



Akutan Harbor Project: Development of a Digital Elevation Model and Topographic Map

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PURPOSE: This is the second of two technical notes describing work done at the request of the Regulatory Branch and Planning Division of the U.S. Army Engineer District, Alaska, as part of a feasibility study for the potential development of a harbor at the head of Akutan Bay on Akutan Island in the Aleutian Island chain. Wakeley, Noble, and Bishop (2001) described the background of the project, alternative harbor designs, vegetation and soils, and the delineation of wetlands on the site. A technical report by Dunbar, Corcoran, and Murphy (2001) gives results of a geologic and hydrologic assessment including the predicted impacts of harbor construction on local groundwater flow and salinity. The purpose of this technical note is to describe the topographic survey that was conducted in support of the aforementioned studies, and the use of those data to develop a digital elevation model and detailed topographic map.

METHODS:

The Proposed Harbor Area. The area for the topographic survey consisted of the broad, relatively flat terrain at the head of Akutan Bay and extended into the uplands beyond the wetland study area (Figure 1). The area was bounded by the bay on the east and by the lower slopes of the hills to the north and south. On the west, the area extended inland approximately 1650 ft (500 m) from the mouth of the south creek and 2000 ft (600 m) from the mouth of the north creek. In the west-central portion of the site, the survey included transects up to an elevation of 150 ft (46 m) msl. The area was approximately 150 acres (60 ha) in size and encompassed all of the proposed alternative designs for Akutan Harbor, its related infrastructure, and access road. Figure 1 shows the outline of one alternative design, developed by Tryck, Nyman, and Hayes, Inc. (TNH), Anchorage, including a 12-acre (5-ha) harbor basin and approximately 55 acres (22 ha) of associated fill.

The Topographic Survey. Topographic survey data and stream cross sections/profiles were collected by Messrs. Thomas Berry and John Newton. The extent of the area to be surveyed was defined using a map prepared at ERDC composed of an aerial photograph georeferenced from a U.S. Geological Survey (USGS) 1:63,360-scale digital raster graphic (DRG) data file. One purpose of the survey was to collect more "calibrated ground truth" for use in correcting the map. This photo-map was initially used to prepare a geographic information system (GIS) database of a classification of the wetland complex using remote sensing techniques. An NAD 83 Universal Transverse Mercator (UTM) grid was superimposed on the photo-map, which was used as a base for all preliminary and on-site planning.

Field Work. Reference positions for use in this survey were obtained from the Tryck Nyman Hayes (TNH) engineering company offices in Anchorage, AK. TNH had previously conducted survey work in the harbor area and had produced a map with a reference grid of six survey markers (pots), State Plane coordinates included. ERDC was furnished with the TNH survey map and coordinates

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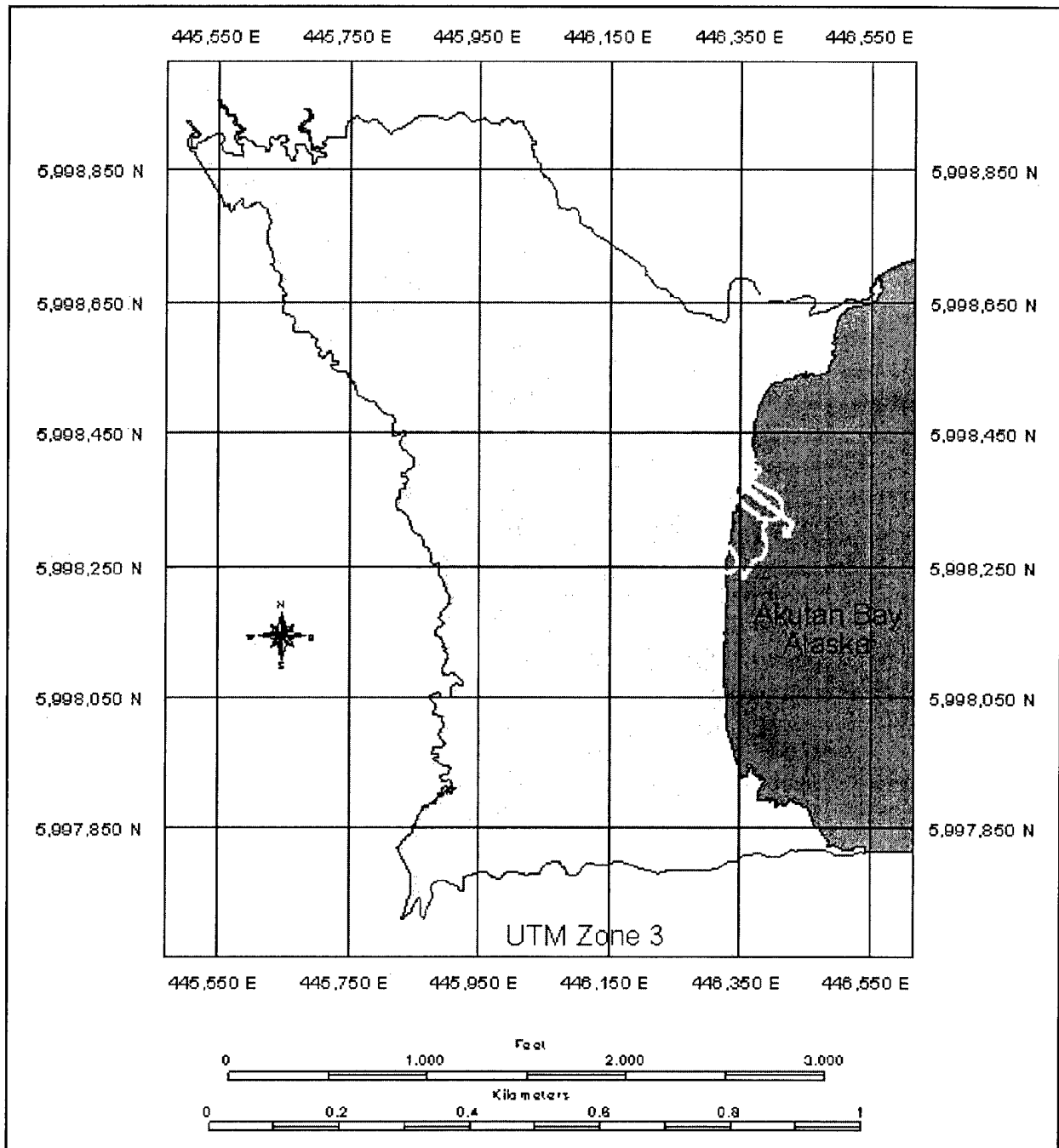


Figure 1. Primary study area (shaded) at the western end of Akutan Bay, Akutan Island, Alaska. The yellow line drawing is the approximate footprint of the latest proposed alternative for Akutan Harbor and associated construction (prepared by Tryck, Nyman, and Hayes, Inc., Anchorage). The grid is based on 200-m Universal Transverse Mercator (UTM) grid ticks

of these markers for use in the topographic survey. Original horizontal coordinates were NAD 83/Alaska State Plane zone 10 5010/US survey feet. Vertical elevations were computed from a Vertical Control survey, also conducted by TNH, and referenced to Mean Lower Low Water (MLLW) using USGS Tidal Bench #3 located at the American Pacific Whaling Company Dock (est.1934), located on the south side of the bay.

To use an NAD 83 UTM metric reference coordinate system in the ERDC survey, the Alaska State Plane coordinates furnished by TNH were transformed using Arc/Info GIS software (Environmental Systems Research Institute (ESRI) 2000). Using the converted coordinates for three of the above markers, a 100-m reference grid was established at the proposed harbor site. The grid and grid lines were marked in the field using 2- by 2-in. wood stakes 4 ft in length. Then horizontal (x, y) and vertical (z) positions were collected at 25-m spacing over the whole site. The beach ridge and stream channels were surveyed using the “slope break” method along the grid lines. These break points were later connected to describe the location of the beach ridge and stream channels.

In addition to positional data, such as the stream cross sections, elevation grid, and groundwater well locations, other x, y, z data were collected on linear features, such as small streams, pond margins, springs, fences, delineated wetland boundary, and small animal trails throughout the area. Some of these data were used to georeference the aerial photograph and densify the elevation data near the streams.

All coordinate data were collected using Trimble 4700 total station global positioning survey (GPS) equipment. This system uses state-of-the-art, real-time kinematic (RTK) technology. Using this system with the Trimble Survey Controller (TSC1), topographic survey accuracy specifications can be acquired in real time. The accuracies of positional data (while stationary) were sub-centimeter; accuracies of linear data (while moving) were centimeter.

RESULTS: RTK survey coordinate data were collected during on-site sampling from 12-22 August 2000. Approximately 2,750 positions were collected for use in developing the topographic map, and 2,400 positions were collected for use in delineating the streams, ponds, fences, and trails. In association with the hydrology studies, there were 20 positions at 10 groundwater well sites, 21 positions at 7 stream gauge sites, 2 positions at the tide gauge site, and 1,450 positions defining stream cross sections and profiles. An additional 1,285 positions defined the wetland boundary and 24 positions located the soil sampling sites. In total, nearly 8,000 points were collected in the field in support of this effort.

DEVELOPMENT OF DIGITAL ELEVATION MODEL AND CONTOUR MAP: Data collected by the field team were provided to the Environmental Laboratory’s Geospatial Data Analysis Facility team in the form of an Excel spreadsheet. This spreadsheet, containing all 7,913 surveyed point locations (Figure 2), was imported into a format required for use in the ArcView and Arc/Info GIS software packages.

SELECTION OF SURFACING ALGORITHM: Developing an accurate digital elevation model (DEM) from point data is not a straightforward task. There are a number of algorithms and software packages that can be used to generate such a model, with each carrying its own set of advantages and disadvantages. The distribution of sample points and the type of surface being modeled usually help guide which method is most appropriate. For this project, surfacing procedures in ArcView Spatial Analyst 2.0, Surfer 7, and Arc/Info 8.0.2 software packages were tested, including kriging, spline, inverse distance weighting, trend surface, and triangulated irregular network (TIN) approaches.

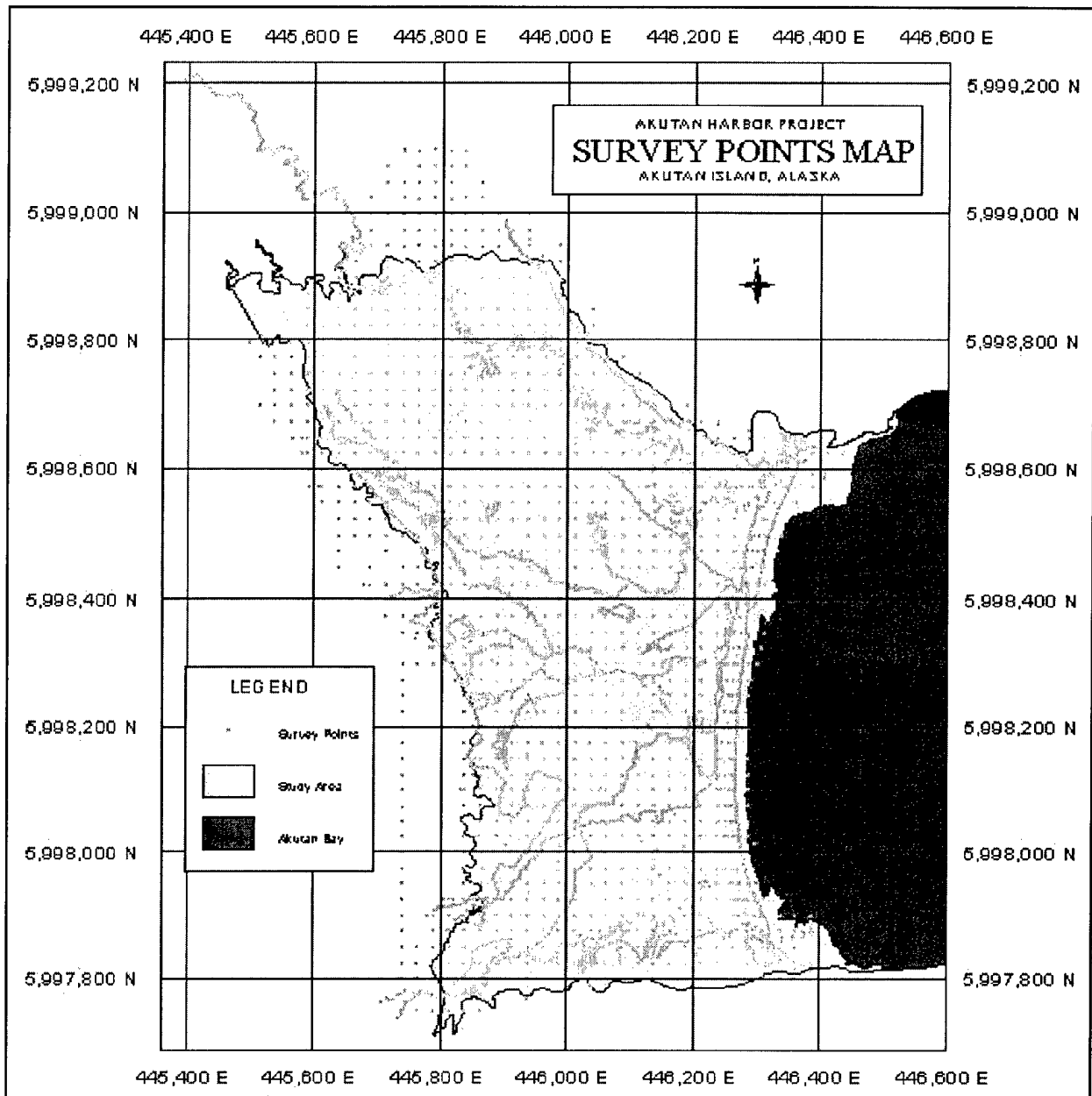


Figure 2. GPS survey points collected by the field team

Due to the nature of the field data, with widely scattered points in much of the area and closely spaced points in others, and the need to preserve the shape of drainage features collected by the field team, it was found that the TOPOGRID (ESRI 2000) surfacing procedure in Arc/Info yielded the best results. TOPOGRID is an interpolation method specifically designed for the development of hydrologically correct DEMs from comparatively small, but well-selected elevation and stream data. It is based upon the ANUDEM program developed by Michael Hutchinson (1988, 1989).

Procedure. After the points were input into Arc/Info, in many cases it was necessary to separate them and construct the linear or polygonal features (such as streams or ponds) that they were intended to represent. The field team tagged points with identifying attributes to help in this process.

While most of the points merely represented simple point features collected in a 25-m or 100-m grid spacing, many of the other points represented features such as cross sections collected across stream channels, points along linear features (such as trails, stream beds, etc.) or polygonal features such as ponds.

Data Preparation.

- *Stream features.* The TOPOGRID software requires streams to be represented as linear features representing the center line. In the large stream features in the northern and southern portions of the area, the field team was not able to collect continuous points along the stream center line, but instead collected points as cross sections at fairly regular distances up the channel. In these cases, stream center lines had to be delineated using an orthophoto overlaid with the cross-section points to ensure the constructed center line matched the field data. TOPOGRID also requires that stream network data have all arcs pointing downslope. Therefore, it was necessary to edit the line features to ensure that this was indeed the case and that all arcs were connected properly.
- *Pond features.* The field team collected point data along the boundary of areas containing ponded water. These were stored in Arc/Info as closed polygon features. TOPOGRID assigns to the raster cell values in the DEM within a lake or pond the minimum elevation value of all cells along the shoreline.
- *Boundary polygon.* A boundary polygon, used to represent the outer boundary of interpolation for the DEM, was constructed using on-screen digitizing techniques. In addition, a polygon to represent the ocean was developed viewing the digital orthophoto as a backdrop.

Constructing the DEM. Table 1 lists the Arc/Info coverages that were used to generate the raster digital elevation model in TOPOGRID:

Table 1 Input Coverages Used for TOPOGRID Surface Interpolation			
Coverage Name	Topology Type	Attribute Used	Description
all_ground	Point	EL	All points collected by the field team (elevation in meters)
cl_creek	Line	None	Centerline of stream features
s_center			
small_streams			
Ocean	Polygon	None	Polygons to represent the water features
Ponds	Polygon	None	Polygons to represent flat surfaces in the final elevation model
Boundary	Polygon	None	Marks boundary of DEM

The following Arc/Info Arc Macro Language (AML) code was used to generate the DEM.

```

TOPOGRID elev_grid 5
ENFORCE ON
DATATYPE SPOT
MARGIN 0.0

```

```
ITERATIONS 10
TOLERANCES 5 1.0 0.0
XYZLIMITS ## ####
POINT all_ground EL
STREAM cl_creek
STREAM s_center
STREAM small_streams
LAKE ocean
LAKE ponds
BOUNDARY boundary
OUTPUTS sinks drainage diagnostics
END
```

The resulting elevation model had a 5-m raster cell size.

Generating Contours from the DEM. The Arc/Info LATTICECONTOUR command was used to produce vector contour coverage from the DEM:

```
latticecontour elev_grid contours 0.5 0
```

The output of this command was a coverage named “contours” with a 0.5-m contour interval, starting with a contour at the 0-m elevation.

The contour diagram produced during this process contained some contours depicting very small depressions or mounds. In addition, some contour lines were somewhat jagged. The ArcEdit module of Arc/Info was used to correct some of these errors. A “GRAIN” tolerance was set and the SPLINE command was used to smooth the contours. This also eliminated a good many of the small irregularities noticed in the initial contour coverage. The final contour map is shown in Figure 3.

ArcView and an extension to ArcView called CartoView (Geoware 2000) were used to produce the final topographic map delivered to the Alaska District. Metadata files compliant with the latest Federal Geographic Data Committee (FGDC) standards were generated to document the DEM and contour databases produced during this project. All data and metadata resulting from this effort were provided to the Alaska District in CD-ROM format.

POINTS OF CONTACT: For additional information, contact Mr. Thomas E. Berry, Environmental Laboratory, U. S. Army Engineer Research and Development Center, Vicksburg, MS (601-634-3927, Thomas.E.Berry@erdc.usace.army.mil) or the Manager of the Wetlands Regulatory Assistance Program, Dr. Russell F. Theriot (601-634-2733, Russell.F.Theriot@erdc.usace.army.mil). This technical note should be cited as follows:

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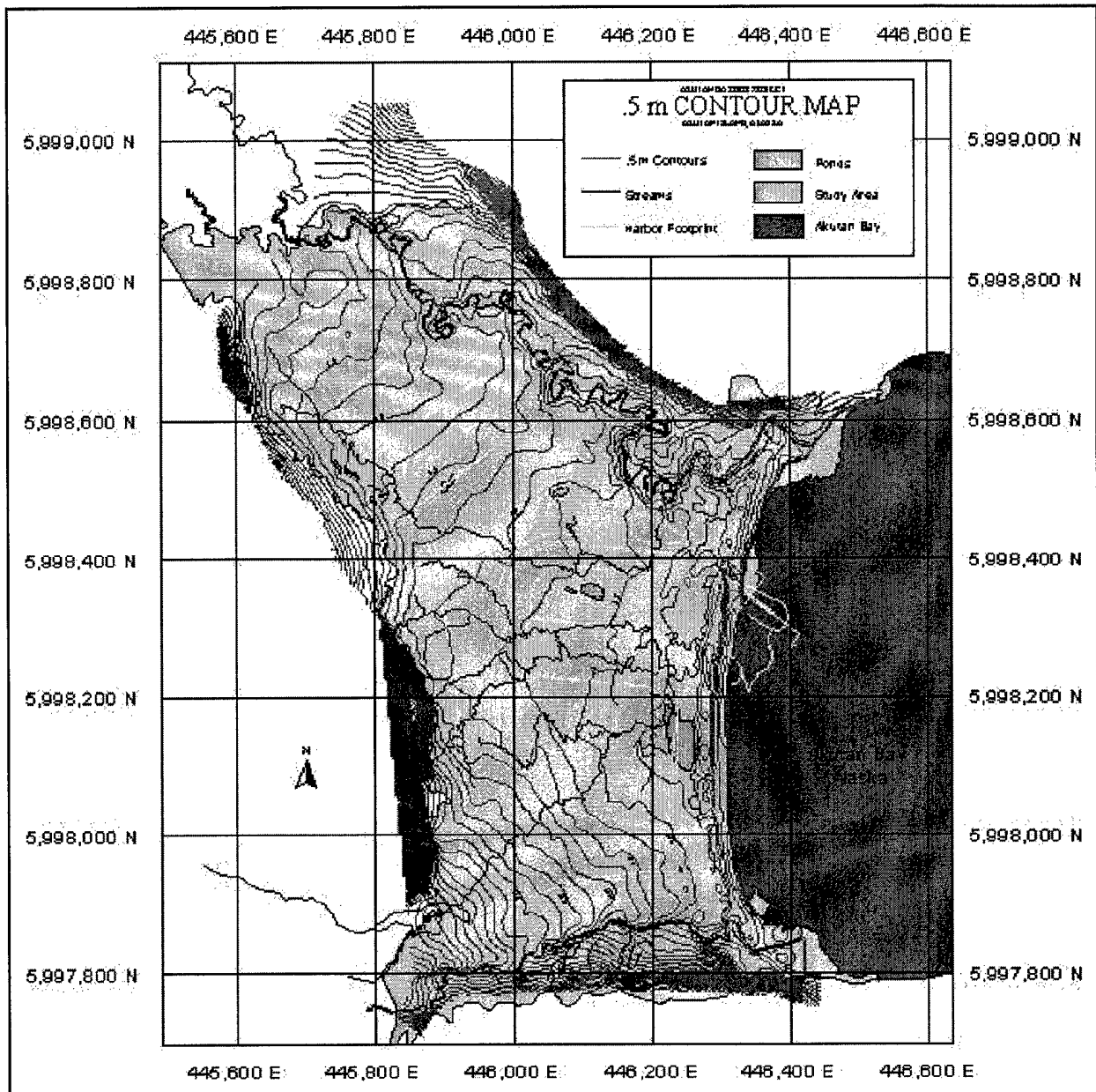


Figure 3. Final contour map (0.5-m contour interval) of the study area

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