ARCTIC IMPAK MODEL DOCUMENTATION

Welcome to Arctic IMPAK! This document 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. For detailed information on how the model was developed, refer to:

> *Arctic Economic Impact Model for Petroleum Activities in Alaska (Arctic IMPAK), Final Technical Report*, December 20002 (OCS Study MMS 2001-066, Technical Report No. 164). Prepared by Jack Faucett Associates for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Region, Anchorage, Alaska.

This document is accessible through a hyperlink on IMPAK's Documentation screen. It is also available to the public through the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, Fax: 703-605-6900, www.ntis.gov.

For technical assistance, please contact

Kim Coffman, Leasing Division, 703-787-122
Tim Holder, Alaska OCS Regional Office, 907-271-6625
U.S. Minerals Management Service

Or

Jonathan Skolnik or Chris Holleyman
Jack Faucett Associates, Inc.
4550 Montgomery Avenue
Suite 300 North
Bethesda, MD 20814
301-961-8800

ARCTIC IMPAK MODEL DOCUMENTATION

CONTENTS

I. OVERVIEW 3
II. INSTALLATION 6
III. USER INTERFACE 7
- III.A Documentation Screen 7
- III.B Model Setup Screen 7
- III.C Data Entry 15
- III.D Output Screens 16
- III.E Manpower Graph 17

IV. MODEL PROCESSING ENGINE 18
- IV.A Conversion of Data Entry Input into IMPAK Activity Levels 18
- IV.B Generation of Model Output 26

V. LOCAL GAS PROCESSING 27

ARCTIC IMPAK MODEL DOCUMENTATION

I. OVERVIEW

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 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.

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.

Costs are provided in 1999 dollars.

Exhibit 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

Activity	***Unit***
Seismic Survey	1 Month
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

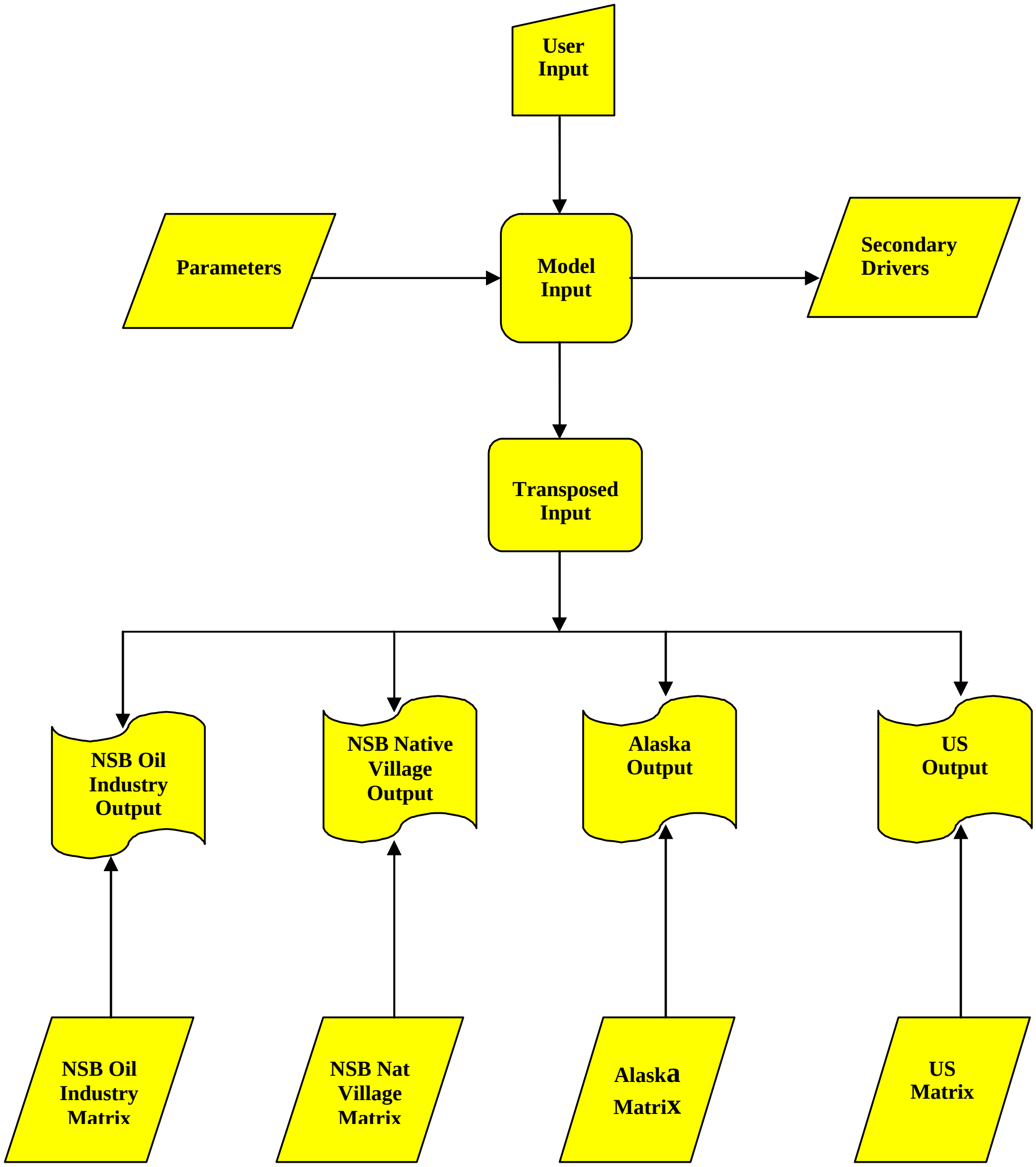
The user is required to input some general data that describe a particular E&D scenario being evaluated. To make things easy for the user, most of these data can be obtained from MMS' E&D reports. These reports are prepared by MMS staff and describe any given proposed lease sale.

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 areas where the associated economic impacts accrue. Four regions are utilized: the North Slope Borough oil industry, 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 2.

Exhibit 2


User Input
Parameters
Model Input
Secondary Drivers
Transposed Input
NSB Oil Industry Output
NSB Native Village Output
Alaska Output
US Output
NSB Oil Industry Matrix
NSB Nat Village Matrix
Alaska MatriX
US Matrix

ARCTIC IMPAK MODEL DOCUMENTATION

II. 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.

III. 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.

III.A 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.

III.B 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.

Edit Model Parameters

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.

III.C Data Entry

The Data Entry screen presents the user with a table organized by year and E&D activity. Shown below in Exhibit 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 1. Through a number of formulas, the data entered by the user are converted into quantities that correspond to the activities defined in the Exhibit 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 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[1]	(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 $)

III.D Output Screens

[1] 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.

III.E 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.

IV. MODEL PROCESSING ENGINE

IV.A 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.

Drill Exploration Well: 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.

Place Gravel (Island): 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.

Protect Gravel Island: 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.

IV.B 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".

V. 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 Sound 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 Slope[2]. 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.

[2] *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.