	0.8%	0.8%	0.8%	0.0%	2.5%	9.6%	43.3%
Hydraulics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ice Breaker	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ice Mill	75.1%	0.1%	0.3%	0.1%	0.1%	0.6%	0.3%	0.2%	0.5%	0.1%	1.1%	15.7%	7.5%
Incinerator	72.4%	1.0%	3.0%	0.8%	0.0%	4.8%	0.3%	0.3%	1.9%	0.0%	2.5%	16.3%	4.0%
Industrial Lights	79.3%	0.1%	0.1%	0.1%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%	0.1%	16.3%	4.0%
Insulated Drum	43.3%	0.3%	0.5%	0.3%	0.1%	1.2%	0.8%	0.8%	0.8%	0.0%	2.5%	9.6%	43.3%
Insulation	44.4%	0.1%	0.2%	0.2%	0.1%	0.6%	0.3%	0.1%	0.4%	0.4%	1.2%	9.4%	44.4%
Interest	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Large Grader	69.0%	2.7%	5.5%	2.7%	0.0%	10.9%	0.6%	0.5%	2.0%	0.0%	3.1%	17.0%	0.0%
Large Loader	67.6%	1.3%	2.6%	1.0%	0.3%	5.2%	2.2%	1.0%	6.0%	1.0%	10.2%	17.0%	0.0%
Large Water Truck	50.5%	3.5%	5.4%	1.4%	0.5%	10.8%	8.0%	3.7%	10.0%	0.0%	21.7%	17.0%	0.0%
Loading Ramps	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Long Reach Attachment	72.7%	0.5%	1.7%	0.5%	0.0%	2.7%	0.2%	0.0%	0.4%	0.0%	0.6%	15.6%	8.4%
MBFS	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX TABLE A-2

New Equipment Margin Matrix
Percent of Total Delivered Price

	Producer	Transportation to Alaska					Transportation Within Alaska					Wholesale	Retrofit
Asset	**Price**	**Rail**	**Water**	**Truck**	**Air**	**Total**	**Rail**	**Water**	**Truck**	**Air**	**Total**	**Trade**	**Labor**
Motor Vehicle Parts	35.7%	1.5%	2.6%	1.5%	0.3%	5.9%	4.0%	3.9%	4.0%	0.0%	11.9%	10.9%	35.6%
Nodwell	75.8%	1.0%	2.3%	0.9%	0.3%	4.5%	0.6%	0.6%	1.2%	0.3%	2.7%	17.0%	0.0%
Ocean Vessel	92.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	1.8%	0.0%	2.4%	5.0%	0.0%
Pickup Truck	60.0%	1.5%	2.5%	1.5%	0.5%	6.0%	3.0%	1.5%	6.0%	1.5%	12.0%	16.0%	6.0%
Pile Driving Template	76.8%	1.2%	2.4%	1.2%	0.0%	4.8%	0.3%	0.3%	0.8%	0.0%	1.4%	17.0%	0.0%
Pipeline Coating Machine	79.3%	0.1%	0.1%	0.1%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%	0.1%	16.3%	4.0%
Pipeline Heating Machine	79.3%	0.1%	0.1%	0.1%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%	0.1%	16.3%	4.0%
Power Facility Construction	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Power Generator	77.9%	0.1%	0.3%	0.1%	0.0%	0.5%	0.0%	0.1%	0.2%	0.0%	0.3%	16.1%	5.2%
Prefabricated Modules	32.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.8%	6.0%	0.0%	9.8%	8.7%	48.9%
Relays	77.2%	0.2%	0.2%	0.2%	0.2%	0.8%	0.1%	0.1%	0.3%	0.3%	0.8%	16.1%	5.1%
Rig Mats	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
River Boat	87.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.5%	0.0%	7.5%	5.0%	0.0%
Seismic Equipment	82.7%	0.0%	0.0%	0.0%	0.2%	0.2%	0.0%	0.0%	0.0%	0.1%	0.1%	17.0%	0.0%
Self Propelled Barge	76.5%	0.2%	0.4%	0.2%	0.0%	0.8%	0.1%	0.2%	0.1%	0.0%	0.4%	15.9%	6.4%
Sewage Treatment Construction	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sewage Treatment Equipment	63.5%	0.4%	1.0%	0.4%	0.4%	2.2%	0.2%	0.3%	1.5%	0.2%	2.2%	13.9%	18.2%
Shaker Truck	78.8%	0.7%	2.0%	0.7%	0.0%	3.4%	0.2%	0.2%	0.4%	0.0%	0.8%	17.0%	0.0%
Skimmer/Separators	94.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.1%	0.3%	5.0%	0.0%
Small Flatbed Truck	53.0%	1.0%	9.0%	0.0%	0.0%	10.0%	15.0%	0.0%	5.0%	0.0%	20.0%	17.0%	0.0%
Small Grader	76.0%	0.5%	1.2%	0.5%	0.1%	2.3%	1.6%	1.5%	1.6%	0.0%	4.7%	17.0%	0.0%
Small Rollagon	63.8%	1.6%	2.8%	1.6%	0.4%	6.4%	4.3%	4.3%	4.3%	0.0%	12.8%	17.0%	0.0%
Small Water Truck	53.0%	1.0%	9.0%	0.0%	0.0%	10.0%	15.0%	0.0%	5.0%	0.0%	20.0%	17.0%	0.0%
Snow Melter	72.4%	1.0%	3.0%	0.8%	0.0%	4.8%	0.3%	0.3%	1.9%	0.0%	2.5%	16.3%	4.0%
Snowblower	43.0%	0.0%	13.3%	0.0%	0.0%	13.3%	6.7%	0.0%	20.0%	0.0%	26.7%	17.0%	0.0%
Survey Equipment	82.5%	0.0%	0.0%	0.0%	0.3%	0.3%	0.0%	0.0%	0.0%	0.2%	0.2%	17.0%	0.0%
Switchgear	77.2%	0.2%	0.2%	0.2%	0.2%	0.8%	0.1%	0.1%	0.3%	0.3%	0.8%	16.1%	5.1%
Texoma Drill	72.9%	2.0%	4.3%	1.9%	0.0%	8.2%	0.4%	0.4%	1.2%	0.0%	2.0%	16.9%	0.0%
Tires	39.0%	1.0%	1.7%	1.0%	0.2%	3.9%	2.6%	2.6%	2.6%	0.0%	7.8%	10.3%	39.0%
Transformers	77.2%	0.2%	0.2%	0.2%	0.2%	0.8%	0.1%	0.1%	0.3%	0.3%	0.8%	16.1%	5.1%
Transport Trailer	71.4%	2.2%	5.0%	2.2%	0.0%	9.4%	0.3%	0.7%	1.3%	0.0%	2.3%	16.9%	0.0%
Truck Tractor	53.0%	1.0%	9.0%	0.0%	0.0%	10.0%	15.0%	0.0%	5.0%	0.0%	20.0%	17.0%	0.0%
Truck Trailer	71.4%	2.2%	5.0%	2.2%	0.0%	9.4%	0.3%	0.7%	1.3%	0.0%	2.3%	16.9%	0.0%
Tug	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Van	60.0%	1.5%	2.5%	1.5%	0.5%	6.0%	3.0%	1.5%	6.0%	1.5%	12.0%	16.0%	6.0%
Water Pumps	42.7%	0.4%	0.5%	0.5%	0.3%	1.7%	1.0%	0.2%	1.0%	1.0%	3.2%	9.7%	42.7%
Water Treatment Construction	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Water Treatment Equipment	62.8%	0.4%	0.4%	0.4%	0.4%	1.6%	0.2%	0.2%	1.0%	0.2%	1.6%	13.5%	20.5%
Welding Machine	79.3%	0.1%	0.1%	0.1%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%	0.1%	16.3%	4.0%
Wiring Devices	77.2%	0.2%	0.2%	0.2%	0.2%	0.8%	0.1%	0.1%	0.3%	0.3%	0.8%	16.1%	5.1%
Workboat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX TABLE A-3

Used Equipment Margin Matrix
Percent of Total Delivered Price

	Producer	Transportation to Alaska					Transportation Within Alaska					Wholesale	Retrofit
Asset	Price	Rail	Water	Truck	Air	Total	Rail	Water	Truck	Air	Total	Trade	Labor
100 Barrel Water Tank	38.4%	1.0%	2.2%	1.0%	0.0%	4.2%	3.5%	1.5%	3.5%	0.0%	8.5%	10.5%	38.4%
300 Barrel Water Tank	36.4%	1.2%	2.7%	1.2%	0.4%	5.5%	3.9%	2.0%	4.0%	1.0%	10.9%	10.8%	36.4%
3000 Gallon Fuel Tank	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
500 Gallon Fuel Tank	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
60 Foot Sleigh	39.9%	0.0%	0.0%	0.0%	0.0%	0.0%	2.0%	2.0%	5.0%	1.0%	10.0%	10.2%	39.9%
966 CAT Loader	36.2%	0.2%	0.2%	0.2%	0.2%	0.8%	1.1%	1.1%	4.5%	1.0%	7.7%	9.1%	46.2%
988 CAT Loader	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Air Boat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Angle Blade	38.4%	0.4%	1.5%	0.4%	0.2%	2.5%	2.0%	2.0%	5.1%	1.0%	10.1%	10.5%	38.5%
Auger	44.1%	0.1%	0.2%	0.1%	0.0%	0.4%	0.5%	0.5%	0.5%	0.0%	1.5%	10.0%	44.0%
Backhoe	31.9%	0.2%	0.1%	0.2%	0.2%	0.7%	0.5%	0.5%	4.0%	1.3%	6.3%	7.8%	53.3%
Booms	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Bridge Section	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	1.0%	10.0%	69.0%
Bus	27.7%	0.5%	0.5%	0.5%	0.5%	2.0%	2.0%	2.0%	16.7%	3.0%	23.7%	11.0%	35.6%
CAT Challenger	30.3%	0.2%	0.2%	0.2%	0.2%	0.8%	2.0%	2.0%	5.1%	1.0%	10.1%	8.4%	50.4%
Cement Mixing Plant	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Compactor	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Concrete Truck	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
Conveyors	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
Crane	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
D10 CAT	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
D6 CAT	31.9%	0.2%	0.1%	0.2%	0.2%	0.7%	0.5%	0.5%	4.0%	1.3%	6.3%	7.8%	53.3%
D7 CAT	27.5%	0.1%	0.1%	0.1%	0.2%	0.5%	0.7%	0.8%	3.0%	0.4%	4.9%	6.7%	60.4%
Ditch Witch	31.9%	0.2%	0.1%	0.2%	0.2%	0.7%	0.5%	0.5%	4.0%	1.3%	6.3%	7.8%	53.3%
Dive Boat	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Drill Rig	28.9%	0.1%	0.1%	0.1%	0.1%	0.4%	0.0%	0.1%	0.1%	0.1%	0.3%	3.0%	67.4%
Drill Ship	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Drilling Machine	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Dump Truck	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
Electrical Apparatus, NEC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Engine	43.6%	0.2%	0.6%	0.2%	0.1%	1.1%	0.6%	0.4%	1.0%	0.2%	2.2%	9.5%	43.6%
Forklift	36.4%	0.5%	0.5%	0.5%	0.5%	2.0%	3.0%	3.0%	3.0%	1.5%	10.5%	17.0%	34.1%
Front-end Loader	36.4%	0.5%	0.5%	0.5%	0.5%	2.0%	3.0%	3.0%	3.0%	1.5%	10.5%	17.0%	34.1%
Fuel Barge	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Generator	41.5%	0.2%	0.3%	0.3%	0.2%	1.0%	1.0%	1.0%	3.0%	1.0%	6.0%	9.9%	41.6%
Hammer	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Heater	41.9%	0.5%	0.6%	0.5%	0.5%	2.1%	0.5%	0.5%	2.0%	1.2%	4.2%	9.9%	41.9%
Helicopter	45.0%	0.5%	0.5%	0.5%	0.5%	2.0%	0.0%	0.0%	0.1%	0.0%	0.1%	8.9%	44.0%
Hoists	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
Hydraulic Pump	43.5%	0.2%	0.3%	0.2%	0.1%	0.6%	0.8%	0.8%	0.9%	0.0%	2.5%	10.0%	43.4%
Hydraulics	44.7%	0.1%	0.1%	0.1%	0.1%	0.4%	0.2%	0.1%	0.3%	0.2%	0.8%	9.4%	44.7%
Ice Breaker	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Ice Mill	43.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	0.8%	2.0%	0.3%	4.3%	9.7%	43.0%
Incinerator	40.1%	0.1%	0.2%	0.1%	0.1%	0.5%	1.0%	2.0%	5.0%	1.0%	9.0%	10.2%	40.2%
Industrial Lights	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Insulated Drum	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Insulation	44.4%	0.1%	0.2%	0.2%	0.1%	0.6%	0.3%	0.1%	0.4%	0.4%	1.2%	9.4%	44.4%
Interest	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Large Grader	30.9%	0.0%	0.0%	0.0%	0.0%	0.0%	4.9%	2.2%	13.0%	2.0%	22.1%	17.0%	30.0%
Large Loader	30.9%	0.0%	0.0%	0.0%	0.0%	0.0%	4.9%	2.2%	13.0%	2.0%	22.1%	17.0%	30.0%
Large Water Truck	22.7%	0.0%	0.0%	0.0%	0.0%	0.0%	14.2%	6.5%	17.6%	0.0%	38.3%	17.0%	22.0%
Loading Ramps	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	1.0%	10.0%	69.0%
Long Reach Attachment	44.8%	0.1%	0.1%	0.1%	0.2%	0.5%	0.0%	0.0%	0.2%	0.2%	0.4%	9.4%	44.9%
MBFS	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX TABLE A-3

Used Equipment Margin Matrix
Percent of Total Delivered Price

Asset	Producer Price	Transportation to Alaska					Transportation Within Alaska					Wholesale Trade	Retrofit Labor
		Rail	Water	Truck	Air	Total	Rail	Water	Truck	Air	Total		
Motor Vehicle Parts	37.0%	0.5%	0.5%	1.1%	1.0%	3.1%	3.5%	1.8%	4.0%	3.0%	12.3%	10.7%	36.9%
Nodwell	39.4%	0.2%	0.3%	0.3%	0.2%	1.0%	1.5%	1.5%	6.0%	0.9%	9.9%	10.3%	39.4%
Ocean Vessel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pickup Truck	27.7%	0.5%	0.5%	0.5%	0.5%	2.0%	2.0%	2.0%	16.7%	3.0%	23.7%	11.0%	35.6%
Pile Driving Template	40.5%	0.1%	0.1%	0.2%	0.2%	0.6%	0.0%	0.0%	2.0%	1.5%	3.5%	9.1%	46.3%
Pipeline Coating Machine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Pipeline Heating Machine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Power Facility Construction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Power Generator	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Prefabricated Modules	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Relays	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Rig Mats	20.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	1.0%	10.0%	69.0%
River Boat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Seismic Equipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Self Propelled Barge	33.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%	0.4%	0.0%	0.8%	6.9%	59.3%
Sewage Treatment Construction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sewage Treatment Equipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Shaker Truck	42.3%	0.5%	0.5%	0.5%	0.5%	2.0%	0.7%	0.7%	2.0%	0.2%	3.6%	9.8%	42.3%
Skimmer/Separators	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Small Flatbed Truck	20.0%	0.0%	0.0%	2.0%	0.0%	2.0%	15.0%	6.5%	20.0%	0.0%	41.5%	17.0%	19.5%
Small Grader	36.4%	0.5%	0.5%	0.5%	0.5%	2.0%	3.0%	3.0%	3.0%	1.5%	10.5%	17.0%	34.1%
Small Rollagon	33.0%	0.5%	0.5%	0.5%	0.5%	2.0%	4.0%	4.0%	4.0%	2.0%	14.0%	18.0%	33.0%
Small Water Truck	20.0%	0.0%	0.0%	2.0%	0.0%	2.0%	15.0%	6.5%	20.0%	0.0%	41.5%	17.0%	19.5%
Snow Melter	40.1%	0.1%	0.2%	0.1%	0.1%	0.5%	1.0%	2.0%	5.0%	1.0%	9.0%	10.2%	40.2%
Snowblower	26.6%	0.0%	0.0%	0.0%	0.0%	0.0%	10.0%	5.0%	25.0%	0.0%	40.0%	6.8%	26.6%
Survey Equipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Switchgear	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Texoma Drill	24.5%	0.0%	0.0%	0.5%	0.5%	1.0%	0.0%	0.0%	2.0%	1.1%	3.1%	5.9%	65.5%
Tires	39.0%	1.0%	1.0%	1.0%	0.8%	3.8%	2.3%	1.0%	4.0%	0.5%	7.8%	10.4%	39.0%
Transformers	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Transport Trailer	36.2%	0.2%	0.2%	0.2%	0.2%	0.8%	1.1%	1.1%	4.5%	1.0%	7.7%	9.1%	46.2%
Truck Tractor	20.0%	0.0%	0.0%	2.0%	0.0%	2.0%	15.0%	6.5%	20.0%	0.0%	41.5%	17.0%	19.5%
Truck Trailer	36.2%	0.2%	0.2%	0.2%	0.2%	0.8%	1.1%	1.1%	4.5%	1.0%	7.7%	9.1%	46.2%
Tug	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Van	27.7%	0.5%	0.5%	0.5%	0.5%	2.0%	2.0%	2.0%	16.7%	3.0%	23.7%	11.0%	35.6%
Water Pumps	40.4%	0.7%	0.9%	0.9%	0.5%	3.0%	1.9%	0.4%	1.9%	1.9%	6.1%	10.1%	40.4%
Water Treatment Construction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Water Treatment Equipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Welding Machine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Wiring Devices	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Workboat	94.0%	0.0%	6.0%	0.0%	0.0%	6.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

APPENDIX TABLE A-4

RPC Coefficients for Capital Expenditures and Associated Margins

Commodity	NSB	Other AK	Other US	Foreign
100 Barrel Water Tank	0.0%	5.0%	70.0%	25.0%
300 Barrel Water Tank	0.0%	5.0%	70.0%	25.0%
3000 Gallon Fuel Tank	0.0%	5.0%	70.0%	25.0%
500 Gallon Fuel Tank	0.0%	5.0%	70.0%	25.0%
60 Foot Sleigh	0.0%	95.0%	0.0%	5.0%
966 CAT Loader	0.0%	5.0%	70.0%	25.0%
988 CAT Loader	0.0%	5.0%	70.0%	25.0%
Air Boat	0.0%	100.0%	0.0%	0.0%
Angle Blade	0.0%	5.0%	70.0%	25.0%
Auger	0.0%	5.0%	70.0%	25.0%
Backhoe	0.0%	5.0%	70.0%	25.0%
Booms	0.0%	100.0%	0.0%	0.0%
Bridge Section	100.0%	0.0%	0.0%	0.0%
Bus	0.0%	5.0%	70.0%	25.0%
CAT Challenger	0.0%	5.0%	70.0%	25.0%
Cement Mixing Plant	0.0%	5.0%	85.0%	10.0%
Compactor	0.0%	5.0%	70.0%	25.0%
Concrete Truck	0.0%	5.0%	70.0%	25.0%
Conveyors	0.0%	5.0%	70.0%	25.0%
Crane	0.0%	5.0%	70.0%	25.0%
D10 CAT	0.0%	5.0%	70.0%	25.0%
D6 CAT	0.0%	5.0%	70.0%	25.0%
D7 CAT	0.0%	5.0%	70.0%	25.0%
Ditch Witch	0.0%	5.0%	70.0%	25.0%
Dive Boat	0.0%	75.0%	20.0%	5.0%
Drill Rig	0.0%	5.0%	70.0%	25.0%
Drill Ship	0.0%	75.0%	20.0%	5.0%
Drilling Machine	0.0%	5.0%	70.0%	25.0%
Dump Truck	0.0%	5.0%	70.0%	25.0%
Electrical Apparatus, NEC	0.0%	5.0%	70.0%	25.0%
Engine	0.0%	0.0%	100.0%	0.0%
Forklift	0.0%	5.0%	70.0%	25.0%
Front-end Loader	0.0%	5.0%	70.0%	25.0%
Fuel Barge	0.0%	75.0%	20.0%	5.0%
Generator	0.0%	5.0%	70.0%	25.0%
Hammer	0.0%	5.0%	70.0%	25.0%
Heater	0.0%	5.0%	70.0%	25.0%
Helicopter	0.0%	5.0%	85.0%	10.0%
Hoists	0.0%	5.0%	70.0%	25.0%
Hydraulic Pump	0.0%	5.0%	70.0%	25.0%
Hydraulics	0.0%	5.0%	70.0%	25.0%
Ice Breaker	0.0%	10.0%	45.0%	45.0%

APPENDIX TABLE A-4

RPC Coefficients for Capital Expenditures and Associated Margins

Commodity	NSB	Other AK	Other US	Foreign
Ice Mill	0.0%	5.0%	70.0%	25.0%
Incinerator	0.0%	5.0%	70.0%	25.0%
Industrial Lights	0.0%	5.0%	70.0%	25.0%
Insulated Drum	0.0%	5.0%	70.0%	25.0%
Insulation	0.0%	5.0%	70.0%	25.0%
Interest	5.0%	45.0%	50.0%	0.0%
Large Grader	0.0%	5.0%	70.0%	25.0%
Large Loader	0.0%	5.0%	70.0%	25.0%
Large Water Truck	0.0%	5.0%	70.0%	25.0%
Loading Ramps	50.0%	50.0%	0.0%	0.0%
Long Reach Attachment	0.0%	5.0%	70.0%	25.0%
MBFS	0.0%	75.0%	20.0%	5.0%
Motor Vehicle Parts	0.0%	5.0%	70.0%	25.0%
Nodwell	0.0%	5.0%	0.0%	100.0%
Ocean Vessel	0.0%	100.0%	0.0%	0.0%
Pickup Truck	0.0%	5.0%	70.0%	25.0%
Pile Driving Template	0.0%	5.0%	70.0%	25.0%
Pipeline Coating Machine	0.0%	5.0%	70.0%	25.0%
Pipeline Heating Machine	0.0%	5.0%	70.0%	25.0%
Power Facility Construction	75.0%	24.0%	0.0%	1.0%
Power Generator	0.0%	5.0%	70.0%	25.0%
Prefabricated Modules	0.0%	50.0%	25.0%	25.0%
Relays	0.0%	5.0%	70.0%	25.0%
Rig Mats	50.0%	50.0%	0.0%	0.0%
River Boat	0.0%	100.0%	0.0%	0.0%
Seismic Equipment	0.0%	5.0%	70.0%	25.0%
Self Propelled Barge	0.0%	5.0%	70.0%	25.0%
Sewage Treatment Construction	75.0%	24.0%	0.0%	1.0%
Sewage Treatment Equipment	0.0%	5.0%	70.0%	25.0%
Shaker Truck	0.0%	5.0%	70.0%	25.0%
Skimmer/Separators	0.0%	100.0%	0.0%	0.0%
Small Flatbed Truck	0.0%	5.0%	70.0%	25.0%
Small Grader	0.0%	5.0%	70.0%	25.0%
Small Rollagon	0.0%	5.0%	70.0%	25.0%
Small Water Truck	0.0%	5.0%	70.0%	25.0%
Snow Melter	0.0%	5.0%	70.0%	25.0%
Snowblower	0.0%	5.0%	70.0%	25.0%
Survey Equipment	0.0%	5.0%	70.0%	25.0%
Switchgear	0.0%	5.0%	70.0%	25.0%
Texoma Drill	0.0%	5.0%	70.0%	25.0%
Tires	0.0%	5.0%	70.0%	25.0%
Transformers	0.0%	5.0%	70.0%	25.0%

APPENDIX TABLE A-4

RPC Coefficients for Capital Expenditures and Associated Margins				
Commodity	**NSB**	**Other AK**	**Other US**	**Foreign**
Transport Trailer	0.0%	5.0%	70.0%	25.0%
Truck Tractor	0.0%	5.0%	70.0%	25.0%
Truck Trailer	0.0%	5.0%	70.0%	25.0%
Tug	0.0%	75.0%	20.0%	5.0%
Van	0.0%	5.0%	70.0%	25.0%
Water Pumps	0.0%	5.0%	70.0%	25.0%
Water Treatment Construction	75.0%	24.0%	0.0%	1.0%
Water Treatment Equipment	0.0%	5.0%	70.0%	25.0%
Welding Machine	0.0%	5.0%	70.0%	25.0%
Wiring Devices	0.0%	5.0%	70.0%	25.0%
Workboat	0.0%	75.0%	20.0%	5.0%
Rail to Alaska	0.0%	50.0%	50.0%	0.0%
Rail Within Alaska	0.0%	100.0%	0.0%	0.0%
Water to Alaska	0.0%	50.0%	50.0%	0.0%
Water Within Alaska	0.0%	100.0%	0.0%	0.0%
Truck to Alaska	20.0%	30.0%	50.0%	0.0%
Truck Within Alaska	25.0%	75.0%	0.0%	0.0%
Air to Alaska	20.0%	30.0%	50.0%	0.0%
Air Within Alaska	25.0%	75.0%	0.0%	0.0%
Wholesale Trade	10.0%	60.0%	30.0%	0.0%
Labor for Retrofitting	30.0%	60.0%	10.0%	0.0%

APPENDIX TALBE A-5 Asset to IMPLAN Sector Concordance		
Asset/Commodity	IMPLAN Sector	Sector Description
100 Barrel Water Tank	284	Fabricated Plate Work
300 Barrel Water Tank	284	Fabricated Plate Work
3000 Gallon Fuel Tank	284	Fabricated Plate Work
500 Gallon Fuel Tank	284	Fabricated Plate Work
60 Foot Sleigh	399	Transportation Equipment, N.E.C.
966 CAT Loader	311	Construction Machinery and Equipment
988 CAT Loader	311	Construction Machinery and Equipment
Air Boat	393	Boat Building and Repairing
Angle Blade	311	Construction Machinery and Equipment
Auger	312	Mining Machinery, Except Oil Field
Backhoe	311	Construction Machinery and Equipment
Booms	219	Fabricated Rubber Products, N.E.C.
Bridge Section	282	Fabricated Structural Metal
Bus	384	Motor Vehicles
CAT Challenger	311	Construction Machinery and Equipment
Cement Mixing Plant	311	Construction Machinery and Equipment
Compactor	311	Construction Machinery and Equipment
Concrete Truck	317	Industrial Trucks and Tractors
Conveyors	315	Conveyors and Conveying Equipment
Crane	311	Construction Machinery and Equipment
D10 CAT	311	Construction Machinery and Equipment
D6 CAT	311	Construction Machinery and Equipment
D7 CAT	311	Construction Machinery and Equipment
Ditch Witch	311	Construction Machinery and Equipment
Dive Boat	393	Boat Building and Repairing
Drill Rig	313	Oil Field Machinery
Drill Ship	392	Ship Building and Repairing
Drilling Machine	312	Mining Machinery, Except Oil Field
Dump Truck	317	Industrial Trucks and Tractors
Electrical Apparatus, NEC	360	Electrical Apparatus, NEC
Engine	308	Internal Combustion Engines
Forklift	317	Industrial Trucks and Tractors
Front-end Loader	311	Construction Machinery and Equipment
Fuel Barge	393	Boat Building and Repairing
Generator	357	Motors and Generators
Hammer	311	Construction Machinery and Equipment
Heater	386	Motor Vehicle Parts and Accessories
Hellicopter	389	Aircraft
Hoists	316	Hoists, Cranes, and Monorails
Hydraulic Pump	352	Fluid Power Pumps and Motors
Hydraulics	352	Fluid Power Pumps and Motors
Ice Breaker	392	Ship Building and Repairing
Ice Mill	311	Construction Machinery and Equipment
Incinerator	337	Industrial Furnaces and Ovens
Industrial Lights	369	Lighting Fixtures and Equipment
Insulated Drum	317	Industrial Trucks and Tractors
Insulation	251	Mineral Wool
Large Grader	311	Construction Machinery and Equipment
Large Loader	311	Construction Machinery and Equipment
Large Water Truck	317	Industrial Trucks and Tractors
Loading Ramps	317	Industrial Trucks and Tractors
Long Reach Attachment	311	Construction Machinery and Equipment
Mobile Bottom Founded Structure (MBFS)	392	Ship Building and Repairing
Motor Vehicle Parts	386	Motor Vehicle Parts and Accessories

APPENDIX TALBE A-5 Asset to IMPLAN Sector Concordance		
Asset/Commodity	IMPLAN Sector	Sector Description
Nodwell	311	Construction Machinery and Equipment
Ocean Vessel	392	Ship Building and Repairing
Pickup Truck	384	Motor Vehicles
Pile Driving Template	311	Construction Machinery and Equipment
Pipeline Coating Machine	331	Special Industry Machinery, N.E.C.
Pipeline Heating Machine	331	Special Industry Machinery, N.E.C.
Power Facility Construction	050	New Utility Structures
Power Generator	357	Motors and Generators
Prefabricated Modules	287	Fabricated Metal Buildings
Relays	359	Relays
Rig Mats	282	Fabricated Structural Metal
River Boat	393	Boat Building and Repairing
Seismic Equipment	403	Mechanical Measuring Devices
Self Propelled Barge	392	Ship Building and Repairing
Sewage Treatment Construction	50	New Utility Structures
Sewage Treatment Equipment	349	Service Industry Machines, N.E.C.
Shaker Truck	312	Mining Machinery, Except Oil Field
Skimmer/Separators	338	General Industrial Machinery, N.E.C.
Small Flatbed Truck	384	Motor Vehicles
Small Grader	311	Construction Machinery and Equipment
Small Rollagon	311	Construction Machinery and Equipment
Small Water Truck	317	Industrial Trucks and Tractors
Snow Melter	281	Heating Equipment, Except Electrical
Snowblower	311	Construction Machinery and Equipment
Survey Equipment	400	Search and Navigation Equipment
Switchgear	356	Switchgear
Texoma Drill	312	Mining Machinery, Except Oil Field
Tires	215	Tires and Inner Tubes
Transformers	355	Transformers
Transport Trailer	317	Industrial Trucks and Tractors
Truck Tractor	384	Motor Vehicles
Truck Trailer	387	Truck Trailers
Tug	392	Ship Building and Repairing
Van	384	Motor Vehicles
Water Pumps	332	Pumps and Compressors
Water Treatment Construction	050	New Utility Structures
Water Treatment Equipment	349	Service Industry Machines, N.E.C.
Welding Machine	324	Welding Apparatus
Wiring Devices	368	Wiring Devices
Workboat	392	Ship Building and Repairing
Rail to Alaska	433	Railroads and Related Services
Rail Within Alaska	433	Railroads and Related Services
Water to Alaska	436	Water Transportation
Water Within Alaska	436	Water Transportation
Truck to Alaska	435	Motor Freight Transport and Warehousing
Truck Within Alaska	435	Motor Freight Transport and Warehousing
Air to Alaska	437	Air Transportation
Air Within Alaska	437	Air Transportation
Wholesale Trade	447	Wholesale Trade
Labor for Retrofitting	482	Miscellaneous Repair Shops

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit[†] by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Seismic Survey	251	Mineral Wool	0	34	472	169	674
	281	Heating Equipment, Except Electrical	0	153	2,149	767	3,069
	284	Fabricated Plate Work	0	52	734	262	1,049
	287	Fabricated Metal Buildings	0	4,890	2,445	2,445	9,780
	311	Construction Machinery and Equipment	0	5,187	25,060	73,485	103,731
	312	Mining Machinery, Except Oil Field	0	8,747	122,455	43,734	174,936
	337	Industrial Furnaces and Ovens	0	153	2,149	767	3,069
	357	Motors and Generators	0	1,053	14,746	5,267	21,066
	386	Motor Vehicle Parts and Accessories	0	59	825	295	1,178
	399	Transportation Equipment, N.E.C.	0	3,861	0	203	4,064
	400	Search and Navigation Equipment	0	619	8,663	3,094	12,375
	403	Mechanical Measuring Devices	0	12,405	173,670	62,025	248,100
	433	Railroads and Related Services	0	3,721	1,768	0	5,488
	435	Motor Freight Transportation and Warehousing	2,743	7,223	1,677	0	11,644
	436	Water Transportation	0	7,868	4,583	0	12,451
	437	Air Transportation	468	1,100	504	0	2,072
	447	Wholesale Trade	12,591	75,545	37,772	0	125,908
	482	Miscellaneous Repair Shops	14,118	28,235	4,706	0	47,059
		TOTAL	**29,919**	**160,905**	**404,378**	**192,512**	**787,715**
North Slope Camp Support	050	New Utility Structures	391,686	125,340	0	5,222	522,249
	349	Service Industry Machines, N.E.C.	0	1,267	17,744	6,337	25,349
	355	Transformers	0	1,861	26,051	9,304	37,216
	356	Switchgear	0	1,861	26,051	9,304	37,216
	357	Motors and Generators	0	9,388	131,438	46,942	187,768
	359	Relays	0	1,861	26,051	9,304	37,216
	360	Electrical Apparatus, NEC	0	1,861	26,051	9,304	37,216
	368	Wiring Devices	0	1,861	26,051	9,304	37,216
	433	Railroads and Related Services	0	763	442	0	1,205
	435	Motor Freight Transportation and Warehousing	600	1,535	442	0	2,577
	436	Water Transportation	0	1,314	735	0	2,049
	437	Air Transportation	329	795	321	0	1,446
	447	Wholesale Trade	8,311	49,864	24,932	0	83,106
	456	Banking	30,813	277,314	308,127	0	616,253
	482	Miscellaneous Repair Shops	9,800	19,600	3,267	0	32,666
		TOTAL	**441,539**	**496,485**	**617,704**	**105,022**	**1,660,750**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit[†] by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
General Personnel Transport	384	Motor Vehicles	0	2	23	8	33
	433	Railroads and Related Services	0	2	0	0	3
	435	Motor Freight Transportation and Warehousing	3	10	0	0	13
	436	Water Transportation	0	2	0	0	3
	437	Air Transportation	1	2	0	0	3
	447	Wholesale Trade	1	7	3	0	11
	482	Miscellaneous Repair Shops	8	15	3	0	26
		TOTAL	**13**	**40**	**30**	**8**	**91**
Construct Ice Road	215	Tires and Inner Tubes	0	1	14	5	20
	251	Mineral Wool	0	76	1,060	379	1,514
	284	Fabricated Plate Work	0	231	3,240	1,157	4,628
	287	Fabricated Metal Buildings	0	147	73	73	293
	308	Internal Combustion Engines	0	0	91	0	91
	311	Construction Machinery and Equipment	0	857	12,003	4,287	17,147
	312	Mining Machinery, Except Oil Field	0	232	3,253	1,162	4,648
	317	Industrial Trucks and Tractors	0	622	8,706	3,109	12,437
	332	Pumps and Compressors	0	253	3,545	1,266	5,065
	352	Fluid Power Pumps and Motors	0	201	2,808	1,003	4,012
	357	Motors and Generators	0	36	499	178	714
	384	Motor Vehicles	0	135	1,897	677	2,709
	386	Motor Vehicle Parts and Accessories	0	99	1,389	496	1,984
	399	Transportation Equipment, N.E.C.	0	191	0	10	201
	433	Railroads and Related Services	0	4,861	539	0	5,400
	435	Motor Freight Transportation and Warehousing	1,575	4,427	496	0	6,498
	436	Water Transportation	0	3,173	1,435	0	4,608
	437	Air Transportation	184	488	109	0	781
	447	Wholesale Trade	1,563	9,380	4,690	0	15,633
	482	Miscellaneous Repair Shops	8,877	17,754	2,959	0	29,590
		TOTAL	**12,200**	**43,164**	**48,806**	**13,803**	**117,973**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Construct Ice Island	215	Tires and Inner Tubes	0	0	2	1	3
	251	Mineral Wool	0	50	702	251	1,002
	284	Fabricated Plate Work	0	271	3,794	1,355	5,419
	287	Fabricated Metal Buildings	0	147	73	73	293
	308	Internal Combustion Engines	0	0	118	0	118
	311	Construction Machinery and Equipment	0	366	5,124	1,830	7,320
	312	Mining Machinery, Except Oil Field	0	22	310	111	443
	317	Industrial Trucks and Tractors	0	750	10,501	3,750	15,001
	332	Pumps and Compressors	0	297	4,152	1,483	5,931
	352	Fluid Power Pumps and Motors	0	27	383	137	547
	357	Motors and Generators	0	36	499	178	714
	384	Motor Vehicles	0	54	759	271	1,084
	386	Motor Vehicle Parts and Accessories	0	39	552	197	789
	399	Transportation Equipment, N.E.C.	0	191	0	10	201
	433	Railroads and Related Services	0	4,251	429	0	4,679
	435	Motor Freight Transportation and Warehousing	1,158	3,247	378	0	4,783
	436	Water Transportation	0	2,288	1,134	0	3,422
	437	Air Transportation	131	347	75	0	553
	447	Wholesale Trade	1,118	6,706	3,353	0	11,176
	482	Miscellaneous Repair Shops	6,062	12,124	2,021	0	20,207
		TOTAL	**8,468**	**31,212**	**34,358**	**9,646**	**83,685**
Move Drill Ships and Mobile Bottom Founded Structures	392	Ship Building and Repairing	0	38,723	22,264	15,084	76,070
	393	Boat Building and Repairing	0	5,222	1,393	348	6,963
	433	Railroads and Related Services	0	0	0	0	0
	435	Motor Freight Transportation and Warehousing	0	0	0	0	0
	436	Water Transportation	0	2,650	2,650	0	5,300
	437	Air Transportation	0	0	0	0	0
	447	Wholesale Trade	0	0	0	0	0
	482	Miscellaneous Repair Shops	0	0	0	0	0
		TOTAL	**0**	**46,595**	**26,307**	**15,432**	**88,333**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Operate Exploration Drill Drill Ship in Calm Waters	392	Ship Building and Repairing	0	21,933	5,849	1,462	29,244
	393	Boat Building and Repairing	0	5,222	1,393	348	6,963
	433	Railroads and Related Services	0	0	0	0	0
	435	Motor Freight Transportation and Warehousing	0	0	0	0	0
	436	Water Transportation	0	1,156	1,156	0	2,311
	437	Air Transportation	0	0	0	0	0
	447	Wholesale Trade	0	0	0	0	0
	482	Miscellaneous Repair Shops	0	0	0	0	0
		TOTAL	**0**	**28,311**	**8,397**	**1,810**	**38,519**
Operate Exploration Drill Drill Ship in Rough Waters	392	Ship Building and Repairing	0	60,656	28,113	16,546	105,315
	393	Boat Building and Repairing	0	5,222	1,393	348	6,963
	433	Railroads and Related Services	0	0	0	0	0
	435	Motor Freight Transportation and Warehousing	0	0	0	0	0
	436	Water Transportation	0	3,583	3,583	0	7,167
	437	Air Transportation	0	0	0	0	0
	447	Wholesale Trade	0	0	0	0	0
	482	Miscellaneous Repair Shops	0	0	0	0	0
		TOTAL	**0**	**69,462**	**33,089**	**16,894**	**119,444**
Operate Mobile Bottom Founded Structure for Exploration	392	Ship Building and Repairing	0	46,217	12,324	3,081	61,622
	393	Boat Building and Repairing	0	7,833	2,089	522	10,444
	433	Railroads and Related Services	0	0	0	0	0
	435	Motor Freight Transportation and Warehousing	0	0	0	0	0
	436	Water Transportation	0	2,300	2,300	0	4,600
	437	Air Transportation	0	0	0	0	0
	447	Wholesale Trade	0	0	0	0	0
	482	Miscellaneous Repair Shops	0	0	0	0	0
		TOTAL	**0**	**56,350**	**16,713**	**3,603**	**76,667**
Helicopter Support	389	Aircraft	0	20	342	40	402
	433	Railroads and Related Services	0	1	1	0	3
	435	Motor Freight Transportation and Warehousing	1	1	1	0	3
	436	Water Transportation	0	1	1	0	3
	437	Air Transportation	1	1	1	0	3
	447	Wholesale Trade	5	32	16	0	53
	456	Banking	13	117	131	0	261
	482	Miscellaneous Repair Shops	65	130	22	0	216
		TOTAL	**85**	**304**	**515**	**40**	**944**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit[†] by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Barge Support	251	Mineral Wool	0	0	0	0	1
	311	Construction Machinery and Equipment	0	5	69	25	98
	386	Motor Vehicle Parts and Accessories	0	0	1	0	1
	392	Ship Building and Repairing	0	85	1,191	425	1,702
	433	Railroads and Related Services	0	6	3	0	9
	435	Motor Freight Transportation and Warehousing	3	8	3	0	14
	436	Water Transportation	0	14	7	0	21
	437	Air Transportation	0	0	0	0	1
	447	Wholesale Trade	38	227	113	0	378
	482	Miscellaneous Repair Shops	138	276	46	0	459
		TOTAL	**179**	**621**	**1,434**	**451**	**2,685**
Drill Exploration Well	311	Construction Machinery and Equipment	0	181	2,536	906	3,623
	313	Oil Field Machinery	0	7,931	111,036	39,656	158,622
	317	Industrial Trucks and Tractors	0	104	1,454	519	2,078
	384	Motor Vehicles	0	29	413	147	590
	433	Railroads and Related Services	0	2,271	740	0	3,011
	435	Motor Freight Transportation and Warehousing	1,249	3,304	740	0	5,294
	436	Water Transportation	0	3,901	1,502	0	5,403
	437	Air Transportation	616	1,176	1,122	0	2,915
	447	Wholesale Trade	938	5,629	2,815	0	9,382
	456	Banking	8,024	72,219	80,244	0	160,487
	482	Miscellaneous Repair Shops	52,349	104,698	17,450	0	174,497
		TOTAL	**63,177**	**201,445**	**220,052**	**41,228**	**525,902**
Drill Production Well	311	Construction Machinery and Equipment	0	60	845	302	1,208
	313	Oil Field Machinery	0	2,644	37,012	13,219	52,874
	317	Industrial Trucks and Tractors	0	35	485	173	693
	384	Motor Vehicles	0	10	138	49	197
	433	Railroads and Related Services	0	757	247	0	1,004
	435	Motor Freight Transportation and Warehousing	416	1,101	247	0	1,765
	436	Water Transportation	0	1,300	501	0	1,801
	437	Air Transportation	205	392	374	0	972
	447	Wholesale Trade	313	1,876	938	0	3,127
	456	Banking	2,675	24,073	26,748	0	53,496
	482	Miscellaneous Repair Shops	17,450	34,899	5,817	0	58,166
		TOTAL	**21,059**	**67,148**	**73,351**	**13,743**	**175,301**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Well Workover	313	Oil Field Machinery	0	288	4,037	1,442	5,768
	433	Railroads and Related Services	0	87	29	0	117
	435	Motor Freight Transportation and Warehousing	50	131	29	0	210
	436	Water Transportation	0	154	61	0	216
	437	Air Transportation	24	45	47	0	116
	447	Wholesale Trade	22	134	67	0	223
	456	Banking	195	1,753	1,948	0	3,896
	482	Miscellaneous Repair Shops	1,456	2,911	485	0	4,852
		TOTAL	**1,747**	**5,504**	**6,703**	**1,442**	**15,396**
Construct Gravel Island (Place Gravel)	251	Mineral Wool	0	86	1,207	431	1,725
	311	Construction Machinery and Equipment	0	3,404	47,656	17,020	68,080
	317	Industrial Trucks and Tractors	0	2,524	35,342	12,622	50,489
	386	Motor Vehicle Parts and Accessories	0	164	2,290	818	3,272
	433	Railroads and Related Services	0	2,304	1,311	0	3,615
	435	Motor Freight Transportation and Warehousing	1,503	3,670	1,397	0	6,570
	436	Water Transportation	0	3,779	2,857	0	6,635
	437	Air Transportation	263	716	121	0	1,100
	447	Wholesale Trade	2,919	17,513	8,757	0	29,189
	482	Miscellaneous Repair Shops	11,609	23,218	3,870	0	38,696
		TOTAL	**16,293**	**57,378**	**104,809**	**30,891**	**209,371**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Construct Gravel Island (Protect Island)	251	Mineral Wool	0	43	599	214	856
	284	Fabricated Plate Work	0	56	785	280	1,121
	311	Construction Machinery and Equipment	0	5,594	83,294	22,993	111,882
	312	Mining Machinery, Except Oil Field	0	1,018	14,257	5,092	20,367
	317	Industrial Trucks and Tractors	0	264	3,690	1,318	5,272
	324	Welding Apparatus	0	57	796	284	1,137
	332	Pumps and Compressors	0	63	886	317	1,266
	357	Motors and Generators	0	63	878	313	1,254
	384	Motor Vehicles	0	231	3,235	1,155	4,621
	386	Motor Vehicle Parts and Accessories	0	81	1,136	406	1,623
	433	Railroads and Related Services	0	3,000	1,181	0	4,182
	435	Motor Freight Transportation and Warehousing	1,627	4,126	1,260	0	7,013
	436	Water Transportation	0	3,549	2,526	0	6,076
	437	Air Transportation	350	966	139	0	1,455
	447	Wholesale Trade	3,445	20,668	10,334	0	34,446
	482	Miscellaneous Repair Shops	12,948	25,896	4,316	0	43,160
		TOTAL	**18,370**	**65,675**	**129,312**	**32,373**	**245,729**
Install Production Module	251	Mineral Wool	0	20	279	99	398
	282	Fabricated Structural Metal	1,150	1,150	0	0	2,300
	311	Construction Machinery and Equipment	0	4,504	63,054	22,519	90,077
	317	Industrial Trucks and Tractors	0	1,417	19,833	7,083	28,333
	324	Welding Apparatus	0	227	3,183	1,137	4,547
	384	Motor Vehicles	0	70	978	349	1,397
	386	Motor Vehicle Parts and Accessories	0	38	528	189	755
	433	Railroads and Related Services	0	1,782	1,097	0	2,879
	435	Motor Freight Transportation and Warehousing	1,156	2,724	1,242	0	5,122
	436	Water Transportation	0	3,286	2,357	0	5,643
	437	Air Transportation	208	549	125	0	883
	447	Wholesale Trade	2,977	17,865	8,932	0	29,774
	482	Miscellaneous Repair Shops	12,262	24,523	4,087	0	40,872
		TOTAL	**17,754**	**58,154**	**105,695**	**31,377**	**212,979**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Operate Production Island	251	Mineral Wool	0	25	350	125	500
	311	Construction Machinery and Equipment	0	2,359	33,025	11,795	47,179
	384	Motor Vehicles	0	361	5,049	1,803	7,213
	386	Motor Vehicle Parts and Accessories	0	47	663	237	947
	433	Railroads and Related Services	0	1,255	557	0	1,812
	435	Motor Freight Transportation and Warehousing	914	2,381	602	0	3,898
	436	Water Transportation	0	1,838	1,154	0	2,992
	437	Air Transportation	180	489	86	0	755
	447	Wholesale Trade	1,335	8,008	4,004	0	13,346
	482	Miscellaneous Repair Shops	5,186	10,373	1,729	0	17,288
		TOTAL	**7,615**	**27,136**	**47,219**	**13,960**	**95,930**
Construct Trenched Offshore Pipeline	251	Mineral Wool	0	52	734	262	1,049
	282	Fabricated Structural Metal	1,050	0	0	0	1,050
	284	Fabricated Plate Work	0	15	212	76	303
	287	Fabricated Metal Buildings	0	880	440	440	1,760
	311	Construction Machinery and Equipment	0	3,858	54,018	19,292	77,168
	317	Industrial Trucks and Tractors	0	207	2,899	1,035	4,142
	324	Welding Apparatus	0	971	13,600	4,857	19,429
	331	Special Industry Machinery, N.E.C.	0	324	4,533	1,619	6,476
	357	Motors and Generators	0	130	1,821	651	2,602
	369	Lighting Fixtures and Equipment	0	46	648	231	925
	384	Motor Vehicles	0	42	590	211	843
	386	Motor Vehicle Parts and Accessories	0	99	1,393	497	1,990
	399	Transportation Equipment, N.E.C.	0	572	0	30	602
	433	Railroads and Related Services	0	1,734	991	0	2,725
	435	Motor Freight Transportation and Warehousing	1,276	3,257	954	0	5,488
	436	Water Transportation	0	3,176	2,118	0	5,294
	437	Air Transportation	145	397	65	0	608
	447	Wholesale Trade	2,733	16,398	8,199	0	27,331
	482	Miscellaneous Repair Shops	10,756	21,513	3,585	0	35,855
		TOTAL	**15,961**	**53,674**	**96,802**	**29,202**	**195,638**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit[†] by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Construct Onshore Pipeline	251	Mineral Wool	0	26	367	131	524
	284	Fabricated Plate Work	0	15	212	76	303
	287	Fabricated Metal Buildings	0	880	440	440	1,760
	311	Construction Machinery and Equipment	0	2,007	28,097	10,035	40,138
	312	Mining Machinery, Except Oil Field	0	312	4,362	1,558	6,232
	317	Industrial Trucks and Tractors	0	122	1,703	608	2,433
	324	Welding Apparatus	0	486	6,800	2,429	9,714
	331	Special Industry Machinery, N.E.C.	0	162	2,267	810	3,238
	357	Motors and Generators	0	130	1,821	651	2,602
	369	Lighting Fixtures and Equipment	0	23	324	116	463
	384	Motor Vehicles	0	36	506	181	723
	386	Motor Vehicle Parts and Accessories	0	50	696	249	995
	399	Transportation Equipment, N.E.C.	0	572	0	30	602
	433	Railroads and Related Services	0	1,037	576	0	1,613
	435	Motor Freight Transportation and Warehousing	798	2,059	558	0	3,416
	436	Water Transportation	0	2,006	1,248	0	3,254
	437	Air Transportation	83	223	45	0	350
	447	Wholesale Trade	1,601	9,607	4,804	0	16,012
	482	Miscellaneous Repair Shops	6,395	12,790	2,132	0	21,317
		TOTAL	**8,877**	**32,542**	**56,958**	**17,312**	**115,690**
Lay Seafloor Tie-back Pipeline	251	Mineral Wool	0	16	220	79	315
	311	Construction Machinery and Equipment	0	5,815	94,492	15,993	116,300
	317	Industrial Trucks and Tractors	0	63	876	313	1,251
	384	Motor Vehicles	0	87	1,214	434	1,734
	386	Motor Vehicle Parts and Accessories	0	30	418	149	597
	392	Ship Building and Repairing	0	7,386	1,970	492	9,848
	393	Boat Building and Repairing	0	1,763	470	118	2,350
	433	Railroads and Related Services	0	1,451	893	0	2,344
	435	Motor Freight Transportation and Warehousing	1,047	2,581	935	0	4,564
	436	Water Transportation	0	2,754	2,180	0	4,934
	437	Air Transportation	252	707	80	0	1,038
	447	Wholesale Trade	2,706	16,234	8,117	0	27,057
	482	Miscellaneous Repair Shops	8,789	17,578	2,930	0	29,296
		TOTAL	**12,794**	**56,463**	**114,795**	**17,577**	**201,628**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit[†] by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total
Land Base Operations	251	Mineral Wool	0	300	4,196	1,499	5,994
	311	Construction Machinery and Equipment	0	9,204	128,853	46,019	184,076
	315	Conveyors and Conveying Equipment	0	1,099	15,381	5,493	21,972
	316	Hoists, Cranes, and Monorails	0	2,197	30,761	10,986	43,944
	317	Industrial Trucks and Tractors	2,444	5,455	42,145	15,052	65,096
	384	Motor Vehicles	0	5,596	78,339	27,978	111,914
	386	Motor Vehicle Parts and Accessories	0	568	7,958	2,842	11,369
	387	Truck Trailers	0	560	7,839	2,800	11,198
	433	Railroads and Related Services	0	33,214	4,392	0	37,606
	435	Motor Freight Transportation and Warehousing	10,466	28,719	4,463	0	43,647
	436	Water Transportation	0	22,105	12,724	0	34,829
	437	Air Transportation	1,237	3,359	586	0	5,182
	447	Wholesale Trade	12,136	72,814	36,407	0	121,357
	482	Miscellaneous Repair Shops	41,045	82,089	13,682	0	136,815
		TOTAL	**67,327**	**267,278**	**387,726**	**112,669**	**835,000**
Spill Contingency	219	Fabricated Rubber Products, N.E.C.	0	17,747	0	0	17,747
	338	General Industrial Machinery, N.E.C.	0	189,400	0	0	189,400
	392	Ship Building and Repairing	0	46,300	0	0	46,300
	393	Boat Building and Repairing	0	42,947	0	0	42,947
	433	Railroads and Related Services	0	0	0	0	0
	435	Motor Freight Transportation and Warehousing	1,354	4,063	0	0	5,417
	436	Water Transportation	0	300	0	0	300
	437	Air Transportation	76	228	0	0	305
	447	Wholesale Trade	1,592	9,550	4,775	0	15,917
	482	Miscellaneous Repair Shops	0	0	0	0	0
		TOTAL	**3,022**	**310,535**	**4,775**	**0**	**318,332**

APPENDIX TABLE A-6

Capital Expenditures Per Activity Unit† by Activity, Region and IMPLAN Sector

Activity	IMPLAN Sector	Description	NSB	Other AK	Other US	Foreign	Total

†Activity Units

Activity	*Units*	*Units Per Year*
Barge Support	1 Day	120
Camp Support	1 Year	1
Drill Ship – Calm Water	1 Day	270
Drill Ship – Rough Water	1 Day	270
Equip Production Island	1 Island	1
Exploration Well	1 Well	3
Gravel Island	1 Island	1
Helicopter Support	1 Day	365
Ice Island	1 Island	1
Ice Road	10-Miles	1
Land Base Operations	1 Year	1

Activity	*Units*	*Units Per Year*
Mobile Bottom Founded Structure	1 Day	270
Move Platform	1 Day	270
Offshore Pipeline	1 Mile	1
Onshore Pipeline	1 Mile	1
Personnel Transport	1 Day	365
Production Operations	1 Year	1
Production Well	1 Well	9
Seafloor Tieback Pipeline	10 Miles	1
Seismic Survey	1 Month	4
Spill Contingency	1 Year	1
Well Work-over	1 Well	30

APPENDIX B: TOTAL REQUIREMENTS

Exhibit B-1 summarizes total per unit costs by activity and region. Please note that due to the way in which the vectors were constructed, such totals are not directly comparable to cost estimates obtained outside of this effort. For example, JFA developed cost vectors for camp support, personnel transport and other secondary activities separately from those developed for the main activity vectors in IMPAK. Such expenditures, however, are likely to be incorporated in outside cost estimates of these main activities. To corroborate the results produced by the model, the user is advised to draw upon the "TotalExpenditure" graph in the model. This graphic presents the temporal profile of total expenditures required for a given E&D scenario. Taking into account differences in activity levels and combining various units of analysis, this aggregate estimate will be more accurate and more readily comparable to outside estimates than IMPAK's per-unit estimates at the activity level. Note that the totals in the graph do exclude foreign purchases, which are assumed to be a relatively small percent of total expenditures.

The table does not provide savings and government tax revenues per activity unit. IMPAK estimates these figures based upon total activity levels, as opposed to a per-unit basis. For a given E&D scenario, savings can be obtained on the output screen for each region. NSB Government Revenues are presented on the NSBLocalOutput screen and the accompanying graph (NSBGovRevenueGraph).

In Exhibit B-2, domestic business expenditures are itemized by activity, region, major cost category (e.g., capital, labor and materials), and IMPLAN sector.

Appendix Table B-1: Expenditures Per Activity Unit† by Region and Activity

	NSB Local				NSB Oil Economy				Alaska				US				Total				
Activity	Intermediate Purchases	Personal Consumption Expenditures	Total Expenditures	Total Personal Income	Intermediate Purchases	Personal Consumption Expenditures	Total Expenditures	Total Personal Income	Intermediate Purchases	Personal Consumption Expenditures	Total Expenditures	Total Personal Income	Intermediate Purchases	Personal Consumption Expenditures	Total Expenditures	Total Personal Income	Foreign Purchases	Domestic Intermediate Purchases	Personal Consumption Expenditures	Total Expenditures	Total Personal Income
Seismic Survey	0	82,915	82,915	119,576	257,086	n.a.	257,086	n.a.	395,609	568,698	964,307	698,413	640,751	129,910	770,660	165,059	192,512	1,293,446	781,522	2,267,481	983,047
Construct Ice Island	0	70,684	70,684	106,180	77,691	n.a.	77,691	n.a.	117,891	270,115	388,006	321,749	141,143	58,975	200,118	74,932	9,646	336,725	399,774	746,145	502,860
Drill Exploration Well	0	192,274	192,274	265,489	410,803	n.a.	410,803	n.a.	1,361,459	1,802,404	3,163,864	2,236,442	1,158,262	558,713	1,716,975	709,882	340,703	2,930,524	2,553,391	5,824,619	3,211,813
Construct Gravel Island (Place Gravel)	0	178,288	178,288	247,552	464,539	n.a.	464,539	n.a.	617,352	1,786,355	2,403,707	2,219,673	730,976	316,578	1,047,555	402,234	30,891	1,812,867	2,281,220	4,124,979	2,869,460
Construct Gravel Island (Protect Island)	0	663,348	663,348	967,990	1,256,428	n.a.	1,256,428	n.a.	2,467,687	4,146,451	6,614,138	5,072,791	3,064,996	730,412	3,795,408	928,037	32,373	6,789,111	5,540,211	12,361,694	6,968,818
Install Production Modules	0	1,015,493	1,015,493	1,455,581	953,510	n.a.	953,510	n.a.	48,021,889	7,388,568	55,410,457	9,093,616	39,777,715	1,727,423	41,505,138	2,194,807	18,024,037	88,753,114	10,131,483	116,908,634	12,744,004
Drill Production Well	0	64,091	64,091	88,496	143,916	n.a.	143,916	n.a.	663,670	600,801	1,264,472	745,481	598,445	186,238	784,683	236,627	313,218	1,406,031	851,130	2,570,380	1,070,604
Operate Production Island	0	1,068,869	1,068,869	1,491,738	910,130	n.a.	910,130	n.a.	6,772,857	9,792,204	16,565,061	12,140,293	5,303,772	2,337,250	7,641,022	2,969,633	13,960	12,986,759	13,198,323	26,199,042	16,601,664
Construct Trenched Offshore Pipeline	0	241,980	241,980	326,714	665,558	n.a.	665,558	n.a.	2,655,047	2,766,121	5,421,168	3,448,540	5,946,749	670,592	6,617,341	852,032	1,145,777	9,267,354	3,678,693	14,091,823	4,627,286
Construct Onshore Pipeline	0	138,831	138,831	187,134	712,874	n.a.	712,874	n.a.	5,256,116	1,602,538	6,858,654	1,998,328	6,135,241	388,739	6,523,980	493,919	1,248,662	12,104,231	2,130,108	15,483,001	2,679,381
Well Workover	0	8,546	8,546	11,800	11,328	n.a.	11,328	n.a.	48,787	80,107	128,894	99,397	35,863	24,832	60,694	31,550	1,442	95,977	113,484	210,903	142,747
Landbase Operations	0	4,991,181	4,991,181	7,022,709	24,748,277	n.a.	24,748,277	n.a.	14,873,982	42,727,940	57,601,922	52,869,994	17,561,084	10,337,770	27,898,854	13,134,832	112,669	57,183,343	58,056,891	115,352,903	73,027,535
Spill Contingency Operations	0	947,046	947,046	1,313,535	597,935	n.a.	597,935	n.a.	3,298,617	9,084,877	12,383,493	11,277,586	3,354,810	2,176,132	5,530,942	2,764,922	0	7,251,362	12,208,054	19,459,416	15,356,043
Abandonment	0	1,180,811	1,180,811	1,669,396	756,918	n.a.	756,918	n.a.	1,988,418	9,747,470	11,735,887	12,047,565	1,686,700	2,306,384	3,993,084	2,930,417	74,634	4,432,035	13,234,665	17,741,334	16,647,377
Construct Ice Road	0	111,273	111,273	166,518	124,067	n.a.	124,067	n.a.	190,755	456,590	647,346	546,489	230,694	101,308	332,002	128,719	13,803	545,516	669,172	1,228,491	841,725
Helicopter Support	0	216	216	294	1,029	n.a.	1,029	n.a.	1,094	2,595	3,689	3,238	997	311	1,308	395	40	3,120	3,122	6,282	3,927
Barge Support	0	103	103	139	589	n.a.	589	n.a.	1,532	1,265	2,798	1,580	2,483	225	2,708	285	451	4,604	1,593	6,648	2,004
Calm Water Drill Ship	0	1,221	1,221	1,682	5,846	n.a.	5,846	n.a.	40,830	12,309	53,139	15,300	14,628	2,959	17,587	3,760	1,829	61,303	16,489	79,621	20,741
Rough Water Drill Ship	0	5,679	5,679	7,814	39,507	n.a.	39,507	n.a.	97,266	57,616	154,883	71,627	56,692	13,857	70,550	17,607	16,969	193,466	77,153	287,588	97,047
Operate MBFS	0	1,173	1,173	1,615	33,602	n.a.	33,602	n.a.	169,386	11,859	181,245	14,741	33,592	2,852	36,444	3,623	3,622	236,580	15,884	256,086	19,980
Lay Seafloor Tie-back Pipeline	0	308,080	308,080	398,676	3,072,087	n.a.	3,072,087	n.a.	4,969,855	4,384,947	9,354,801	5,490,829	6,499,734	1,076,094	7,575,828	1,367,250	1,136,913	14,541,676	5,769,121	21,447,709	7,256,756
Move Drill Ship/MBFS	0	5,679	5,679	7,814	3,664	n.a.	3,664	n.a.	136,524	57,616	194,140	71,627	47,695	13,857	61,553	17,607	15,507	187,883	77,153	280,543	97,047
General Personnel Transport	0	289	289	412	405	n.a.	405	n.a.	859	1,988	2,846	2,443	581	715	1,296	909	8	1,844	2,992	4,845	3,764
Camp Support	0	294,470	294,470	423,462	2,375,646	n.a.	2,375,646	n.a.	2,127,194	2,166,118	4,293,312	2,666,651	1,886,908	390,885	2,277,793	496,646	105,022	6,389,748	2,851,473	9,346,243	3,586,758
NSB Government	0.52	0.27	0.79	0.30	0.00	n.a.	0.00	n.a.	0.09	0.03	0.12	0.00	0.09	0.00	0.09	0.00	0.00	0.70	0.30	1.00	0.30
Alaska State Government	0.00	0.00	0.00	0.00	0.00	n.a.	0.00	n.a.	0.61	0.30	0.91	0.30	0.09	0.00	0.09	0.00	0.00	0.70	0.30	1.00	0.30
Federal Government	0.00	0.00	0.00	0.00	0.00	n.a.	0.00	n.a.	0.00	0.00	0.00	0.00	0.70	0.30	1.00	0.30	0.00	0.70	0.30	1.00	0.30
TAPS	0	0	0	0	0.1	n.a.	0	n.a.	1	0	0.9	0	0	0	0	0	0	1	0	1	0
Purchase MBFS	0	0	0	0	0	n.a.	0	n.a.	168,150,000	0	168,150,000	0	44,840,000	0	44,840,000	0	23,010,000	212,990,000	0	236,000,000	0

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†Activity Units

Activity	*Units*	*Units Per Year*
Barge Support	1 Day	120
Camp Support	1 Year	1
Drill Ship – Calm Water	1 Day	270
Drill Ship – Rough Water	1 Day	270
Equip Production Island	1 Island	1
Exploration Well	1 Well	3
Gravel Island	1 Island	1
Helicopter Support	1 Day	365
Ice Island	1 Island	1
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Activity	*Units*	*Units Per Year*
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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.