USGS DIGITAL CARTOGRAPHIC DATA BASE

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Introduction

The Topographic Division of the U.S. Geological Survey formed a Digital Applications Team in 1977 for the purpose of developing capability to produce digital cartographic data as a standard product of the National Mapping Program. Digitizing, plotting, and editing equipment has been installed in the Reston, Va.; Rolla, Mo.; Denver, Colo.; and Menlo Park, Calif. mapping centers. The centers are linked to the central USGS computer facilities in Reston where the major computer programs to process, edit, structure, and archive the data are located. A major component of the entire processing system is the centralized data base management system.

Digital Cartographic Data

There are two major types of digital cartographic data--the digital elevation model (DEM) and the digital line graph (DLG). Each type is divided into three levels according to the following definitions.

DEM-1: A network of raw elevation data that has only been edited for gross blunders and has not been keyed to planimetry.

DEM-2: Elevation data that have been smoothed for consistency, enhanced to remove noise, and filtered to reduce data volume. The data have not been keyed to planimetry.

DEM-3: Elevation data that have been edited and modified to be consistent with planimetric features such as streams, roads, and shorelines.

DLG-1: Line map information that has been collected and coded to prescribed standards and edited to remove data acquisition blunders.

DLG-2: Line map information that has been interactively edited to add additional attribute codes and to remove visible errors and inconsistencies.

DLG-3: DLG-2 data that has been spatially structured to define all topological relationships.

The levels do not refer to the categories of data (hydrography, transportation, etc.) nor to the scale of a map. It would be possible to have DLG-2 and DLG-3 level hydrography collected from 1:24,000-scale maps and another set of DLG-2 hydrography collected from 1:2,000,000-scale maps. The level is rather a conceptual description of the amount of editing and structure that has been included in the files and therefore a description of the use or complexity of applications the data files will support. DLG-1 data may have minor errors but will support some graphic plotting operations; DLG-2 data will support high-quality plotting operations with no visible errors; and DLG-3 data is usually essential when different categories of data are interrogated or combined in the computer to answer quantitative questions.

USGS Digital Cartographic Data Base

The USGS digital cartographic data base (DCDB) is a unified set of smaller generic data bases that are managed by the System 2000 data base management system. System 2000 was selected because it was already operational on the USGS IBM 370/155 computers in Reston and the hierarchical structure was appropriate and effective. It should be noted that complete files are being managed, not the coordinate and attribute data within the files. It is our opinion that the sheer volume of data and the complex interrelations of cartographic information currently prohibit data base management of individual elements of digital cartographic data.

The purpose of a DCDB management system is to accept, catalog, and archive digital cartographic files in a standard way and to access the files or report information about the files upon request. The data elements in the files will be accepted without any criteria applied to the correctness or completeness of the elements; such

checking is performed by other programs. Certain information about a file such as name, date, geographic location, data categories, and data accuracy are extracted and kept in the DCDB index. The DCDB management system also manages the archival computer tapes, where the file is automatically assigned for storage at 6250 bpi (bits per inch) and appropriate backup copies are made.

DEM Data Base from the Defense Mapping Agency

The USGS has provided public distribution of digital elevation data from the Defense Mapping Agency (DMA) since May 1975. The USGS National Cartographic Information Center (NCIC) obtained copies of the DMA PLANAR tapes, a byproduct of the digital graphic recorder used to control the carving of plaster forms for molded relief maps. The data was derived from the 100- or 200-foot contours on 1:250,000-scale maps with data points interpolated at 0.01-inch intervals. The data has been widely used for diverse applications although only a generalized model of the terrain topography is provided due to the scale and contour interval of the source maps. Numerous edge-join discontinuities, occasional spikes of erroneous data, and stair-step shelves due to contour interpolation along slopes have been noted in these files. The PLANAR tapes cover the entire Coterminous United States.

Recently DMA has reformatted the PLANAR data into their standard format of 1^{o} x 1^{o} blocks with horizontal point spacing of 3 seconds in both latitude and longitude. During reformatting, DMA has attempted to edit some of the problem areas previously noted. USGS has started to acquire the reformatted data and, after adding header records to conform with the USGS standard record format for DEM data, has entered the files into the DCDB. The capability to automatically produce index maps of data files in the DCDB has been implemented and figures 1 and 2 show the status of the new DMA data base on September 30, 1979. As shown in figure 2, this set of DMA data now covers Alaska, which was previously unavailable in the PLANAR files.

USGS DEM Data Base

The USGS has operated a Gestalt Photomapper (GPM2) for several years to produce orthophotoquads from high altitude (45,000-ft) photographs. A byproduct of the GPM2 orthophoto processor is a tape of digital elevations recorded at a horizontal point spacing of approximately 50 ft. There are two tapes for each 7 1/2-minute 1:24,000-scale quadrangle representing the two photogrammetric

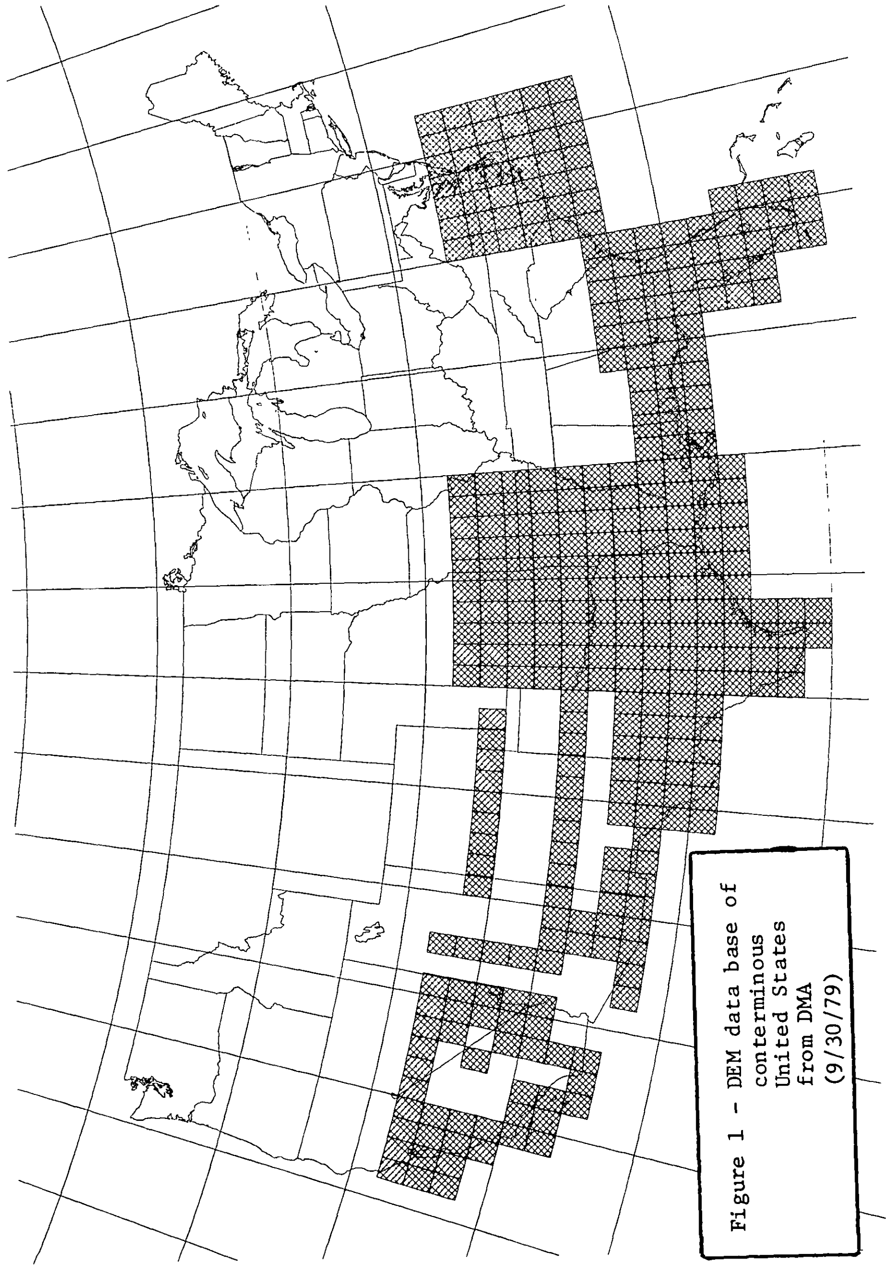

Figure 1 - DEM data base of conterminous United States from DMA (9/30/79)

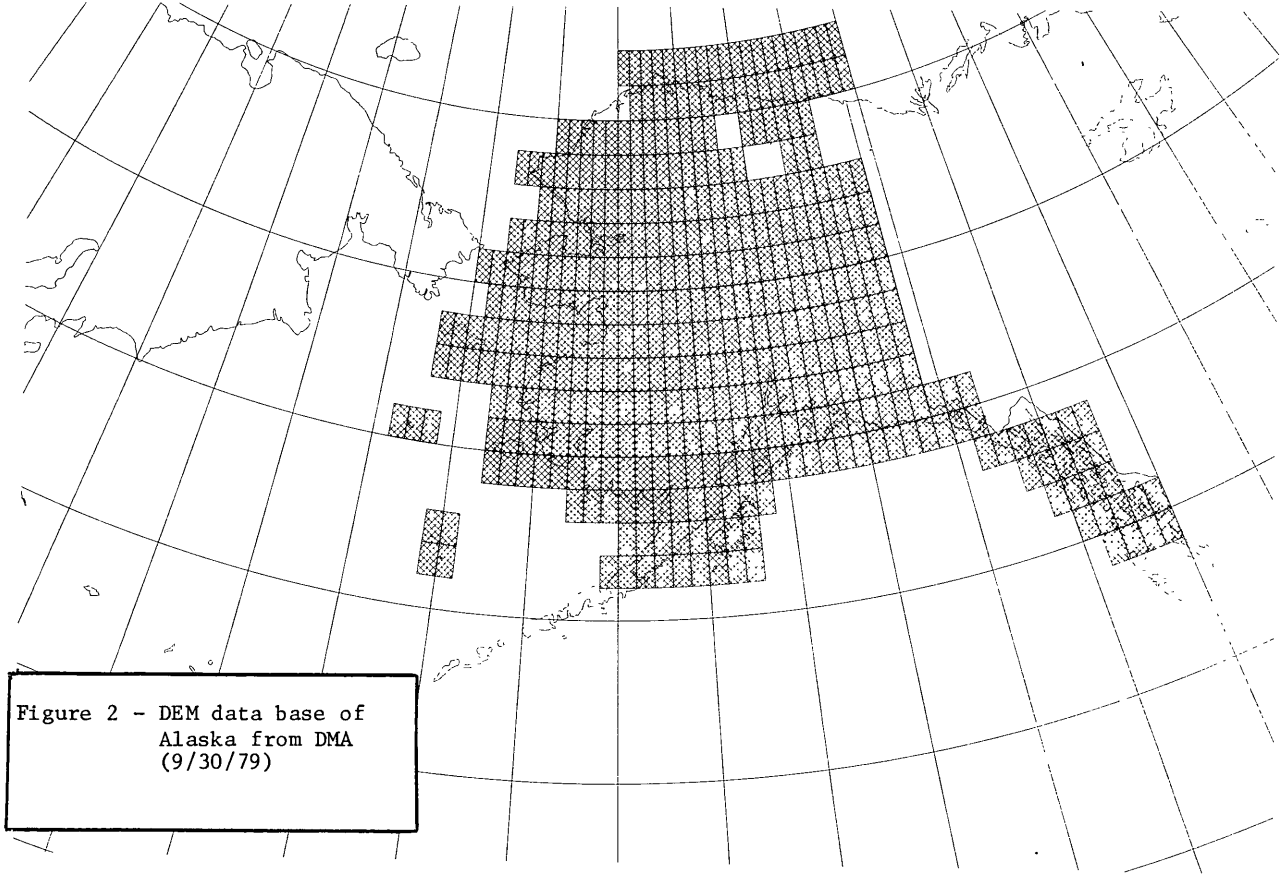

Figure 2 - DEM data base of Alaska from DMA (9/30/79)

models (a north and a south half) used to prepare the orthophotoquad. Each model extends beyond the quadrangle neat lines and the north half overlaps the south half. Each model is also in a separate arbitrary model coordinate system. There are approximately 750,000 elevation values in the two models. Starting in 1978, the GPM2 data has been processed into the DCDB and there are now over 7,000 models in the system representing coverage as shown in figure 3. Since the GPM2 has been used primarily to produce orthophotos in mountainous areas for federal agencies with land management or resource inventory responsibilities (Bureau of Land Management, Soil Conservation Service, U.S. Forest Service), the coverage tends to reflect this orthophoto program.

Starting in 1979, the GPM2 model data has been processed to produce a standard set of DEM data for distribution. The criteria for processing were (1) UTM (Universal Transverse Mercator) coordinate system, (2) horizontal point spacing in both easting and northing at 30 m, (3) inclusion of only the points within a 7 1/2-minute quadrangle that are along 30-m grid lines (500,010; 500,040; 500,070; etc.), and (4) an estimated vertical accuracy of 7 m rms (root mean square). Each resulting file contains between 138,000 points (at a latitude of 50°) and 195,000 points (at a latitude of 25°) for a 7 1/2-minute quadrangle. Approximately 1,200 quadrangles of DEM data meeting these criteria are in the data base (figure 4). The 7-m estimated accuracy criteria has resulted in rejecting many models of GPM2 data; however, a separate part of the DCDB is being reserved for future inclusion of files with an estimated accuracy between 7 and 15 m. When the accuracy exceeds 15 m the model is rejected and rescheduled for data acquisition.

Figures 5 and 6 are larger scale index maps of Montana and New Jersey-Pennsylvania with county boundaries. The figures show the same information as figure 4 but at a scale that allows selection of individual 7 1/2-minute quadrangles. All States in the DEM data base will have a similar index map available from the National Cartographic Information Center, User Services Section, U.S. Geological Survey, 507 National Center, Reston, VA 22092. NCIC will also distribute the data tapes.

As noted previously the data in a file is not edited or corrected. Neither is it feasible to check for all possible errors when transforming the GPM2 data into the quadrangle format and 30-m point spacing. While we are certain each file covers a complete quadrangle with a reasonable statistical estimate of vertical accuracy, some discontinuities may occur as well as regions of data points that do not perfectly represent the actual terrain.

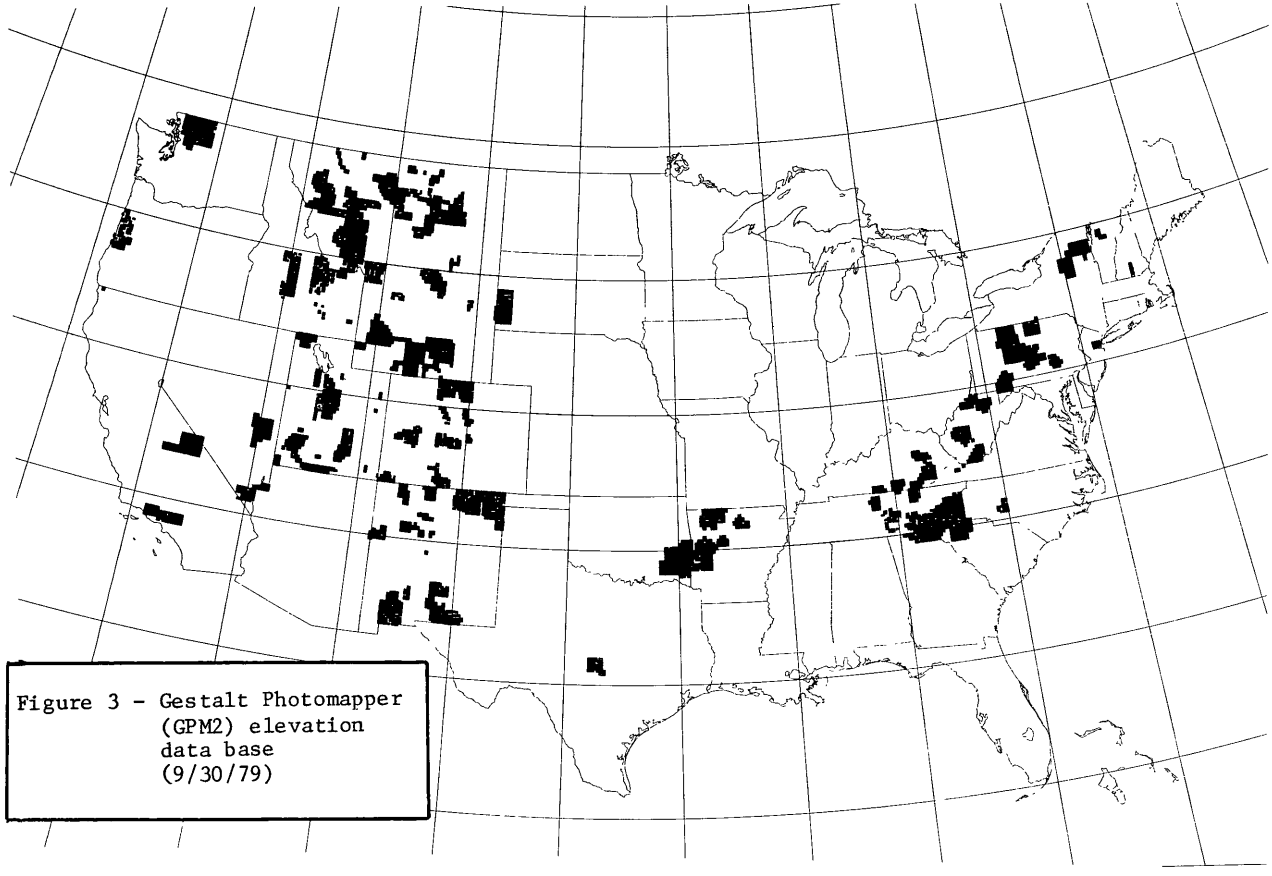

Figure 3 - Gestalt Photomapper (GPM2) elevation data base (9/30/79)

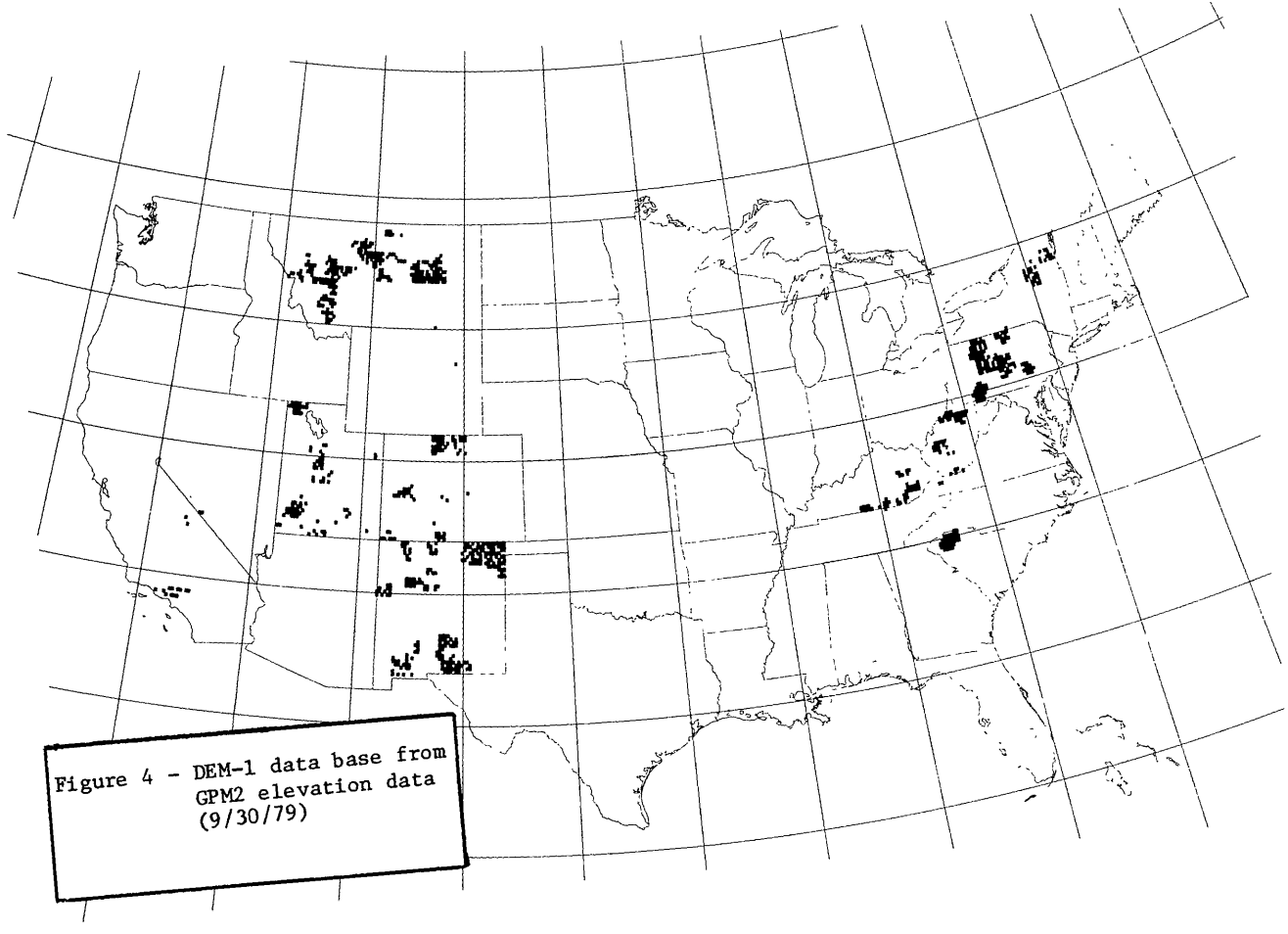

Figure 4 - DEM-1 data base from GPM2 elevation data (9/30/79)

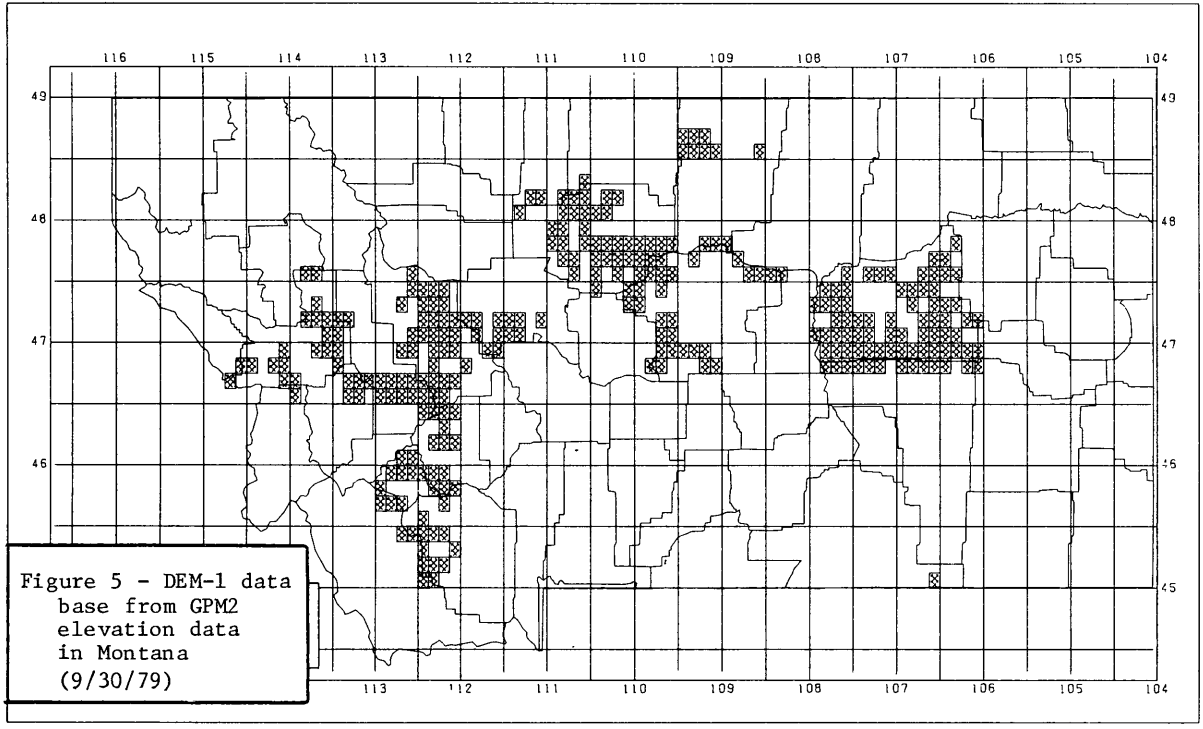

Figure 5 - DEM-1 data base from GPM2 elevation data in Montana (9/30/79)

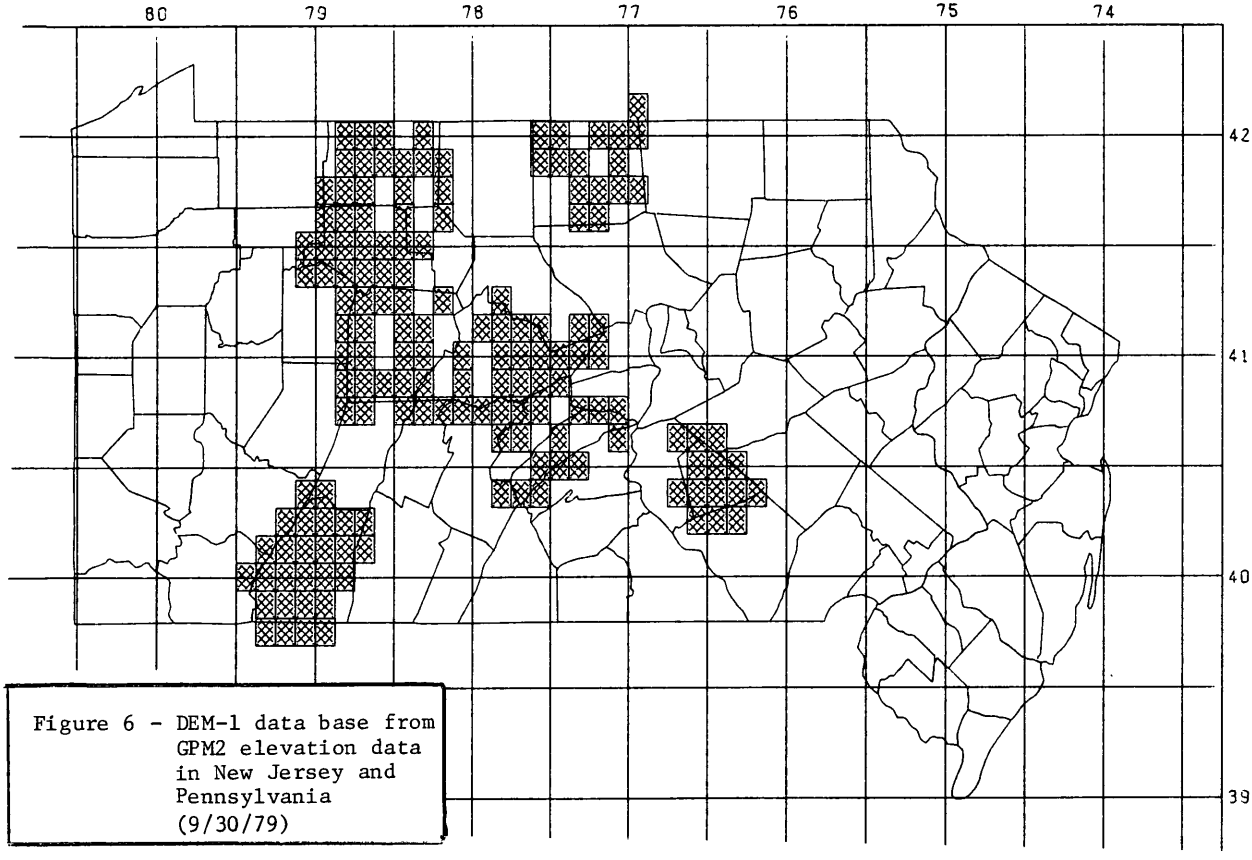

Figure 6 - DEM-1 data base from GPM2 elevation data in New Jersey and Pennsylvania (9/30/79)

The automatic image correlation circuits of the GPM2 are prone to some error when areas of featureless terrain occur (such as water bodies). There is currently no practical technique to edit each and every data point; therefore, the level of the files should be considered DEM-1.

USGS DLG Data Base

Since 1978 the USGS has been conducting digital pilot projects and some limited production to acquire DLG data is underway. Most projects have used the 1:24,000-scale map series as a data source, although there are active projects using 1:500,000-scale and 1:2,000,000-scale materials. Research is continuing to develop better techniques for acquiring and editing data. The DCDB is being expanded to manage the DLG files and it is anticipated that both DLG-2 and DLG-3 files will be entered during 1980.

Conclusion

The USGS digital cartographic data base uses the commercially available System 2000 data base management system. While other systems may have merit, System 2000 has been very satisfactory in managing files of DEM data and we anticipate no problems with DLG data. It has not been necessary to develop a special data base management system for cartographic data, and for the next 3-4 years the current system will be adequate. By 1985 we anticipate that developments in mass storage will require a change from the current use of 6250 bpi tapes, and changes in computer hardware may lead to a distributed data base. It may even be possible to devise schema that allow management of digital cartographic data elements. We are anticipating these changes while simultaneously establishing the concepts, administration, and management required for a DCDB to serve as a central source for digital cartographic data.