

A DIGITAL DATA BASE FOR THE  
NATIONAL PETROLEUM RESERVE IN ALASKA

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ABSTRACT

The Bureau of Land Management (BLM) has the responsibility to prepare environmental assessments and environmental impact statements in support of the upland oil and gas leasing program on public lands. One of the first areas being leased in Alaska is the 23.5 million acre National Petroleum Reserve in Alaska (NPR-A). A digital data base has been prepared for NPR-A. This digital base includes landcover, elevation, slope, aspect, NPR-A administrative boundary, 1:250,000 scale quadrangle boundaries, 8 lease study areas and 124 lease sale blocks. The landcover information is from classified Landsat data; terrain data are derived from digital elevation models; and boundaries are digitized from map bases. When making decisions to approve, disapprove or modify oil and gas activities in NPR-A, BLM is required by law to mitigate "reasonably foreseeable and significantly adverse effects" on surface values. A digital data base allows the resource specialist or land manager to foresee conflicts by analyzing the characteristics of an area which may experience oil and gas operations. Data of interest can be displayed in map or tabular format. The digital data base for NPR-A has been used in the preparation of the environmental assessment, evaluation of lease study areas, characterization of potential lease sale blocks, wildlife habitat analysis, road suitability, winter trail route selection, water supply for potential drilling sites, and viewshed analysis.

INTRODUCTION AND BACKGROUND

The Naval Petroleum Reserve Number 4 (Pet 4) was created by executive order in 1923 by President Harding. The purpose of this large reserve was to protect and retain as a national asset a potential petroleum supply for the Navy. Under Naval jurisdiction, geological and geophysical mapping and surveying was conducted by the U.S. Geological Survey (USGS) from 1923 to 1956. The Naval Petroleum Reserve Production Act of 1976 designated Pet 4 as the National Petroleum Reserve in Alaska (NPR-A) and transferred the area to the jurisdiction of the Department of the Interior. This act (Section 104(d)) authorized further exploratory drilling and seismic exploration under USGS supervision. The Act specified several areas of concern for subsistence, recreation, fish, and wildlife. Section 105 authorized a task force study to evaluate the overall resources and best uses for the land of NPR-A. This study was submitted to Congress in 1979 (U.S.D.I. 1979).

The Department of Interior's Fiscal Year 1981 Appropriations Act authorized the Bureau of Land Management (BLM) to lease up to two million acres by competitive bidding procedures. An environmental impact statement was not required for the leasing process for the first sales. BLM has prepared an environmental assessment as an aid for identifying sensitive areas and selecting lease sale blocks. A total of 4.5 million acres were offered for lease in the first two lease sales on January 27, 1982 and May 26, 1982. About one million acres were leased as a result of those sales. Further leasing in NPR-A is subject to completion of an environmental impact statement, of which the draft will be released in October 1982.

BLM has the responsibility for determining which lands will be offered for competitive sale, but subsequent management of the leasehold is done in concert with the Onshore Division of Minerals Management Service (MMS). The MMS is the Department of Interior's authorized representative on all activities associated with drilling and production. BLM authorizes support development, rights-of-ways, airstrips, camps, etc., which are ancillary to drilling activities. Surface management ultimately requires a sophisticated data base for the preparation of operational stipulations and the evaluation of routine field monitoring.

A decision was made to create a digital data base for NPR-A. The basic elements of the digital data base are landcover, elevation, slope steepness, and aspect. The landcover data were derived from digital analysis of Landsat data which USGS prepared for the Section 105(c) studies. BLM has incorporated digital topographic data with the landcover classification to prepare the digital data base for the 23.5 million acres of NPR-A. Additional data such as quadrangle boundaries, administrative boundaries and seismic trails have been added. This data base allows users to select only the desired set of features and to manipulate them for a wide variety of applications. This paper discusses the components of the digital data base, how the data can be manipulated, and several applications of the data base.

#### STUDY AREA DESCRIPTION

NPR-A is located on the north slope of Alaska (Figure 1) extending from the the crest of the Brooks Range to the Arctic Ocean. It is bounded on the west by 162° W longitude and on the east by the Colville River. It covers portions of three physiographic provinces: the flat Arctic coastal plain, the rolling foothills, and the rugged mountains of the Brooks Range. The area is drained to the north by several large rivers. It covers 23.5 million acres, comparable in size to the State of Virginia.

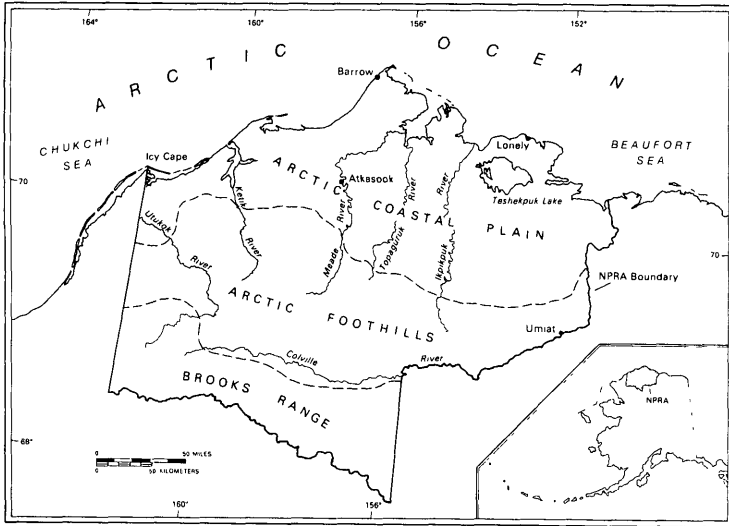


Figure 1. Location of the National Petroleum Reserve in Alaska (adapted from Morrissey and Ennis 1981).

The Arctic coastal area is a flat plain covering approximately one-half of NPR-A. The surface is characterized by thousands of thaw lakes and drained lake basins. There are meandering streams, aeolian dune features and polygonal ground. Polygonal ground is formed by ice wedges which increase in size with every freeze up and push the soil up into small ridges. The landcover is mainly tundra types with scattered brush. Tundra in polygonal ground is dominated by sedges (*Carex* spp. and *Eriophorum* spp.) associated with herbs and ericaceous shrubs and an understory of mosses and lichens. The soil is underlain by continuous permafrost (permanently frozen ground). Much of it is ice rich soil having lenses of pure ice below the surface. A thin layer (0.3-1 m) of surface soil, called the active layer, thaws each summer. Below the active layer, the ground does not thaw.

The foothills, south of the coastal plain, are a region of rolling hills, plateaus and ridges. These features are caused by the thrust faults in the southern foothills and the Colville geosyncline. The landcover of the region is dominated by tussock tundra with tall brush in the drainages and floodplains, and dry tundra or exposed barrens on the windswept ridge tops. Tussock tundra consists of cotton grass (*Eriophorum* spp.) tufts (0.5 - 1.0 m high) with mosses and shrubs. The soils are generally poorly drained and underlain by continuous permafrost.

The Brooks Range Province consists of rugged mountains and glaciated valleys in the southern portion of NPR-A. These mountains are the Alaska portion of the Rocky Mountain Cordillera and have been glaciated. The mountains support a variety of landcover types with alpine tundra and barrens on steep slopes, mesic tundra and tussock tundra on the gentler slopes and valley floors, and high brush along streams and in river flood plains. The soils are generally thin except in morainal deposits, and are permanently frozen. Ice wedge features are not as common as on the coastal plain.

The area has been populated since prehistoric times by Native peoples. They have developed a subsistence life style which is still practiced in the region. Exploration for oil and gas and subsequent developpment of reserves can have many impacts on the people, as well as the land, vegetation and wildlife of NPR-A. There are potentially serious conflicts of this subsistence lifestyle with development impacts. Analysis of prescribed variables by using a geographically referenced data base can be an effective tool to aid managers in designing solutions to minimize such conflicts.

In addition to the socio-economic factors, there are unique problems for engineering and rehabilitation during development. The vegetation and peat mat forms an insulating layer for permafrost soils. When this layer is disturbed, thaw subsidence can result. Once begun, this surface degradation due to thermal erosion is very difficult to stop or stabilize. Measures must be taken during construction to minimize surface disturbance.

#### CREATION AND MANIPULATION OF THE NPR-A DATA BASE

The digital data base for NPR-A was created by specialists within the Bureau of Land Management, Alaska State Office, on the IDIMS computer system at the USGS EROS Field Office in Alaska. The software used (except for the terrain data entry) is available on most IDIMS systems. The data base is manipulated and output products generated on the IDIMS. The data are stored in a tape library for use to meet requests. Some of the data files have been transferred to other computers for analysis not available on IDIMS.

The USGS Geography Program created a digital classification of Landsat data for the entire NPR-A (Morrissey and Ennis 1981). This classification has ten landcover categories. Although regional in scope, it is much more detailed than the vegetation map previously available for NPR-A (Selkregg 1975). This landcover classification was made available to BLM by USGS for incorporation into the digital data base. The other primary data source for the NPR-A data base was digital topographic data produced by the Defense Mapping Agency (DMA). These data are available through the National Cartographic Information Center of USGS. The data are divided into twelve windows, one for each USGS 1:250,000 quadrangle in the study area. This procedure helped reduce the size of images needed for creation and manipulation of

the data base. The data were resampled to 50 m pixels. Each data layer is registered to the map. This results in multiple data layers registered to each other and to a map base.

The landcover data from USGS were originally part of two large images. The data were windowed to quadrangle-sized images and registered to the map base using IDIMS geometric correction procedures. The data were spatially generalized to simulate a ten acre minimum mapping unit for use as landcover maps. Both the original and smoothed data are stored in the data base for each quadrangle. The ten landcover classes in the data set are: deep water, shallow and sedimented water, ice, barrens, wet tundra, mesic tundra, tussock tundra, mixed tundra, fellfield, and high brush. Complete descriptions of these types are in Morrissey and Ennis (1981).

The DMA digital terrain data are recorded as elevation values in one meter increments. The pixel size of the original data was 6 x 3 arc seconds for the southern quadrangles and 9 x 3 arc seconds for the northern quadrangles. The DMA data were in 1 x 1 degree blocks. Three or four blocks of data were mosaiced together to form the quadrangle area. The data were rotated to north, resampled to the 50 m grid and registered to the map. During this work, software was developed at USGS EROS to automatically calculate control points and develop the transformation for registration. This procedure created the elevation data layer for the data base. The registered elevation data then were used to calculate slope steepness and slope aspect. The resulting images were registered to the map base and had 50 m pixels. Slope steepness data are in 1% increments when calculated from elevation. Slope aspect data are in 2° increments, with the 0 and 180 data values at true north.

The digital topographic data are an example of computer processing being able to calculate more detailed data than were in the original data source. The DMA data were digitized from the 1:250,000 topographic maps with 100 foot contours. The digital elevation data have been carefully examined by comparing the map with the video image. The data are adequate for the purposes of this data base to apply to the regional characterization. To avoid pushing the data beyond source accuracy, the topographic data are generalized when being used in manipulations of the data base. The elevation data are used in 25-30 m bands, the slope steepness data in 3-5% units, and the slope aspect data in 3-5° units. These aggregations are based on qualitative evaluations of the data and the regional applications of the data base.

Additional geographic data may be entered into the data set by digitizing from maps. Data which have been incorporated into the NPR-A data base include quadrangle boundaries, the NPR-A boundary, lease study areas and potential lease sale blocks, a winter ice road corridor, and seismic trails. Other data which may be digitized include cultural resource archeologic sites, bear dens, peregrine falcon nests,

caribou calving grounds and migration routes, drill sites, wild and scenic river corridors, potential road and pipeline corridors and land ownership status.

After the data base has been created, each quadrangle section can be manipulated to meet requests. Each data element for each quadrangle is stored as a separate image so that only the data of interest must be put on line for each request. Data base manipulations are accomplished using arithmetic, Boolean, maximum, minimum and mapping functions. Each request is different, requiring a different approach for the manipulation and generation of the output products. A good imagination and knowledge of the programs and data base are requisites for best success in manipulating the data base. After the final image has been achieved, final products such as tables of acreage or feature maps are made using a variety of output devices. Some of the manipulated images can in turn be entered into the data base for additional manipulations.

#### APPLICATIONS OF THE DATA BASE

Continued exploration of NPR-A for oil and gas reserves, and the subsequent development of these reserves, will have varied effects on the land and the people. Many of the issues are complex and intermeshed with other issues. Products from the data base can provide information to assess the effects of development and identify conflicts.

#### Lease Sale Blocks

Prior to preparation of the environmental assessment, 5.8 million acres were selected with the high or moderate potential for oil and gas based on industry nominations. These lands are the lease study areas. The boundaries were digitized into the data base and landcover data extracted for them. The landcover data helped characterize the lease study areas. Landcover maps for each lease study area are in the final environmental assessment (U.S.D.I. 1981). One hundred and twenty four lease sale blocks of approximately 23,000 acres each were selected from the lease study areas for offering at the first two lease sales. Boundaries of the lease sale blocks were digitized. Landcover and slope steepness data were extracted for each block and reformatted to tabular reports. These data characterized the lease sale blocks prior to the sale to private companies. These data may affect which blocks are leased and the offering price based on exploration costs due to steep slopes or wetland areas, or flat terrain, accessibility of surface gravel deposits, and stipulations for use of sensitive areas.

#### View Corridors

The Colville, Etivluk, Nigu, and Utukok rivers are being considered for inclusion in the Wild and Scenic River System. One of the procedures is to establish a view corridor encompassing the area which can be seen from the river. Viewshed images for the entire length of the rivers were created by combining the landcover types of water, barrens, and high brush with elevation data. The willow

(*Salix* spp.) thickets along the river floodplains reach heights of 7 m and are the tallest plants in NPR-A. In areas of high brush, the view from a boat is blocked on that side of the river by the willows. Where no high brush is close to the river, the viewer can see the surrounding terrain. From the elevation data, it can be estimated how far and what features can be seen from various points along the river. This is taken into consideration when planning developments near the river.

### Utility and Transportation Corridors

Development of large oil and gas discoveries in NPR-A will require a network of roads and pipeline corridors. The data base can be used to help select corridors to minimize engineering problems and environmental impacts. Road suitability analysis illustrates this by using slope steepness with other factors as are pertinent such as gravel deposits, water, wetlands or slope aspect. Several potential pipeline corridor routes can be compared with each other. The proposed corridors would be digitized and appropriate data elements extracted for each corridor. The percentage of desirable factors such as gravel sources or gentle terrain can be compared with undesirable factors of steep slopes or wetlands. The corridors can be overlaid with other data combinations such as the viewshed corridors discussed above, wildlife habitat, or privately owned land. These comparison data provide a manager with information to assist in selecting a route. Similar analyses can be done for winter ice roads and rolligon trails.

### Materials Sites

A crucial public issue regarding NPR-A development is gravel. Gravel is needed for development of roads, pipelines, drilling pads, airstrips and camps. Thick pads of gravel are laid down on the tundra so that development activities will not disturb the insulating layer. The gravel pad protects the permafrost soils and prevents thermal erosion. The major source of gravel is the flood plains of large rivers which are part of the barrens type of landcover. Additional known subsurface gravel deposits could be digitized into the data base. These data can be used in siting development camps or evaluating the cost feasibility of developing an oil and gas reserve.

### Water

Water is also needed for winter exploration and development. Although the area abounds with lakes and the soils are saturated, all of the water freezes in winter except in lakes deeper than 2 m. Landcover data and SLAR data (Mellor 1982) can be used to evaluate potential water sources and determine if conflicts exist between fishery and industry needs.

## Wildlife Habitat

Wildlife species, such as caribou, moose, bear, and waterfowl, are an important renewable resource in NPR-A because they are part of the Native subsistence lifestyle. Knowledge of possible locations of critical wildlife habitat can be used to reduce foreseeable impacts when planning and monitoring oil and gas exploration and development activities. One example is spring habitat for moose. Within the context of the digital data base, this habitat has been defined as high brush on south facing slopes. The data manipulation involved several sequential steps. First, the south facing slopes were selected from the aspect data over the area of interest, then brush was pulled out of the landcover data. The two features were combined so that only the areas which had both attributes are shown. All water was added to the image as an aid for location. Since the data were in digital format, it was a simple matter to calculate the acres of each feature and convert to percentage area estimates to present the needed information in tabular format. When habitat is shown with gravel sources, potential conflict areas can be identified when the data is presented in map format.

## Conflict Resolution

Two important types of applications envisioned involve 1) identification of conflict areas and 2) identification of areas for exclusion from a particular activity. Analysis of factors contributing to conflicts between development activities and other resources can enable informed decisions about the conflict, mitigating regulations, or alternatives. Areas which need to be excluded from some development activities may have one or more factors which can be assessed using overlaid data bases. These may include critical wildlife areas, cultural resource sites, or areas with wilderness values. These data can also contribute to design specifications or stipulations for development and rehabilitation.

## SUMMARY AND FUTURE DIRECTIONS

The Bureau of Land Management, Alaska State Office, has created a digital data base for the National Petroleum Reserve in Alaska. The purpose of the data base is to provide a reliable and consistent regional data base in support of: 1) leasing for exploration and development of oil and gas resources in NPR-A, 2) planning, 3) monitoring and 4) day-to-day and long term management. The data base has elements of landcover, elevation, slope steepness, slope aspect, and various geographic and administrative boundaries. This data base is manipulated for a wide variety of applications in NPR-A including the leasing program, development constraints, and conflict identification. The existing data base serves as a framework for the inclusion of other data sets and offers potential for modeling. Data available on other computer systems may be tied in with this data set. Potential data sets are the land net and hydrography in the BLM computer at the Alaska State Office.



Point location data could be digitized. Non-graphic data could be associated with the point data. An example would be archeological sites with dates and materials information. All facets of the expanded data sets could be manipulated with statistical packages. Software needs to be developed to facilitate the exchange of data between computer systems and to allow additional flexibility in manipulation.

At present, creation and manipulation of this data base are done by a BLM staff of remote sensing specialists at the Alaska State Office. Capability of remote terminal access, manipulation, and generation of output products needs to be developed to allow direct accessibility to the data base by BLM staff specialists in the district offices. BLM is creating data bases for other lands in Alaska and a network of remote terminals to query and utilize these data bases will become more important in resource planning and management.

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