# USGS Digital Cartographic Data Standards

National Mapping Program

## Digital Elevation Models

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Geological Survey
Circular 895-B

USGS DIGITAL CARTOGRAPHIC DATA STANDARDS

USGS Circular 895-A: Overview and USGS Activities
B: Digital Elevation Models
C: Digital Line Graphs from 1:24,000-Scale Maps
D: Digital Line Graphs from 1:2,000,000-Scale Maps
E: Land Use and Land Cover Digital Data
F: Geographic Names Information System
G: Digital Line Graph Attribute Coding Standards

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# DIGITAL ELEVATION MODELS

By Atef A. Elassal and Vincent M. Caruso

USGS Digital Cartographic Data Standards

Edited by Robert B. McEwen, Richard E. Witmer, and Benjamin S. Ramey

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Dallas L. Peck, *Director*


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## FOREWORD

In recent years, the disciplines of cartography and geography have undergone a rapid and striking reorientation as the techniques for digital collection and manipulation of data have evolved from fledgling laboratory procedures into dominant and driving forces that now pervade the disciplines. Digital techniques have provided a variety of new and powerful capabilities to collect, manipulate, analyze, and display spatial data. However, this evolution also has introduced a number of new and complex problems. One of the most pressing problems, and one which is receiving particular attention at present, is the issue of digital cartographic data standards.

The U.S. Geological Survey (USGS) has been actively developing digital cartographic and geographic techniques for over a decade and has taken significant steps to develop and define in-house standards governing the various types of digital cartographic data that are being collected and archived in a national digital cartographic data base. The in-house standards are expressed in the form of specifications documents that were prepared to govern collection of the data and in the form of user guides that were prepared for distribution with the data.

In an effort to fulfill lead agency requirements for promulgation of Federal standards in the earth sciences, the documents have been assembled with explanatory text into this USGS Circular consisting of separately bound chapters. This Circular describes some of the pertinent issues relating to digital cartographic data standards, documents the digital cartographic data standards currently in use within the USGS National Mapping Division, and details USGS efforts to define national digital cartographic data standards.

Chapter A is an overview in which the major issues involved in developing digital cartographic data standards are discussed and the activities of the USGS related to digital cartographic data production and standards development are described in detail. Succeeding chapters comprise the pertinent documents that establish USGS in-house standards for the various types of digital cartographic data currently produced by the National Mapping Division; that is, digital elevation data, digital planimetric data, digital land use and land cover data, and digital geographic names data.

This compendium of relevant material is prepared to serve as a benchmark and to assist ongoing efforts to establish acceptable standards and conventions for both Federal agencies and the public.

Dallas L. Peck
Director,
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U.S. Geological Survey

## PREFACE

This Circular is the result of the efforts of numerous individuals who have contributed to the research, development, and preparation of various digital cartographic and geographic standards for the National Mapping Division of the U.S. Geological Survey. The individuals named as chapter authors represent both the originators of the various concepts as well as the writers who expanded and clarified these ideas. Their contributions, either to the concepts or the writing, are of such magnitude as to warrant crediting as authors.

Atef A. Elassal was largely responsible for the original data structures and computer file formats that are used for the digital line graphs and digital elevation models. The attribute coding scheme was first developed by members of the Digital Applications Team under the direction of Robert B. McEwen. The Geographic Names Information System was conceived and developed by Sam Stulberg and Roger L. Payne. The Geographic Information Retrieval and Analysis System was developed by Robin G. Fegeas, K. Eric Anderson, Stephen C. Guptill, Cheryl A. Hallam, and William B. Mitchell. The small-scale digital line graph data structure and attribute coding scheme was developed by Warren E. Schmidt and Michael A. Domaratz.

The Circular was compiled in part from various user guides and technical instructions of the National Mapping Division. These documents were originally prepared by several individuals; credit is acknowledged to G. Michael Callahan, A. Joan Szeide, William R. Allder, Vincent M. Caruso, Hugh W. Calkins, Donna Cedar-Southworth, and Cheryl A. Hallam. The compilation of the various guides, instructions, and other material into the Circular format was performed with major assistance by Clark H. Cramer, Eloise R. Byrd, and Cynthia L. Cunningham.

We acknowledge these substantial contributions that have led to this publication.

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# DIGITAL ELEVATION MODELS

By Atef A. Elassal and Vincent M. Caruso


## Abstract

The discipline of cartography is undergoing a number of profound changes that center on the emerging influence of digital manipulation and analysis of data for the preparation of cartographic materials and for use in geographic information systems. Operational requirements have led to the development by the USGS National Mapping Division of several documents that establish in-house digital cartographic standards.

In an effort to fulfill lead agency requirements for promulgation of Federal standards in the earth sciences, the documents have been edited and assembled with explanatory text into a USGS Circular. This Circular describes some of the pertinent issues relative to digital cartographic data standards, documents the digital cartographic data standards currently in use within the USGS, and details the efforts of the USGS related to the definition of national digital cartographic data standards. It consists of several chapters; the first is a general overview, and each succeeding chapter is made up from documents that establish in-house standards for one of the various types of digital cartographic data currently produced. This chapter, 895-B, describes the digital elevation model data produced and distributed by USGS and similar data at a smaller scale produced by the Defense Mapping Agency and distributed by USGS.


## INTRODUCTION

The U.S. Geological Survey (USGS) distributes digital cartographic and geographic data as part of the National Mapping Program. One of the several types of data distributed is digital elevation data, which consists of arrays of elevations, usually at regularly spaced intervals, for a number of ground positions.

This document describes two distinct digital elevation data products that are distributed by the USGS in the standard digital elevation model (DEM) tape format: (1) DEM's produced by the USGS that correspond in coverage to standard 1:24,000-scale 7.5- x 7.5-minute quadrangles. This type of digital elevation data is referred to in this document as *7.5-minute DEM* data. (2) DEM's produced by the Defense Mapping Agency (DMA) that correspond in coverage to 1° x 1° blocks (one half of standard 1:250,000-scale 1° x 2° quadrangles). This type of digital elevation data is referred to in this document as *1:250,000-scale DEM* data.

The 7.5-minute DEM data files and the 1:250,000-scale DEM data files are identical in logical data structure but differ in sampling interval, geographic reference system, areas covered, and accuracy of data. USGS 7.5-minute DEM data are available for selected quadrangles in the United States; DMA 1:250,000-scale DEM data are available for most of the United States.

The USGS also distributes another type of digital elevation data--1:250,000-scale terrain/planar digital data (digital terrain tapes). Digital terrain tapes are a product of the Defense Mapping Agency and correspond in coverage to one half of a standard 1:250,000-scale 1° x 2° quadrangle. Digital terrain tapes are distributed, as produced by the DMA, and do not conform to the standard DEM tape format. Information on digital terrain tapes is provided in Appendix H.

## 7.5 MINUTE DIGITAL ELEVATION MODELS

### CHARACTERISTICS

A 7.5-minute DEM has the following characteristics:

- The data consist of a regular array of elevations referenced in the Universal Transverse Mercator (UTM) coordinate system. Elevations randomly located in an irregular array also are allowed in the file structure, but only regular arrays have been produced to date.

- The unit of coverage is the 7.5-minute quadrangle. Overedge coverage is not provided.

- The data are ordered from south to north in profiles that are ordered from west to east.

- The data are stored as profiles in which the spacing of the elevations along and between each profile is 30 m.

- The profiles do not always have the same number of elevations due to the variable angle between true north and grid north of the UTM coordinate system.

The generation of profiles for 7.5-minute DEM's is accomplished using a UTM cartesian coordinate system as a base. The profiles are clipped to the straight line intercept between the four geographic corners of the quadrangle--an approximation of the geographic map boundary (neatline). The resulting area of coverage for the DEM is a quadrilateral, the opposite sides of which are not parallel. (See Appendix D for an example of UTM coordinates describing a 7.5-minute quadrilateral figure.)

The UTM coordinates of the DEM's four corners (bounds) are listed in the type A record, data element 10, and the UTM coordinates of the starting points of each profile are listed in the type B record (profiles), data element 3 (see pages 21 and 23). These coordinates describe the shape of the quadrilateral and the variable x,y starting position of each profile. Because of the variable orientation of the quadrilateral, in relation to the UTM coordinate system, profiles intersect the east and west neatlines as well as the north and south neatlines. The intersections result in a regular stair-stepped arrangement of the 30-m nodes just inside the neatline.

### DATA PRODUCTION

The 7.5-minute DEM data are produced in 7.5- x 7.5-minute blocks either from map contour overlays that have been digitized or from automated or manual scanning of photographs usually taken at an average height of 40,000 ft. (1:80,000-scale). The data are processed to produce a DEM with a 30-m sampling interval. The structure of a 7.5-minute DEM data file is shown in figure 1. (See pages 10 - 13 for sample data records.)

The USGS uses three systems to collect the digital elevation data for production of 7.5-minute DEM's: (1) the Gestalt Photo Mapper II (GPM2); (2) manual profiling from stereomodels; and (3) the Digital Cartographic Software System (DCASS).

The GPM2 is a highly automated photogrammetric system designed to produce orthophotos, digital terrain data, and contours. An electronic image correlation component of the GPM2 measures the parallax of 2,444 points within each 9- x 8-mm area of a photogrammetric stereomodel. Of these 2,444 correlated points, subunits of 576, 1,024, or 1,600 points are collected for inclusion in the

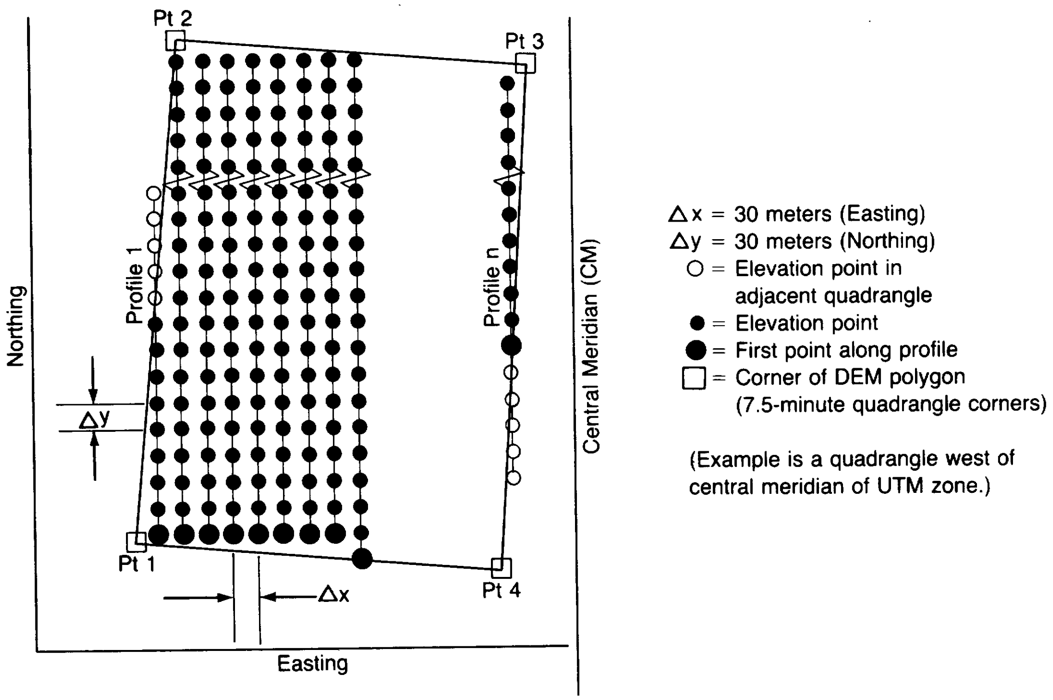



Figure 1.--Structure of a 7.5-minute digital elevation model.

elevation model. These subunits are called patches, and the patch size is selected to accommodate various terrain conditions. The horizontal (x and y) spacing of the elevation points within each patch is approximately 182 micrometers at photo scale (equivalent to a ground distance of approximately 47 ft. when using photographs at 1:80,000 scale). Each of the two stereomodels used to cover a standard 7.5-minute quadrangle contains over 500,000 correlated points; these are regridded to form a DEM in the standard format.

The manual profiling systems use stereoplotters, interfaced with electronic digital profile recording modules, for scanning of stereomodels in the photo y direction. High-altitude aerial photographs are used as source material. The scan speed and slot size (stepover interval) can be selected by the operator to accommodate steepness in topographic slope. The most commonly used slot size is 4-mm, which results in elevation profiles spaced approximately 90-m apart. Elevations are normally recorded every 30-m along each profile. The profiled elevation data are reformatted and regridded to a regular 30-m UTM spacing, written in standard DEM format, and tested for vertical accuracy before placement in the National Digital Cartographic Data Base (NDCDB). Digital profile data are collected in this manner as companion products with the production of orthophotos.

The DCASS forms a DEM from digitally encoded vector contour data. Stereoplotters, equipped with three-axis digital recording modules, are used to collect vector contour data while the instruments are being used for photogrammetric stereocompilation of 1:24,000-scale quadrangle maps. During the acquisition phase, the contours are assigned elevation values (attributes). The vector contour data are processed into profile lines and the elevation matrix at a 30-m spacing is formed using a bilinear interpolation between the intersections of the lines with the contour vectors.

## 1:250,000-SCALE DIGITAL ELEVATION MODELS

### CHARACTERISTICS

A 1:250,000-scale DEM in the United States (except Alaska) has the following characteristics:

- The data consist of a regular array of elevations cast on the geographic (latitude/longitude) coordinate system.
- The unit of coverage is a 1° x 1° block representing one-half of a 1° x 2° 1:250,000-scale map. The unit of coverage includes profiles coincident with the neatlines of the map.
- The data are ordered as profiles ascending northward. The origin is at the southwest corner of the map.
- The data are stored as profiles in which the spacing of the elevations along and between each profile is 3 arc-seconds.
- The data comprise an array having 1,201 profiles with 1,201 elevations per profile.

For the State of Alaska, the spacing of elevations along each profile is 3 arc-seconds (1,201 elevations per profile), and the normal spacing between profiles varies from 6 arc-seconds (601 profiles per DEM) in the south to 12 arc-seconds (151 profiles per DEM) on the north slope of the State. Some Alaska sheets have a 4-arc-second spacing of the profiles.

### DATA PRODUCTION

The 1:250,000-scale DEM data are produced by interpolating elevations at intervals of 3 arc-seconds from contours, ridgelines, and drains digitized from 1:250,000-scale topographic maps. Three seconds of arc represents approximately 90 m in the north-south axis and a variable dimension (approximately 90 m at the equator to 60 m at 50° latitude) in the east-west axis due to convergence of the meridians. The area of each map is divided into an east half and a west half to accommodate the large volume of data required to cover the 1° x 2° topographic map area. The structure of a 1:250,000-scale DEM data file is shown in figure 2. (See pages 14 - 16 for sample data records.)

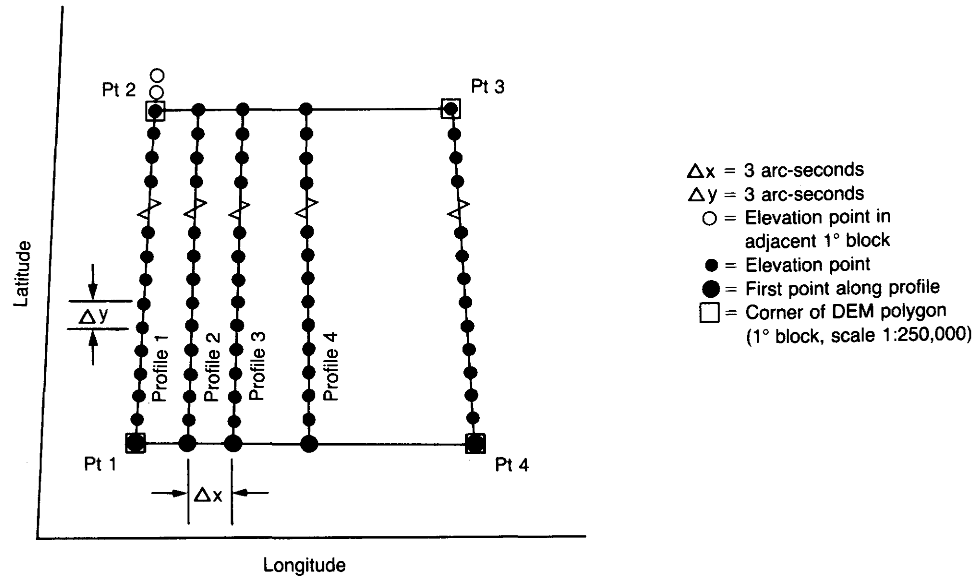



Figure 2.--Structure of a 1:250,000-scale digital elevation model.

## GEOMETRY

Profiles are the basic building blocks of DEM's and are defined as one-dimensional patches, that is, arrays of dimension m rows x n columns, where m is the length of the profile (variable length for 7.5-minute DEM's or fixed length for 1:250,000-scale DEM's) and n is set to 1.

Figure 3 provides an example of the computation for the first data point inside the quadrilateral representing a 7.5-minute DEM west of the UTM central meridian. Figure 4 provides a similar example for a quadrangle east of the central meridian.

Figure 5 illustrates the internal relationship of elevations ordered as profiles in which the spacing of the elevations along each profile is $\Delta y$ and the spacing between profiles is $\Delta x$. Figure 5 also relates the internal array structure to actual ground coordinates ($X_{Gp}$, $Y_{Gp}$), based on an origin of the DEM at the lower left corner ($X_{Go}$, $Y_{Go}$), and a rotation angle, if any (the rotation angle of 7.5-minute DEM's is normally set to zero).

## ACCURACY

The accuracy of digital elevation models is partially dependent on the scale of the source materials from which the data are obtained. For example, the accuracy of 1:250,000-scale DEM's is consistent with the accuracy of the contours (50 ft. in flat terrain, 100 ft. in moderate terrain, and 200 ft. in steep terrain) on the 1:250,000-scale topographic maps used to produce the data. The accuracy of 7.5-minute DEM's depends on the data source (either aerial photographs, or contours on 7.5-minute maps of the USGS Topographic Map Series).

Vertical accuracy of 7.5-minute DEM's derived from aerial photographs is highly dependent on the original resolution and contrast of the source photographs, as well as the presence of natural or man-made features and an abundance of survey control for constraining the stereomodels. Vertical accuracy of 7.5-minute DEM's derived from contours is consistent with the accuracy of the contours on the source map. The 7.5-minute DEM's are stored in one of the two separate DEM data bases in the NDCDB, depending on tested vertical accuracy. Accuracy is either less than 7-m vertical RMSE, or 7- to 15-m vertical RMSE. The 7-m RMSE was determined to be a reasonable standard for DEM's derived from high-altitude aerial photographs taken at 40,000 ft. (1:80,000-scale), attainable under a variety of terrain conditions and instrument constraints.

The methods used for determining vertical accuracy of 7.5-minute DEM's differ with the collection method. For DEM's collected with the GPM2, a weighted root mean square error (RMSE) value is derived from the relative elevation differences between patch joins and the relative elevation difference between coincident points in the overlay area of the two stereomodels covering a quadrangle. The RMSE of the elevation data derived from the manual profiling and the DCASS systems, however, is computed by comparing known ground vertical control elevations (for a minimum of 10 discrete image points) to linearly interpolated DEM elevation points.

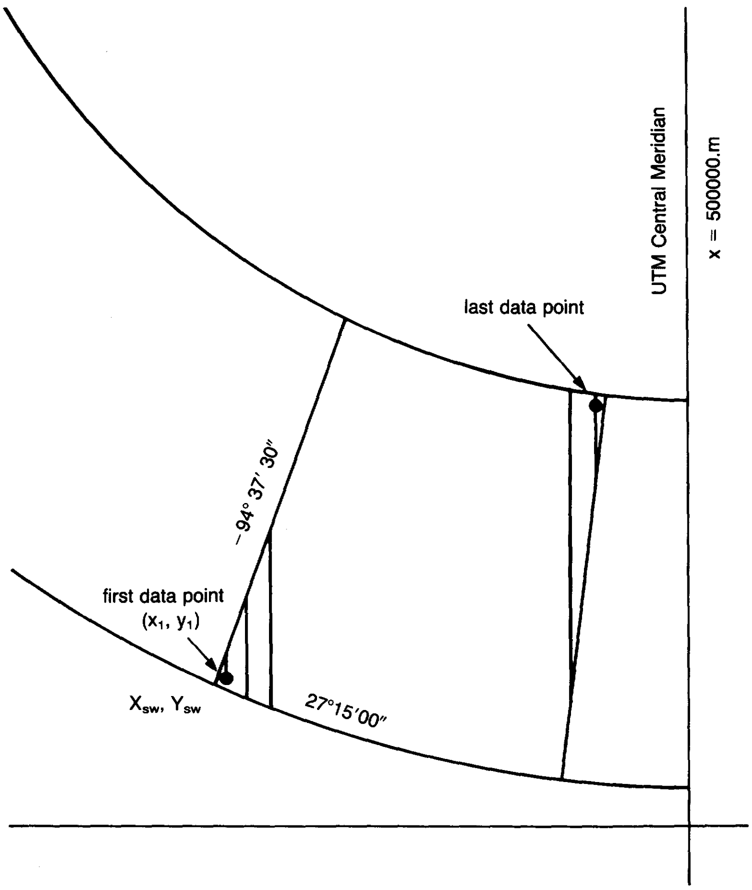
## EDITING

All DEM data are classified into one of three levels depending on editing, enhancements, and spatial structuring:

Level 1 - Raw elevation data sets in a standardized format. Only gross blunders in data capture have been eliminated.

Level 2 - Elevation data sets that have been smoothed for consistency and edited to remove random errors.

Level 3 - Elevation data sets that have been edited and modified to insure positional consistency with planimetric data categories such as hydrography and transportation.




Example computation of UTM coordinates ($x_1$,$y_1$) of the first data point in a 7.5-minute DEM west of the central meridian.

The southwest corner of the 7.5-minute DEM used in this example is at latitude 27°15'00", longitude -94°37'30" ($x_{sw}$ = 339117.754m, $y_{sw}$ = 3015002.066m).

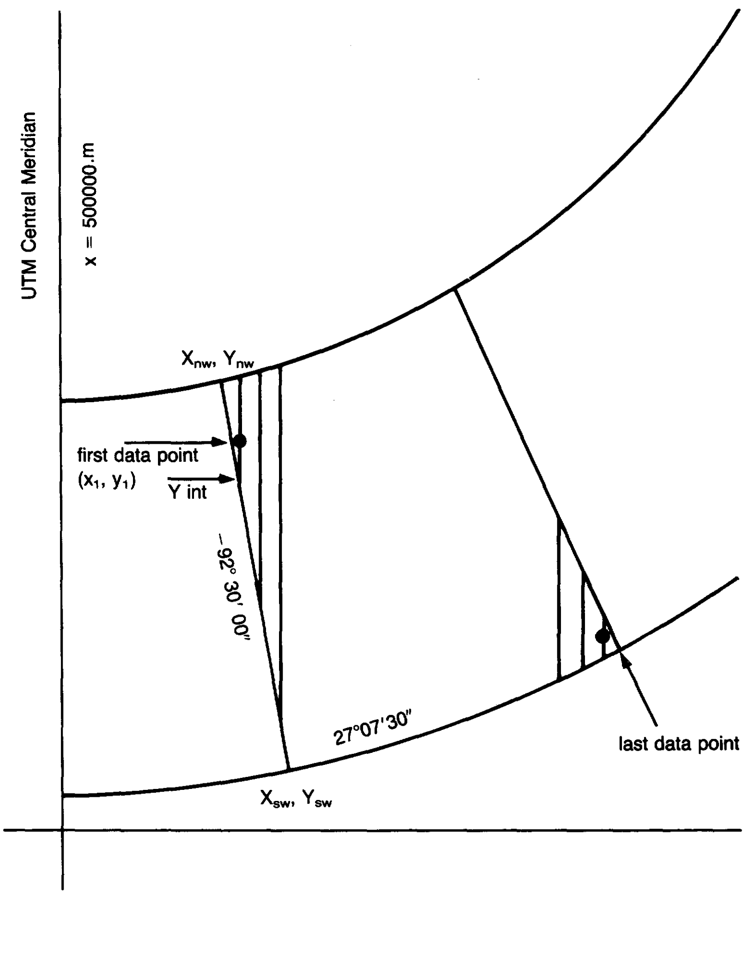
Compute x coordinate ($x_1$) of the first profile. The first profile is offset to the next integer multiple of 30m east of the soutwest corner.

$$
\begin{aligned}
\frac{x_{sw}}{30m} &= \frac{339117.754m}{30m} \\
&= 11303.9 \text{ (round up)} \\
&= 11304 \\
x_1 &= 11304 \text{ (30m)} \\
&= 339120m
\end{aligned}
$$

Compute y coordinate ($y_1$) of the first data point on the first profile. The first data point is offset to the next integer multiple of 30m north of the southwest corner.

$$
\begin{aligned}
\frac{y_{sw}}{30m} &= \frac{3015002.066m}{30m} \\
&= 100500.07 \text{ (round up)} \\
&= 100501 \\
y_1 &= 100501 \text{ (30m)} \\
&= 3015030m
\end{aligned}
$$

Figure 3.--Computation of first data point in a DEM west of the central meridian.




Example computation of UTM coordinates ($x_1$,$y_1$) of the first data point in a 7.5-minute DEM east of the central meridian.

The southwest corner of the 7.5-minute DEM used in this example is at latitude 27°07'30", longitude -92°30'00" ($x_{sw}$ =549553.918m, $y_{sw}$=3000211.052m). The northwest corner is at latitude 27°15'00", longitude -92°30'00" ($x_{nw}$ =549498.713m, $y_{nw}$ =3014056.068m).

Compute x coordinate ($x_1$) of the first profile. The first profile is offset to the next integer multiple of 30m east of the northwest corner.

$$\frac{x_{nw}}{30m} = \frac{549498.713m}{30m}$$
$$= 18316.6 \text{ (round up)}$$
$$= 18317$$
$$x_1 = 18317\ (30m)$$
$$= 549510m$$

Compute y coordinate ($y_1$) of the first data point on the first profile. The first data point is offset to the next integer multiple of 30m north of the intercept ($y_{int}$) of the first profile with the western longitude line of the 7.5-minute quadrangle.

(a) Use the slope intercept formula y=mx+b to compute $y_{int}$.

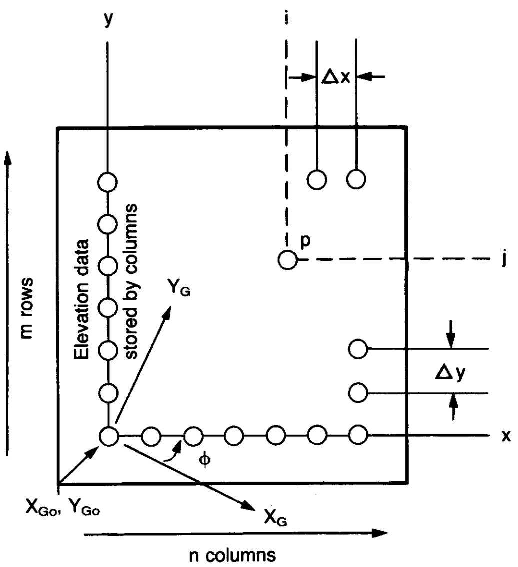
$$m = (y_{nw}-y_{sw})/(x_{nw}-x_{sw})$$
$$= 13845.016/-55.205$$
$$b = y_{sw} - mx_{sw}$$
$$= 3000211.052m - [(-250.79)(549553.919)]$$
$$= 140822838.147m$$

$$y_{int} = b + mx_1$$
$$= 140822838.147m + [(-250.79)(549510m)]$$
$$= 3011225.247m$$

(b) Compute $y_1$

$$\frac{y_{int}}{30m} = \frac{3011225.247m}{30m}$$
$$= 100374.175 \text{ (round up)}$$
$$= 100375$$
$$y_1 = 100375\ (30m)$$
$$= 3011250$$

Figure 4.--Computation of first data point in a DEM east of the central meridian.




(1)

$$x_p = (i-1)\,\Delta x$$

$$y_p = (j-1)\,\Delta y$$

(2)

$$X_{Gp} = X_{Go} + x_p \cos\phi - y_p \sin\phi$$

$$Y_{Gp} = Y_{Go} + x_p \sin\phi + y_p \cos\phi$$

Figure 5.--Geometry and nomenclature of the DEM file.

Virtually all of the 7.5-minute DEM's produced to date are considered to be level 1. Only the limited number of 7.5-minute DEM's generated by interpolation from digital contours are presently considered to be level 2. The USGS does not currently produce level 3 DEM data.

All 1:250,000-scale DEM's have been classified as level 3, although the primary source materials, 1:250,000-scale topographic maps, are more generalized than the 7.5-minute DEM sources. The level 3 designation reflects inclusion of planimetric features as constraints in the DMA gridding process and also reflects editing, where needed, to insure agreement with the 1:250,000-scale source materials.

## DATA RECORDS

A DEM file is organized into a series of three logical records formatted as shown in Appendixes A-C. Appendixes D-G consist of code definitions that are needed to interpret various data elements in the three records. The type A record contains information defining the general characteristics of the DEM, including descriptive header information relating to the DEM's name, boundaries, scale, units of measurement, minimum and maximum data values, number of type B records, and projection parameters. There is only one type A record for each DEM file, and it appears before any other record. The type B record contains elevation data and associated header information. All type B records of the DEM files currently being distributed are made up of data from one-dimensional bands called profiles. Therefore, the number of complete profiles covering the DEM area is synonymous with the number of type B records in the DEM. The type C record contains statistics on the accuracy of the data in the file.

## SAMPLE DATA RECORDS

Following are sample sets of A, B, and C records, corresponding to a typical 7.5-minute DEM (tables 1-3), and sample sets of A and B records for a typical 1:250,000-scale DEM (tables 4, 5). Included in these samples are literal ASCII listings of records directly from DEM distribution tapes. Following the literal listings are tabular explanations of each element in the type A, B, and C records. The tabular explanations may be used as direct references between the literal listings and the logical record type formats shown in Appendixes A-C. Appendixes D-G consist of code definitions that are needed to interpret various data elements in the three records.

## SAMPLE APPLICATIONS

The DEM files may be used in the generation of graphics such as isometric projections displaying slope, direction of slope, and terrain profiles between designated points. They may also be used in combination with other data types, for example, with stream locations and weather data to plan forest fire control or with remote sensing data to classify vegetation. Many nongraphic applications such as modeling terrain gravity data for use in locating energy resources, determining the volume of proposed reservoirs, calculating the amount of material removed during strip mining, and determining landslide probability have also been developed. Figures 6 and 7 show two graphic applications of DEM's.

Table 1.--Sample DEM Type A Logical Record--Mt. St. Helens NW, Washington, Quadrangle (7.5-minute)

```
MT ST HELENS NW,WA. SPIRIT LAKE FH:20000 MSH-M80  3-176 09/06/80  B-8 N=2.00x1.00 s=2.00x1.00MM 9 PANEL FILES 30M x 30M INTERVAL
            1     1     1    10   0.0                       0.0                       0.0                       0.0                       0.0
                  0.0                       0.0                       0.0                       0.0                       0.0
   0.0                       0.0                       0.0                       0.0                       0.0                       2     2
  4   0.557945011821133D+06   0.510799133901730D+07   0.557813813954232D+06   0.512188002753253D+07   0.567449420312715D+06   0.512197873
846927D+07   0.567602487473599D+06   0.510809006713248D+07   0.679000000000000D+03   0.254300000000000D+04   0.0                          1
0.300000E+020.300000+E020.100000E+01     1   327
```

| Data Element | Content | Explanation |
|---|---|---|
| 1 | Mt. St. Helens NW, WA etc. | Quadrangle name field (144 characters) and other descriptive information relating to the digital production process. |
| 2 | 1 | DEM level code. |
| 3 | 1 | Pattern code indicating either a regular or random elevation pattern; 1 indicates a regular pattern. |
| 4 | 1 | Planimetric reference system code; 1 indicates UTM coordinate system. |
| 5 | 10 | Code defining the zone in the ground planimetric reference system. |
| 6 | 0.0 (15 sets of 0.0) | Map projection parameters; all 15 fields are set to zero for the UTM coordinate system and should be ignored. |
| 7 | 2 | Units code; 2 represents meters as the unit of measure for ground planimetric coordinates throughout the file. |
| 8 | 2 | Units code; 2 represents meters as the unit of measure for elevation coordinates throughout the file. |
| 9 | 4 | Number (n) of sides in the polygon which defines the coverage of the DEM file (usually equal to 4). |

Table 1.--Sample DEM Type A Logical Record--Mt. St. Helens NW, Washington, Quadrangle (7.5-minute)--continued

| Data Element | Content | Explanation |
|---|---|---|
| 10 | 0.5579450...D+06<br>................<br>................ | A 4,2 array containing the ground coordinates of the four corners of the DEM. Translation to decimal format yields: 557945.0, 5107991.3; 557813.8, 5121880.0; 567449.4, 5121978.7; 567602.5 5108090.1. |
| 11 | 0.679....D+03<br>0.2543...D+04 | Minimum and maximum elevations for the DEM. |
| 12 | 0.0 | Counterclockwise angle (in radians) from the primary axis of ground planimetric reference to the primary axis of the DEM local reference system. |
| 13 | 1 | Accuracy code; 1 indicates that a record of accuracy exists and is contained in record type C. |
| 14 | 0.3000000E+02<br>0.3000000E+02<br>0.1000000E+01 | A Three-element array containing DEM spatial resolution (x,y,z); usually set to 30, 30, 1. |
| 15 | 1, 327 | A Two-element array containing the number of rows and columns of profiles in the DEM. The row value m is usually set to 1 as an indication that the arrays are actually one dimensional profiles. The column value n equaling 327 indicates that the DEM file consists of a total of 327 profiles. |

Table 2.--Sample DEM Type B Logical Record--Mt. St. Helens NW, Washington, Quadrangle (7.5-minute)

```
     1     2   128     1  0.557850000000000D+06  0.511806000000000D+07   0.0                      0.890000000000000D+03  0.12050000000
000D+04 1202 1204 1203 1205 1205 1202 1198 1194 1191 1188 1185 1176 1170 1168 1166 1165 1167 1168 1167 1165 1160
151 1158 1165 1163 1166 1170 1163 1159 1159 1154 1147 1144 1137 1130 1121 1110 1096 1098 1096 1088 1084 1081 1080
 1082 1084 1080 1071 1055 1045 1039 1040 1039 1035 1029 1025 1023 1021 1018 1010 1009 1011 1010 1007 1001  998   9
6  996  992  988  993  995  995  994  991  983  979  977  970  965  961  955  950  948  953  958  931  943  936
935  934  932  930  928  923  922  924  918  915  916  913  910  911  912  911  910  910  910  910  910  912  912
 913  911  910  911  911  912  910  909  910  907  904  900  898  895 890  890
```

| Data Element | Content | Explanation |
|---|---|---|
| 1 | 1, 2 | Rows and column identification number of the profile contained in this record; 1, 2 represents row 1, column 2, in the DEM data set. |
| 2 | 128, 1 | Number of rows (elevations) and columns in this profile; 128, 1 indicates there are 128 elevations and 1 column in this profile. |
| 3 | 0.557850...D+06<br>0.5118060...D+07 | Translated to the decimal, 557850.0 and 5118060.0 are the ground planimetric coordinates (UTM) of the first elevation in the profile. |
| 4 | 0.0 | Elevation of local datum for the profile. |
| 5 | 0.890...D+03<br>0.1205..D+04 | Minimum and maximum elevations for the profile. |
| 6 | 1202 1204...<br>.............<br>....890 890 | An array of m x n elevations (m=128, n=1) for the profile expressed in units of measure of meters (record A, element 8, indicates meters as units of measure). |

Table 3.--Sample DEM Type C Logical Record--Mt. St. Helens NW, Washington, Quadrangle (7.5-minute)

```
0    0    0    0    0    1    0    0    7    0
```

| Data Element | Content | Explanation |
|---|---|---|
| 1 | 0 | Availability code; elements 1 through 3 relate to absolute accuracy and do not exist for this file. |
| 2 | Three "0"s | See above. |
| 3 | 0 | See above. |
| 4 | 1 | Availability code; 1 indicates that statistics are available in the next element. |
| 5 | 0, 0, 7 | RMSE of DEM data relative to datum (in x, y, and z); the first two zeros indicate that the x and y relative statistics are not available. The value 7 indicates that the DEM met relative vertical (z) accuracy criteria for the 7-m data base. |
| 6 | 0 | Sample size code; 0 indicates that the relative statistic of element 5 is based on an estimated value. |

Table 4.--Sample DEM Type A Logical Records--Reno, Nevada-California, Quadrangle (West Half) (1:250,000-Scale)

```
NJ11-01E   W
                3      1      0      0   0.0                          0.0                          0.0                          0.0                          0.0
                       0.0                          0.0                          0.0                          0.0                          0.0
   0.0                          0.0                          0.0                          0.0                          0.0                          3     2
  4  -0.428400000000000D+06   0.140400000000000D+06  -0.428400000000000D+06   0.144000000000000D+06 -0.424800000000000D+06   0.144000000
000000D+06  -0.424800000000000D+06   0.140400000000000D+06   0.999000000000000D+03  0.264100000000000D+04  0.0                         0
0.30000DE+010.300000E+010.100000E+01      1  1201
```

| Data Element | Content | Explanation |
|---|---|---|
| 1 | NJ11-01E W | Quadrangle name field (144 characters); NJ11-01E W is the designation for the DEM covering the west half of the Reno, Nevada, sheet. |
| 2 | 3 | DEM level code; 3 reflects processing by DMA which includes registration to planimetric features appearing on the source 1:250,000-scale topographic map. |
| 3 | 1 | Pattern code; 1 indicates a regular elevation pattern. |
| 4 | 0 | Planimetric reference system code; 0 indicates geographic coordinate system. |
| 5 | 0 | Zone code; there are no zones in the geographic system. Therefore, the zone code is set to zero. |
| 6 | 0.0 (15 sets of 0.0) | Map projection parameters; all 15 fields are set to zero for the geographic system and should be ignored. |
| 7 | 3 | Units code; 3 represents arc-seconds as the unit of measure for ground planimetric coordinates throughout the file. |
| 8 | 2 | Units code; 2 represents meters as the unit of measure for elevation coordinates throughout the file. |
| 9 | 4 | Number (n) of sides in the polygon which defines the coverage of the DEM file (usually equal to 4). |

Table 4.--Sample DEM Type A Logical Records--Reno, Nevada-California, Quadrangle (West Half) (1:250,000-Scale)--continued

| Data Element | Content | Explanation |
|---|---|---|
| 10 | -04284...D+06,<br>0.1404...D+06<br>.............<br>..............<br>-0.4248...D+06<br>0.1404...D+06 | A 4,2 array containing the ground coordinates of the four corners of the DEM. In this case translation from arc-seconds to degrees, minutes, and seconds yields: -119 00 00, 39 00 00; -119 00 00, 40 00 00; -118 00 00, 40 00 00; -118 00 00, 39 00 00. |
| 11 | 0.9990...D+03<br>0.2641...D+04 | Minimum and maximum elevations for the DEM. |
| 12 | 0.0 | Counterclockwise angle from the primary axis of ground planimetric reference to the primary axis of the DEM local reference system. |
| 13 | 0 | Accuracy code; 0 indicates that a record of accuracy does not exist and that no record type C will follow. |
| 14 | 0.3000000E+01<br>0.3000000E+01<br>0.1000000E+01 | A Three-element array containing DEM spatial resolution (x,y,z); usually set to 3, 3, 1. |
| 15 | 1, 1201 | A Two-element array containing the number of rows and columns of profiles in the DEM. The row value m is usually set to 1 as an indication that the arrays are actually one-dimensional profiles. The column value n set to 1,201 indicates that the DEM file consists of a total of 1,201 profiles. |

Table 5.--Sample DEM Type B Logical Record--Reno, Nevada-California, Quadrangle (West Half) (1:250,000-Scale)

```
     1     1  1201     1  -0.428400000000000D+06   0.140400000000000D+06   0.0                    0.121200000000000D+04  0.17720000000D+04
0000D+04  1538  1539  1539  1534  1529  1520  1513  1508  1501  1493  1488  1483  1479  1475  1474  1473  1472  1469  1469  1467  1466
1464

                        (As per 7.5-minute DEM's, element 6 contains elevations for the DMA DEM.
                            This field always contains 1201 elements per B.1 record.)

                                                   1422  1417  1412  1405  1401  1396  1391  1392  1394  1397  1398  1397  1398
 1398  1397  1394  1390  1386  1383  1380  1377  1374  1372  1369  1367  1366  1367  1368  1368  1369  1369  1370  1371  1371  1371
1371  137
0  1371  1372  1370  1373  1373  1372  1376  1375   1374  1374  1372
 1372  1374  1374   1374  1374  1376  1378  1381
```

| Data Element | Content | Explanation |
|---|---|---|
| 1 | 1, 1 | Row and column identification number of the profile contained in this record; 1, 1 represents row 1, column 1, in the DEM data set. |
| 2 | 1201, 1 | Number of rows (elevations) and columns in this profile; 1201, 1 indicates there are 1201 elevations and 1 column in this profile. |
| 3 | -0.4284...D+06<br>0.1404...D+06 | Translated to the decimal, -428400.0 and 1404000.0 are the ground planimetric coordinates (arc seconds) of the first elevation in the profile, thus -119 and 39 degrees. |
| 4 | 0.0 | Elevation of local datum for the profile. |
| 5 | 0.1212...D+04<br>0.1772...D+04 | Minimum and maximum elevations for the profile. |
| 6 | 1538 1539...<br>.............<br>..1378 1381 | An array of m x n elevations (m=1201, n=1) for the profile expressed in units of measure of meters (record A, element 8, indicates meters as units of measure). |

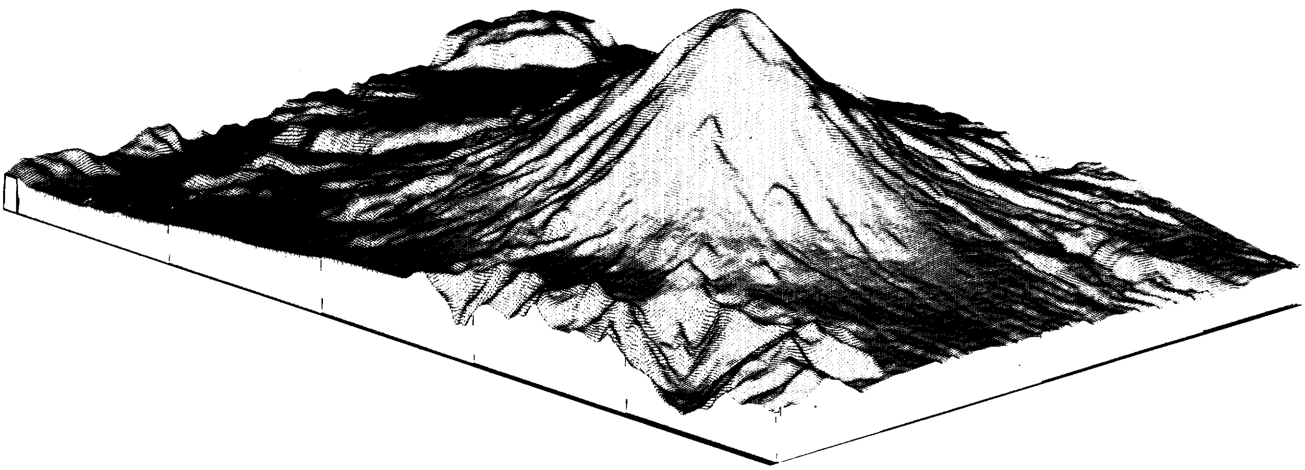


Figure 6.--Pre-eruption isometric plot of Mount St. Helens DEM. Generated from data obtained from July 15, 1979, photographs. View is from the northeast at a 45° altitude angle; vertical exaggeration is 3:1.

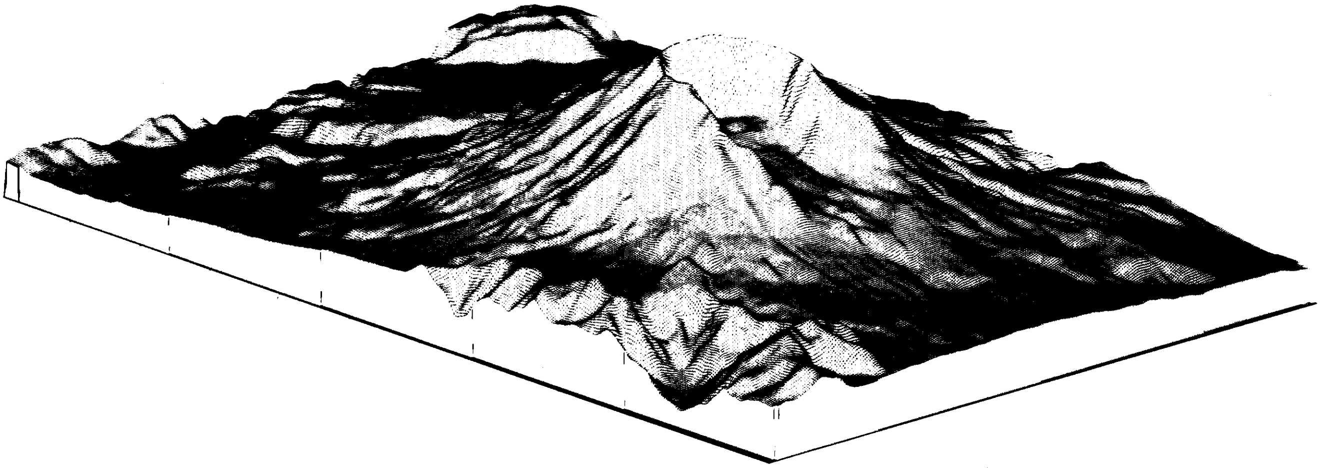


Figure 7.--Post-eruption isometric plot of Mount St. Helens DEM. Generated from data obtained from September 6, 1980, photographs. View is from the northeast at a 45° altitude angle; vertical exaggeration is 3:1.

# APPENDIXES

APPENDIX A.--Digital Elevation Model Data Elements
Logical Record Type A

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format: ASCII Format | Physical Record Format: BINARY Format (Bytes) | Comment |
|---|---|---|---|---|---|
| 1 | File Name | ALPHA | A144 | 144 | |
| 2 | DEM Level Code | INTEGER*2 | I6 | 2 | Code 1=DEM-1<br>2=DEM-2<br>3=DEM-3<br>Normally set to Code 1 for 1:24,000-scale DEM's and Code 3 for 1:250,000-scale DEM's. |
| 3 | Code defining elevation pattern (regular or random) | INTEGER*2 | I6 | 2 | Code 1=regular<br>2=random<br>Normally set to Code 1. |
| 4 | Code defining ground planimetric reference system | INTEGER*2 | I6 | 2 | Code 0,=Geographic<br>1,=UTM<br>2,=State Plane<br>For codes 3-20, see Appendix G. Normally set to code 0 representing the geographic (latitude/longitude) system for 1:250,000-scale DEM's. Normally set to code 1 representing the UTM standard coordinate system for 1:24,000-scale DEM's. |
| 5 | Code defining zone in ground planimetric reference system | INTEGER*2 | I6 | 2 | Codes for State plane and UTM coordinate zones are given in Appendixes E and F for 1:24,000-scale DEM's. Code is set to zero for 1:250,000-scale DEM's. |

APPENDIX A.--Digital Elevation Model Data Elements
Logical Record Type A--continued

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format: ASCII Format | Physical Record Format: BINARY Format (Bytes) | Comment |
|---|---|---|---|---|---|
| 6 | Map projection parameters (see Appendix G) | REAL*8 | 15D24.15 | 15 x 8 = 120 | Definition of parameters for UTM projection is given in Appendix G. All 15 fields of this element are set to zero and should be ignored when geographic, UTM, or State plane coordinates are coded in data element 4. |
| 7 | Code defining unit of measure for ground planimetric coordinates throughout the file | INTEGER*2 | I6 | 2 | Code 0,=Radians<br>1,=feet<br>2,=meters<br>3,=arc-seconds<br>Normally set to Code 2 for 1:24,000-scale DEM's. Normally set to Code 3 for 1:250,000-scale DEM's. |
| 8 | Code defining unit of measure for elevation coordinates throughout the file | INTEGER*2 | I6 | 2 | Code 1,=feet<br>2,=meters<br>Normally code 2 for meters for 1:24,000-scale DEM's and 1:250,000-scale DEM's. |
| 9 | Number (n) of sides in the polygon which defines the coverage of the DEM file | INTEGER*2 | I6 | 2 | Usually n=4. |
| 10 | A 4,2 array containing the ground coordinates of the four corners for the DEM | REAL*8 | 4(2D24.15) | 64 | The coordinates of the quadrangle corners are ordered in a clockwise direction beginning with the southwest corner. The array is stored row-wise as pairs of eastings and northings. |

APPENDIX A.--Digital Elevation Model Data Elements
Logical Record Type A--continued

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format: ASCII Format | Physical Record Format: BINARY Format (Bytes) | Comment |
|---|---|---|---|---|---|
| 11 | A two-element array containing minimum and maximum elevations for the DEM | REAL*8 | 2D24.15 | 16 | The values are in the unit of measure given by data element 8 in this record. |
| 12 | Counterclockwise angle (in radians) from the primary axis of ground planimetric reference to the primary axis of the DEM local reference system | REAL*8 | D24.15 | 8 | See figure 5. Normally set to zero to align with the coordinate system specified in element 4. |
| 13 | Accuracy code for elevations | INTEGER*2 | I6 | 2 | Code 0,=unknown accuracy<br>1,=accuracy information is given in logical record type C. |
| 14 | A three-element array containing DEM spatial resolution (x,y,z). Units of measure for these resolution elements are consistent with those indicated by data elements 7 and 8 in this record | REAL*4 | 3E12.6 | 12 | These elements are usually set to 30, 30, 1 for 7.5-minute DEM's and 3, 3, 1 for 1:250,000-scale DEM's. These units should not be confused with accuracy of the data. |
| 15 | A two-element array containing the number of rows and columns (m, n) of profiles in the DEM | INTEGER*2 | 2I6 | 4 | See figure 5. Normally the row value m is set to 1. Thus, the n value normally describes the number of columns in the DEM file. |

APPENDIX B.--Digital Elevation Model Data Elements
Logical Record Type B

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format | | Comment |
|---|---|---|---|---|---|
| | | | ASCII Format | BINARY Format (Bytes) | |
| 1 | A two-element array containing the row and column identification number of the DEM profile contained in this record | INTEGER*2 | 2I6 | 4 | See figure 5. The identification numbers range from 1 to m and 1 to n. Rows are normally set to 1 and should be disregarded. The column identification is the profile sequence number. |
| 2 | A two-element array containing the number of rows and columns (m,n) of elevations in the DEM profile | INTEGER*2 | 2I6 | 4 | See figure 5. This first element in the field corresponds to the number of nodes in this profile. The second element in this field is normally set to 1, specifying 1 column per B record. |
| 3 | A two-element array containing the ground planimetric coordinates ($X_{go}$, $Y_{go}$) of the first elevation in the profile | REAL*8 | 2D24.15 | 16 | See figure 5. |
| 4 | Elevation of local datum for the profile. | REAL*8 | D24.15 | 8 | The values are in the units of measure given by data element 8 in logical record type A. |

APPENDIX B.--Digital Elevation Model Data Elements
Logical Record Type B--continued

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format ASCII Format | Physical Record Format BINARY Format (Bytes) | Comment |
|---|---|---|---|---|---|
| 5 | A two-element array of minimum and maximum elevations for the profile | REAL*8 | 2D24.15 | 16 | The values are in the unit of measure given by data element 8 in logical record type A. |
| 6 | An array of m x n elevations for the profile. Elevations are expressed in units of resolution elements | INTEGER*2 | mn(I6) | 2mn | See data element 14 in Appendix A. A value in this array would be multiplied by the spatial resolution value and added to the elevation of the local elevation datum for the profile (data element 4 in this record) to obtain the elevation for the point. The planimetric ground coordinates of the point $X_{gp}$, $Y_{gp}$, are computed according to the formulas in figure 5. |

APPENDIX C.--Digital Elevation Model Data Elements
Logical Record Type C

| Data Element | Contents | Type (FORTRAN Notation) | Physical Record Format | | Comment |
|---|---|---|---|---|---|
| | | | ASCII Format | BINARY Format (Bytes) | |
| 1 | Switch indicating availability of statistics in data element 2 | INTEGER*2 | I6 | 2 | Code 1,=available<br>0,=unavailable |
| 2 | RMSE of file's datum relative to absolute datum (x,y,z) | INTEGER*2 | 3I6 | 6 | In same units as indicated by elements 7 and 8 of logical record type A record. |
| 3 | Sample size on which statistics in data element 2 are based | INTEGER*3 | I6 | 2 | If = 0 then accuracy will be assumed to be estimated rather than computed. |
| 4 | Switch indicating availability of statistics in data element 5 | INTEGER*2 | I6 | 2 | Code 1,= available<br>0,=unavailable |
| 5 | RMSE of DEM data relative to file's datum (x,y,z) | INTEGER*2 | 3I6 | 6 | In same units as indicated by elements 7 and 8 of logical record type A. |
| 6 | Sample size on which statistics in datum 5 are based | INTEGER*2 | I6 | 2 | If 0, then accuracy will be assumed to be estimated rather than computed. |

APPENDIX D.--Sample Quadrilateral Coordinates

| Quad Corner No. | Geographic Coordinates | | UTM Coordinates | |
|---|---|---|---|---|
| | Latitude | Longitude | Easting | Northing |
| 1 | 35°30' | 107°37'30" | 261897.700 | 3931463.000 |
| 2 | 35°37'30" | 107°37'30" | 262267.500 | 3945330.700 |
| 3 | 35°37'30" | 107°30' | 273590.400 | 3945035.600 |
| 4 | 35°30' | 107°30' | 273238.300 | 3931168.300 |

## APPENDIX E.--Codes for State Plane Coordinate Zones

| | |
|---|---|
| Alabama, East (AL) | 0101 |
| Alabama, West | 0102 |
| Alaska (AK) | 5001 |
| | thru 5010 |
| Arizona, East (AZ) | 0201 |
| Arizona, Central | 0203 |
| Arizona, West | 0202 |
| Arkansas, North (AR) | 0301 |
| Arkansas, South | 0302 |
| California (CA) | 0401 |
| | thru 0407 |
| Colorado, North (CO) | 0501 |
| Colorado, Central | 0502 |
| Colorado, South | 0503 |
| Connecticut (CT) | 0600 |
| Delaware (DE) | 0700 |
| District of Columbia (DC) | 1900 |
| Florida, North (FL) | 0903 |
| Florida, East | 0901 |
| Florida, West | 0902 |
| Georgia, East (GA) | 1001 |
| Georgia, West | 1002 |
| Hawaii (HI) | 5101 |
| | thru 5105 |
| Idaho, East (ID) | 1101 |
| Idaho, Central | 1102 |
| Idaho, West | 1103 |
| Illinois, East (IL) | 1201 |
| Illinois, West | 1202 |
| Indiana, East (IN) | 1301 |
| Indiana, West | 1303 |
| Iowa, North (IA) | 1401 |
| Iowa, South | 1402 |
| Kansas, North (KS) | 1501 |
| Kansas, South | 1502 |
| Kentucky, North (KY) | 1601 |
| Kentucy, South | 1602 |
| New York, West | 3103 |
| New York, Long Island | 3104 |
| North Carolina (NC) | 3200 |
| North Dakota, North (ND) | 3301 |
| North Dakota, South | 3302 |
| Ohio, North (OH) | 3401 |
| Ohio, South | 3402 |
| Oklahoma, North (OK) | 3501 |
| Oklahoma, South | 3502 |
| Oregon, North (OR) | 3601 |
| Oregon, South | 3602 |
| Pennsylvania, North (PA) | 3701 |
| Pennsylvania, South | 3702 |
| Rhode Island (RI) | 3800 |
| South Carolina, North(SC) | 3901 |
| Louisiana, North (LA) | 1701 |
| Louisiana, South | 1702 |
| Louisiana, Off Shore | 1703 |
| Maine, East (ME) | 1801 |
| Maine, West | 1802 |
| Maryland (MD) | 1900 |
| Massachusetts, Mainland (MA) | 2001 |
| Massachusetts, Island | 2002 |
| Michigan, East (MI) | 2101 |
| Michigan, Central | 2102 |
| Michigan, West | 2103 |
| Michigan, North (Lambert) | 2111 |
| Michigan, Central (Lambert) | 2112 |
| Michigan, South (Lambert) | 2113 |
| Minnesota, North (MN) | 2201 |
| Minnesota, Central | 2202 |
| Minnesota, South | 2203 |
| Mississippi, East (MS) | 2301 |
| Mississippi, West | 2302 |
| Missouri, East (MO) | 2401 |
| Missouri, Central | 2402 |
| Missouri, West | 2403 |
| Montana, North (MT) | 2501 |
| Montana, Central | 2502 |
| Montana, South | 2503 |
| Nebraska, North (NE) | 2601 |
| Nebraska, South | 2602 |
| Nevada, East (NV) | 2701 |
| Nevada, Central | 2702 |
| Nevada, West | 2703 |
| New Hampshire (NH) | 2800 |
| New Jersey (NH) | 2900 |
| New Mexico, East (NM) | 3001 |
| New Mexico, Central | 3002 |
| New Mexico, West | 3003 |
| New York, East (NY) | 3101 |
| New York, Central | 3102 |
| Utah, Central | 4302 |
| Utah, South | 4303 |
| Vermont (VT) | 4400 |
| Virginia, North (VA) | 4501 |
| Virginia, South | 4502 |
| Washington, North (WA) | 4601 |
| Washington, South | 4602 |
| West Virginia, North (WV) | 4701 |
| West Virginia, South | 4702 |
| Wisconsin, North (WI) | 4702 |
| Wisconsin, Central | 4802 |
| Wisconsin, South | 4803 |
| Wyoming, Zone I, East (WY) | 4901 |
| Wyoming, Zone II, East Central | 4902 |

APPENDIX E.--Codes for State Plane Coordinate Zones--continued

| | |
|---|---|
| South Carolina, South | 3902 |
| South Dakota, North (SD) | 4001 |
| South Dakota, South | 4002 |
| Tennessee (TN) | 4100 |
| Texas, North (TX) | 4201 |
| Texas, North Central | 4202 |
| Texas, Central | 4203 |
| Texas, South Central | 4204 |
| Texas, South | 4205 |
| Utah, North (UT) | 4301 |
| Wyoming, Zone III, West Central | 4903 |
| Puerto Rico (RQ) | 5301 |
| Virgin Islands, St. John, (VQ) St. Thomas | 5201 |
| Virgin Islands, St. Croix | 5202 |
| American Samoa (AQ) | 5300 |
| Guam (GQ) | 5400 |

## APPENDIX F.--Universal Transverse Mercator Zone Locations and Central Meridians

| Zone | C.M. | Range | Zone | C.M. | Range |
|---|---|---|---|---|---|
| 01 | 177W | 180W-174W | 31 | 003E | 000E-006E |
| 02 | 171W | 174W-168W | 32 | 009E | 006E-012E |
| 03 | 165W | 168W-162W | 33 | 015E | 012E-018E |
| 04 | 159W | 162W-156W | 34 | 021E | 018E-024E |
| 05 | 153W | 156W-150W | 35 | 027E | 024E-030E |
| 06 | 147W | 150W-144W | 36 | 033E | 030E-036E |
| 07 | 141W | 144W-138W | 37 | 039E | 036E-042E |
| 08 | 135W | 138W-132W | 38 | 045E | 042E-048E |
| 09 | 129W | 132W-126W | 39 | 051E | 048E-054E |
| 10 | 123W | 126W-120W | 40 | 057E | 054E-060E |
| 11 | 117W | 120W-114W | 41 | 063E | 060E-066E |
| 12 | 111W | 114W-108W | 42 | 069E | 066E-072E |
| 13 | 105W | 108W-102W | 43 | 075E | 072E-078E |
| 14 | 099W | 102W-096W | 44 | 081E | 078E-084E |
| 15 | 093W | 096W-090W | 45 | 087E | 084E-090E |
| 16 | 087W | 090W-084W | 46 | 093E | 090E-096E |
| 17 | 081W | 084W-078W | 47 | 099E | 096E-102E |
| 18 | 075W | 078W-072W | 48 | 105E | 102E-108E |
| 19 | 069W | 072W-066W | 49 | 111E | 108E-114E |
| 20 | 063W | 066W-060W | 50 | 117E | 114E-120E |
| 21 | 057W | 060W-054W | 51 | 123E | 120E-126E |
| 22 | 051W | 054W-048W | 52 | 129E | 126E-132E |
| 23 | 045W | 048W-042W | 53 | 135E | 132E-138E |
| 24 | 039W | 042W-036W | 54 | 138E | 138E-144E |
| 25 | 033W | 036W-030W | 55 | 147E | 144E-150E |
| 26 | 027W | 030W-024W | 56 | 153E | 150E-162E |
| 27 | 021W | 024W-018W | 57 | 159E | 156E-162E |
| 28 | 015W | 018W-012W | 58 | 165E | 162E-168E |
| 29 | 009W | 012W-006W | 59 | 171E | 168E-174E |
| 30 | 003W | 006W-000E | 60 | 177E | 174E-180W |

## APPENDIX G.--Parameters Required for Definition of Map Projections

| Parameter | (00)* Geographic | (01)** Universal Transverse Mercator (UTM) | (02) State Plane | (03) Albers Conical Equal Area | (04) Lambert Conformal |
|---|---|---|---|---|---|
| 1 | *** | Longitude of any point within the zone | *** | Semi-major axis of ellipsoid. If this field is left blank (=0), the value for Clarke's 1866 spheroid in meters will be assumed. | |
| 2 | *** | Latitude of any point within the UTM zone | *** | Eccentricity squared of ellipsoid ($e^2$). If field is zero, this will indicate a sphere. If the field is >1, this field will be interpreted as containing the semi-minor axis of the ellipsoid. | |
| 3 | *** | *** | *** | Latitude of 1st Standard Parallel | |
| 4 | *** | *** | *** | Latitude of 2d Standard Parallel | |
| 5 | *** | *** | *** | Longitude of Central Meridian | |
| 6 | *** | *** | *** | Latitude of projection's origin | |
| 7 | *** | *** | *** | False easting in the same units of measure as the semi-major axis of ellipsoid | |
| 8 | *** | *** | *** | False northing in the same units of measure as the semi-major axis of ellipsoid | |
| 9-15 (not used on this page) | | | | | |

* Projection code number.

** For the Northern Hemisphere, supplying UTM zone will result in ignoring any given projection parameters.

*** Parameter is not applicable to projection.

Note: All angles (latitudes, longitudes, or azimuth) are required in degrees, minutes, and arc-seconds in the packed real number format +DDDOMMOSS.SSSSS.

APPENDIX G.--Parameters Required for Definition of Map Projections--continued

| Parameter | (05) Mercator | (06) Polar Stereographic | (07) Polyconic | (08) Equidistant Conic Type A | (08) Equidistant Conic Type B |
|---|---|---|---|---|---|
| 1 | Semi-major axis of ellipsoid. If this field is left blank (=0), the value for Clarke's 1866 spheroid in meters will be assumed. | | | | |
| 2 | Eccentricity squared of ellipsoid (e). If this is left blank (=0), this will indicate a sphere. If the field is >1, this field will be interpreted as containing the semi-minor axis of the ellipsoid. | | | | |
| 3 | *** | *** | *** | Latitude of Standard Parallel | Latitude of 1st Standard Parallel |
| 4 | *** | *** | *** | *** | Latitude of 2d Standard Parallel |
| 5 | Longitude of Central Meridian | Longitude directed straight down below pole of map | . . . . . . Longitude of Central Meridian . . . . . . . | | |
| 6 | *** | Latitude of true scale | . . . . . . Latitude of projection's origin . . . . . . | | |
| 7 | . . . . . False easting in the same units of measure as the semi-major axis of ellipsoid . . . . . . . | | | | |
| 8 | . . . . . False northing in the same units of measure as the semi-major axis of ellipsoid . . . . . . . | | | | |
| 9 | *** | *** | *** | Zero | Any non-zero number |
| 10-15 (not used on this page) | | | | | |

APPENDIX G.--Parameters Required for Definition of Map Projections--continued

| Parameter | (09) Transverse Mercator | (10) Stereographic | (11) Lambert Azimuthal Equal-Area | (12) Azimuthal Equidistant | (13) Gnomonic | (14) Orthographic |
|---|---|---|---|---|---|---|
| 1 | Same as Projections 03 thru 08 | . . . . . . . . . . . . . . Radius of the sphere of reference . . . . . . . . . . . If this field is left blank, the value 6370997.0 meters will be assumed | | | | |
| 2 | Same as Projections 03 thru 08 | *** | *** | *** | *** | *** |
| 3 | Scale factor at Central Meridian | *** | *** | *** | *** | *** |
| 4 | *** | *** | *** | *** | *** | *** |
| 5 | Longitude of Central Meridian | . . . . . . . . . . . . Longitude of center of projection . . . . . . . . . . . . . | | | | |
| 6 | Latitude of origin | . . . . . . . . . . . . . Latitude of center of projection . . . . . . . . . . . . | | | | |
| 7 | False easting in the same units of measure as the semi-major axis or radius of the sphere | | | | | |
| 8 | False northing in the same units of measure as the semi-major axis or radius of the sphere | | | | | |
| 9-15 (not used on this page) | | | | | | |

APPENDIX G.--Parameters Required for Definition of Map Projections--continued

| Parameter | (15) General Vertical Near-Side Perspective | (16) Sinusoidal | (17) Equirectangular (Plate Caree) | (18) Miller Cylindrical | (19) Van Der Grinten I |
|---|---|---|---|---|---|
| 1 | . . . . . . . . . . . . . . . . Radius of the sphere of reference . . . . . . . . . . . . . . . . If this field is left blank, the value 6370997.0 meters will be assumed. | | | | |
| 2 | *** | *** | *** | *** | *** |
| 3 | Height of perspective point above sphere | *** | *** | *** | *** |
| 4 | *** | *** | *** | *** | *** |
| 5 | Longitude of center of projection | . . . . . . . . . . Longitude of Central Meridian . . . . . . . . . . . . | | | |
| 6 | Latitude of center of projection | *** | *** | *** | *** |
| 7 | . . . . . . . . False easting in the same units of measure as radius of the sphere . . . . . . . | | | | |
| 8 | . . . . . . . . False northing in the same units of measure as radius of the sphere . . . . . . | | | | |
| 9-15 (not used on this page) | | | | | |

APPENDIX G.--Parameters Required for Definition of Map Projections--continued

| Parameter | (20) Oblique Mercator (Definition Format A) | (20) Oblique Mercator (Definition Format B) |
|---|---|---|
| 1 | Same as for projections 03 thru 09 | |
| 2 | Same as for projections 03 thru 09 | |
| 3 | Scale factor at the center of projection | |
| 4 | *** | Angle of azimuth east of north for central line of projection |
| 5 | *** | Longitude of point along central line of projection at which angle of azimuth is measured |
| 6 | Latitude of origin of projection | |
| 7 | Same as for projections 03 thru 19 | |
| 8 | Same as for projections 03 thru 19 | |
| 9 | Longitude of first point defining central geodetic line of projection | *** |
| 10 | Latitude of first point defining central geodetic line of projection | *** |
| 11 | Longitude of second point defining central geodetic line of projection | *** |
| 12 | Latitude of second point defining central geodetic line of projection | *** |
| 13 | Zero | Any non-zero number |
| 14 and 15 (not used for this projection) | | |

## APPENDIX H.--Digital Terrain Tapes

Contents



Tables

## DIGITAL TERRAIN TAPES

### Introduction

Digital terrain tapes are a type of digital elevation data produced by the DMA and distributed by USGS. Each digital terrain tape file corresponds in coverage to a 1° x 1° block (one-half of a standard 1:250,000-scale 1° x 2° quadrangle). Digital terrain tapes are available for the conterminous United States and Hawaii. The data are distributed by USGS as produced by the DMA and, as such, they do not conform to the standard USGS DEM tape format.

### Characteristics

A 1:250,000-scale digital terrain tape file has the following characteristics:

- The data consist of a regular array of elevations referenced in digitizer coordinates at increments of 0.01 inch.
- The unit of coverage is a 1° x 1° block representing one half of a 1:250,000-scale 1° x 2° map.
- The positions of the four corners of the 1° x 1° block are stated in digitizer and geographic (latitude/ longitude) coordinates.
- The data are ordered from south to north in profiles that are ordered from west to east.
- The data are stored as profiles in which the spacing of elevations along and between each profile is 0.01 inch (approximately 200 feet at the source map scale of 1:250,000).

### Data Production

Digital terrain tapes were produced as a byproduct of the production of three-dimensional relief maps. Production began in the early 1960's with the development of the Digital Graphics Recorder (DGR) system. The DGR system consisted of manual line-following digitizer connected to a computer system; it was capable of recording digital elevation data by tracing contour lines etched on metal plates. Digital traces of ridges and streams were added to the digital contour data and an interpolation algorithm was applied to produce a cartesian grid of elevation values spaced at 0.01 inch intervals. The gridded elevation data were then employed as a digital template to control a tool for carving the plaster forms used to mold raised-relief maps.

Although the DGR system was initially developed solely to automate the production of raised-relief maps, the versatility of the gridded digital elevation data was quickly recognized, and the concept of a 1:250,000- scale digital elevation data base was born. As the demand for the digital terrain tapes increased, the data collection and processing techniques were refined and streamlined, and the DGR system was eventually replaced by the Automated Graphic Digitizing System (AGDS). The AGDS is an automated scanning system that digitizes data along regularly spaced scan-lines. For production of digital terrain tapes, stable base materials containing contour lines and ridge and stream traces, as depicted on 1:250,000-scale topographic maps, were digitized on the AGDS. The data were then vectorized, tagged, and edited using an interactive digitizing station. An interpolation algorithm was subsequently applied to produce the cartesian grid of elevation values at 0.01 inch intervals.

The 1:250,000-scale digital terrain tape data base was completed for the conterminious United States and Hawaii in the late 1970's. Since that time, 1:250,000-scale DEM's (described on page 4) have been completed for nearly all of the area covered by the digital terrain tapes. In addition, 1:250,000-scale DEM data is available for most of Alaska where digital terrain tapes were never produced. Because the 1:250,000-scale DEM's are more rigorously checked for accuracy and consistency, they are generally considered the preferable source of digital elevation data at this scale. The digital terrain tapes, however, remain a valuable resource and will continue to be distributed by USGS.

## Accuracy

The accuracy of the digital terrain tapes is compatible with the accuracy of the stable-base 1:250,000-scale map sheets from which they were digitized. Neither the maps nor the tapes have been completely tested for vertical accuracy.

## Data Records

Digital terrain tape data are distributed by the USGS on multifile nine-track magnetic tape, usually in odd parity at 1,600 bpi. Each data file represents elevations for a planimetric grid of points covering part (usually one-half) of a 1:250,000-scale map sheet.

Within each file, data are arranged in sequential logical records. Three types of logical record formats are used:

Type A logical record--The first logical record in a digital terrain tape file is a type A record. It contains general information about the digital model. Figure H1 depicts the layout of the 78 bytes which constitute the record and provides a description of each data field in the record. Unless otherwise specified, all data fields represent binary integer numbers.

Type B logical record--The type B record is a variable length record which contains elevation profile data. Figure H2 depicts the layout of this variable length record and provides a description of each data field.

Type C logical record--The type C record is the last logical record in a digital terrain tape file and describes the number of profiles in the file. Figure H3 depicts the layout of the record's 12 bytes, and provides a description of each data field.

Table H1.--Type A logical record data content for a digital terrain tape

| Byte | | Content |
|---|---|---|
| 1-12 | ............ | Sheet number (EBCDIC) |
| 13-18 | ............ | Map series (EBCDIC) |
| 19-24 | ............ | Map edition (EBCDIC) |
| 25-26 | ............ | Map projection code number, code 1 is for UTM projection |
| 27-28 | ............ | Map projection zone number |
| 29-30 | ............ | Code number for elevation-data units =0 for meters =1 for feet |
| 31-32 | ............ | x-coordinate of southwest map corner[1] |
| 33-34 | ............ | y-coordinate of southwest map corner |
| 35-36 | ............ | x-coordinate of northwest map corner |
| 37-38 | ............ | y-coordinate of northwest map corner |
| 39-40 | ............ | x-coordinate of northeast map corner |
| 41-42 | ............ | y-coordinate of northeast map corner |
| 43-44 | ............ | x-coordinate of southeast map corner |
| 45-46 | ............ | y-coordinate of southeast map corner |
| 47-50 | ............ | Longitude of southwest map corner[2] |
| 51-54 | ............ | Latitude of southwest map corner |
| 55-58 | ............ | Longitude of northwest map corner |
| 59-62 | ............ | Latitude of northwest map corner |
| 63-66 | ............ | Longitude of northeast map corner |
| 67-70 | ............ | Latitude of northeast map corner |
| 71-74 | ............ | Longitude of southeast map corner |
| 75-78 | ............ | Latitude of southeast map corner |

[1]All x and y coordinates are in 0.01-inch units.
[2]All longitudes and latitudes are in arc-second units.

Table H2.--Type B logical record data content for a digital terrain tape

| Byte | Content |
|---|---|
| 1-2 .......... | Map x-coordinate of the first point in the profile ($x_o$) in one-hundredths of an inch |
| 3-4 .......... | Map y-coordinate of the first point in the profile ($y_o$) in one-hundredths of an inch |
| 5-6 .......... | x-component of map step between profile elevation points (x) in one-hundredths of an inch (always equals 0) |
| 7-8 .......... | y-component of map step between profile elevation points (y) in one-hundredths of an inch (always equals 1) |
| 9-10 ........ | Number of elevation points (m) in the profile |
| 11-12 ........ | Elevation of first profile point ($H_1$) |
| 13-14 ........ | Elevation of second profile point ($H_2$) |
| • | |
| • | |
| • | |
| (2m+9) - (2m+10)... | Elevation of $m^{th}$ profile point ($H_m$) |

Table H3.--Type C logical record data content for a digital terrain tape

| Byte | Content |
|---|---|
| 1-2 ........................... | A string of 16 '1' bits |
| 3-4 ........................... | A string of 16 '1' bits |
| 5-6 ........................... | A string of 16 '1' bits |
| 7-8 ........................... | A string of 16 '1' bits |
| 9-10 ........................... | The number 1 |
| 11-12 ........................... | Number of profiles (type B logical records) in the digital terrain file |

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