United States
Department of
Agriculture

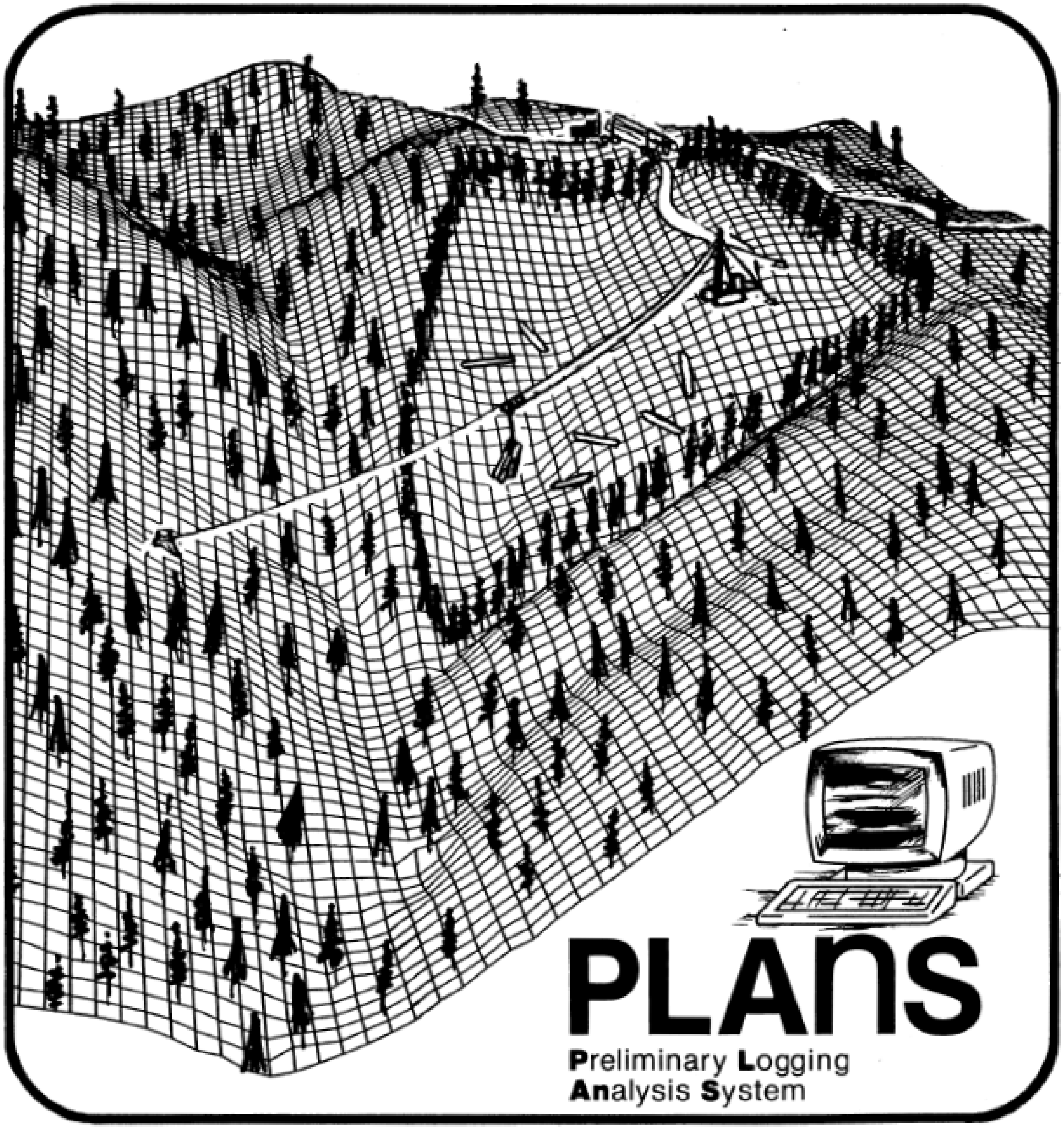
Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-200

The MAP Program: Building the Digital Terrain Model

Roger H. Twito, Ronald W. Mifflin, and Robert J. McGaughey



Authors

ROGER H. TWITO is a research engineer and ROBERT J. McGAUGHEY is a research forester, Pacific Northwest Research Station, Forestry Sciences Laboratory, 4043 Roosevelt Way, NE, Seattle, Washington 98105. RONALD W. MIFFLIN was a research engineer with the Pacific Northwest Research Station during the initial work on this program. He is now a software engineer with General Dynamic's CONVAIR Division in San Diego, California.

April 1987

Abstract

Twito, Roger H.; Mifflin, Ronald W.; McGaughey, Robert J. The MAP program: building the digital terrain model. Gen. Tech. Rep. PNW-GTR-200. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; **1987**. 22 p.

PLANS, a software package for integrated timber-harvest planning, uses digital terrain models to provide the topographic data needed to fit harvest and transportation designs to specific terrain. MAP, an integral program in the PLANS package, is used to construct the digital terrain models required by PLANS. MAP establishes digital terrain models using digitizer-traced contour lines from topographic maps, which are, in turn, processed into an elevation grid and stored in matrix form. MAP builds continuous digital terrain models that can cover large planning areas and builds them to any elevation grid spacing desired. Though the MAP method does not always result in digital terrain models that are a perfect equivalent to the topographic map, they should be adequate for planning. A guide giving detailed operating instructions for the programs is included.

Keywords: Timber harvest planning, computer programs/programing, models, logging operations analysis/design.

Contents

Introduction

Digital terrain models are data files, accessible to computers, that provide detailed topographic information. This report presents a process for producing gridded digital terrain models from topographic maps. The models are used by a system of computer programs called PLANS (acronym for preliminary logging analysis system) (Twito and others 1987) to develop large-area timber-harvesting and road-network plans. The digital terrain models add greatly to. this efficiency by providing convenient and automatic access to the large amount of data on slopes and elevation profiles that must be analyzed in timber-harvest planning.

The digital terrain models are produced by hand-tracing contour lines from a topographic map (with a digitizing cursor). Digitized contour data are converted by the program to a gridded elevation matrix, which is stored for later use. Large planning areas can be subdivided into smaller units for purposes of inputting data. These units, after the digital terrain model is constructed, can be recombined to provide continuous coverage across maps that are larger than the digitizer tablet.

Digital terrain models (DTMs), digital elevation models (DEMs), and digital terrain tapes (DTTs) are part of a system that uses numeric data to represent the surface elevation of the ground. These data, referred to as a digital terrain model (DTM) for the remainder of this report, consist of numerical arrays. The concept of a DTM may be more readily visualized as a model that is equivalent to a topographic map. Both the DTM and the topographic map are models that represent the surface elevation of the earth. A topographic map translates the surface to a form readily understood and visualized by people, and a DTM translates the surface into numeric data readily processed by a computer.

Documented use of DTMs began in the early 1950's at the Massachusetts Institute of Technology (Miller 1957). The system was originally developed to represent the elevation surface of a highway construction zone; the goals were to reduce the burden of routine calculations on transportation planners and to investigate alternative alignment strategies (Grist 1972). In the late 1950's, the Defense Mapping Agency Topographic Center (DMATC) began producing digital terrain data as a byproduct of the construction of plastic relief models of the earth's surface (Carter 1984). DMATC, encouraged by military and civilian groups, developed increasingly complex data-collection systems that, in turn, provided for the development of gridded DTMs. DMATC began releasing this collected data as DTTs in the early 1960's. DTTs, characterized by a 200-foot ground spacing between gridlines, were criticized for their lack of quality (Carter 1984). The original DTTs have been improved by the U.S. Geological Survey (USGS) and are now available as DEMs keyed to the 1:250,000 topographic map series. In addition to the 1 :250,000 DEMs, USGS produces 71/2-minute DEMs as a byproduct of orthophoto mapping. These DEMs, with a 30-meter spacing between elevation points, are keyed to the 71/2-minute topographic maps. Currently about 15 percent of the United States is covered by DTMs (Carter 1984). The development of a DTM used specifically for forest-resource planning was reported by Lemkow (1977). Even though this model was limited by computer-system constraints, it demonstrated the usefulness of a DTM for timber-harvest planning.

Building DTMs With the MAP Program

The MAP program creates the DTMs used by the rest of the PLANS programs. DTMs are created in three basic operations:

1. Establishing the boundary of the DTM.
2. Digitizing the DTM's contour lines.
3. Converting the digitized contour-line data into a DTM.

Establishing the Boundary of the DTM Unit

The topographic map of the project planning area is the source from which DTMs are built. The physical size of the topographic map(s) and the resulting DTM coverage area require careful preparation before building the DTM, especially when large areas are being planned for. Usually, large areas have to be subdivided into smaller DTM units. Subdivision is required when:

1. The DTM coverage area is larger than the digitizer tablet, or
2. The DTM coverage area cannot, as a single unit, meet the desired gridline spacing

When subdivision is required, the DTM coverage area is divided into equal-size, rectangular DTM units. Later, up to six adjacent DTM units can be loaded and combined into an enlarged DTM when the design programs in PLANS are used.

The first step in building a DTM is to delineate the planning area on the topographic map[1/] by carefully enclosing the planning area within a rectangle that defines the DTM coverage area. Next, the user enters the measured dimensions of the rectangle and the desired gridline spacing for the DTM (additional detail on gridline spacing is provided in the appendix), and the program determines if subdivision is required. If subdivision is needed, the program calculates the DTM-unit size necessary to obtain the desired gridline spacing and instructs the user on locating and marking the subdivision boundaries within the DTM coverage area.

Digitizing Contour Lines of the DTM Unit

After the DTM unit is enclosed in a rectangle, elevation data can be entered via the digitizer. First, the location of the DTM unit on the digitizer tablet is established by digitizing the lower left corner of the unit and a point on the lower boundary. Then a process-control menu is taped to the digitizer tablet. The DTM building process is controlled by the user, who simply digitizes inside the menu square labeled for the desired action. A typical sequence of events is as follows:

1. Enter the elevation of the lowest contour line on the DTM unit. (This is optional; the user may start with the highest or anywhere else.)

2. Enter the difference in elevation between adjacent contour lines; that is, the contour interval.

3. Enter the elevation increment mode, which is uphill or downhill. This causes the elevation of each new contour line to be set a_ the elevation of the last line digitized plus, if in the uphill mode, the contour interval.

[1/]The appendix provides more detail on the preparation steps for building a DTM from a topographic map.

4. Trace the contour line with the digitizer cursor. Digitized input automatically stops when the contour line being traced exits the DTM unit or, if the contour line is a continuous loop inside the DTM unit, when the traced loop has been completed.

This process is repeated until the DTM unit is completed or the user wants to change modes. As each line is digitized, it is plotted on the computer screen, which also shows the position of the digitizer cursor. This graphic aid shows the progress of the contour-line tracing operation. The user can stop this operation whenever convenient by digitizing the "terminate contour-line tracing" square in the menu; this action stores the completed contour lines as a partially completed and unprocessed DTM unit. The partially completed unit can be reloaded, and the contour-line tracing can be completed at another time.

The user can select several other menu options that permit variation of digitizing routine, correction of errors, and other operational conveniences. When all contour lines are digitized, the user can instruct the program to process the contour data into a gridded DTM.

Converting the Digitized Contour-Line Data to a DTM

The third and final operation in the process of creating the DTM units needed for operating the PLANS program is an automated process that converts the elevation and contour-line data into gridded elevation data and stores the DTM unit for later use. The user can also store the contour lines to preserve these data for plotting or reprocessing the gridded DTM. The process requires no user input but usually takes up to a minute of computer processing time.

Analytical Description of the MAP Program

A topographic map is the basic source of information used with the MAP program to build digital terrain models. We begin a simplified example of the process with the topographic map (fig. 1).

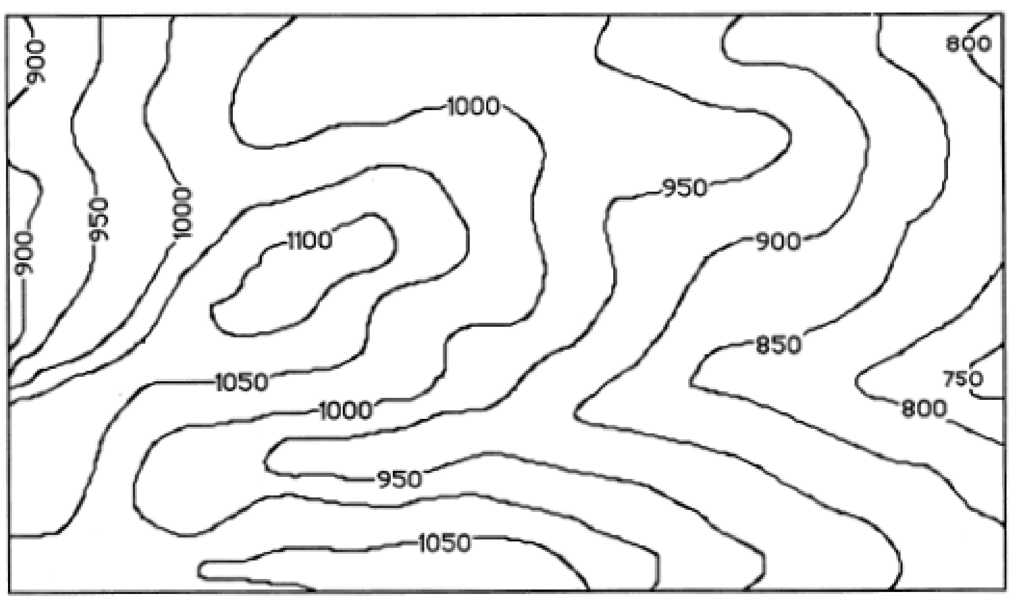


Figure 1—Topographic map from which a gridded DTM can be created.

Digitized Contour Lines as Source Data for DTMs

The user of the MAP program converts topographic maps, like the one shown in figure 1, to DTM data files by tracing each contour line with the digitizer cursor. Each contour line is stored with an elevation "header" (that is, the elevation of the contour line) and a series of closely spaced x and y coordinates, entered by digitizing, that describe the location of the contour line on the DTM unit. Collecting these data is the first step in building the gridded terrain model (fig. 2).

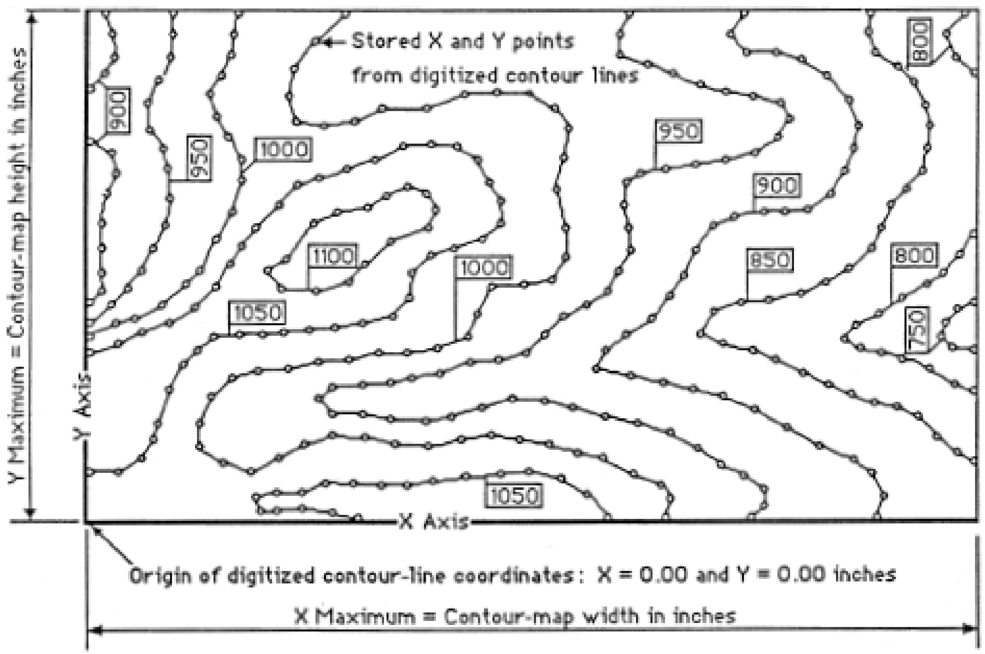


Figure 2—Topographic elevation model represented as a series of discrete x and y coordinate data sets collected by tracing the contour lines with a digitizer cursor.

These data alone constitute one type of DTM as the stored x and y coordinates with their associated contour-line elevations can be considered a numerical representation (model) of the topographic map. The data are, however, the source the gridded DTM is derived from. One reason for converting these data into a gridded DTM is the amount of disk storage space required; a gridded terrain model requires about 5 to 10 percent of the storage space needed for the terrain model in the contour-line form. Even though large amounts of storage space are required, the contour-line data should be stored on a magnetic-tape drive. Doing so allows the user to replot the hand-digitized contour lines and compare their accuracy with the original map. In addition, the stored contour-line data can be reprocessed by other DTM programs that address other analytical needs. Saving the contour-line data is a good general practice because the contour lines do not have to be retraced later.

The remaining steps in the process of creating a DTM, after hand-digitizing the contour lines, are automated and require minimal effort by the user.

The DTM Grid

Figure 3 shows a grid imposed on the contour map. An elevation in the DTM matrix will be derived at each intersection of gridlines.

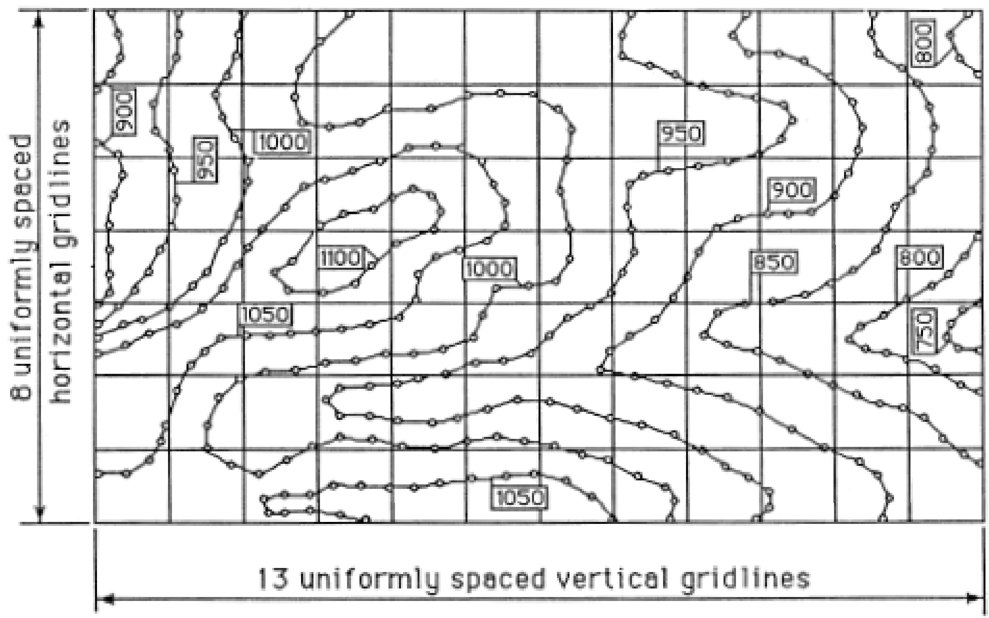


Figure 3—Digitized contour lines displayed with the square grid of the DTM.

The user chooses the spacing for the elevation grid of the DTM. Choosing a fine grid spacing will result in a DTM that corresponds accurately with the contour map; however, fine grids require excessive amounts of disk space. A grid spacing of 25 feet requires about 16 times as much disk space as a grid spacing of 100 feet. Using a fine grid also increases the number of DTM units needed to cover a given planning area and generally complicates planning activities. A grid spacing between 0.10 and 0.15 inch on the map is suggested as a suitable compromise between accuracy and convenience.

Intersections of Contour Lines and Gridlines

The next step in the process is shown in figure 4.

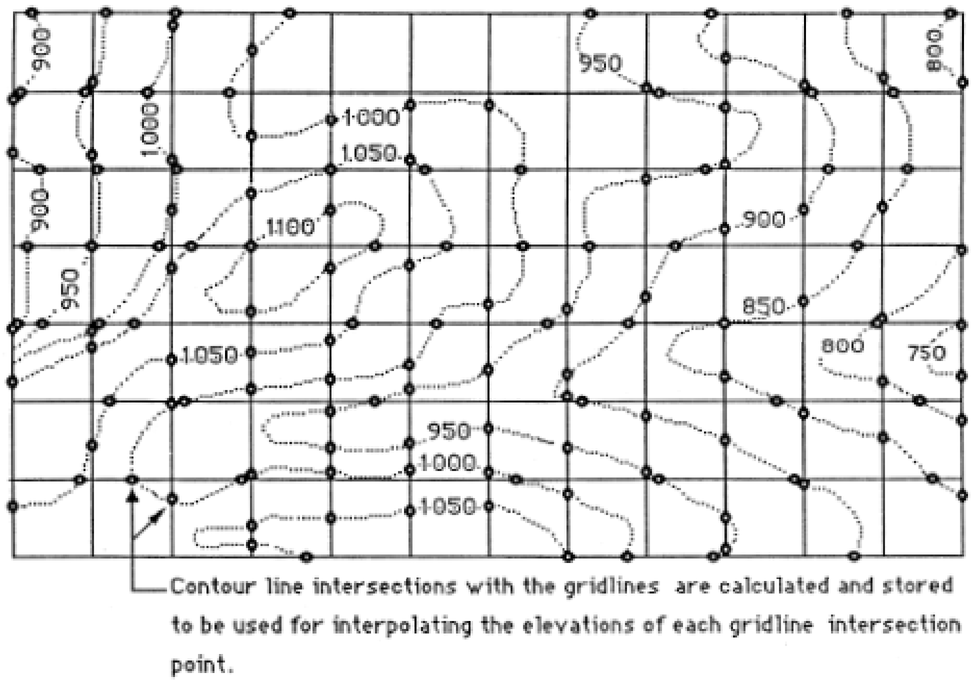


Figure 4—Intersections of the square grid of the DTM with digitized contour lines,

Intersections of the contour lines and the horizontal or vertical gridlines are calculated and stored along with the elevation of the contour line. These data are used in an interpolation to determine the elevation of each corner point in the grid cell.

Interpolating Grid-Point Elevations From Contour-Line Intersections

The rules governing elevation interpolation in the grid cell are shown in figure 5. The interpolated elevation will have, at most, four adjacent contour-line intersections from which to calculate an elevation value. The interpolation will be based on two of these intersections: either the two on the horizontal gridline or the two on the vertical gridline. The value of saving the adjacent four intersections is that the interpolation algorithm can systematically choose the pair of intersections (horizontal or vertical) that will provide the most accurate elevation.

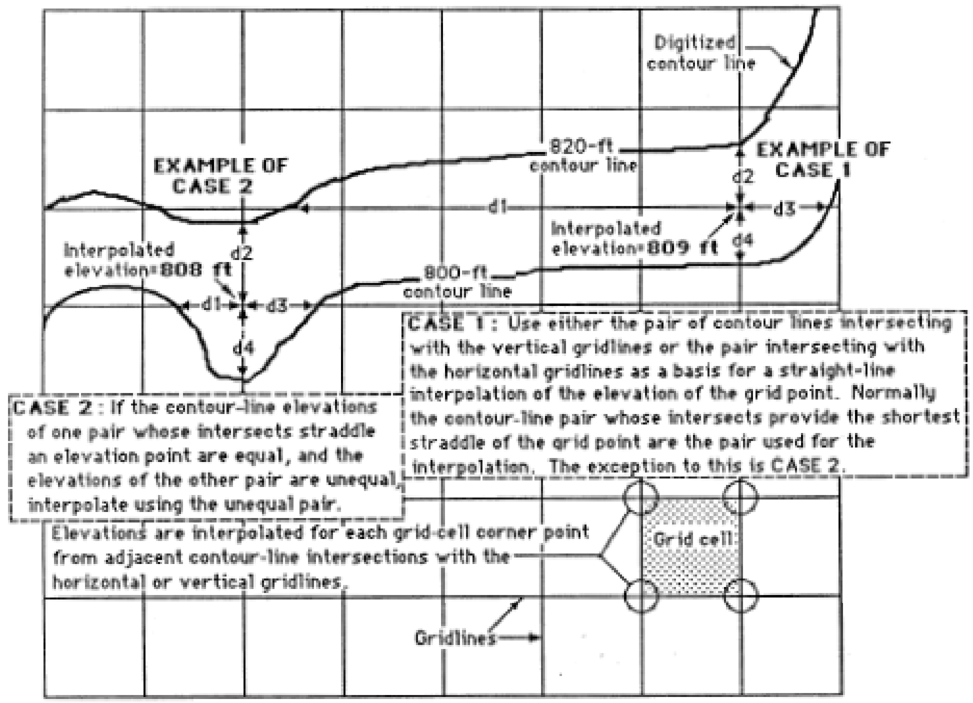


Figure 5—The two major interpolation rules that control the initial elevation-calculation process of the DTM.

The elevation interpolation for the grid point generally is established from either the two contour-line intersections (straddling the grid point) on the vertical gridline or the two contour-line intersections (straddling the grid point) on the horizontal gridline. The choice normally favors whichever pair (horizontal or vertical) surrounds the grid point by the narrowest straddle distance (case 1). If, however, the two straddling pairs of contour lines are of equal elevation (case 2), the algorithm bases the elevation interpolation on the contour-line straddle where the contour lines differ in elevation. Other grid-elevation points that are not surrounded by four contour-line-intersection points use combinations of whatever- data are available. If surrounded by three contour-line-intersection points, the elevation will be interpolated between the two points that straddle the grid-elevation point. This usually occurs only on the edges of DTM units. If only two contour-line-intersection points are available, and the two do not straddle the grid-elevation point, no interpolation is possible, and the elevation from either contour line will be transferred to the grid elevation point. The same holds true if only one contour-line-intersection point is available; such circumstances occur only at the corners of DTM units.

Second-Stage Processing of DTM Elevations

After an initial elevation has been calculated for all the grid-cell corner points, a secondary DTM elevation-conditioning process occurs (fig. 6).

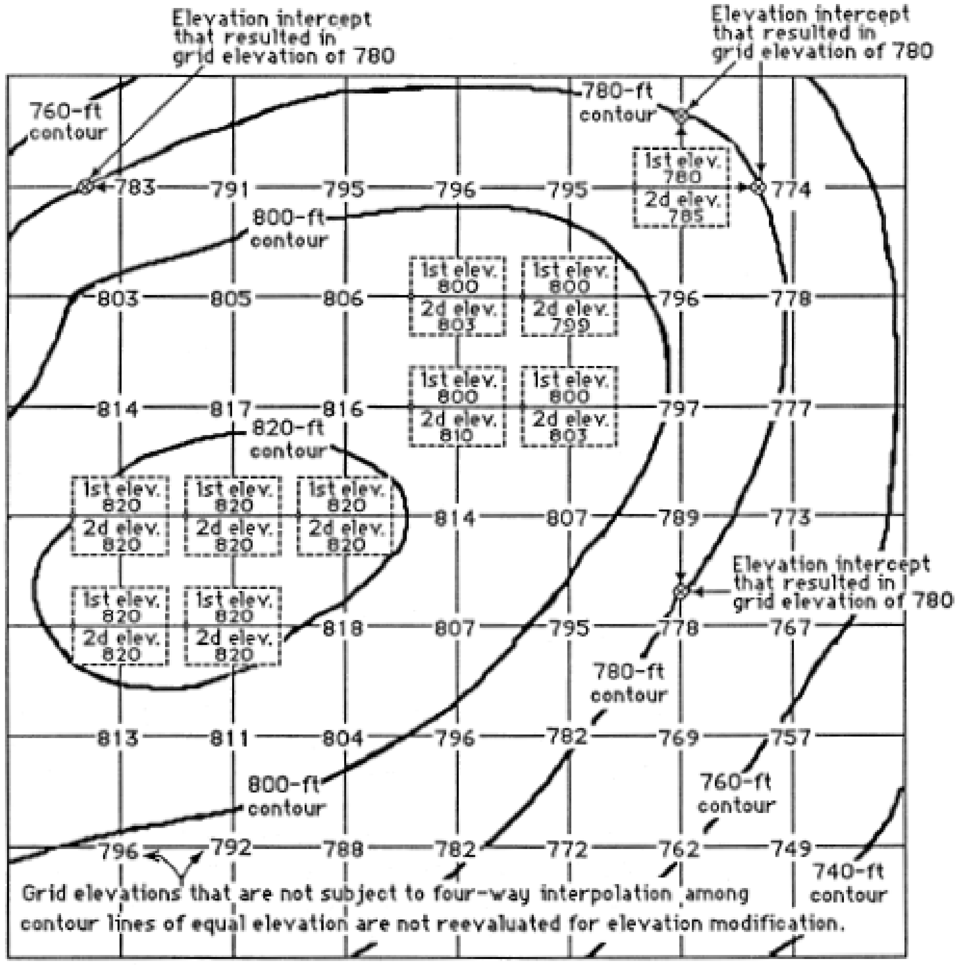


Figure 6—Areas for which grid elevations are initially interpolated between four equal-elevation contours are recalculated when a smoothed transition to adjacent, higher terrain can be provided.

All elevations for grid-cell corner points that were interpolated from four surrounding contour lines of equal elevation are flagged during the initial processing. In figure 6, this occurs 10 times (at locations marked with labels for first and second elevations). If adjacent grid points have higher elevations on one side of these flagged points and lower elevations on the opposite side, an additional straight-line interpolation is done along either the horizontal gridline or the vertical gridline. This smoothing algorithm prevents an abrupt elevation jump between adjacent elevations for grid-cell corner points. If there is no combination of higher and lower terrain bordering these grid-cell corner points, as is true for the 820-foot elevations shown in figure 6, the elevation of the corner point is left at its original value.

Structure of the Elevation Data

Once the interpolation processes are completed, each gridline-intersection point is assigned an elevation, and the DTM is stored in a data file. The calculated grid elevations are shown in figure 7. The original contour lines that the DTM was derived from are also shown to illustrate the change.

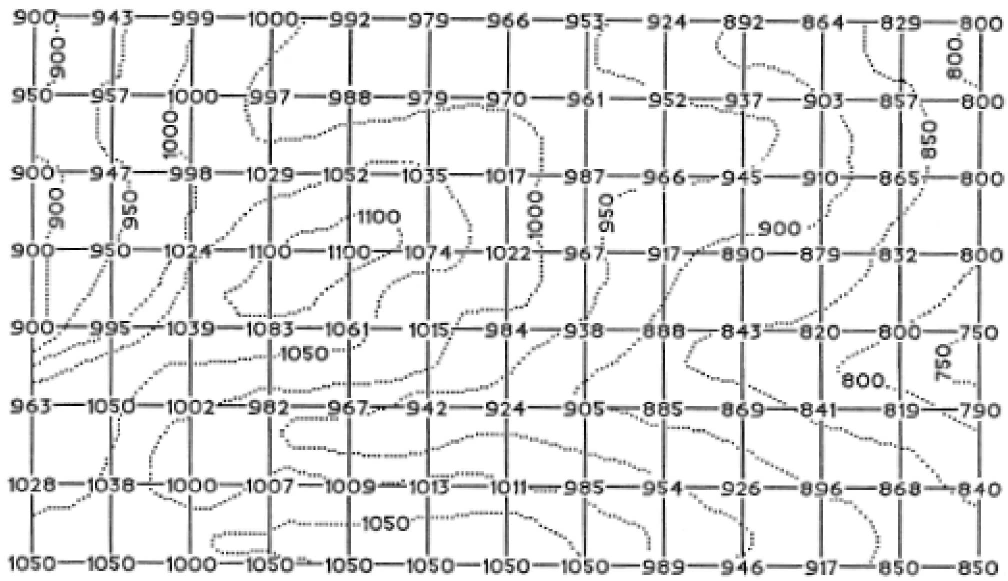


Figure 7—Grid- intersection elevations of the DTM as interpolated from digitized contour lines.

The DTM in figure 7 shows portions of the data required; it is an incomplete file included to illustrate the transition from contour-line map to gridded terrain data. The complete listing of the data stored in a DTM data file is shown in figure 8.

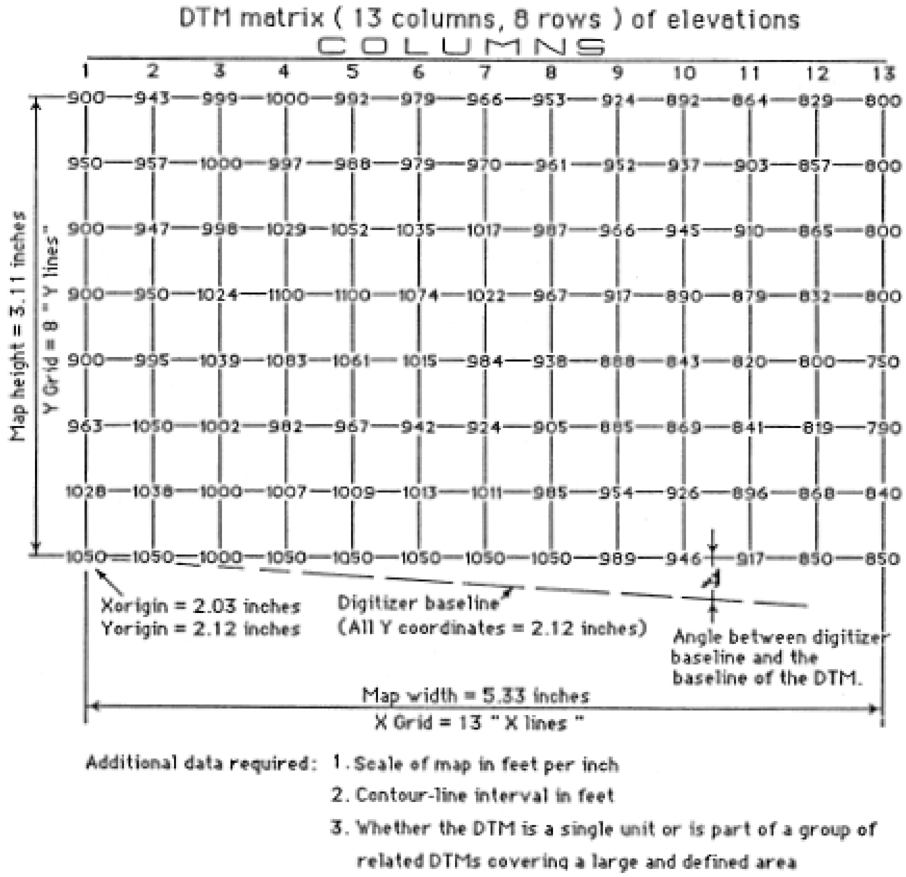


Figure 8—Site-specific numeric data that must be stored or calculated to provide a usable DTM for PLANS design programs.

The data list from figure 8 provides the variables needed to extract elevations from any digitized point on the planning area map via the following system: After the DTM is loaded into the computer, the user enters (by digitizing) the coordinates of the lower left corner (Xorigin and Yorigin) and the baseline (AngleA) of the DTM unit. This establishes the location of the DTM on the digitizer tablet and, along with the information loaded from the model's data file, is all that is needed to correlate the position of the digitizer cursor with the DTM on the topographic map. The coordinates (Xmap,Ymap) of any point digitized (Xi,Yi) on the map are calculated from the following equations:

$$\text{Xmap} = [(\text{Xi}-\text{Xorigin}) \times \text{cosine A} + (\text{Yi}-\text{Yorigin}) \times \text{sine A}] \times \text{map scale ; and}$$

$$\text{Ymap} = [(\text{Yi}-\text{Yorigin}) \times \text{cosine A} + (\text{Xi}-\text{Xorigin}) \times \text{sine A}] \times \text{map scale ;}$$

where Xi and Yi are digitized points inside the DTM border, expressed in inches, and map scale is expressed in feet per inch.

The topographic elevation of any point on the map of the DTM unit is calculated with a method that exploits the structure of the DTM elevation matrix. The elevation data are contained in the elevation matrix of the DTM, which in this example is a 13-row by 8-column matrix of 104 elevations. Each elevation applies to a discrete point on the map of the DTM; the point is expressed in terms of x and y coordinates, with the origin (x=0.00 and y=0.00) set at the lower left corner of the map. The **column and row position of the elevation in the matrix is keyed to its x and y coordinate position on the map.** The elevation matrix is uniformly spaced to cover the height and width of the map of the DTM unit. The elevation in the first row and the first column of the 13-row by 8-column matrix pertains to the grid-elevation point at the lower left corner of the digital terrain model, which is 1,050 feet. The grid-elevation point at the upper right corner of the DTM (800 feet) is recorded in the 13th row and the 8th column of the DTM matrix. In this manner, the location (x and y coordinates) of every elevation can be determined from the elevation's position in the matrix, the number of rows and columns in the matrix, and the height and width of the DTM unit. Organizing the elevation data in this manner saves storage space because the x and y position of each grid elevation point can be determined without storing the x and y values associated with each elevation point.

Elevation of Points Falling Within a Grid Cell

The planner using the DTM in PLANS design programs usually will have design control points falling at locations within a grid-cell rather than directly on the grid cell corner point. Elevations must be calculated for these control points whenever they are digitized from the map of the DTM or projected from the DTM. Each of these elevations is interpolated from the specific location within a grid cell. The basis for this interpolation is shown in figure 9.

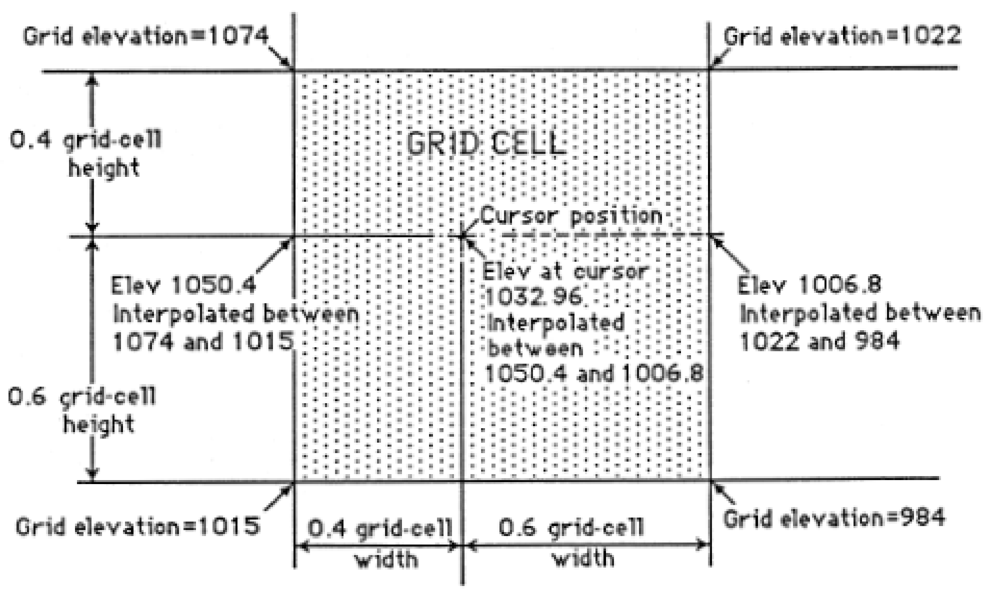


Figure 9—Interpolations used to solve for elevations within the grid structure.

The elevation of any point inside a grid cell is approximated using the three-step linear interpolation in figure 9. An alternate method of computing elevations bases the elevation of a point on the inverse of the distance squared of the point to the four grid-cell corner-point elevations. Lemkow (1977) compared the three-step linear interpolation with the inverse of the distance-squared method and found the three-step method was just as accurate; it also required only one-third the computational effort.

Technical inadequacies of the three-step interpolation method used in PLANS become minuscule when grid cells of the recommended size are established; but inadequacies do, nevertheless, exist. If all four corner elevations of a grid cell are on the same plane surface, the three-step method provides correct answers consistent with precise geometric solutions; however, three elevation points establish a plane, and it is unlikely that the fourth elevation point of a grid cell will fall on the same plane. Dividing the grid cell into two 45-degree triangles, each with three elevation points, will establish two planes. There are, however, two alternatives for this division. One alternative, which would improve the accuracy if a terrain divide (stream or ridge) ran between the lower left and the upper right corners of the grid cell, is to divide the grid cell into triangles in the upper left and lower right. The second alternative, which improves the accuracy when the terrain divide runs between the upper left and the lower right corners of the grid cell, is to divide the cell into triangles in the upper right and lower left. Use of the double-triangle approach did not appear to provide sufficient advantage to compensate for the increased complexity in problem formulation because terrain divides, when they occur within any grid cell, are random.

Spacing of Gridlines

Establishing a sufficiently fine spacing between gridlines is one important prerequisite to obtaining a DTM that corresponds well to actual terrain. The relation between grid spacing and accuracy must be understood by the user because the user controls grid spacing. The importance of this relation may be intuitively understood after examining perspective plots of two different DTMs. Both model the same topographic map; however, one of the DTMs has a spacing of 2 lines per map-inch (fig. 10), and the other (fig. 11) has a spacing of 10 lines per map-inch. The plotted, distorted squares are the individual grid cells. The digitized contour lines are also plotted on each figure.

If having the correct elevation at each grid-cell corner point is the established measure of DTM accuracy, then the DTM depicted in figure 10 is just as accurate as the DTM depicted in figure 11. But, if accuracy is defined as having a DTM that corresponds closely to the terrain being modeled, the DTM depicted in figure 11 is structured to be, and is, considerably more accurate than the DTM in figure 10.

Experience has led us to believe that spacings between gridlines of 0.07 to 0.15 map-inch are best for timber -harvest planning.

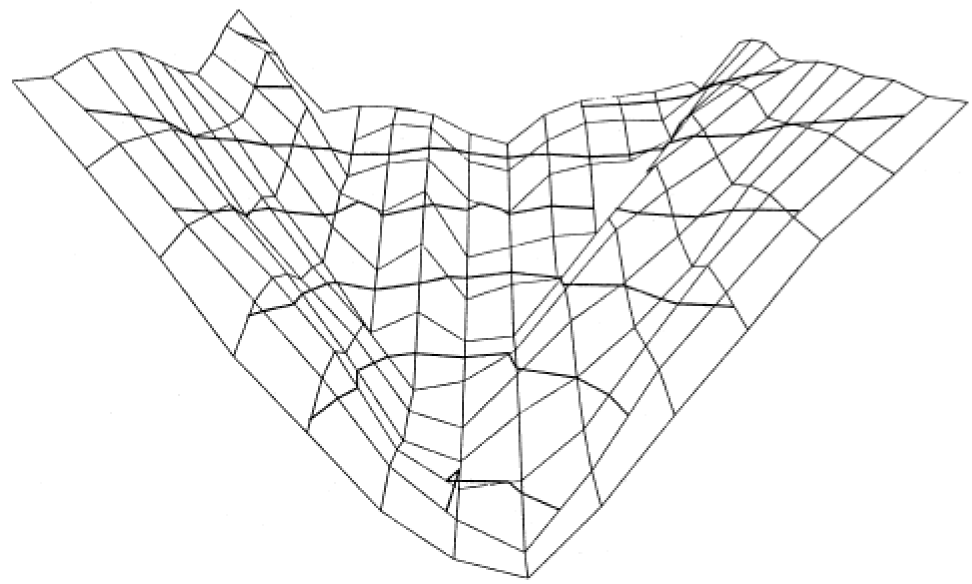


Figure 10—Perspective plot of a DTM ; the gridline spacing was set at 0.5 inch.

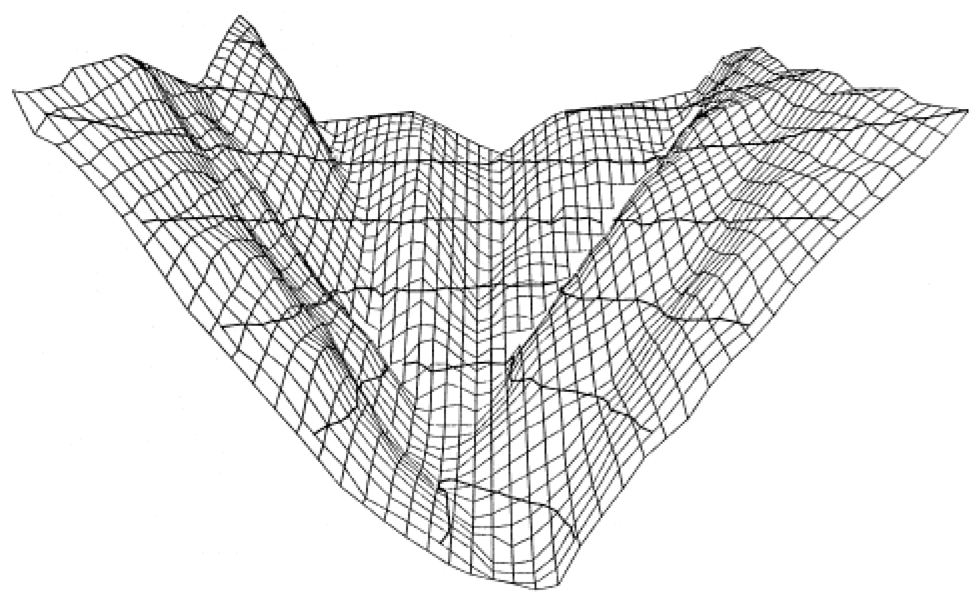


Figure 11—Perspective plot of a DTM ; the gridline spacing was set at 0.1 inch.

DTM Coverage for Large Planning Areas

The problem of integrating large planning areas with continuous and finely gridded DTM coverage requires special consideration in PLANS. The problem exists because:

1. DTMs cannot be created from map blocks (that is, input units) that are larger than the digitizer tablet; however, planning-area maps can be and often are larger than the digitizer tablet.

2. Even if the entire planning area fits on the digitizer, it still might be unwise to establish it as a single DTM input unit. DTM input units larger than 15 by 15 inches require an elevation grid that may be too coarse for planning purposes. The 15-inch dimension is because the widest spacing of gridlines advisable[2/] for timber-harvest planning is about 0.15 inch, and a single DTM input unit cannot have more than 99 gridline spaces. The digitizer PLANS was developed on has an active surface area of 36 by 48 inches. Filling this active surface area with a single DTM input unit would result in a 0.48-inch gridline spacing, which is generally too coarse for good planning.

To circumvent these problems, the PLANS DTM approach provides for and recommends dividing large DTM coverage areas into smaller DTM input units. Figure 12 illustrates the recommended -approach.

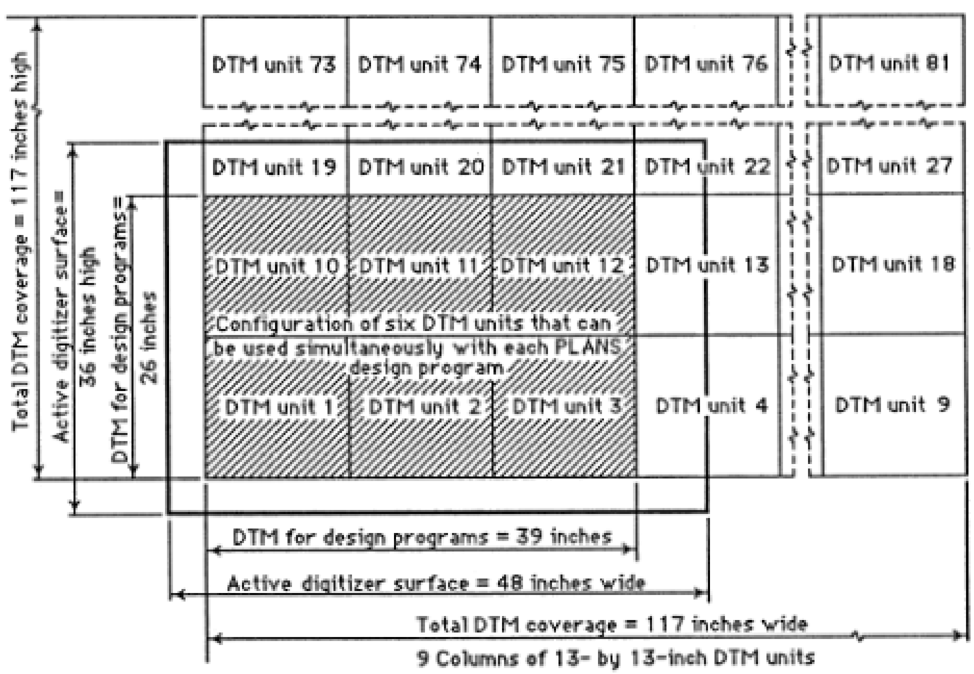


Figure 12—Arrangement of small, tightly gridded DTM input units that cover a large DTM area and provide a combined design DTM that uses the active digitizer space.

[2/]This recommendation of a 0.15-inch maximum gridline spacing is not absolute. Use of a very large-scale (1 inch=100 feet) planning map with widely spread contour lines would warrant a wider spacing between gridlines.

Each of the 81 DTM units indicated in figure 12 has to be created and processed individually; yet the units have a relational structure so they can be grouped to provide continuous elevation coverage over larger areas. The continuity is needed during the design phase because profiles and other design elements cannot be constrained to terminate at DTM-unit boundaries. The continuity is possible because of a provision for loading six DTM units into an enlarged DTM (shown in fig. 12 as a shaded area).

Even though the DTM coverage inferred in figure 12 is theoretically unlimited, it has practical limitations; for example, the handling of large topographic maps. Assembling and measuring large base maps requires careful drafting and handling (the appendix explains the problems and outlines a procedure for creating large DTMs). If the base map is divided to facilitate handling, the transfer of DTM-unit control points from the initial to the continuation maps must be precise. Slight differences in map size from one print to another can become critical. Errors in line projection increase in proportion to map size. These potential problems make it is advisable to restrict planning projects to manageable-size map areas.

Corrections to Border Elevations for Enlarged DTMs

The common elevations on the borders of DTM units are modified when the units are grouped into an enlarged (six-unit) DTM. Border elevations for one unit show the same points of actual terrain as do elevations for the adjacent unit, yet the figures are often contradictory. It is likely that neither is correct. This occurs because the boundary grid-point elevations are not interpolated from contour lines surrounding them on four sides, but are restricted to contour lines inside the DTM unit. This problem and the manner in which it is resolved are shown in figure 13.

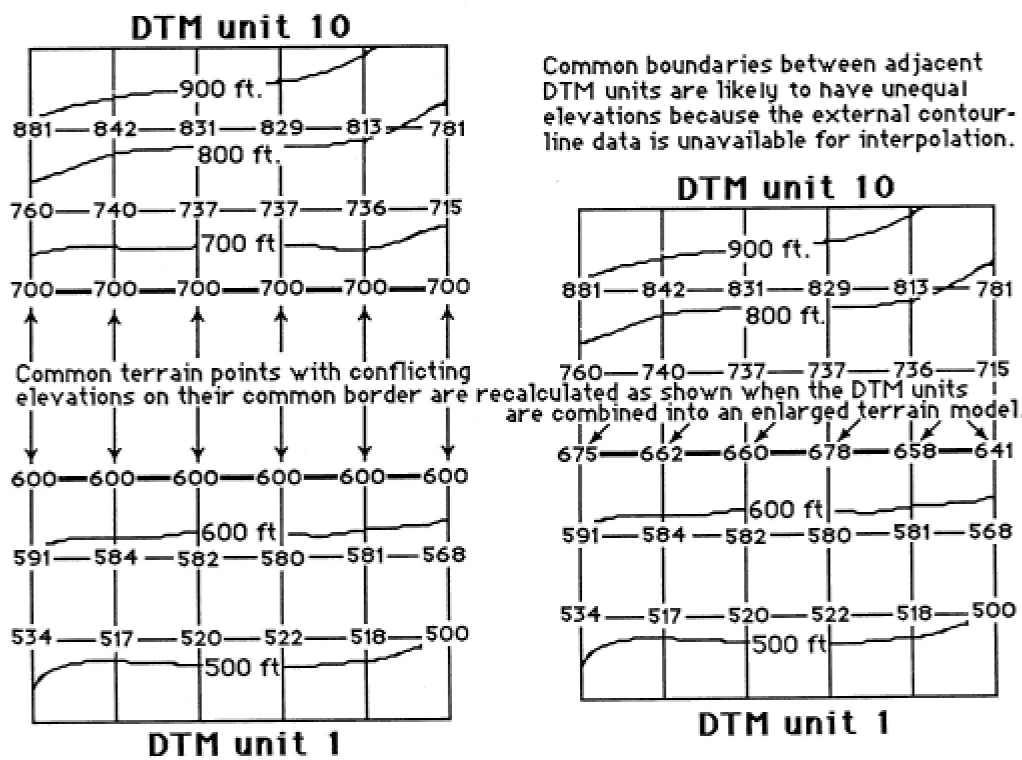


Figure 13—Adjacent, individually processed DTM units have incorrect and conflicting grid-point elevations for common border points. This error is corrected when the DTM units are combined into an enlarged DTM.

After the DTM block is loaded, the program simply calculates the common-border elevations as the numerical average of the elevations one grid row inside each of the adjacent DTM units.

Limitations of the MAP Program

The primary limitation of the MAP program is the accuracy, relative to the ground, of DTMs constructed with it. These DTMs are based on (constructed from) a topographic map of the, planning area and are approximate representations of the topographic map. The topographic map is, in turn, an approximate representation of the ground. DTMs are thus distorted by two levels of error. A user of PLANS must learn how to restrict the error enough to provide an adequate basis for planning.

Discrepancies Between the DTM and the Topographic Map

Our design objective for the MAP program was to develop a gridded DTM that produced elevations for each point equal to what would be logically interpolated from the source topographic map (fig. 5). The basic design algorithm, though it substantially satisfies this objective, falls short of it in special circumstances. One example of this lapse can be seen in figure 14. No provision was made for incorporating point elevations into the DTM interpolation process. This is displayed by the grid points inside the 820-foot contour line. These grid points are labeled "820" feet in elevation.

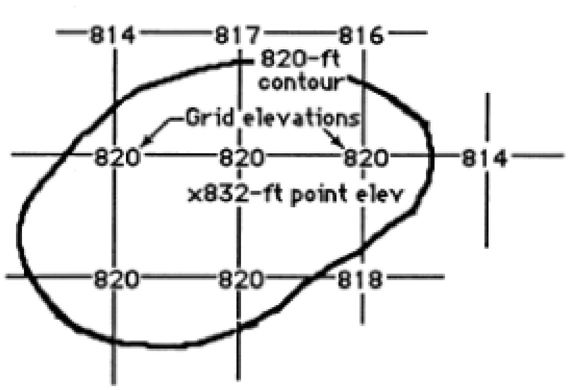


Figure 14—Point elevations on topographic maps are not taken into account when the grid elevations are calculated.

A map user seeing this type of contour-line configuration and a point-elevation label of 832 feet for an interior high point would know the grid elevations should actually be between 820 and 832 feet. A point-elevation interpolation procedure was deemed a minor omission because it would affect mainly areas on top of knobs and ridges where slopes are not generally severe and, therefore, would have minor impact on timber-harvest planning.

The second example of failure to meet our objectives for DTM building is shown by the elevation near the upper right center of figure 6 labeled "2d elev 799." A more correct interpolation of the elevation for that point on the topographic map is 804 feet. This example illustrates how an arbitrary elevation-correction algorithm that, in this case, interpolated a value of 799 between elevations of 795 and 807, can assign a grid-point elevation that is more in error than its initial, uncorrected elevation of 800 feet. This elevation-correction algorithm usually works well, and does more good than harm. Yet routines that rely on straight-line--interpolation algorithms cannot always provide solutions that fit natural slopes.

The two preceding situations, where the MAP program solves for values of grid elevations that are different from values attained by conventional interpolation[3/] techniques, normally affect a small portion of the elevation data in DTMs and do not invalidate the DTM as a basis for planning. A more fundamental difference between the DTM and the topographic map is the square grid structure of the DTM and the more correct curvilinear data structure of a topographic map. The grid structure of the DTM can, when the grid is correctly spaced, provide an adequate description of the topographic map and yet minimize the amount of terrain-description data that must be stored. As the grid spacing of the DTM decreases, the accuracy with which the DTM models the topographic map increases. Although it is not necessary to build DTMs with a tiny grid spacing to achieve usable terrain data, the relation cannot be ignored. Grid spacings of about 0.10 inch represent a reasonable compromise between an accurate depiction of the topographic map and a manageable amount of data.

A final factor influencing the fit between the DTM and the topographic map is the care and skill exercised by the user in digitizing contour lines. Errors made while tracing the contour lines with the digitizer cursor will be replicated in the DTM. This source of error has not, however, been a major problem.

DTMs may be obtained from several sources, but most of the widely available DTMs—such as the USGS DEM tapes and the DDTs from the U.S. Department of Defense—tend to fall unacceptably short of the MAP approach in accurately modeling a topographic map. DTMs from these sources are generally derived directly from aerial photogrammetry techniques that ignore existing mapping. These DTMs, when compared to existing maps, contain discrepancies that make them inadequate for planning. The inadequacy is not because the topographic map is necessarily more accurate than the DTM; it is because the planner, who views and is guided by the topographic map, is handicapped when using computer routines based on a distorted DTM. A few DEMs are being made by processes using digitized contour lines on existing maps. These DEMs, like the DTMs produced using MAP, yield a better fit between the resulting DTM and the topographic map.

Discrepancies between the topographic map and the ground—It is widely acknowledged that topographic maps often do not fit actual ground conditions. Topographic map error becomes more prevalent on maps made from aerial photos where the ground is obscured from the view of the stereoplotter operator by dense tree cover. Here, because the ground cannot be seen to be measured, a best guess at the ground elevation is made using the tree tops minus the assumed tree heights to establish the contour lines. The results are maps needed for timber-harvest planning being those most affected by discrepancies.

Topographic maps provide so much potentially useful information for preliminary planning and analysis that no real alternative to them exists. Two requirements for land management are to obtain adequate planning-area maps and to be aware of how to resolve the discrepancies between a map-based plan and the ground. Accurate topographic maps scaled at 1 inch to 400 feet with a 20-foot contour interval are recommended as a source of DTMs for PLANS.

[3/] In general practice, this is linear interpolation along a line as perpendicular as possible to the contour lines above and below the point the elevation is to be solved for.

Time Required To Construct DTMs With the MAP Program

Creating DTMs with the MAP program requires that some time and effort be expended to trace contour lines. A cost of $0.08 per acre for developing DTMs (for use in PLANS) by hand digitizing is reported by Twito and McGaughey (1984). This cost per acre will vary with the scale of the topographic base map, the number of contour lines, and the wage rate and ability of the person digitizing. The reported figure was based on a topographic map scale of 1 inch to 400 feet. The contour lines were digitized at a 20-foot interval over steep terrain. The wage rate was $12.00 per hour. The costs were based on a 3,200-acre planning project in the Cascade Range in Washington.

It should not take an experienced operator more than 4 hours to complete a DTM unit covering a 14-inch-square map section when the digitized contour lines are at 20-foot intervals and the terrain is mountainous. The process of building digital terrain models should be understood, but not necessarily performed, by the planner. Computer expertise and planning skills are not required for this work. What is needed are operators who are meticulous and thorough and who have good hand-to-eye coordination and a good understanding of contour maps.

Conclusions

The improved data-processing capability of current computer systems makes it an unnecessarily burdensome constraint to assemble slope and profile information on the basis of one input step producing only one elevation data point that can be used for just one design. Current computers can efficiently process designs related to the topography using DTMs. This capability has much to offer organizations that manage large areas of land because permanent DTM files of their holdings can be easily accessed for engineering designs and management information; consequently, there is increased interest in computer-based Geographic Information Systems (GIS), which include topographic (DTM) data. Adaption and use of PLANS constitutes, in one sense, an indoctrination to using a GIS because PLANS has specialized GIS characteristics tailored to designing timber-harvesting plans. The MAP program facilitates development of DTMs that will provide continuous topographic coverage of finely gridded elevation points at an easily justified price.

Operating Instructions and Worked Examples

An appendix to this report contains step-by-step operating instructions for the MAP program. A copy can be obtained on request (see the last page in this report). The appendix includes the following six examples that illustrate how the MAP program can be used:

1. Creating a new DTM.
2. Completing a partially completed and temporarily stored DTM.
3. Completing additional DTMs after the first DTM unit is finished.
4. Transferring DTM units between the hard disk and diskettes.
5. Correcting a DTM by redigitizing its incorrect portions.
6. Regridding a DTM unit from a file of contour lines.

All necessary topographic maps needed for these examples are included. The DTMs will be used in subsequent examples of related PLANS design programs.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.3048 meter

Literature Cited

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Twito, Roger H.; McGaughey, Robert J. Computer aided timber harvest planning: an example. In: Peters, Penn A.; Luchok, John, eds. Mountain logging symposium proceedings; 1984 June 5-7; Morgantown, WV. Morgantown, WV: West Virginia University; **1984**: 150-159.

Twito, Roger H.; Reutebuch, Stephen E.; McGaughey, Robert J.; Mann, Charles N. Preliminary logging analysis system (PLANS): overview. Gen. Tech. Rep. PNW-GTR-199. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; **1987**. 24 p.

Appendix

Recommended Approach for Building Large DTMs

Constructing large DTMs that have to be spliced (taped) together requires a reasonable amount of thought, care, and technique. Without these, time and effort may be wasted in an unsalvageable project. Certain principles that affect DTM fabrication from spliced contour maps should be kept clearly in focus to ensure success. The steps recommended here focus on techniques that can be applied by a typical engineering office.

1. Assemble and tape all topographic map sections into one composite map. See figure 15 for an example. The map sections may have to be assembled on an open floor space if the planning area is large. The composite map should have to be assembled only once. Not only is it inconvenient to repeat this step, but it is very difficult to reassemble the composite map to exactly the same dimensions as done initially, and a slight change in the dimensions of the tract can cause problems in the DTM building process.

2. Draw a straight baseline across the lower boundary of the area slated for DTM coverage.

3. Draw a straight line perpendicular to the baseline and extend it across the vertical length of the area slated for DTM coverage.

4. Carefully measure the total height and width of the DTM coverage area. These dimensions are both 117 inches in the example (fig. 15).

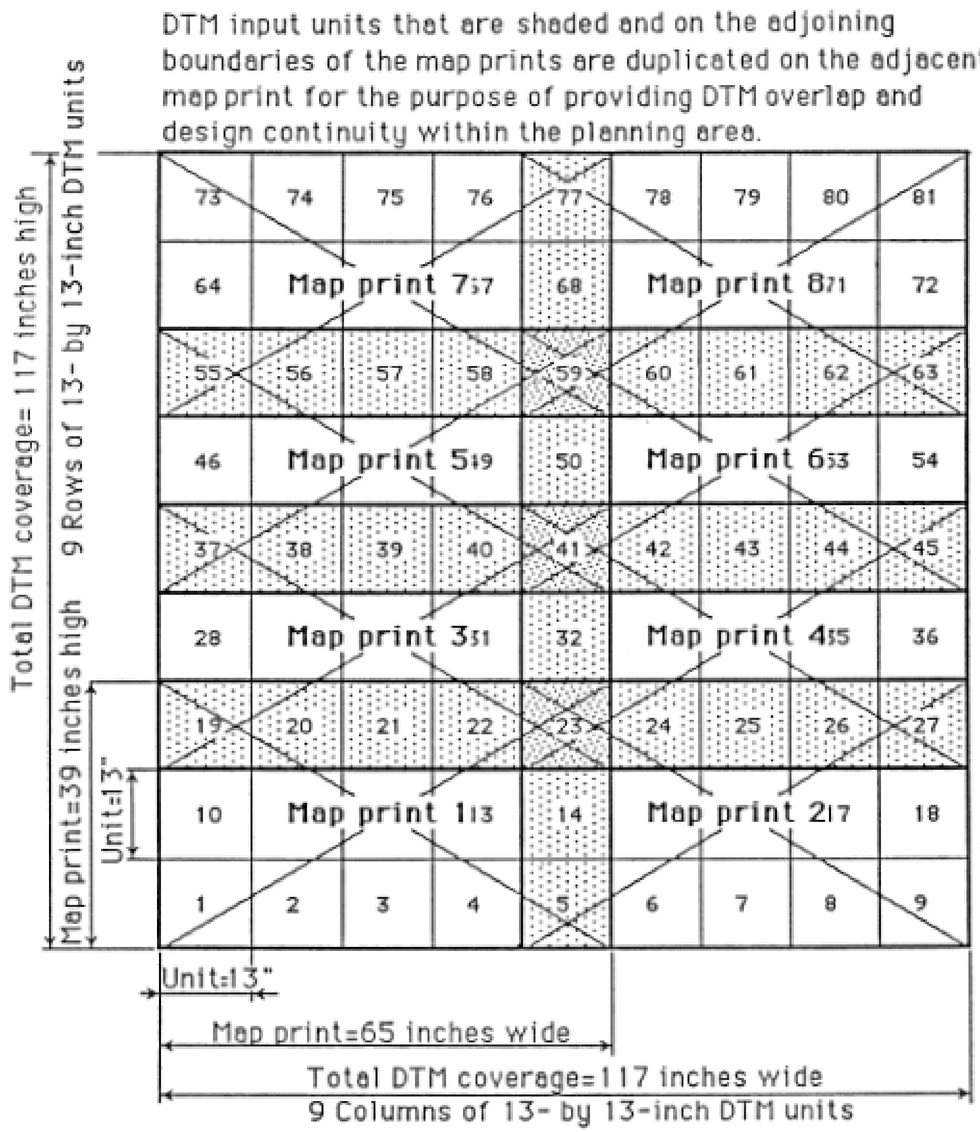

Figure 15—Prints covering a large DTM can be established at a size that is easy to manage and can also provide for the duplication of DTM units needed for design continuity.

5. Determine the size of the DTM input units. The MAP program aids in this choice by displaying the DTM unit size and the arrangement that will provide the desired grid spacing. In the example (fig. 15), a minimum grid spacing of approximately 53 feet would be possible with a DTM unit size of 13 inches square at a map scaled 1 inch to 400 feet (that is, 13 inches x 400 feet per inch map scale ÷ 99 possible grid spaces per DTM unit = 52.53 feet).

6. Choose the best size of topographic map print, one that will be of manageable size and yet provide for full duplication of the DTM units that are on borders common to adjacent map prints. This point can be better understood after studying figure 15. DTM-unit duplication means, for example, that the top row of DTM units (19 through 23) on map print 1 must be the same as the bottom row of DTM units on map print 3, and so forth. This need for overlapping prints does not exist if a single print as large as the DTM coverage area can be managed. Of course in this example, a DTM coverage area would require one print of almost 10 feet by 10 feet-obviously not of manageable size. Many graphic reproduction labs, in fact, cannot process prints and Mylar reproductions larger than 25 square feet. The large, 46- by 58-inch board area of the digitizer (see Required Computer Hardware in Twito et and others (1987) used with the PLANS programs should permit use of a large print. The example assumes (and shows) map prints covering a 39- by 65-inch area to be of manageable size. Six DTMs covering an area 26 by 39 inches can be simultaneously loaded and used on the digitizer. The remaining portions of the print and the matching acetate overlay (see appendix in Twito and others 1987) can hang over the edges of the digitizer board.

7. Send taped DTM-coverage-area map to a graphics reproduction lab for photocopying new reproducible originals that correspond to the desired map-print coverage. These new originals will provide topographic map coverage of the planning area on conveniently sized prints. It is also important that these prints provide full DTM-unit overlap with a monolithic (unspliced) map sheet.

8. Begin DTM construction at the lower left corner of the DTM coverage area and complete the units in numerical sequence.

9. Transfer the boundaries of the completed units from one map print to the other using a light table. Any error in the original measurements of the DTM coverage area can, and will, shift the map location of the upper right corner of the DTM units and, eventually, the upper right corner of the coverage area. Slight shifting of these corners should be of minor consequence.

It may be worthwhile to use the MAP program to go through the entire boundary-transfer process (a dry run) without actually tracing the contour lines and completing the DTMs. If this proves satisfactory, the borders of the units will not have to be reestablished, and the contour lines can be processed on the second run.

An appendix to this report containing step-by-step operating Instructions for the MAP program is available on request from the Pacific Northwest Research Station. A copy of this appendix can be obtained by photocopying this page, filling in the necessary information, and sending it to:

USDA Forest Service
PNW Research Station
Forestry Sciences Lab
Forest Engineering Systems
4043 Roosevelt Way NE
Seattle, WA 98105 (206) 442-7814

This appendix includes examples of creating DTMs and demonstrates many of the options and manipulations that can be exercised during this process.

If you wish to receive the PLANS program set, which includes MAP stored on diskettes, enclose five 5¼-inch double-sided, double-density, flexible, mini discs.

Please send supplementary material for the MAP program to:

NAME ____

ADDRESS ____

____

CITY ____

STATE & ZIP CODE __________________________________

Twito, Roger H.; Mifflin, Ronald W.; McGaughey, Robert J. The MAP program: building the digital terrain model. Gen. Tech. Rep. PNW-GTR-200. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; 1986. 22 p.

PLANS, a software package for integrated timber-harvest planning, uses digital terrain models to provide the topographic data needed to fit harvest and transportation designs to specific terrain. MAP, an integral program in the PLANS package, is used to construct the digital terrain models required by PLANS. MAP establishes digital terrain models using digitizer-traced contour lines from topographic maps, which are, in turn, processed into an elevation grid and stored in matrix form. MAP builds continuous digital terrain models that can cover large planning areas and builds them to any elevation grid spacing desired. Though the MAP method does not always result in digital terrain models that are a perfect equivalent to the topographic map, they should be adequate for planning. A guide giving detailed operating instructions for the programs is included.

Keywords: Timber harvest planning, computer programs/programing, models, logging operations analysis/design.

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208

U.S. Department of Agriculture Pacific
Northwest Research Station 319 S.W.
Pine Street
P.O. Box 3890
Portland, Oregon 97208

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MAP Program--Users Instructions

EXAMPLE 1: *CREATING A NEW DIGITAL TERRAIN MODEL*

The planner wishes to construct a digital terrain model (DTM) from the contour map shown in figure 1. This DTM should be nearly identical to the DTM that is to be used in the other examples illustrating the PLANS design programs as it will be processed from the same contour map area. The map (fig. 1) should be taped to the digitizer tablet.

The DTM unit, for example 1, constitutes only one-quarter of the DTM coverage area, which encompasses four DTM units. The other three units are shown in figures 2, 3, and 4. Figure 5 shows all four units on one map at reduced scale. The boundaries of the DTM units have been marked on the figures, so the planner need not plot the DTM unit boundary for this example.

The planner accesses the MAP program by typing:
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 1-1

PLANS
PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:
1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8 (all keyboard inputs are followed by pressing the RETURN key)

comment: All the PLANS programs begin with this prompt. This response will initiate the building of a DTM by digitizing a contour map.

Step 1-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskettes.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 1

Step 1-3

Is this DTM unit part of a DTM coverage area that contains other previously completed (converted to gridded DTMs) units?

Enter (Y or N).

Keyboard input: N

Step 1-4

When selecting the size of the DTM unit be aware of the following:

-A DTM unit is limited to a 100 by 100 grid.
-Divide the map area for which you want DTM coverage into DTM units if you need good fit between the map and the DTM. This fit is more readily achieved with a tightly meshed elevation grid, which results from using smaller DTM input units.
-For example: DTM units 12" by 12" based on a 400 ft per inch scaled map permit an elevation grid spacing of .121 inches or 48.2 map scale ft., etc.
-Assuming the planning area is larger than the DTM unit, these DTM units can be combined into a 6 unit DTM block for use in the PLANS design programs. This DTM block can cover a map area 24 inches high by 36 inches wide.
-Combining adjacent DTM units into an enlarged DTM block permits planning harvest systems and features that overlap the DTM unit boundaries.

One unit input OK	Map too big for board	Map fits-want tighter grid
Entire map will fit on digitizer. Grid spacing up to .45 of an inch is OK for this DTM unit. (or DTM is small enough for a sufficiently tight grid.)	Map larger than digitizer. The area would have to be divided in any event.	Will fit but grid would be too coarse for desired accuracy.

PICK ONE OF THESE 3 CHOICES - press soft key

INPUT MAP IN ONE UNIT	MAP TOO BIG FOR THE DIGITIZER'S BOARD	MAP WILL FIT-SECTION TO TIGHTEN GRID

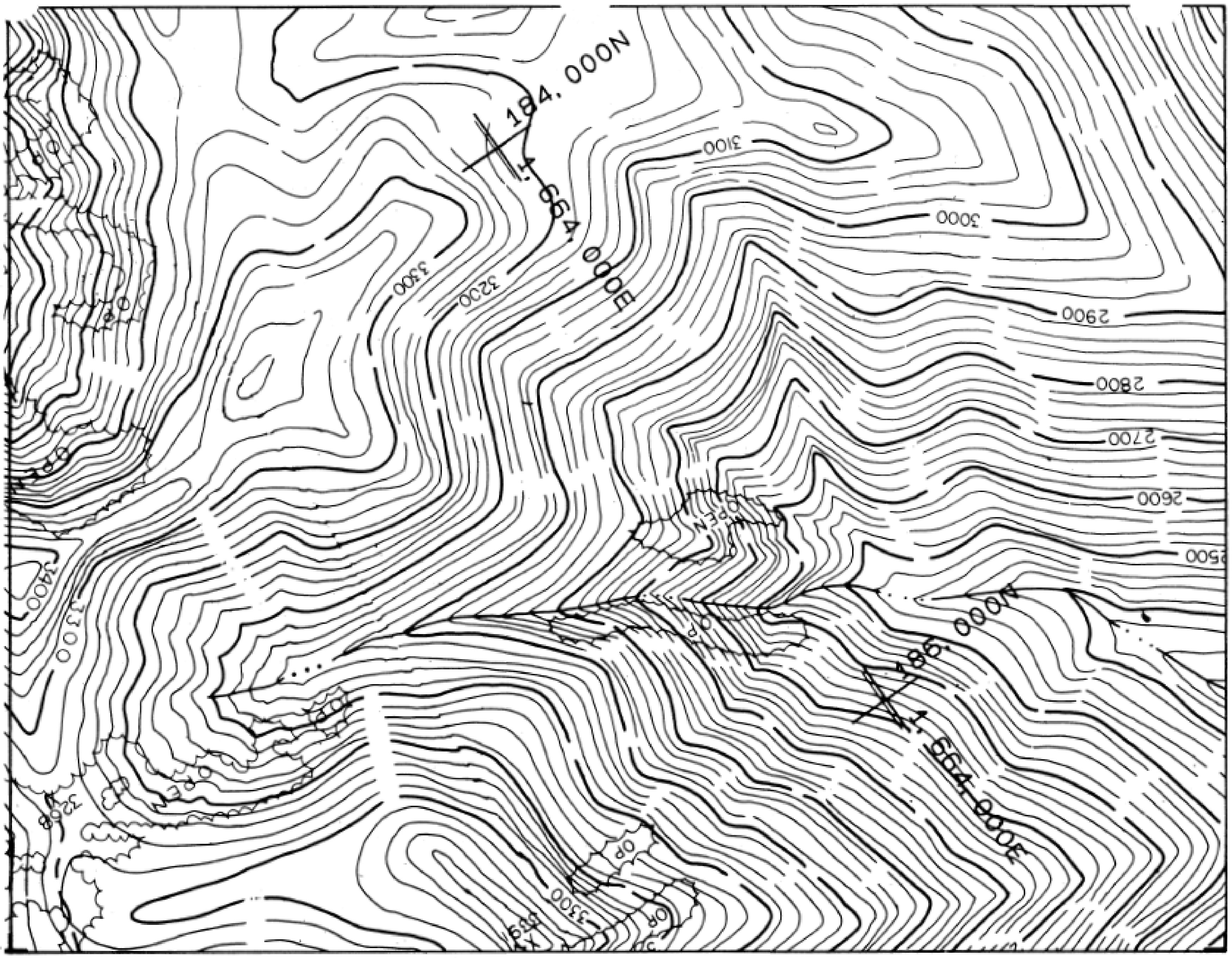


FIGURE 1. TEST_DTM1

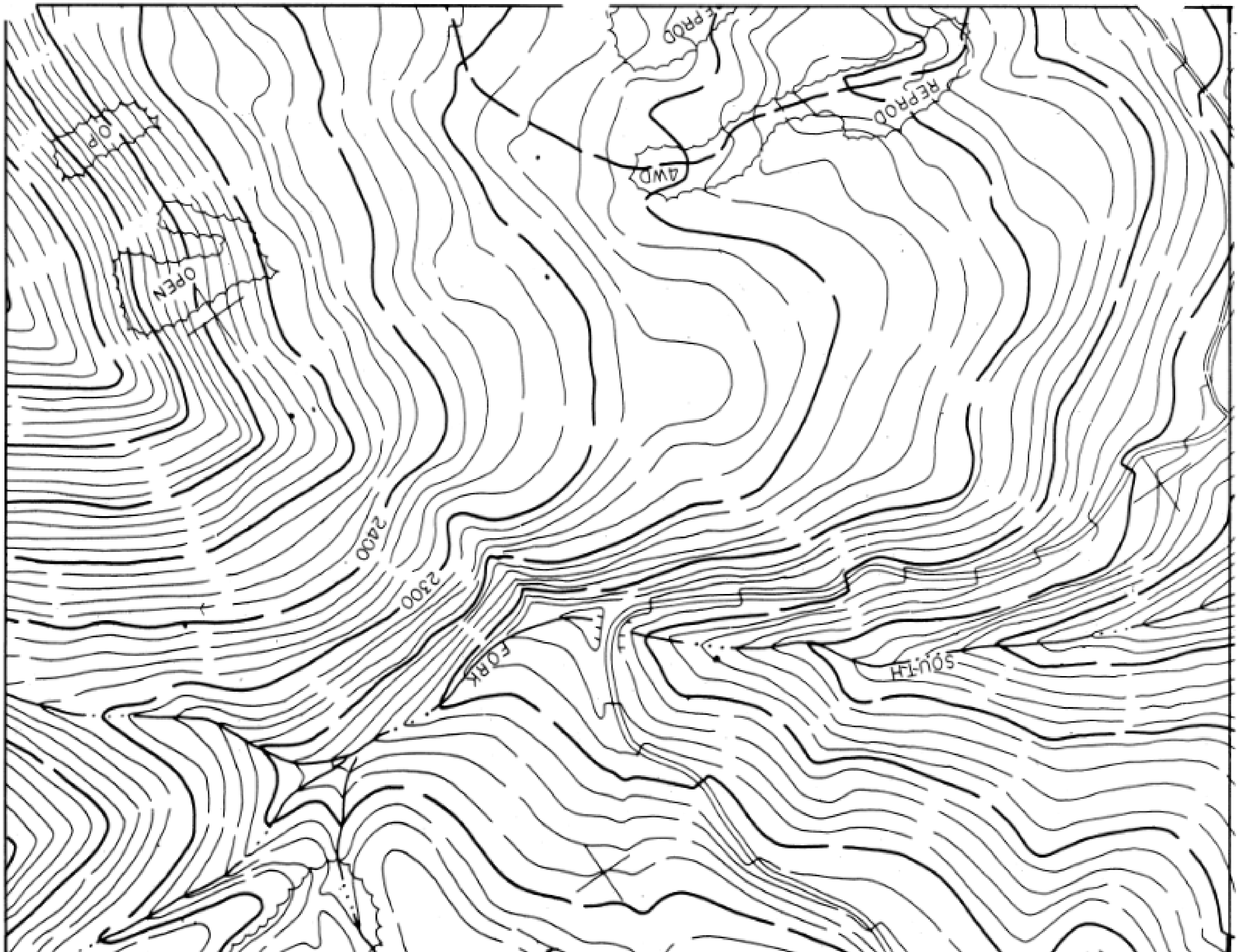


FIGURE 2. TEST_DTM2

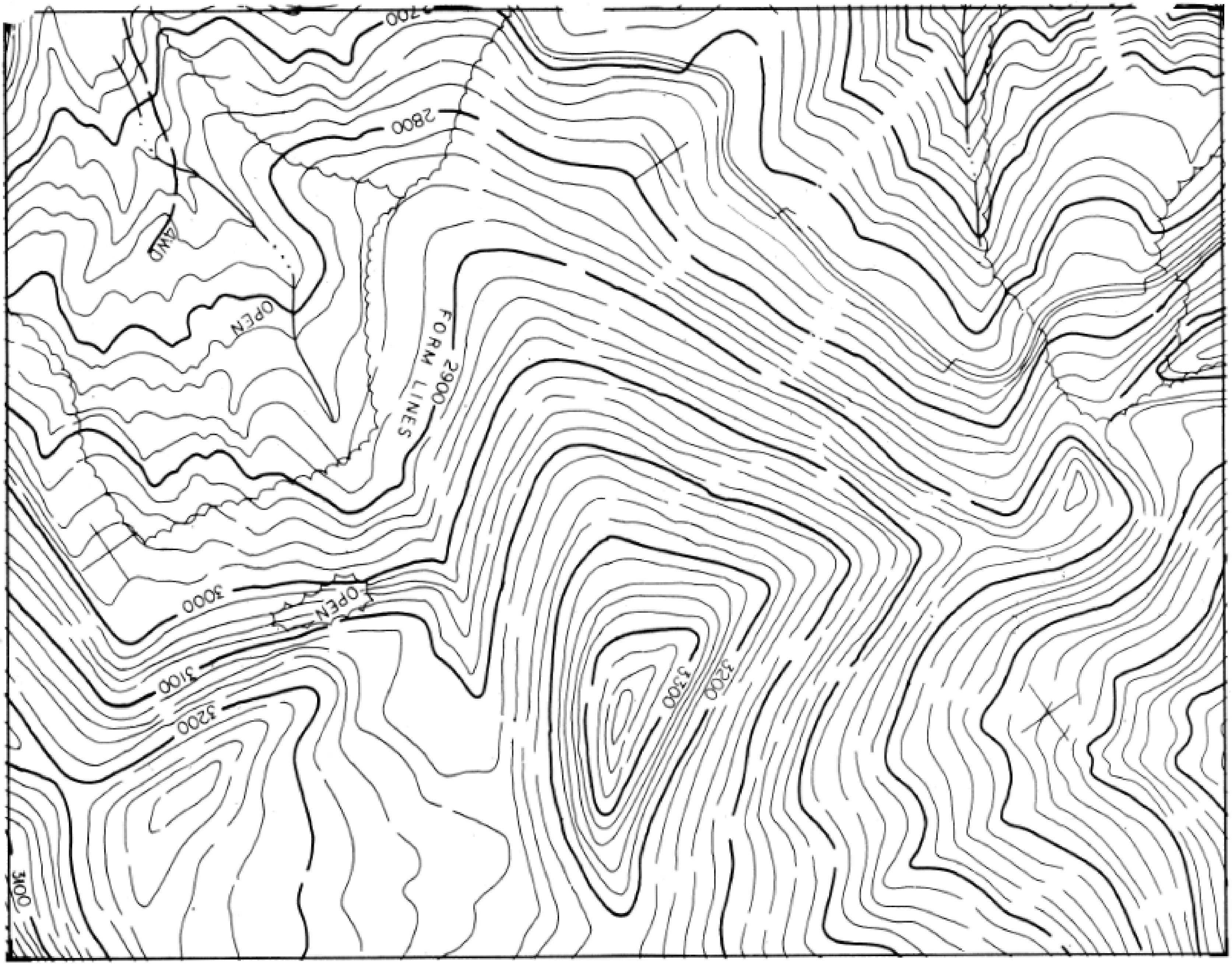


FIGURE 3. TEST_DTM3

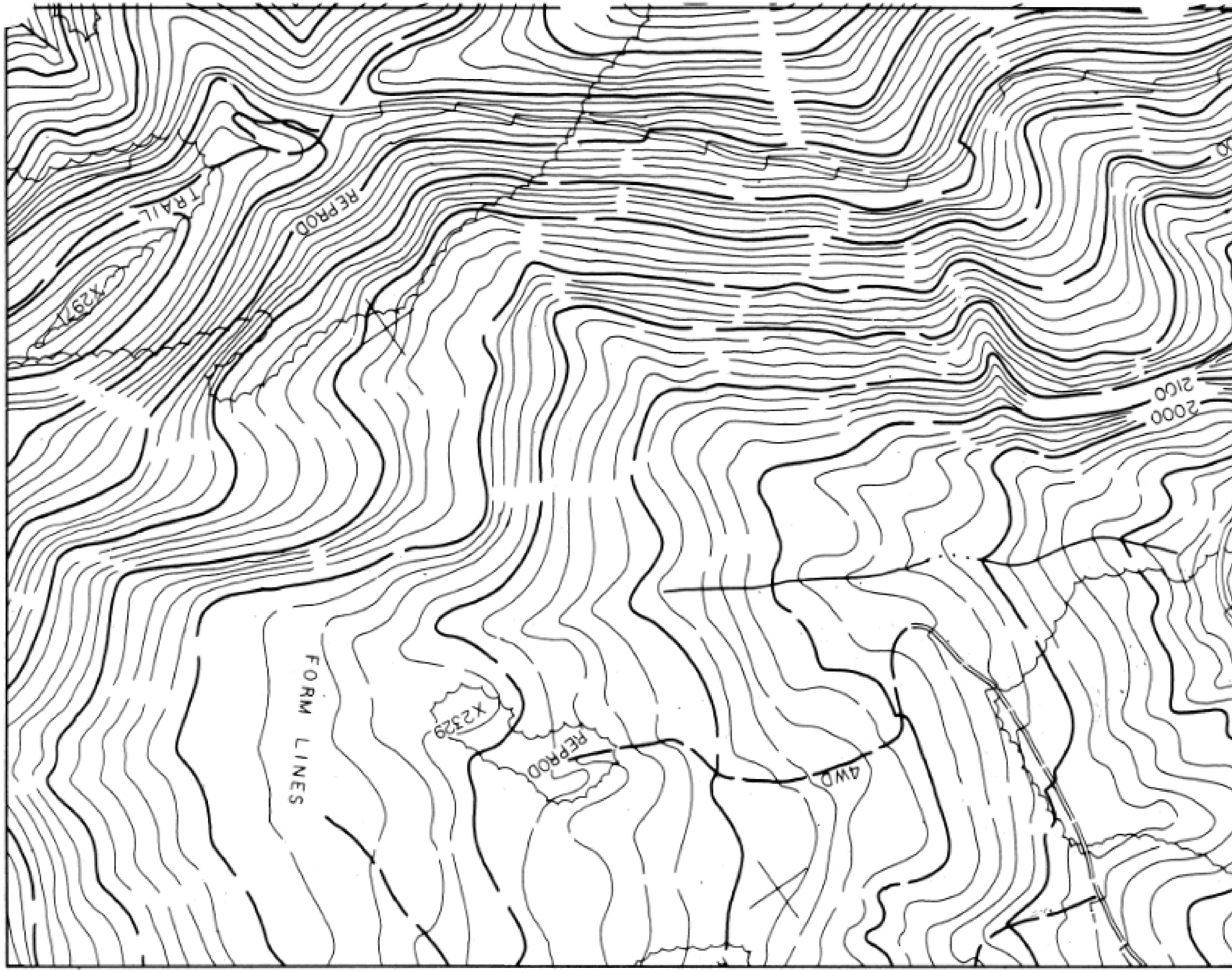


FIGURE 4. TEST_DTM4

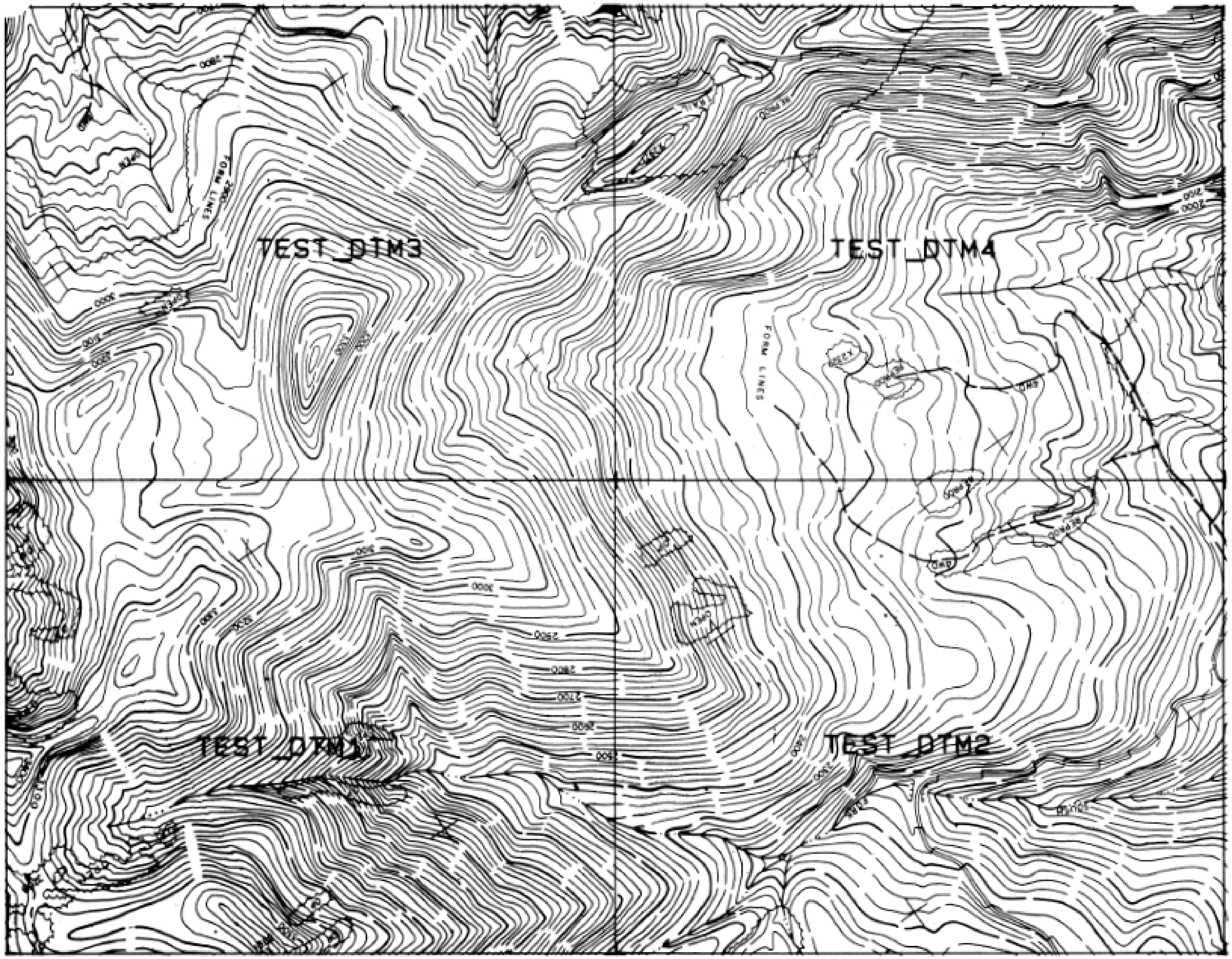


FIGURE 5. DTM COVERAGE AREA

Softkey input:	***MAP WILL FIT-SECTION TO TIGHTEN GRID***	***(input by pressing softkey)***

comment: The finer grid requires no more effort to construct than a more open grid as contour lines are traced over the total area in either case. The finer grid does, however, enable the DTM to more closely approximate the terrain as represented by the contour map.

PRINTED INSTRUCTIONS:

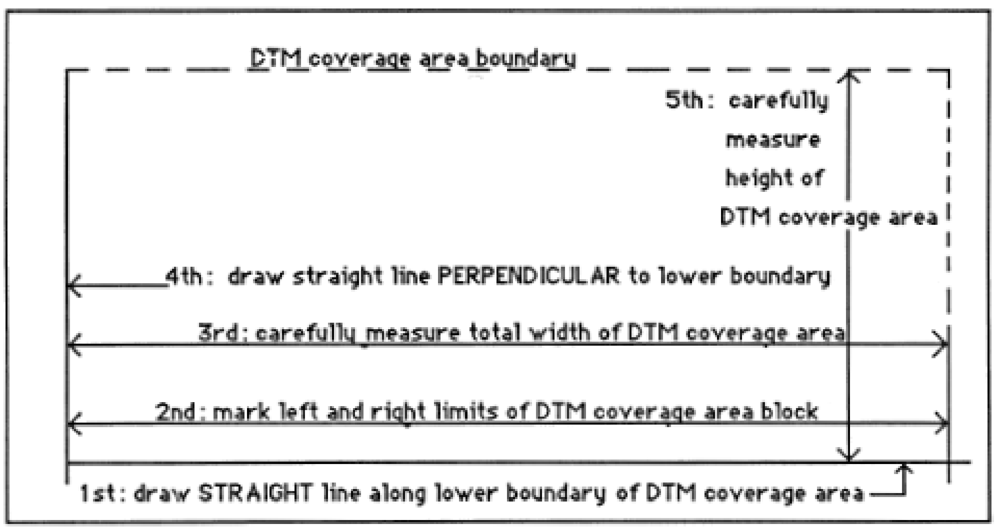
Since the DTM coverage area is too large to give the desired grid spacing, you must divide it into smaller units and input those a unit at a time.

First measure the size of the total DTM coverage area as shown on the hard copy below. This coverage area will be input in equal-sized units, which will give you the desired grid spacing.

DTM units can be loaded for design in groups of up to 6 units: (3 units wide by 2 units high) with the called unit at the lower left corner.

For now, one map print is needed on which the DTM coverage-area boundary can be marked as described below:

Step 1-5



Want a hard copy? YES enter Y, NO just press RETURN

Keyboard input: Y

Step 1-6

When the DTM coverage area boundary has been marked, press RETURN.

comment: No input instructions are provided for prompts that request a specific action and do not require entering variable data.

Step 1-7

Enter the width of the DTM coverage area (in inches).

Keyboard input: 18.00

comments: The example map is 18 inches wide by 14 inches high.

Step 1-8

Enter the height of the DTM coverage area (in inches).

Keyboard input: 14.00

Step 1-9

Enter the map scale (feet per inch).

Keyboard input: 400

Step 1-10

What spacing of the elevation-point grid do you want established for the DTM? (Enter in feet-map scale.)

Keyboard input: 50

comment: This value establishes the fineness of the grid and, consequently, the number of DTM units required to overlay the 18- by 14-inch DTM coverage area.

Entering a value of 50 feet will require that the DTM coverage area be input in four DTM units. A DTM unit is limited to a maximum of 100 vertical and/or horizontal gridlines, which equate to 99 grid spaces. The grid spacing on the map is 0.125 inch (50 feet/400 feet per inch map scale=0.125). It follows that the largest height or width a map can be to be entered in one DTM unit is 12.375 inches (99 x 0.125=12.375). The height and width of the DTM coverage area is 18 by 14 inches; therefore four DTM units (9 by 7 inches) will be needed to meet 50-foot grid-spacing requirements. Note that this is consistent with the response in step 1-4.

Step 1-11

The DTM coverage area can be divided into:

1. 1 unit with 72.7-foot grid spacing.
2. 4 units with 50.0-foot grid spacing.
3. 4 units with a minimum 36.4-foot grid spacing.
   or press RETURN to enter a new spacing _

Enter a 1 or 2 or 3 (or just RETURN) to match your choice:

Keyboard input: 3

comment: The resulting number of units needed to meet the requirements of a 50-foot grid spacing is four. Choice 3 calculates and offers the tightest grid possible without increasing the number of units required.

Because of the constraint of illustrating the various routines on publication-size maps, this example uses a tighter grid spacing (36.4/400=0.09 inch) than that proven convenient for normal applications.

Step 1-12

PRINTED INSTRUCTIONS:

The 18.00-inch by 14.00-inch DTM coverage area must be divided into 4 units, 2 horizontally and 2 vertically as shown below.

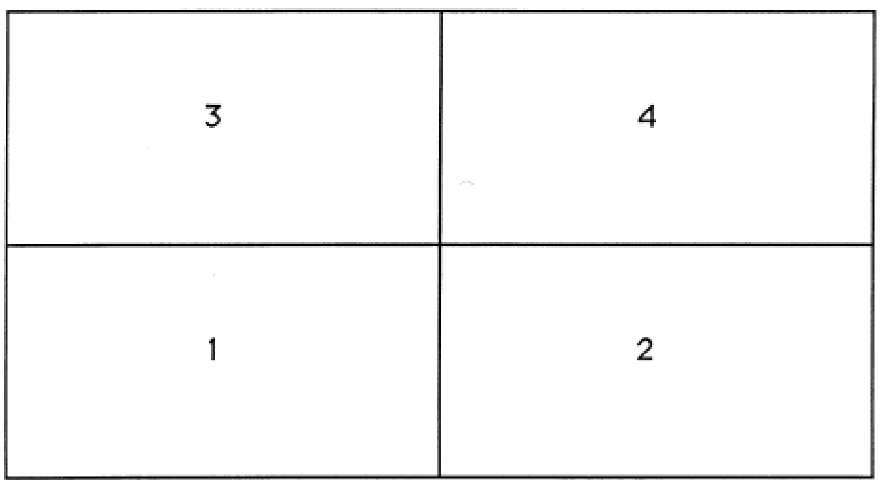
A data file will be created to store the DTM of each map unit. The name of the data file for storing the DTM will be in the following form:

1 to 12 characters + the number of the DTM unit (1 to 4).

Note: DTM units must be numbered left to right, bottom to top as shown in the diagram below. It is recommended that this print be saved and used as a record of which DTM units have been digitized and stored.

The first DTM unit to be digitized must be the lower left unit of the DTM coverage area and so must have the number 1 assigned to its name.

Each unit must be squared at 9.00 inches width by 7.00 inches height.



CRT PROMPT:

What is the character portion of the DTM unit name (1 to 12 characters)?

Keyboard input: TEST_DTM

Step 1-13

There is already a set of DTM units with the name: TEST_DTM containing 4 DTM units. Of the 4 units, 4 have been completed.

If you know the history of the existing DTM units (who created them, what area they represent, etc.) and know they are no longer needed, you can PURGE them.

However, if you are unsure of the DTM units' history, you should enter a new name for your DTM.

Or if DTM units are part of your own project, and somebody else completed them without your knowledge, you can complete the set of DTM units.

ENTER A NEW NAME FOR MY DTM UNITS	PURGE THE EXISTING DTM UNITS	COMPLETE THE SET OF DTM UNITS

Softkey input: PURGE THE EXISTING DTM UNITS

comment: Two files having the same name cannot be stored in the same directory. The CRT prompt above will only appear when it is needed to avoid duplication in file names.

The user is cautioned to use the purging (file erasing) option with care. Erasing DTM units constructed as learning exercises is a trivial matter, but erasing all the DTMs in somebody else's planning project is not.

If the user responded incorrectly in step 1-3 with a "N(o)" when other DTM units had in fact been completed, the "complete the set" option will provide a second chance to enter the correct "Y(es)" input at step 1-3.

Step 1-14

What is the number of the TEST _DTM DTM unit that you want to digitize?

Keyboard input: 1

comment: Always start with the lowest numbered DTM unit and complete the DTMs in ascending numerical sequence.

The common borders of adjacent DTM units must match without gap or overlap. Corner-projecting routines are used to locate the three remaining corners after the lower left corner and the unit's alignment are established by digitized input. The lower right corner of unit 1 must therefore be accurately established before the position of the lower left corner of unit '2 is known because they are common points.

Step 1-15

Digitize the LOWER LEFT corner of the DTM unit.

Digitizer input: 1. Center the cursor over the lower left corner of the DTM unit.
2. Press any cursor key.

Step 1-16

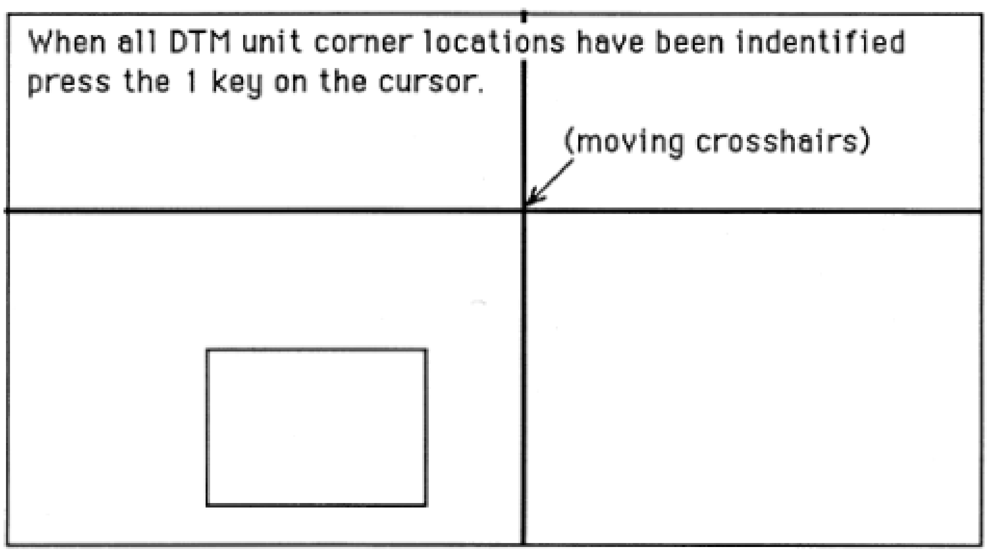
Digitize point on LOWER BOUNDARY of the DTM unit.

Digitizer input: ***1. Center the cursor on the lower boundary line of the DTM unit.***
2. Press any cursor key.

comment: It is critical that the map not be shifted on the digitizer's surface until -the digitizing of the contour lines is concluded.

Establish an accurate projection of the alignment of the DTM unit by digitizing a lower boundary point at least 9 inches, if possible, to the right of the lower left corner

----
Step 1-17



PRINTED INSTRUCTIONS:

-Pressing the 1 key on the cursor terminates this process. Do not press it until all the corners have been marked as detailed below.
-Move the cursor until a DTM unit corner is found (a beep will sound). The proximity of the cursor to the corner can be gauged on the CRT, and corner locations may be found in any order.
-Mark the location on the map.
-Check the accuracy of the mark by positioning the cursor on it. If a steady beep does not sound, the corner must be remarked and rechecked.
-Draw lines to connect the corners of the map.

Digitizer input: ***After all the corners have been found, marked, and checked, press the 1 key.***

comment: If this procedure is carelessly done, the common border lines between adjacent units will develop gaps or overlaps during the DTM construction process. The potential for this type of error increases for large DTM coverage areas that require many DTM units.

Step 1-18

A DIGITIZER MENU will be required for program control. Do you need a plot of this menu?

(Y or N)

Keyboard input: Y

comment: The user will direct the various phases of DTM building by using the cursor as a pointer and digitizing the appropriate menu selection.

Step 1-19

This menu will be plotted on the 75808 DRUM PLOTTER.

Load it with an 8- by 11-inch minimum-size sheet.
When ready, press RETURN.

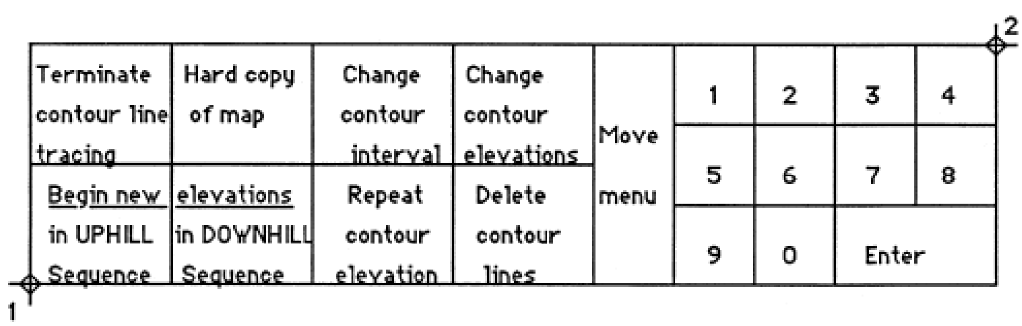
Step 1-20

Attach the menu to the digitizer, aligning its edges parallel with the digitzer's active surface boundary, then press RETURN.

comment: The menu should be horizontally aligned with the digitizer base.

Place the menu anywhere on the active surface of the digitizer outside the DTM unit.

Menu plot:



Step 1-21

Digitize the menu corner labeled '1' by pressing any cursor key.

Step 1-22

Digitize the menu corner labeled '2' by pressing any cursor key.

Step 1-23

Enter the starting contour elevation in feet from the keyboard.

Keyboard input: 3420

comment: The user can begin tracing the contour lines of the map at any location within the DTM unit. A good method is to begin contour-line input at the highest contour line and work downhill, or vice versa.

Step 1-24

Enter the contour interval in feet from the keyboard.

Keyboard input: 20

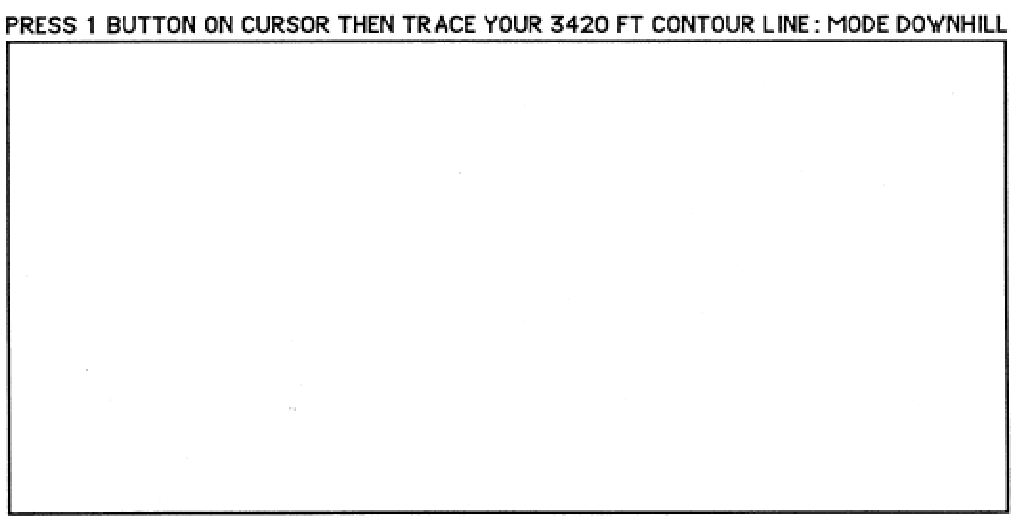
comment: At times a user may enter 100 and digitize only the major, labeled contour lines when a less accurate DTM suffices.

Step 1-25

The elevation of each subsequent contour line will automatically:
1. Increase 20 feet.
2. Decrease 20 feet.
Enter a 1 or 2 from the keyboard to match your choice.

Keyboard input: 2

Step 1-26



comment: 1. Center the cursor crosshairs on the contour line slightly outside the DTM unit's boundary.
2. One press of the cursor's "1" key activates the contour-line digitizing routine.
3. Hold the cursor in two hands. Keep the crosshairs on the contour line as you move the cursor along the contour line to its entry into the DTM unit, along its route through the DTM unit, and past the point where it exits the DTM unit.
4. As each contour line is traced by the cursor, it is plotted on the CRT. A beep sounds when the contour-line trace exits the DTM unit. This beep means the digitized input stops until the next contour line is initiated.
5. The procedure is similar for tracing contour lines that are entirely inside a DTM unit. Then, however, a beep sounds when the contour line has been traced back to its beginning point. If an internal contour line does not loop back to its beginning point, it must be terminated by pressing the cursor's "1" key at the end of the contour line.
6. Long contour lines will be automatically terminated if the file space allotted for one contour line becomes filled with digitized coordinate data. When this happens, move the cursor to where the line's plot stopped, press the "1" key, and continue tracing the line to its completion (DTM unit exit or closure). The CRT plot showing the position of the cursor and the end of the terminated contour line provide the visual prompt needed for contour-line continuation.

Digitizer input: 1. Center cursor on the 3,420-foot contour line just outside the DTM unit boundary.

2. Press the "1" key on the cursor.

3. Trace the contour line into the DTM unit and continue tracing it until it exits the DTM unit.

PRINTER OUTPUT:

Contour Line No.	Elevation (feet)
1	3420

comment: As each contour line is completed, its line number and elevation is printed. This verification should be used to check and, if need be, correct false entries.

Step 1-27

comment: Use the digitizer menu operations while digitizing contour lines to complete a DTM unit. The step format resumes on page 24 and is incorporated into the explanation of the menu selection item: "Terminate contour-line tracing."

DIGITIZER MENU OPERATIONS

comment: The function of each menu selection is explained under the underlined headings that follow. These should be studied before you begin digitizing contour lines. There is no one absolute and correct sequence of use for menu operations. Understanding the purpose and function of each menu operation will, however, enable you to contrive a sequence of menu operations that will give you a correctly digitized DTM unit.

The menu selections are made by digitizing the appropriate menu block. Never try to make a new menu selection when you are tracing a contour line with the digitizer. Wait until the line is finished.

Begin new elevations in UPHILL or DOWNHILL sequence

Digitizer input: 1. Center cursor crosshairs on the appropriate menu block for UPHILL or DOWNHILL sequence.
2. Press any cursor key.

Enter the contour elevation (feet) by first digitizing the number squares on the menu, then the 'Enter' rectangle.

Digitizer input: Digitize square "3"; square "4"; square "2"; square "0"; and square "Enter" to commence with elevation 3420.

comment: These are the most frequently used menu selections in DTM building. Each successive contour line is automatically assigned an elevation one contour interval higher (if uphill sequence is in effect) or one contour interval lower than the elevation of the previous contour line.

When the user wants to digitize the contour lines by working uphill, the "Uphill sequence" mode should be selected. When working downhill, use the "Downhill sequence" mode. "Uphill sequence" remains in effect until "Downhill sequence" is pressed, and vice versa.

The incrementing (or decrementing) of elevations between successive contour lines is temporarily suspended for long contour lines that are automatically ended when their file space is filled. The next contour line (which must be started at the end point of the long contour line) is automatically assigned the same elevation as its predecessor. The uphill or downhill mode automatically resumes after the "tag on" contour line is completed (by DTM unit exit or contour-line closure).

The user may want to remain in the current uphill (or downhill) mode but move to another series of contour lines requiring an elevation change; in this case, the user should digitize the uphill (or downhill) sequence block on the menu and enter the new starting contour-line elevation.

Repeat contour elevation

Digitizer input: 1. Center cursor crosshairs on the Repeat contour elevation block.
2. Press any cursor key.

comment: This menu selection permits the user to label and store the next contour line at the same elevation as the line that preceded it.

This option can be useful for continuing contour lines that exit and reenter the DTM unit.

Change contour interval

Digitizer input: 1. Center cursor crosshairs on the Change contour interval block.
2. Press any cursor key.

Enter the contour interval (feet) by first digitizing the number squares on the menu then the "Enter" rectangle.

Digitized input: Digitize: square "1"; square "0"; square "0"; and square "Enter" to enter a contour interval of 100.

comment: Sometimes a user may accept zones within the DTM of reduced accuracy if the DTM can be developed with, commensurately, less effort. Digitizing only the darker, labeled (boss) contour lines provides for this compromise. The user can enter the contour interval matching the elevation between the boss contours and digitize just those contour lines. Automatic incrementing or decrementing elevations to match the boss contour lines will expedite the process.

Change contour elevations

Digitizer input: 1. Center cursor crosshairs on the Change contour elevation block.
2. Press any cursor key.

You can change the elevation of:

1. A single contour line.
2. Any number of consecutive contour lines.

Enter a 1 or 2 from the keyboard to match you choice.

Keyboard input: 1
Enter the contour line number from the keyboard.
Keyboard input: 11
The old elevation for contour line 11 was 3200 feet.

Enter the new elevation in feet from the keyboard.
Keyboard input: 3220
Printer output:
Contour Elevation
Line No. (feet)

11 3220 (changed)

If Keyboard input: 2
Enter the starting contour line number from the keyboard.
Keyboard input: 5
Enter the ending contour line number from the keyboard.
Keyboard input: 10

Contour line elevations will be:
1. Automatically incremented
2. Set manually for each contour line.

Enter a 1 or 2 from the keyboard to match your choice.
Keyboard input: 2
The old elevation for contour line 5 was 3320 feet.

Enter the new elevation in feet from the keyboard.
Keyboard input: 3340

comment: These input requests are repeated for contour lines 6 through 10.

Printer output:

Contour Line No.	Elevation (feet)	
5	3340	(changed)
6	3320	(changed)
7	3300	(changed)
8	3280	(changed)
10	3260	(changed)

comment: This menu selection option allows users to correct the elevation on any contour line.

Delete contour lines

Digitizer input: ***1. Center cursor crosshairs on the Delete contour lines block.***
2. Press any cursor key.

You can delete:

1. The last contour line.
2. A single contour line.
3. Any number of consecutive contour lines.

Enter a 1, 2, or 3 from the keyboard to match your choice.

If Keyboard input: 1

Printer output:
Contour Elevation
Line No. (feet)

5 DELETED -if the last contour line entered was 5

If Keyboard input: **2**
Enter the contour line number from the keyboard.
Keyboard input: 4
comment: The output would be similar to the preceding example, except contour line number 4 would be deleted.

If Keyboard input: **3**
Enter the starting contour line number from the keyboard.
Keyboard input: 1
Enter the ending contour line number from the keyboard.
Keyboard input: 5
comment: The output would be similar to the preceding example, except contour lines numbered 1 through 5 would be deleted.

Move menu

Digitizer input: ***1. Center cursor crosshairs on the Move menu block.***
2. Press any cursor button.
Move the menu to a new location, aligning its edges parallel with the digitizer's active surface boundary, then press RETURN.

Digitize the menu corner label '1' by pressing any cursor key.

Digitize the menu corner label '2' by pressing any cursor key.

comment: The menu can be moved at any time, to any location on the active surface of the digitizer. Always place the long axis of the menu parallel to the horizontal axis of the digitizer.

Hard copy of map

Digitizer input: 1. Center cursor crosshairs on the Hard copy of map block.
2. Press any cursor key.

comment: The picture on the CRT of the contour lines traced is copied by the printer.

Terminate contour line tracing

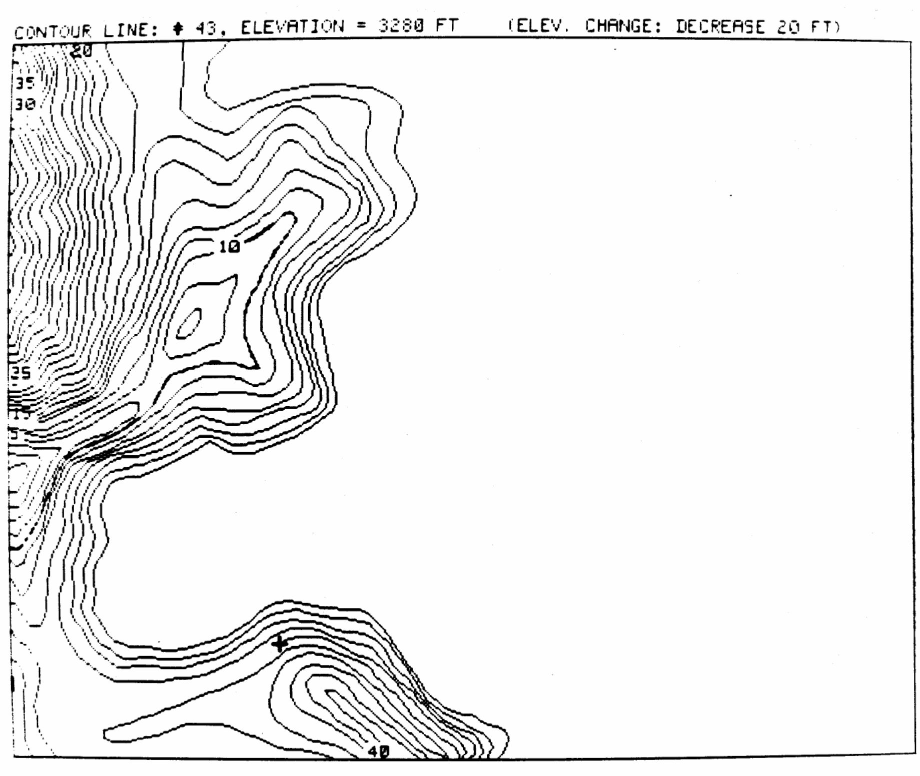
Digitizer input: 1. Center cursor crosshairs on the Terminate contour line tracing block.
2. Press any cursor key.

Step 1-28

comment: When the user wants to end the contour-line digitizing process, the "Terminate contour line tracing" option must be selected. This suspends additional menu operations.

It is not necessary to have all the contour lines that will constitute the final DTM unit digitized when this selection is made. This example shows a case where digitizing is terminated before all the contour lines of the map were digitized.

CRT status when Conclude digitizing is selected



comment: The CRT picture shows the number of contour lines that were traced and stored when the digitizing was terminated. A hard copy of this is automatically printed for the user's future reference in step 1-31.

CRT prompt:

The DTM unit you have been digitizing is now:
1. Completed (Le., all contour lines have been digitized) and will be converted to a gridded digital terrain model now.
2. Partially completed and will be stored on disk (or diskette) so that further digitizing can be continued later.
3. Partially completed and will be stored for further digitizing and converted to a gridded digital terrain model now.
Enter a 1, 2, or 3 from the keyboard to match your choice.

Keyboard input: 2

comment: Entering a value of "3" would be applicable if the user wanted to build a DTM unit by tracing only the boss contour lines and reserve the option of improving the accuracy of the DTM by digitizing the remaining contour lines later.

This option might also be used if a DTM unit is needed immediately for logging system analysis over a portion of the total area of the DTM. The user can complete the rest of the DTM unit when it is needed.

Step 1-29

It is possible to STORE CONTOUR LINE INPUT DATA onto the H.P. 7908 tape drive. From this data, the traced contour lines can be plotted and errors checked against the original map. Saving this DTM source data can provide the needed data for other DTMs of varying grid or structure to be processed at a later date WITHOUT RETRACING THE CONTOUR LINES.
If you want to STORE this data on tape, you'll need an INITIALIZED magnetic tape for STORING CONTOUR LINE DATA.

Would you like to store the traced contour lines on magnetic tape? (Y or N)

Keyboard input: Y

comment: This step ensures that the digitized contour lines will not have to be redigitized to produce DTMs needed for different applications. The digitized contour lines constitute a data source from which the gridded PLANS DTM is processed. Other DTMs for other applications such as PERSPECTIVE PLOT can be processed from this data source. Although the other DTMs could conceivably be reprocessed from the gridded PLANS DTM, special conversion programs would be needed, and the accuracy would still suffer. Saving original input data when it is feasible to do so is a good practice.

Saving digitized contour lines does require a large amount of magnetic storage space. A 16-megabyte backup tape on the H. P. 7908P tape/disc drive should provide enough space for approximately 40 DTM units, assuming approximately 240 contour lines are required per DTM unit.

Step 1-30

INSERT A TAPE CARTRIDGE IN THE H.P. 7908 DISC DRIVE, THEN PRESS RETURN.

comment: If RETURN is pressed before the BUSY light on the tape drive goes out, the following message is displayed:

WHEN TAPE IS INSERTED, WAIT UNTIL THE BUSY LIGHT GOES OUT, THEN PRESS RETURN

Step 1-31

:CS80,5, 1
LABEL:
FORMAT: SDF
AVAILABLE SPACE: 15464

FILE NAME	LEV	SYS TYPE	FILE TYPE	NUMBER RECORDS	RECORD LENGTH	MODIFIED DATE	TIME	PUB ACC	OPEN STAT1
PANTHER_CREEK1RC	1	9000	BDAT	300	1608	17-DEC-84	08:30	MRW	

** STAND BY ARCHIVING CONTOUR LINES STAND BY **

comment: This catalog listing shows other contour-line files that have been stored on the magnetic tape. It will remain on the CRT until the current contour lines have been stored. This may take up to 5 minutes.

A hard copy of the traced contour lines (see step 1-28) is printed prior to storing the partial DTM unit on the H.P. 7908 hard disk.

There is space alloted on the hard disk for storing just one partial DTM unit. When contour-line digitizing is resumed on that partial unit, the space on the hard disk is freed for storing a different partial DTM unit. Partial DTM units require considerably more storage space than completed, gridded DTMs. The limit (one partial DTM unit) was set to ensure that excessive amounts of disk storage space are not consumed. It is assumed that once a partial DTM unit is stored, it will be finished before there is a need to store a different partial DTM unit.

If, however, a user should try to store a partial DTM unit when another partial unit already resides on the hard disk, the following salvage method is provided.

CRT PROMPT:

You cannot store this partial DTM on the main hard disk (:CS80,5). Space is allotted for one partial DTM on the main disk, and there is one there now.

But not to worry—your partial DTM can be stored on a diskette. You will need a blank initialized diskette for this.

Put a blank diskette in the internal drive. If it has not been initialized, you may do so now.

DO YOU WANT THIS DISKETTE INITIALIZED? (ENTER Y OR N)

comment: From this point, the partial DTM unit can be stored on the diskette. Regardless of whether the partial DTM unit was stored on the disk or on a 5-¼-inch diskette, the program sequence is the same for the next step.

Step 1-32

comment: After the partially completed DTM is stored, the program recycles to step 1-1. Generally the user would stop using PLANS at this point, though the prompt permits continued use of other PLANS programs.

To clear the H. P. 9020 for use of different programs other than PLANS: type SCRATCH A, and press EXECUTE. .

To shut down, simply turn off the power switches for the H.P. 9020 and peripherals.

EXAMPLE 2: COMPLETING A PARTIALLY DIGITIZED DTM

The planner wishes to complete the TEST__DTM1 unit. Contour-line digitizing was started on this DTM unit in example 1, but digitizing was concluded before all the contour lines were digitized, and it was stored as a partially completed DTM unit.

The planner again accesses the MAP program by typing:
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 2-1

PLANS

PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:
1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8

Step 2-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskettes.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 2

comment: The partially completed DTM stored in step 1-32 will be completed.

Step 2-3

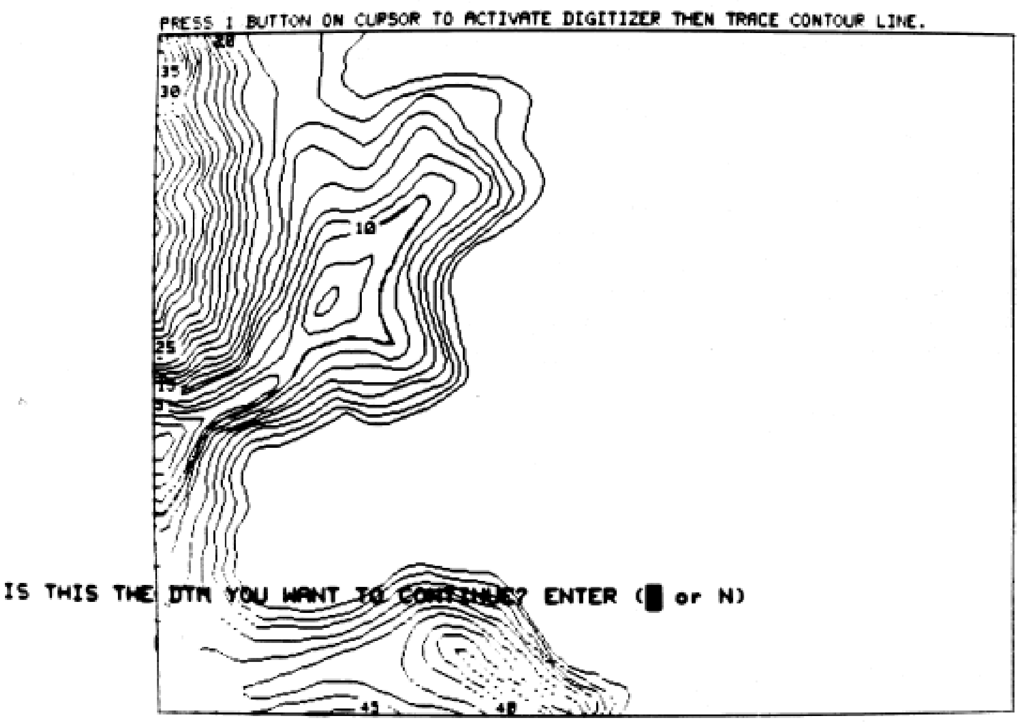
Is the partial DTM unit stored on the HARD DISK or on a DISKETTE?

HARD DISK	DISKETTE	START OVER

Softkey input: HARD DISK

comment: This step provides for loading partial DTM units that had to be stored on 5¼-inch diskettes (see step 1-31).

Step 2-4



IS THIS THE DTM YOU WANT TO CONTINUE? ENTER (Y or N)

Keyboard input: Y

comment: The contour-line pattern should be identical to the pattern printed in step 1-31. If not, input "N" and let program recycle through step 2-3. This gives a chance to recover if the partial DTM was stored on a different 5¼-inch diskette, and the user forgot.

Step 2-5

Attach the DTM unit to the digitizer making sure that its boundary is within the active digitizer surface.

When the unit is attached to the digitizer, press RETURN.

comment: The partial DTM unit will remain stored on the hard disk until it is completed and stored as a gridded DTM unit. At that time, it will be automatically purged from the disk to make the storage space available for a different partial DTM unit. The same holds true for partial DTM units stored on diskettes, providing the diskette is not removed from the internal drive before the DTM is completed.

Only the partial DTM unit that is loaded from the disk can be stored again as an uncompleted partial on disk space. It does not have to be completed during the second contour-line tracing session.

Planners can purge their own partial DTMs from diskettes by typing: PURGE "Cdata1:INTERNAL" (then press the EXECUTE key), and repeating this for Cdata2, Cdata3, Cdata4, and Cdata5.

Step 2-6

Digitize the LOWER LEFT CORNER OF THE DTM UNIT by pressing any cursor key.

Digitizer input: 1. Center the cursor on the lower left corner of the DTM unit.
2. Press any cursor key.

Step 2-7

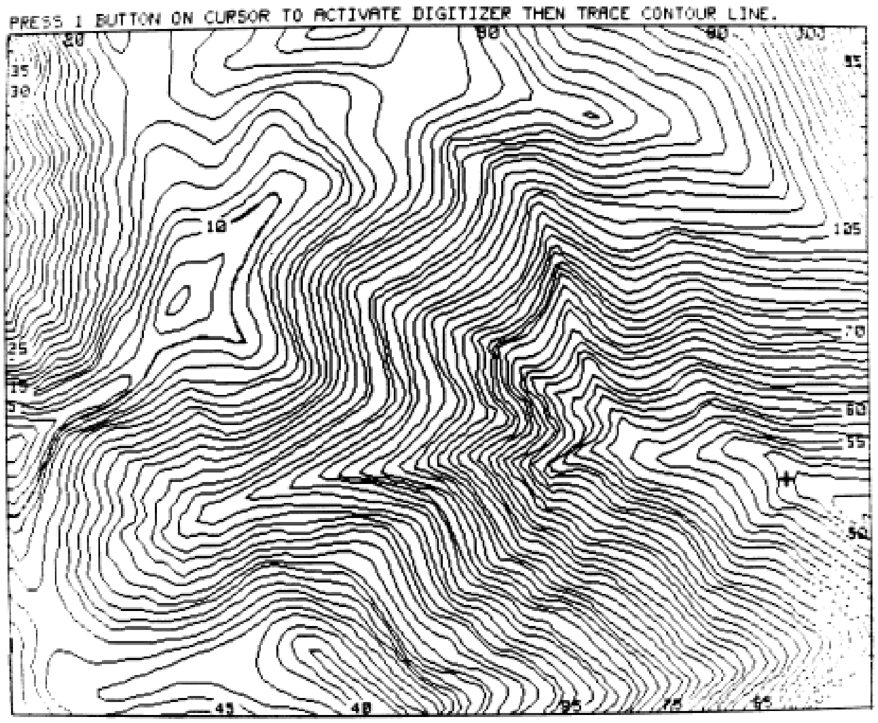
Digitize the LOWER RIGHT CORNER of the DTM unit.

Digitizer input: 1. Center the cursor on the lower right corner of the DTM unit.
2. Press any cursor key.

Step 2-8

comment: The steps required to complete the DTM unit by digitizing the remaining contour lines are the same as the sequence beginning at step 1-18. The basic operations consist of digitizing the position of the base contour map and the digitizing menu, and digitizing all the remaining contour lines. This procedure was detailed in steps 1-18 through 1-27, and will not be repeated. The procedure (step 2-9) resumes at the point where "Terminate contour line tracing" is activated from the digitizer menu.

Step 2-9



comment: The CRT picture indicates all the contour lines within the DTM unit have been traced.

CRT prompt: The DTM unit you have been digitizing is now:
1. Completed (i.e., all contour lines have been digitized) and will be converted to a gridded digital terrain model now.
2. Partially completed and will be stored on a disk so that further digitizing can be continued later.
3. Partially completed and will be stored for further digitizing and converted to a gridded digital terrain model now.

Enter a 1 through 3 to match your choice.

Keyboard input: 1

comment: Now the DTM unit is complete and ready to be processed into a gridded DTM for PLANS design programs.

Step 2-10

Were contours stored on tape when digitizing of this unit was started? (Y or N)

Keyboard input: Y

comment: The decision was made to store the contour lines in step 1-29; therefore, the additional contour lines should also be stored.

Step 2-11

INSERT A TAPE CARTRIDGE IN THE 7908 DISK DRIVE, THEN PRESS RETURN

comment: The additional contour lines are added to the same data file on the magnetic tape that stored the contour lines of the partial DTM. This data storage may take up to 5 minutes.

Step 2-12

Do you want to add SPOT ELEVATIONS or REFERENCE POINTS to the tape stored contour line file?
(Y or N)

Keyboard input: Y

comment: This option has been included to ensure that the effort made to construct a DTM unit for PLANS can also provide the data base for other DTMs. As there are DTM programs that use spot elevation and reference point data, entering this data might enhance the usefulness of the file. The PLANS DTM processing program (MAP) does not, however, use this data.

The opportunity to enter spot elevation and reference point data is offered only when the DTM unit is completed and ready to be converted to a gridded DTM.

Step 2-13

Use the cursor keys on the digitizer to enter SPOT ELEVATION or REFERENCE POINT DATA.

Center the cursor cross hair on the point you wish to enter.

-If the point is a SPOT ELEVATION: press Cursor key 1
-If the point is a REFERENCE POINT: press Cursor key 2
-When you are done entering points: press Cursor key #

DIGITIZE NOW

Digitizer input: ***1. Center the cursor over the spot elevation point labeled 3391 feet (near the midway point of TEST__DTM1 unit's lower boundary).***
2. Press cursor key 1.

Step 2-14

Enter the elevation in feet from the keyboard.

Keyboard input: 3391

Step 2-15

Use the cursor keys on the digitizer to enter SPOT ELEVATION or REFERENCE POINT DATA.

Center the cursor cross hair on the point you wish to enter.

-If the point is a SPOT ELEVATION: press Cursor key 1
-If the point is a REFERENCE POINT: press Cursor key 2
-When you are done entering points: press Cursor key #

DIGITIZE NOW

Digitizer input: ***1. Center the cursor over the reference point shown as a large*** "+" ***in the lower right \ quadrant of the TEST_DTM1 unit.***
2. Press cursor key 2.

Step 2-16

Enter the REFERENCE POINT description? (80 characters maximum) - > I

Keyboard input:
Point 184,000N and 1,664,000E— Washington State Coordinate (South zone)

comment: The most appropriate reference points for digital terrain model applications tie to State Plane coordinate systems. Recording these points, which establish a specific location for the DTM unit, provides the needed data to make reuse of the DTM more feasible.

Step 2-17

Use the cursor keys on the digitizer to enter SPOT ELEVATION or REFERENCE POINT DATA.

Center the cursor cross hair on the point you wish to enter.

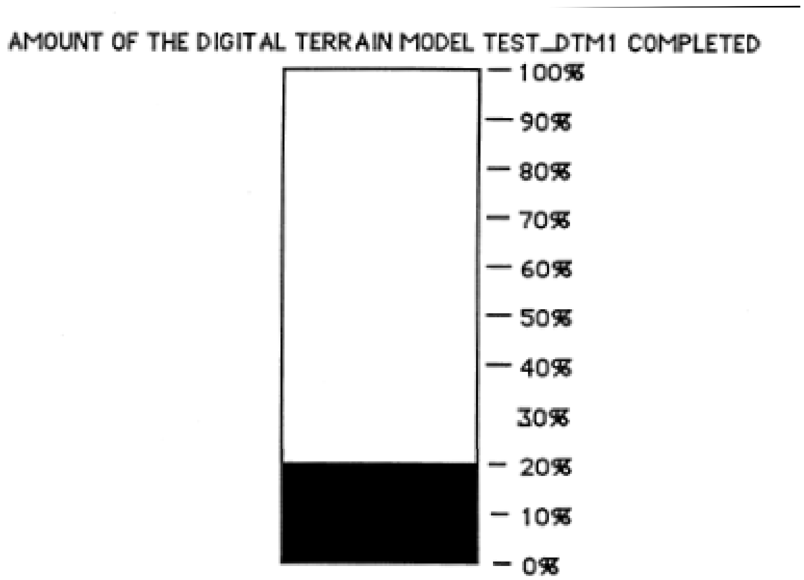
-If the point is a SPOT ELEVATION: press Cursor key 1
-If the point is a REFERENCE POINT: press Cursor key 2
-When you are done entering points: press Cursor key #

DIGITIZE NOW

Digitizer input: 1. Press cursor key #

comment: This terminates the example of point-storage operations. A minimum of two reference points are needed, however, to actually establish the location of a DTM coverage area.

Step 2-18



comment: The program processes the DTM unit into a gridded DTM. This bar chart fills to show progression of processing. This operation takes about 40 seconds to complete.

Step 2-19

SMOOTHING THE DTM

comment: This prompt is displayed until second-stage processing of the DTM unit is completed. Then the PLANS starting menu shown in step 2-1 appears on the CRT.

EXAMPLE 3: COMPLETING ADDITIONAL DTM UNITS AFTER THE FIRST UNIT IS STORED

At this point, the first DTM unit has been completed and stored. The planner now wishes to complete the next DTM unit. Step 1-12 shows that four DTM units comprise the DTM coverage area. The procedure for completing the additional DTMs (that is, TEST_DTM2, TEST_DTM3, and TEST_DTM4) is simpler than that required for TEST_DTM1. The following section details the procedure for building additional DTM units after the first in a group is completed.

"The planner accesses the MAP program by typing: .
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 3-1

PLANS
PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:
1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8

Step 3-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskettes.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 1

Step 3-3

Is this DTM unit part of a larger DTM coverage area that contains other previously completed (converted to gridded DTMs) units?
Enter (Y or N).

Keyboard input: Y

comment: TEST_DTM1 has been completed.

Step 3-4

Enter only the character portion of the data files' names for the DTM unit (e.g., enter QUARTZ__CR for data files QUARTZ__CR1, etc.).

Character portion?

Keyboard input: TEST__DTM

Step 3-5

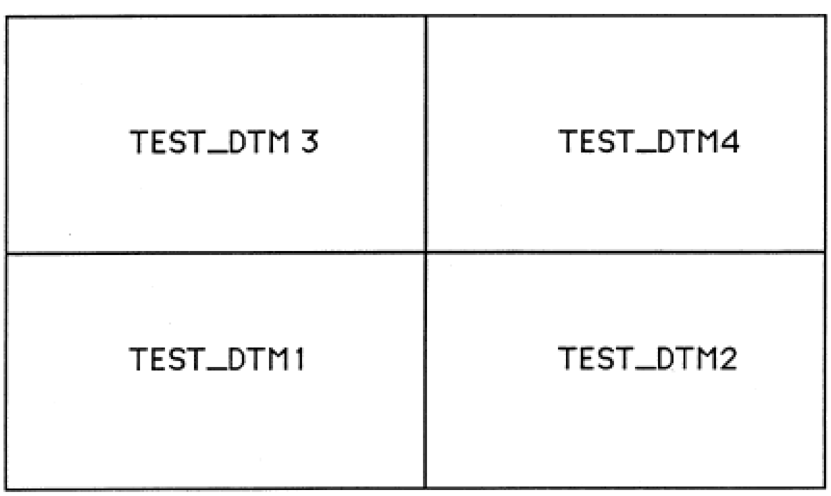
PRINTER OUTPUT:

The 18.00-inch by 14.00-inch DTM coverage area must be divided into 4 units, 2 horizontally and 2 vertically as shown below.

A data file will be created to store each DTM unit. The name of the data file for storing a DTM unit must be in the following form:

TEST__DTM + the number of the DTM unit (1 to 4).

Note: DTM units must be numbered left to right, bottom to top as shown in the diagram below. It is recommended that this print be saved and used as a record of which map units have been digitized and stored.



Step 3-6

What is the number of the TEST_DTM DTM unit that you want to digitize?

Keyboard input: 2

comment: It is best to do the DTM units in ascending numerical order. The boundary to be established prior to digitizing TEST_DTM2 must perfectly match the established boundary of its predecessor, TEST_DTM1. Building the DTM units in order makes accurate fitting of each unit possible.

Step 3-7

comment: From this point on, the procedure is the same as was required for building the first DTM unit (TEST_DTM1). The detailed instructions for this start at step 1-15 (page 16). The documentation there begins with a prompt for digitizing the lower left corner of the unit and proceeds to the point where the DTM unit has been completely digitized and stored. The only difference between digitizing the first unit and additional units is that no input related to sizing the DTM coverage area or establishing the grid spacing is repeated after the first DTM unit has been digitized.

EXAMPLE 4: TRANSFERRING DTM UNITS BETWEEN DISK AND DISKETTE

The planner has completed the DTM units required for the project and an initial timber-harvest plan. Now it is necessary to move the project's DTM unit files from the hard disk to diskettes because memory space on the hard disk is too limiting for it to serve as a permanent storage device for all processed data files. The diskettes that the DTM unit files will be transferred to will be labeled and safeguarded with the project records. When and if additional design on the timber.. harvest plan is resumed, the planner will transfer the project's DTM unit files from the diskettes back to the hard disk.

The planner accesses the MAP program by typing:
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 4-1:

PLANS

PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:

1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8

Step 4-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskettes.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 3

Step 4-3

These are the DTMs stored in main memory

Partial__dtm	1	DIR	42	24 17-Dec-84 10:04 MRW
TEST__DTM1	1 9000	BDAT	101	164 17-Dec-84 13:30 MRW
TEST__DTM2	1 9000	BDAT	101	164 18-Dec-84 09:06 MRW
TEST__DTM3	1 9000	BDAT	101	164 18-Dec-84 14:01 MRW
TEST__DTM4	1 9000	BDAT	101	164 19-Dec-84 09:21 MRW

When the diskette is loaded press RETURN

comment: The CRT lists the PLANS DTMs that are stored on the disk and requests a diskette be put in the internal drive of the H. P. 9020. If this diskette has not been initialized there will be a 2-minute delay. while the program automatically initializes it.

Step 4-4

NO FILES ON DISKETTE

Select option—press soft key:

TRANSFER FILE	WRONG DISKETTE LET ME CHANGE IT	END OF TRANSFER

Softkey input: TRANSFER FILE

Step 4-5

This is what is now stored on the diskette.

Enter the name of the DTM file you want to transfer.

Keyboard input: TEST __DTM1

Step 4-6

THE FOLLOWING OPTIONS FOR MANIPULATING THE DTM FILE: TEST_DTM1 ARE AVAILABLE:
-Copy from the hard disk to the diskette and PURGE the original hard disk DTM file
-Copy from the hard disk to the diskette and keep both DTM files
-Copy from diskette to the disk and PURGE the original diskette DTM file
-Copy from diskette to the disk and keep both DTM files

comment: The file "TEST_DTM1" on the disk is to be copied to the diskette.

Select the transfer option for TEST_DTM1

DISK->DISKETTE PURGE DISK COPY	DISK->DISKETTE KEEP BOTH COPIES	DISKETTE->DISK PURGE DISKETTE	DISKETTE->DISK KEEP BOTH COPIES

Softkey input: DISK- > DISKETTE
KEEP BOTH COPIES

comment: Clearing hard disk space requires that the "purge disk copy" softkey be used. Use the "keep both copies" softkey now because purging the TEST_DTM1 unit from the hard disk will impact ready use by others of the PLANS program user's documentation.

Steps 4-4 through 4-6 will be repeated to allow more DTMs to be copied. When the "end of transfer" softkey is pressed in step 4-4, the program returns to the PLANS starting menu shown in step 4-1.

Note that the options provided in this routine can transfer the project's DTM unit files from the diskettes back to the hard disk. Putting the DTM units back on the hard disk when project design is resumed greatly conveniences DTM operations. It can also be a necessity if all the project's DTM units cannot be stored on a single diskette.

EXAMPLE 5: CORRECTING A DTM BY REDIGITIZING ITS INCORRECT SECTIONS

The planner has finished constructing the TEST__DTM1 DTM unit. Subsequent analysis of the DTM unit via the PLANS SLOPE program discloses that a limited section of the TEST__DTM1 unit has elevation data that does not correspond to the contour map it was traced from (that is, the DTM unit is not correct). Most of the DTM unit is correct, however. The planner wants an entirely correct DTM, but does not want to redigitize any more contour information than is absolutely necessary.

The planner begins the DTM unit's correction by typing:
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 5-1

PLANS

PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:
1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8

Step 5-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskette.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 4

Step 5-3

Enter the data file name for the desired DTM unit.

Keyboard input: TEST _DTM1

Step 5-4

Attach map to digitizer surface, then press RETURN.

Step 5-5

Digitize the LOWER LEFT corner of the DTM UNIT.

Step 5-6

Digitize the LOWER RIG HT corner of the DTM UNIT.

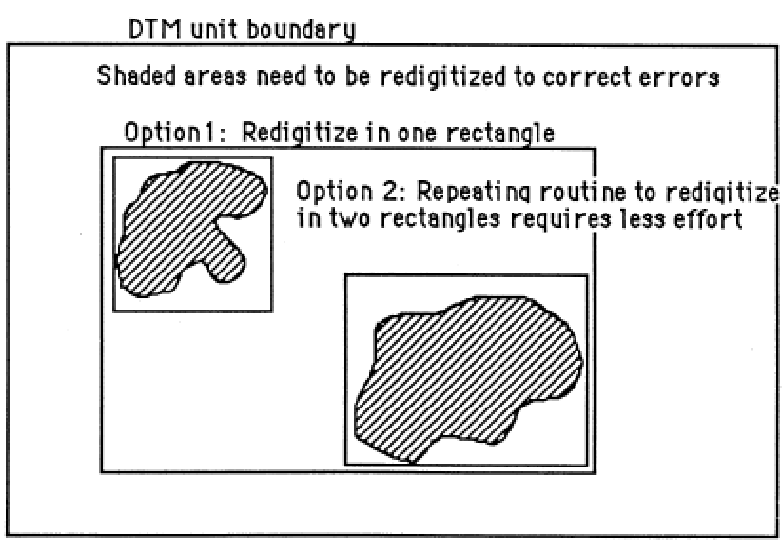
Step 5-7

Mark the area to be redigitized (it must be rectangular), then press RETURN.

comment: The area to be. redigitized is essentially a small DTM inside the boundary of the DTM unit. The error in the DTM unit must be contained within the boundaries of the redigitized areas. This error can be caused by inaccurate contour-line digitizing or mislabeling of contour-line elevations.

If there are several areas containing errors within the DTM unit, it may take less digitizing to repeat the process several times with smaller rectangles than to encompass all these areas into one rectangle for redigitizing (see figure below).

Be sure to mark the rectangular boundaries parallel to to the DTM unit's boundaries.



Step 5-8

Digitize the LOWER LEFT corner of the area to be redigitzed.

Step 5-9

Digitize the LOWER RIGHT corner of the area to be redigitzed.

Step 5-10

Digitize the UPPER RIGHT corner of the area to be redigitzed.

comment: This defines the area that will be redigitized. The boundary may shift slightly from the boundary digitized because the new DTM subunit that will be redigitized is fit within the gridline framework of the larger DTM unit.

From this point on, the detailed instructions proceed from step 1-18 in the same manner as if a new DTM unit were being built.

EXAMPLE 6: REGRID A DTM UNIT FROM A CONTOUR-LINE FILE

The planner had completed the DTM units required for the project and an initial timber harvest plan. The DTM units for the project were transferred to a diskette and purged from the hard disk. Some revisions are required on the initial harvest plan, but the diskette on which the project's DTM units are stored cannot be found! The planner, however, had stored the contour lines on magnetic tape that were digitized while the DTM units were created. To avoid redigitizing the contour lines to recreate the gridded DTM units needed for the plan revisions, the planner elects to automatically re-create the gridded DTM units needed from the contour-line data stored on the magnetic tape.

The planner begins this recovery process by typing::
LOAD "PLANS/BEGIN:CS80,5",1 (followed by pressing the EXECUTE key)

Step 6-1

PLANS
PRELIMINARY LOGGING ANALYSIS SYSTEM

Please choose one of the following eight PLANS programs:
1. SKYMOBILE . . . .Analyze skyline payloads and spans for individual profiles.
2. SKYTOWER. . . . Analyze payloads and spans for large central landings.
3. HIGHLEAD. . . . . Analyze direct pull and tightlining limits for highlead.
4. ROUTES. . . . . . . Project trial grade lines and calculate % sideslopes.
5. SLOPE. . . . . .Plot overlay maps for areas of specified slope, aspect, etc.
6. VISUAL. . . . . View a terrain model in perspective from desired viewpoint.
7. SIMYAR . . . . Simulate yarding activities to estimate yarding cost.
8. MAP. . . . . .Digitize contour lines to create a digital terrain model.

Enter a 1 through 8 to match your choice.

Keyboard input: 8

Step 6-2

You can now:

1. Create a new DTM unit by digitizing contour lines.
2. Continue digitizing a partially completed DTM unit.
3. Transfer stored DTM unit(s) between the disk and diskette.
4. Redigitize part of an existing DTM unit.
5. Regrid a DTM unit from a contour-line file.

Enter a 1 through 5 to match your choice.

Keyboard input: 5

comment: The reprocessed DTM unit will have the same size, grid spacing, and elevations as the DTM unit that was processed when the contour lines were stored on the tape.

Step 6-3

TO BUILD A DTM UNIT FROM A CONTOUR-LINE DATA FILE, YOU MUST HAVE STORED THE CONTOUR LINES WHILE DIGITIZING THE CONTOUR MAP. IF CONTOUR LINES WERE NOT STORED, YOU CANNOT RECREATE THE DTM.

What is the name of the contour-line file?

Keyboard input: TEST_DTM1RC

comment: Note that the contour-line files have an RC ending. The routine that stores the raw contour-line data automatically assigns the same file name as the user previously had input in steps 1-12 and 1-14, with an RC ending to differentiate it from the gridded DTM file.

Step 6-4

INSERT A TAPE CARTRIDGE IN THE H.P. 7908 TAPE DRIVE, THEN PRESS RETURN

comment: Wait for the BUSY light to go out before pressing RETURN.

Step 6-5

Enter a name for storing the gridded DTM unit (1 to 14 characters).

Keyboard input: TEST_DTM1

comment: Messages prior to the name request show briefly on the CRT. A catalog of the files on the magnetic tape is shown. If TEST_DTM1RC was not present, the user would be asked to load a different tape or return to the main PLANS menu.

A calculation progress message occupies the screen while the contour data is processed.

The input prompt requests the user enter a name for the gridded DTM. Using the original name relates it to TEST_DTM2, TEST_DTM3, and TEST_DTM4. Related DTM units can be combined to form a larger DTM coverage area for use in PLANS design routines.

Step 6-6

comment: The final steps are identical to steps 2-15 and 2-16. These conclude with the gridded DTM unit being stored on the H.P. 7908P disk in a file named TEST_DTM1.