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U.S. Department of Agriculture
Forest Service

National Mapping Program Technical Instructions

Part 7
Hypsography

Standards for USGS and USDA Forest Service Single Edition Quadrangle Maps

U.S. Department of the Interior
U.S. Geological Survey

CONTENTS

7. HYPSOGRAPHY

This part of the standard provides a description of the Hypsography features shown on USGS and USDA Forest Service single edition quadrangle maps.

CONTOUR - A line connecting points of equal elevation with reference to a vertical datum.

Characteristics

Show the following CONTOURS:

Depression	A contour around a basin or sink.
General Case	Those that are in common use.

Show the following CONTOURS based on their positional accuracy:

Definite	Conditions permit the feature to be confidently positioned. Horizontal data are confidently positioned within 0.02" (40 feet at 1:24,000 scale), at map scale, of true ground position. Vertical data are confidently positioned within one-half contour interval of the true ground position.
Indefinite	Conditions prevent the feature from being confidently positioned. Horizontal data cannot be confidently positioned within 0.02" (40 feet at 1:24,000 scale), at map scale, of the true ground position. Vertical data cannot be confidently positioned within one-half contour interval of the true ground position.
Unspecified	Does not have to be known or specified for the feature to be shown.

Show the values of CONTOURS in decimal or whole numbers. See tables 7A-1 and 7A-2 for more information.

Delineation

The limit of a CONTOUR is the line connecting points of equal elevation.

Depiction Conditions

If a CONTOUR has an elevation that is a multiple of the contour interval, and the CONTOUR is not coincident with a SHORELINE (Hydrography theme),
Then show.

Source Interpretation Guidelines

All

See appendix 7-A for additional information on the depiction and portrayal of CONTOURS.

For nearly vertical slopes where not all contours can be represented, some or all of the intermediate contours may be dropped. When dropping contours, use a "feathering" technique, where the highest elevation and lowest elevation contours are extended the farthest and dropped, then the next highest and lowest contours are extended and dropped.

If a vertical escarpment, such as a cliff, is so steep that not all the contours can be represented, then a single contour may be used to depict multiple CONTOURS. Show each CONTOUR in its entirety across the slope.

Do not show a CONTOUR when it is coincident with a nonearthen DAM/WEIR, FISH LADDER, LOCK CHAMBER, NONEARTHEN SHORELINE, SHORELINE, SPILLWAY, WALL, or the perimeter of an AREA TO BE SUBMERGED or INUNDATION AREA. (See the Hydrography theme for AREA TO BE SUBMERGED, DAM/WEIR, FISH LADDER, INUNDATION AREA, LOCK CHAMBER, NONEARTHEN SHORELINE, SHORELINE, SPILLWAY, and WALL.)

Do not show a CONTOUR when it is < 0.005" (10 feet at 1:24,000 scale) from a CANAL/DITCH represented as an area, an EMBANKMENT, RESERVOIR, or the edge of a ROAD that is under construction. (See the Hydrography theme for CANAL/DITCH and RESERVOIR. See the Transportation theme for ROAD. See the Built-up theme for EMBANKMENT and RESERVOIR.)

Do not show a CONTOUR to represent a spoil bank or levee that is < 0.04" (80 feet at 1:24,000 scale) along the shortest axis. (See EMBANKMENT in the Built-up theme for spoil banks and levees.)

If a CONTOUR previously defined a dry area of land that has since been submerged by a newly created hydrologic feature and the submerged area is ≥ 5.28 square inches (¾ square mile at 1:24,000 scale), show the underwater CONTOUR. Do not show underwater CONTOURS if the associated water body is < 5.28 square inches.

If a CONTOUR is on an ICE MASS (Hydrography theme), depict the positional accuracy of the line as indefinite.

If a CONTOUR is generalized and is within a disturbed surface area, such as a MINE (Built-up theme), depict the positional accuracy of the line as unspecified.

Graphic

Do not connect CONTOURS that are broken on previously published maps for other features or due to feathering.

Obsolete contours were shown on previously published maps between 1994 and 1998 to indicate that the contours no longer represented the ground accurately. Change the obsolete contour symbols to unbroken lines. Be careful not to confuse obsolete contours with indefinite contours.

Do not depict hachures used to symbolize the extent of pits and mines on previously published maps as CONTOURS. (See appendix 7-A for information on hachures.)

Symbolization

Characteristics	Symbol*	Label**
Depression, Definite	532.6 532.7 adjacent depression 533.2 supplementary	N/L
Depression, Indefinite	532.26 533.6 supplementary 541.66 glacier or permanent snowfield	N/L
Depression, Unspecified	532.6 532.7 adjacent depression 533.2 supplementary	N/L
General Case, Definite	532.1 index 532.2 intermediate 532.4 feathering-out 532.5 carrying 532.8 at ditches and canals 532.9 large earth dam, large levee 532.10 at levee or spoil bank 532.12 at levee with canal, road, or railroad 533.1 supplementary	N/L
General Case, Indefinite	532.3 533.5 supplementary 541.44 glacier or permanent snowfield	N/L

CONTOUR

Characteristics	Symbol*	Label**
General Case, Unspecified	532.1 index 532.2 intermediate 532.4 feathering-out 532.5 carrying 532.8 at ditches and canals 532.9 large earth dam, large levee 532.10 at levee or spoil bank 532.12 at levee with canal, road, or railroad 533.1 supplementary	N/L

* Index depression and general case CONTOURS are shown with a 0.007" line. Intermediate depression and general case CONTOURS are shown with a 0.003" line. Do not show ticks beyond adjacent CONTOURS. Place the label "DEPRESSION" (black, UL-10, upper case, 4-pt spacing) in the center of depressed areas ≥ 69.7 square inches (10 square miles at 1:24,000 scale).

** See tables 7A-1 and 7A-2 for information on elevation values. See appendix 2-F in the Standards for Revised Primary Series Quadrangle Maps for selection and positioning instructions.

DEPTH CURVE - A line connecting points of equal depth below the hydrographic datum.

Characteristics
Show the values of DEPTH CURVES in whole numbers.

Delineation
The limit of a DEPTH CURVE is the line connecting points of equal depth.

Depiction Conditions
If a DEPTH CURVE is shown on a published USGS quadrangle and a cooperating agency has requested that it be shown,
Then show.

Source Interpretation Guidelines
All
N/A

Graphic
Retain DEPTH CURVES and SOUNDINGS in inland lakes and ponds shown on previously published maps if provided by a State (such as, Illinois, Minnesota, and Wisconsin).

Symbolization

Characteristics	Symbol*	Label**
N/A	542.1 label	N/L; Show value with whole number

* Show DEPTH CURVES with blue 0.007" lines.
** See appendix 2-F in the Standards for Revised Primary Series Quadrangle Maps for selection and positioning instructions.

SOUNDING - The measured or charted depth of water below the hydrographic datum.

Characteristics
Show the values of SOUNDINGS in whole numbers.

Delineation
The limit of a SOUNDING is the point at which the depth is measured or charted.

Depiction Conditions
If a SOUNDING is shown on a published USGS quadrangle and a cooperating agency has requested that it be shown,
Then show.

Source Interpretation Guidelines
All
N/A

Graphic
Retain DEPTH CURVES and SOUNDINGS in inland lakes and ponds shown on previously published maps if provided by a State (such as, Illinois, Minnesota, and Wisconsin).

Symbolization

Characteristics	Symbol	Label*
N/A	542.1 label	N/L; Show value with whole number
* See appendix 2-F in the Standards for Revised Primary Series Quadrangle Maps for selection and positioning instructions.		

SPOT ELEVATION - A point with a measured vertical position of less than third order accuracy, measured relative to a reference datum.

Characteristics

Show the values of SPOT ELEVATIONS in decimal or whole numbers. See tables 7A-1 and 7A-2 for more information.

Delineation

The limit of a SPOT ELEVATION is the point at which the elevation is measured.

Depiction Conditions

If an area is composed of medium relief, show SPOT ELEVATIONS at a minimum of one per square mile.

If an area is composed of low relief, complex topography, or has dense culture, show SPOT ELEVATIONS at a minimum of one per square mile and add more as needed to enhance the usability of the data.

If a SPOT ELEVATION is at the highest point of a HELIPORT or RUNWAY/APRON/TAXIWAY that does not have a previously established elevation on the highest point, Then show. (See the Transportation theme for HELIPORT or RUNWAY.)

Source Interpretation Guidelines

All

Do not depict water surface, spillway, or riser elevations as SPOT ELEVATIONS. (For information on water surface, spillway, and riser elevations see INUNDATION AREA, LAKE/POND, RESERVOIR, SPILLWAY, and STREAM/RIVER in the Hydrography theme.)

Depict elevations on features shown with point symbols as SPOT ELEVATIONS, except for WATER INTAKE/OUTFLOWS (Hydrography theme). Do not depict elevations on WATER INTAKE/OUTFLOWS as SPOT ELEVATIONS. See INUNDATION AREA, LAKE/POND, or RESERVOIR (Hydrography theme).

Locate SPOT ELEVATIONS at positions or on features that are easily and positively identifiable and recoverable; however, SPOT ELEVATIONS can be shown at unidentifiable positions in very flat areas if there are no identifiable positions available. The following are appropriate positions for SPOT ELEVATIONS. They are grouped together and listed in descending order of preference:

Heliport or end of runway

Road or trail intersection or fork
Road or trail intersection with railway
Road or trail intersection with aqueduct
PLSS corner (especially in flat areas)
Gaging station
Bridge
Boundary marker
Triangulation station
Top of nonearthen or large earthen dam
Road or trail intersection with fenceline, well defined field line, or underground pipeline scar

Road or trail intersection with stream
Isolated corral
Prominent top, saddle, or depression
Alternate top and bottom of levee or spoil bank
Sharp bend in road or trail
Windmill
Water well
Isolated well (other than water well)

Road or trail intersection with well-defined edge of woodland
High point along road
Along abandoned or dismantled railway

Top or depression in sand dune area
Low point on large dry lake
Spring
Geyser
Rock pinnacle or outcrop within glacier
Isolated located object

Stream fork
Sharp bend in stream
Top of large mine dump

Top or lowpoint of large excavation such as quarry, open-pit mine, strip mine, dredge tailing or intricate surface area
Upper and lower limits of rapids
Top and bottom of waterfall
Off-ice moraine
Swamp/marsh

Unrecoverable point (on very flat surface)

Do not adjust SPOT ELEVATIONS so that they differ from adjacent CONTOURS.

For elevations shown in tenths of a meter, round the value down if the hundredth value is 1 to 4, or 5 following an even number. Round the value up if the hundredth value is 6 to 9, or 5 following an odd number.

For elevations shown in half meters, round the value down if the tenth and hundredth value is 01 to 24, 25 following an even digit, 51 to 74, or 75 following an even number. Round the value up if the tenth and hundredth value is 26 to 49, 25 following an odd number, 76 to 99, or 75 following an odd number.

For elevations shown in whole meters, round the value down if the tenth value is 1 to 4, or 5 following an even number. Round the value up if the tenth value is 6 to 9, or 5 following an odd number.

Graphic

SPOT ELEVATIONS on previously published provisional maps may be overcrowded. Thin the SPOT ELEVATIONS to a maximum of one every ¼ mile. When thinning the elevations, first delete the elevations identified with a "T" (unchecked photogrammetric elevations), then delete the elevations identified with either an "A" or "B", and then delete the elevations with no letter indication.

Prior to 1970, spot elevations compiled by photogrammetric methods were shown in brown and field established fourth order supplemental control elevations were shown in black on previously published maps. Do not show any distinction between SPOT ELEVATIONS shown with black type and those shown with brown type.

If elevation type is shown adjacent to a point symbol (other than a SPOT ELEVATION cross) or to the intersection of two linear symbols on a previously published map, the SPOT ELEVATION is generally applicable to the point symbol or the intersection of the linear symbols.

Symbolization

Characteristics	Symbol	Label*
N/A	512.99 on horizontal control sta 512.108	N/L; Show value
* See tables 7A-1 and 7A-2 for information on elevation values. See appendix 2-F in the Standards for Revised Primary Series Quadrangle Maps for selection and positioning instructions.		

APPENDIX 7-A

Background Information on Relief Treatment

CONTENTS

TABLES

7A. BACKGROUND INFORMATION ON RELIEF TREATMENT

The information in this appendix is intended to serve as guidelines for the treatment of relief features when the revision of hypsography is warranted. In most cases, these procedures are consistent with past practices. However, in some cases, current procedures may differ from past practices.

7A.1 PRINCIPLES OF RELIEF TREATMENT

7A.1.1 Objectives in Representing Relief

The height and shape of the land surfaces--collectively, the relief features--are represented on topographic maps for two purposes. The first and most important is to present an accurate geometric description of the terrain; the second, to give a picture of the landscape. Relief symbolization is designed to attain both objectives.

7A.1.1.1 Slope and Elevation

The geometric aspects of relief treatment are those concerned with the elevation of points and with ground slopes. Relief information of this kind is necessary in solving problems of land use--problems of reclamation or road construction, for example. It is primarily engineering information.

Geometric map quality is an evaluation of accuracy, which can be measured objectively. Specifications for accuracy of elevation are detailed and exact. Accuracy is tested by comparing map elevations with surveyed elevations of the same points.

7A.1.1.2 Pictorial Effect

The picture of the landscape presented on topographic maps is useful to those not primarily interested in exact elevation information. It is a limited picture, which varies in fidelity and detail with the map scale and contour interval, but it should permit the map user to visualize the terrain readily.

Pictorial map quality is a measure of the similarity of the graphic representation and the appearance of the terrain. This is commonly called topographic expression and, unlike accuracy, cannot be tested objectively. The only valid test of topographic expression is to compare the map with the actual ground it represents or with a stereo view of the landscape.

7A.1.2 Relief Symbolization

Contour lines are the best means of portraying relief as they present both elevation information and a picture of the terrain.

Other relief symbols in common use represent only one or the other. Spot elevations, for example, indicate the elevation above or below sea level of selected points, but they give no indication of topographic forms. Hachures and relief shading suggest the appearance and shape of the land, but they give no measurable information about elevations and slopes. In representing relief, several kinds of symbols are used to indicate various types of topographic features, but contour lines provide the most comprehensive portrayal.

For easier reading, contour lines are drawn in several widths and styles, according to their function. The following types of contour lines are used:

Index contours (every fourth or fifth line depending on the contour interval) are accentuated by increasing their line weight and labeling many of them with the elevations they represent. Index contours are, with few exceptions, continuous throughout a map even though the contours may coalesce because of steep slopes.

Intermediate contours (the three or four lines between adjacent index contours) are about half the line weight of index contours. They are normally continuous throughout a map, but may be dropped or joined with an index contour where the slope is steep and where there is insufficient space to show all of the intermediate lines.

Supplementary contours are used to portray important relief features that would otherwise not be shown by the index and intermediate contours (basic contours). They are normally added only in areas of low relief, but they may also be used in rugged terrain to emphasize features. Supplementary contours are shown as screened lines so that they are distinguishable from the basic contours, yet not unduly prominent on the published map.

Indefinite contours are used in limited areas where accurate contours are not feasible, usually in areas where the vegetative surface cover precludes economically contouring the ground so that the contours will meet National Map Accuracy Standards. They are shown with a dashed line.

Depression contours are closed contours that surround a basin or sink. They are shown by right-angle ticks placed on the contour lines, pointed inward (down slope). Fill contours are a special type of depression contours, used to indicate an area that has been filled to support a road or railway grade.

Carrying contours are single contour lines that represent two or more contours. They are used to portray vertical or near vertical topographic features such as cliffs, cuts, and fills.

Underwater contours are contours that were compiled before the area was inundated by the construction of a dam and are retained after the area has been inundated. They are published in brown.

Obsolete contours are no longer shown on graphic products. They were contours that no longer represented the ground accurately. They were used only in revised data sets compiled using non-stereoscopic techniques. When the existing contours conflicted with planimetric features but could not be updated, they were retained and shown as dashed obsolete contours. No depression ticks were used on obsolete contours.

Glacial contours are those that represent the surface of an ice mass or permanent snow field at the date of the photography used to compile the feature. They are published in blue rather than brown.

7A.1.3 Limitations in Representing Relief

Relief treatment is generally limited by two factors--the publication scale and the contour interval. Both factors are determined before compilation is begun and are not usually subject to any major changes. The topographer must clearly understand the limits imposed by these factors and the extent of interpretation that is permitted.

The most important limitation is the map publication scale. The scale determines the paper area available for representing a unit of ground and so broadens or restricts the amount of topographic information that can be shown. The contour interval is chosen to be appropriate to the publication scale and the type of terrain being mapped.

The contour interval imposes two limitations on the topographer. First, it determines the minimum height, above the surrounding terrain, of topographic features that can be clearly represented. Features that are located between two contours or that are intersected by only one contour must either not be shown or be merely suggested. Second, the contour interval fixes the standards of vertical accuracy to which the map must conform.

7A.1.4 Absolute and Relative Accuracy of Contours

The National Map Accuracy Standards (NMAS) relating to vertical accuracy are:

> Vertical accuracy, applied to contour maps at all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

(The permissible horizontal error for 1:24,000-scale maps according to the NMAS is 0.02" or 40 feet.)

It should be noted that the standard does not contain a direct requirement for contour accuracy; the specification applies only to the elevation accuracy of well defined test points on the map. However, for all practical purposes the contours themselves have to be compiled to within one-half the contour interval in order for the test elevations to be accurate to within one-half the contour interval.

The vertical accuracy of a map is related directly to the contour interval, and this is taken to mean the smallest interval between contours. Thus, when supplementary contours are added, a new interval is established in that part of the map, and both the basic and supplementary contours in that area are required to be accurate within one-half of the smaller interval.

This tolerance is considered sufficient for most engineering purposes. It is not always adequate, however, for portraying either the true slope or the correct shape of topographic features. For these purposes the relative accuracy--the accuracy of the intervals between adjacent contours--must be considerably higher. For example, a uniform slope portrayed by contours placed alternately about a half interval above and below their true elevations would appear as a series of terraces. Although the contours would meet NMAS requirements, the actual representation of the terrain would be entirely misleading. However, when the contours are plotted with a high relative accuracy, a uniform slope is represented with a series of evenly spaced lines. High relative accuracy, therefore, is essential for portraying the gradient of any slope and for presenting an accurate portrayal of any relief feature.

The present accuracy standards do not include a requirement for relative accuracy because of the difficulty of testing for compliance with such a requirement. However, satisfactory relative accuracy can be attained by comparing the compiled contours with the stereo-model, feature by feature, and correcting contours wherever their spacing does not correspond to the ground slope.

7A.1.5 Topographic Expression

Effective topographic expression is achieved by shaping and spacing contour lines in relationship to each other. By adjusting the contours, topographic features can be represented more realistically and interpreted more easily. Proper spacing of contours is required to; (1) omit small, relatively unimportant detail that cannot be drawn to scale; (2) show important features that fall between exact contour elevations and cannot be represented without deliberate moving of the contours from their true position; and (3) emphasize significant characteristics of the terrain. The first objective, the omission of small detail, is attained by appropriate generalization. The second and third objectives are attained by the judicious use of "topographic license" in shifting the positions of contours to accentuate particular features.

7A.1.5.1 Generalization

Generalization is the term applied to the elimination of insignificant ground details in order to make the map more readable. It is impossible to draw a contour that follows every irregularity of the ground. The thickness of the line itself limits the radius of curvature and, consequently, the size of irregularities that can be portrayed. All contours are therefore generalized, regardless of scale.

In contouring quadrangle maps the topographer must decide what ground detail can be represented adequately. Some information may have to be sacrificed so that the remainder is clear and understandable. Usually this can be done by plotting most of the ground features to scale and then eliminating those that cannot be represented at publication scale.

7A.1.5.2 Generalization by Sampling

Sometimes, terrain that has an intricate surface must be contoured by a sampling technique; such as, by contouring a representative sample of small features. This type of surface may be found in a highly dissected "badlands" region; in an area with a great many small drains, all of the same size; or in an area composed of many small hills or depressions. Wherever possible, the larger features are shown and the smaller ones omitted, but sometimes the selection must be made arbitrarily among features of equal size. The features should be plotted in correct position and as many features should be depicted as can be clearly reproduced at publication scale.

7A.1.5.3 Emphasis and Exaggeration

Occasionally it is desirable to emphasize small features or to portray features that would not otherwise be portrayed by the contours. This can be accomplished by deliberately moving contours from their plotted positions. Features delineated in this manner must be significant and of a landmark character; that is, distinctive in relation to surrounding features. Their representation provides identifiable ground positions and improves the usefulness of the map. This treatment is commonly referred to as the use of "topographic license". This deliberate adjustment of contours may result in a slight impairment of contour accuracy. The contours, however, must not be moved from their true positions more than plus-or-minus one-fourth the contour interval and must meet NMAS requirements.

In the past, the technique of "shaping" contours was used to create a preconceived, uniform representation of the topography. Shaping was initiated when contours were compiled in the field using a planetable, alidade and the sketching ability of the topographer.

The need to cover large areas, sometimes of high relief, as quickly as possible, limited the number of elevations that could be acquired. Thus, a contour was sketched using widely spaced elevations and the eye level view of the topographer. The contours were then shaped into a stylized representation of the terrain. The practice of shaping was carried over in the early use of photogrammetric methods of compilation. Shaping was initially necessary because the early instrumentation, photography, and flight heights did not allow for the precise tracing of contours. However, current instrumentation provides the capability to very precisely contour terrain that is not obscured by vegetative cover. Shaping has therefore been replaced by the minor smoothing and adjustment of the contours, which is usually all that is necessary to accurately and adequately portray the terrain.

7A.2 CONTOUR INTERVALS

7A.2.1 Selecting Contour Intervals

The selection of the optimum contour interval is one of the most important considerations in topographic mapping. One of the factors to be considered is the intended purpose of the map. A large interval may be acceptable for reconnaissance maps, whereas a smaller interval is usually required for maps made for development of the Nation's water and mineral resources or its transportation systems.

Another important factor is the amount and complexity of relief in the area to be mapped. The contour interval must adequately represent the terrain. Too small an interval may result in the crowding of contour lines or the showing of insignificant details; too large an interval may prevent adequate representation of the significant details of the terrain. The possibility of using supplementary contours or dual contour intervals should also be considered when selecting the appropriate basic contour interval.

The Department of the Interior Geological Survey Manual, dated September 29, 1989, defines the Survey policy on contour intervals for the primary map series. Where needed for adequate portrayal of the terrain, supplementary contours are shown, generally at half the basic contour interval. Dual basic contour intervals, rather than supplementary contours, are used on maps containing areas of abrupt and extreme relief variation.

7A.2.1.1 Customary Unit Contour Intervals

The basic contour intervals used for 1:24,000- and 1:25,000-scale 7.5-minute maps are 5, 10, 20, 40, and 80 feet.[1] On maps containing basic contour intervals of 10 feet or larger, supplementary contour intervals of a half, fourth, fifth, or eighth of the basic interval may be appropriate (see table 7A-1).

[1] There are some published 7.5-minute maps with 25 and 50 foot contour intervals. These are no longer standard intervals but they will continue to be used until a change of interval is authorized.

The basic contour intervals for 1:63,360-scale maps of Alaska are 25, 50, 100, and 200 feet.

Table 7A-1
Customary unit (foot) contour intervals and spot elevations

BASIC INTERVAL	SUPPLEMENTARY CONTOUR INTERVALS*				SPOT ELEVATIONS SHOWN TO NEAREST
	HALF**	FOURTH	FIFTH	EIGHTH	
5	---	---	---	---	1 foot
10	5	---	---	---	1 foot
20	10	5	---	---	1 foot
25	---	---	5	---	1 foot
40	20	10	---	5	1 foot
50	25	---	10	---	1 foot
80	40	20	---	10	1 foot
100	50	25	20	---	1 foot
200	100	50	40	25	1 foot

* Supplementary contour intervals are subdivisions of the basic interval as indicated on the chart. Supplementary contour intervals are not mixed on a single map.

** Half interval supplementary contours are preferred but other subdivisions of the basic interval are appropriate in areas of extreme relief variation, or where it is desirable to keep supplementary contours compatible with basic intervals on adjoining maps.

7A.2.1.2 Metric Contour Intervals

The basic metric contour intervals for primary series maps are 1, 1.5, 2, 3, 4, 5, 6, 10, 12, 15, 20, 25, 30, 40, and 50 meters. On maps containing a basic contour interval of 2 meters or larger, supplementary contour intervals of a half, third, fourth, fifth, sixth, eighth, or tenth of the basic contour interval may be appropriate (see table 7A-2).

The maps in the Puerto Rico 7.5-minute series are published at 1:20,000 scale (originally published at 1:30,000 scale). The contour intervals appropriate for this series are 1, 5, and 10 meters.

7A.2.2 Dual Contour Intervals

In an area of abrupt contrasts in relief, two basic contour intervals are used on a quadrangle, rather than supplementary contours. The break in slope is the appropriate line of transition between the intervals. In most areas this will mean that some of the smaller-interval contours will not be continuous across the map.

The following are specific points to keep in mind when implementing dual contour intervals:

1. Show a contour diagram or key to delineate the area for which each contour interval applies.

2. Show the smaller interval first in the contour interval statement.

3. Use contour labels effectively to clarify the location of an interval change.

4. Change the contour interval at an abrupt change in slope.

5. End the smaller interval by either feathering or by stopping the contours at a place where the larger interval adequately portrays the relief.
6. Do not crowd the smaller interval into small side drains. Compile the smaller contour interval in side drains only where

needed to show topographic detail.

7. As with supplementary contours, pair the smaller interval contours properly for tops, saddles and depressions.

Table 7A-2
Metric unit contour intervals and spot elevations

BASIC INTERVAL	SUPPLEMENTARY CONTOUR INTERVALS*							SPOT ELEVATIONS SHOWN TO NEAREST***
	HALF**	THIRD	FOURTH	FIFTH	SIXTH	EIGHTH	TENTH	
1	---	---	---	---	---	---	---	0.1 meter
1.5	---	---	---	---	---	---	---	0.5 meter
2	1	---	---	---	---	---	---	0.5 meter
3	1.5	1	---	---	---	---	---	0.5 meter
4	2	---	1	---	---	---	---	1 meter
5	2.5	---	---	1	---	---	---	1 meter
6	3	2	1.5	---	1	---	---	1 meter
10	5	---	2.5	2	---	---	1	1 meter
12	6	4	3	---	2	1.5	---	1 meter
15	7.5	5	---	3	---	---	1.5	1 meter
20	10	---	5	4	---	---	2	1 meter
25	---	---	---	5	---	---	---	1 meter
30	15	10	7.5	6	5	---	3	1 meter
40	20	---	10	---	---	5	4	1 meter
50	25	---	---	10	---	---	5	1 meter

* Supplementary contour intervals are subdivisions of the basic interval as indicated on the chart. Do not show multiple supplementary contour intervals on the same map.

** Half interval supplementary contours are preferred but other subdivisions of the basic interval are appropriate in areas of extreme relief variation, or where it is desirable to keep supplementary contours compatible with basic intervals on adjoining maps.

*** Always show third order or better elevations (control points) to the nearest 0.1 meter, regardless of the contour interval.

7A.2.3 Supplementary Contour Intervals

Supplementary contours are used when important relief features would not be represented by the basic contours. Most often they are used in areas of low relief; however, they may be used in areas of higher relief to emphasize features.

The use of supplementary contours on USGS maps is authorized by the Department of the Interior Geological Survey Manual. One or more supplementary contours can be added between the basic contours. The interval established by the supplementary contours is usually half the basic interval, but other intervals may be used when necessary (see tables 7A-1 and 7A-2). Multiple supplementary contour intervals are not used on the same map. Supplementary contours are not used when the basic contour interval is 5 feet, 1 meter, or 1.5 meters.

Areas where supplementary contours are needed are determined by review of published maps, by inspection of the compilation manuscript, or through field investigation. If the areas are extensive, additional aerial photography at a lower flight height is planned so that the supplementary contours can be compiled by photogrammetric methods. If the areas are so small that it would not be economical to obtain special photographic coverage, the supplementary contours are added by field methods.

Accuracy requirements are dependent on the supplementary contour interval established in an area. The basic contours that are within and adjacent to the supplementary contours must meet the accuracy requirements for the smaller contour interval.

7A.2.3.1 Adding Supplementary Contours

The primary purpose of supplementary contours is to provide additional elevation data in areas of low relief. Supplementary contours are shown only where it is necessary to reduce the contour interval locally in order to portray features that cannot be shown with the basic contours, or where interpolation would not be precise enough. Supplementary contours should be used consistently throughout an area, as haphazard use lessens their effectiveness.

As a general rule, supplementary contours are added if the basic contours are one-half mile apart for a distance of one-half mile. If there are basic contours that delineate a top, depression, or drain channel within a half mile area void of other contours, then this rule is not met and supplementary contours should not be added. It may be prudent in these cases to adjust the existing contours in order to better portray the features.

In some areas the one-half mile rule may not be met, but the topography may not be effectively portrayed by the basic contour interval. Supplementary contours can be added if necessary to depict these features. In some situations, though, an adjustment of the contours may be all that is needed to effectively portray the feature and eliminate the need for supplementary contours. Contour adjustment is preferable to the use of supplementary contours in these situations.

The following are appropriate applications of supplementary contours:

1. In flood plains, deserts, plains, uniform slopes or valley bottoms that are one-half mile or more in width and the basic contours are one-half mile or more apart.

2. On plateaus, mesa tops, flat-topped ridges when necessary to delineate broad topographic features such as tops, saddles, benches, and so forth.

3. At tops and saddles of any size when the basic contours do not portray the desired topographic expression.

4. At sharp toes and shoulders that would not be otherwise adequately portrayed by the basic contours.

7A.2.3.2 Ending Supplementary Contours

Once a supplementary contour is started, it is often difficult to find an appropriate place to end its use. Where a supplementary contour starts and ends is not necessarily determined by the rule defining the need for it (the half-mile rule). Supplementary contours should end at points where the contours can be interpolated with reasonable accuracy. On a uniform slope, supplementary contours with intervals of one-half the basic contour interval should be within the center one-third of the area between the basic contours. For other intervals, the supplementary contours should be evenly spaced between the basic contours. At the point where the supplementary contours end, the basic contours should be spaced about a quarter of a mile or less apart. Supplementary contours should be extended until an appropriate ending point is found, even if they must be extended through areas that would not normally require them.

A supplementary contour should not be dropped just because it closely parallels the basic contour. In the case where a supplementary contour parallels a bank, it can be banded if the bank is steep enough, but it must become unbanded before the contour is ended. When contouring drainage, supplementary contours can end in the drain channel if there is a basic contour in the channel.

7A.2.3.3 Pairing Supplementary Contours

Supplementary contours must be properly paired when they are used. For example, if a supplementary contour occurs on one side of a saddle, it must be shown on the opposite side, even if the basic contours are spaced to otherwise preclude the need for additional contours. In these cases, only a segment of the supplementary contour needs to be shown in order to bracket the feature. All tops and depressions within the applicable area, as well as the associated tops and depressions above and below the bordering basic contours, must be contoured. An exception to the pairing principal occurs when supplementary contours are used in a valley or river bottom. Here, they do not have to be shown on both sides of the drainage if they are only needed on one side.

7A.2.4 Contour Interval Planning

7A.2.4.1 State Customary Unit Contour Interval Plans

To ensure adequate and consistent relief portrayal of contiguous maps, comprehensive contour-interval plans have been prepared by the mapping centers and are maintained for each State. Published maps and charts, aerial photographs, and personal knowledge of the area are used in preparing these plans.

Blocks of contiguous quadrangles with the same contour interval are made as large as possible. Checkerboard patterns of blocks with different intervals are avoided wherever practicable. The completed plans are used as a guide in the preparation of specifications for new projects. They also provide the data needed for estimating and scheduling projects within the National Mapping Program.

As new projects are authorized, a mapping center may recommend changes in a State plan on the basis of new information provided by field reconnaissance. In some cases, cultural development or planned use of the project area may influence contour interval selection.

7A.2.4.2 State Metric Unit Contour Interval Plans

State metric contour interval plans are prepared using the intervals listed in section 7A.2.1.2. Generally, metric maps should provide as much contour density as that shown on previously published foot-interval maps. In previously unmapped areas, the contour density should be the same as that called for on the State plans for foot-interval maps. Table 7A-3, derived from State foot interval plans, shows the predominant foot intervals, their metric equivalents, percent of the conterminous U.S. covered by each interval, and suggested replacement metric intervals.

Table 7A-3
Comparison of foot- and metric-interval plans

Foot Interval	Metric Equivalent	Percentage of U.S. Coverage	Metric Interval
5 feet	1.52 meters	12.5 %	1 or 1.5 meters*
10 feet	3.05 meters	39 %	2 or 3 meters
20 feet	6.10 meters	31 %	4,5, or 6 meters
40 feet	12.20 meters	17 %	10 meters
80 feet	24.38 meters	0.5 %	15,20, or 30 meters*

* A one-meter basic interval is selected only when special requirements warrant its use and it is apparent that the derived benefits will outweigh the costs. A 30-meter interval is selected only when it is evident that planned or existing 80-ft contours are too dense.

7A.2.4.3 Guidelines for Contour Interval Planning

1. **Plan for large block of quadrangles** - Select a consistent interval for as large a conterminous block of quadrangles as possible, and avoid checker-boarding.

2. **Consider contour interval requirements for derived maps** - To the extent possible, make contour intervals on large scale maps compatible throughout a county and/or intermediate-and small scale quadrangle areas because the same contour interval, or multiples of the contour interval, will be maintained on the derived map.

3. **Plan for 7.5- x 15-minute units** - Plan contour intervals for full 7.5- x 15-minute units in States where 1:25,000-scale metric maps are produced. This requirement is also applicable to metric maps prepared at the scale of 1:24,000 on a 7.5-minute format.

4. **Minimize the use of dual intervals** - Avoid the use of dual intervals except for extraordinary cases of extreme relief variation. The use of supplementary contours is preferable (see section 7A.2.3).

5. **Coordinate plans with State cooperators or State Mapping Advisory Committee** - Apprise the appropriate State officials of the recommended State customary and metric contour interval plan.

6. **Coordinate plans with adjacent mapping centers** - Coordinate plans with adjacent mapping centers to ensure consistent treatment of similar topography, to effect joins between bordering States, and for the subsequent development of new plans for intermediate scale maps.

7A.2.4.4 Changing the Selected Contour Interval During Production

Although every reasonable precaution is taken to insure selection of the proper contour interval, it may become evident during compilation that the next larger or smaller contour interval is more appropriate. If so, the mapping center recommends the change in contour interval along with any necessary corrective action.

When changing to a larger interval after the contours have been compiled, the alternate contours may be retained as half-interval supplementary contours wherever needed. The retention of these contours must not, however, result in the overcrowding of the map.

7A.3 STEREOCONTOURING TECHNIQUES

In the past when photogrammetric instrumentation was in its infancy, it was difficult to precisely trace a contour line even under the best of conditions. A multiplex instrument with a C-factor of 600 had a zone of uncertainty.[2] Contour lines that were traced using a multiplex instrument could be unevenly spaced even on uniform slopes. They also usually contained many small anomalies that had no relationship to the actual ground surface. The range of these irregularities could be considered the zone of uncertainty inherent in the system. The magnitude of the zone of uncertainty varied from area to area and from model to model, depending on such factors as the quality of the photographs, the orientation of the models, and the muscular coordination of the stereocompiler. In a particular model the size of the zone could be demonstrated by reorienting the model and retracing some of the contours. The uncertainties of the plotting process would be evident in the difference between the first and second tracing.

As the instrumentation improved, the zone of uncertainty has grown smaller. The current technology in photogrammetric plotting instrumentation provides the capability of doing very precise contouring even at the limits of the C-factor (1200 to 1500), if the ground is not hidden by vegetative surface cover. If adequate care is taken, the contours can be accepted as drawn with only very minor smoothing, shaping and adjustments. Deliberate contour displacements, in order to accommodate planimetric feature symbolization or emphasize important hypsographic features, can be made when tracing the contours from the model. This has been demonstrated by the Stereo Model Digitization method. The contours were digitized and reproduced for publication directly from the stereo model with very little interactive editing.

[2] A multiplex was a stereoscopic plotting instrument of the double-projection anaglyphic type characterized by its use of reduced-scale diapositives, stationary lamphouses with condensing lenses, and projectors designed for an optimum projection distance of 360 mm. A C-factor is an empirical value that expresses the contour plotting capability of a stereoscopic system; generally defined as the ratio of the flight height to the smallest contour interval accurately plottable.

7A.3.1 Consecutive Steps in Contouring

The representation of relief by stereocompilation methods consists of three steps, in order: 1) plotting planimetry, 2) drawing contours, and 3) smoothing or shaping. The planimetry, particularly the drainage pattern, is by nature a constructional framework to which the contours must conform and is therefore plotted first. The contours are then drawn from the stereomodel. Because the stereocompiler is not able to maintain perfect contact with the model surface throughout an area, the compiled contours must usually be adjusted, smoothed, or shaped in order to more accurately represent the terrain at the imposed map scale.

7A.3.2 Objectives of Contour Adjustment

Contour adjustment accomplishes several important objectives:

First, it removes the meaningless irregularities from the plotted contour lines. Changes in the direction of contours, no matter how small, should represent specific ground shapes and not irregularities caused by the erratic motion in the operation of the stereoplotter.

Second, it improves topographic expression by emphasizing significant relief features. Contours sometimes need be moved only the width of a line to increase relative accuracy and make the pictorial representation of the topography more effective.

Third, contour adjustment and shaping produce a uniform treatment of relief so that models or strips contoured by different topographers will not contain abrupt changes in style. The treatment of contours should be consistent, representing similar kinds of terrain with the same style of contouring, without personal idiosyncracies.

7A.4 TREATMENT OF COMMON RELIEF FEATURES

Topographic or relief features are characteristic land shapes or physiographic units that occur often enough and are distinctive enough to acquire a class name. Unlike most other map features, they cannot be exactly limited in area or size. Different features are frequently interrelated and overlap each other. Small features sometimes are the component parts of large features. Mountains, valleys, re-entrants, mesas, buttes, saddles, peaks, and canyons are a few of the many class names applied to topographic features.

7A.4.1 Contouring Re-entrants

A re-entrant is defined as an indentation in a landform, analogous to a valley. On topographic maps, a re-entrant is depicted by the part of a contour line that curves toward and then away from the drainage channel. Re-entrants are among the most common topographic features. Slight changes in the contours can greatly affect the appearance of re-entrants on a map.

The contouring of re-entrants is important because they indicate the course and gradient of drainage features. The shape and spacing of the contours suggests the depth of the stream banks, the amount of erosion and sometimes the type of soil or rock. Portrayed re-entrants may resemble a narrow V, a broad shallow U, a square boxlike shape, or almost any modification of these shapes. Typically, one characteristic shape is repeated, with small variations, throughout a particular geologic formation.

The greatest similarities between re-entrant contours are found in those that portray the course of a single stream. Generally, both the shape and size of the contours change gradually as the stream course becomes larger and deeper in the downstream direction. This pattern is a useful guide when shaping the contours where trees or shadows obscure the ground.

Contour adjustments are made to re-entrants in order to best portray the feature. The width of a drainage channel is often exaggerated for the sake of appearance. When compiled, the re-entrant on a single line stream usually looks like a pointed "V". The contours are then adjusted to a more rounded point (with a minimum curvature radius of 0.02", or 40 feet at 1:24,000 scale) to more realistically represent the ground terrain. A contour in a drain might be moved up or down a stream in order to better represent the gradient. Also, the contour should closely parallel the stream for at least a short distance before moving away from the channel.

7A.4.2 Contouring Slopes

The ground slope or gradient can be portrayed correctly by maintaining the accuracy of the contours in relation to each other, even if the contour datum is inaccurate. The importance of gradient information to the engineering user is one of the chief reasons for maintaining a high standard of relative accuracy. Before the advent of precise stereoplotting instruments, the topographer could use visual interpretation to relate the contour spacing to the apparent slope and adjust the plotted lines accordingly. Even with modern technology this type of adjustment is still necessary, especially in areas where the timber coverage drastically obscures the ground surface.

7A.4.2.1 Uniform Slopes

Uniform slopes are represented by evenly spaced contours. On steep regular slopes, where contours are closely spaced, it is common practice to plot only the index contours and interpolate the others. In these cases, an even spacing can be attained more quickly and as accurately by eye as by instrument. However, on slopes that are not actually uniform, this practice would produce an artificial "banded" appearance of the contours and the slope would incorrectly seem to change only at the index contours. Therefore, where slopes are not uniform, each contour must be drawn independently.

7A.4.2.2 Concave and Convex Slopes

Concave slopes, such as those bordering flat-topped buttes, are represented by a contour spacing that is close near the top and gradually widens toward the foot. For convex slopes, the contour spacing changes in the opposite direction, from close near the foot to wide at the top.

7A.4.2.3 Terraces and Scarps

Terraces, or benches, are strips of level or nearly level ground that interrupt the continuity of a slope. If they are narrow in relation to the average spacing of the contours or if one contour falls near the center of the level strip, contours frequently do not represent them adequately. An adjustment of the contours is then required. The contour falling on the bench is raised or lowered so that it approximately coincides with the line of change in slope. The contours above and below the flatter slope would be moved further apart; the higher contour would be moved up and/or the lower contour moved down the slope, depending on which movement would provide the better portrayal of the feature. As in other adjustments of this type, accuracy is reduced slightly to improve the portrayal of the landform.

A similar treatment is appropriate where a bank or scarp interrupts an otherwise gradual slope. If the contours fall on both sides of the escarpment, the position or even the presence of the feature may not be apparent. The contours are moved in the opposite direction, that is, closer together; the uphill contour moved down as close as possible to the upper edge of the bank, and the downhill contour adjusted upward.

7A.4.2.4 Vertical Escarpments

Vertical escarpments, such as cliffs and vertical embankments, are portrayed by carrying contours. Carrying contours are formed by bringing together all the contours contained within the escarpment into a single contour line. This practice is also referred to as "banding". It is the favored technique when the spacing between the top and bottom contours of the escarpment would be less than 0.005" (10 feet at 1:24,000 scale).

The portrayal of cliffs can be accomplished by first tracing all contours from the model as carefully as possible. A "cliff line" is then selected and each contour drawn into it, taking care to indicate exactly where each contour enters and leaves the cliff. Where the cliff consists only of intermediate contours, the carrying contour will be the same lineweight as the intermediate contours. If the cliff includes an index contour, the carrying contour will be the same lineweight as the index contour.

Low cliffs, such as those formed by recent erosion of a stream bank, may also be portrayed by carrying contours. If the cliff falls between contours, they can often be represented by an adjustment of the contours. However, if the cliff cannot be portrayed by use of contour adjustment (see section 7A.1.5.3), it should be disregarded.

7A.4.2.5 Near-Vertical Slopes

Near-vertical slopes are represented using a technique called feathering. Feathering is employed when the slope is even and the space between the index contours does not permit the representation of all the intermediate contours. When feathering, some or all of the intermediate contours are dropped depending on the amount of space available. The index contours are always shown as continuous and a minimum spacing of 0.005" (10 feet at 1:24,000 scale) is maintained between contours.

A particular procedure is followed when feathering. The contour with the highest elevation is extended and dropped first, then the contour with the lowest elevation. Next, the contour with the second highest elevation is extended and dropped, and lastly the contour with the second lowest elevation. The contour with the highest elevation is extended the furthest.

When the slope is not even, or the near vertical area does not fall between two or more index contours, the actual position of the top contour of the steep slope is maintained and the contours within the slope are feathered. The same feathering procedures as outlined above are followed (for example, if three contours are feathered, the contour with the highest elevation will be drawn first and extended the furthest). If there is space between the index contours for only two continuous intermediate contours, and the two upper intermediate contours define the steepest part of the slope, then the two lower intermediate contours are drawn continuous and the two higher intermediate contours are feathered.

The representation of a tall steep hill often presents problems similar to those of cliffs. These pinnacles may be near vertical but it may not be possible to feather or even indicate some of the contours. Although the use of carrying contours to portray a near vertical feature as vertical would be a slight misrepresentation, it is preferable to the displacement of the contours that would otherwise be required to portray the slope. Even if the contours were banded, it may not be possible to interpolate the elevation of the top contour. In these situations, a spot elevation may be required to aid the map user in interpreting elevations. Sometimes, both carrying contours and feathered contours will be used in close proximity. One must take care not to confuse or combine these practices. A contour that is banded must have an entry and exit point with the carrying contour. It must not be banded on one end of the escarpment and feathered on the other.

7A.4.2.6 Natural Bridges and Arches

Natural bridges and arches are another example of a vertical or near vertical feature. These features create a unique problem because the contours, and possibly (in the case of a natural bridge) a stream or other feature, actually pass through the feature. The overpassing surface is contoured normally, using banded or feathered contours. The contours that would pass through the opening are dropped 0.01 inch (20 feet at 1:24,000 scale) from the overriding structure on both sides of the "bridge", much the same as the treatment used for a road underpassing a railway or another road.

7A.4.3 Skyline Topographic Features

The tops and accompanying saddles of mountains, hills, and ridges are among the most prominent and significant features shown on a topographic map. These features form the limits of watersheds, often define civil boundaries, and sometimes influence the placement of communications facilities.

A contour interval that is appropriate for the map as a whole sometimes makes it difficult to portray skyline features adequately, especially where the relief along a ridge top falls within the range of a single contour. As viewed in profile, the ridge may consist of a series of tops and saddles. If the contours are plotted strictly according to their true elevations, the map representation of the ridge may appear as a smooth unbroken profile. To depict the shape of the ridge line more accurately, some contour displacement is often required. A saddle might be narrowed or broadened by moving the contours on each side of the ridge either closer or further apart. If features cannot be satisfactorily represented within the allowed adjustment limits, supplementary contours should be used.

7A.4.3.1 Ridge Lines

The horizontal axes of relatively narrow and sharply defined ridges may be plotted as guidelines to control the shaping of the upper contours, in somewhat the same way that plotted drainage lines control the shaping of contours in re-entrants. The contours should not be forced into symmetry merely to give an orderly appearance. The objective is to produce a true picture, and few ridge features are truly symmetrical.

7A.4.3.2 Tops

Contours encircling tops should suggest the character of the terrain, such as angular or smooth, and should be consistent with the size of the highest flat area. For example, the top of a needle peak should not be depicted with a large round contour, nor should a broad round top be shown by a very small contour which might indicate a pointed feature. The contours should be adjusted, within the allowable limits, to represent the size and shape of the top as nearly as possible. Moreover, where sharp, angular contours are appropriate, as for Matterhorn-type peaks, the shaping should be somewhat exaggerated to make the feature stand out on the map. The minimum size diameter for a contour that represents a top is 0.015" (30 feet at 1:24,000 scale).

7A.4.4 Flatland Topography

In flood plains, plateaus, and other terrain of low relief, contours become less important as a means of depicting the landscape and more important as a means of indicating the elevation and slope. In these areas, relief features are less prominent, and the widely spaced contours are less effective.

7A.4.4.1 Accuracy

Although the NMAS does not require it, the contours in relatively flat terrain are compiled with a higher accuracy than in other areas. Elevation information is more critical in these areas and a slight change of elevation can move the contour a considerable distance horizontally. For areas with a slope of 10 feet (or less) per mile, contour accuracy within one-fourth the contour interval should be maintained. This higher accuracy does not mean that minor irregularities caused by shallow ditching, furrows, and so forth, should affect the general smoothness of the contour. However, if there are distinct or abrupt changes in the contour direction that reflect a natural or artificial land form, they should be represented in the final contouring.

7A.4.4.2 Photogrammetric Techniques

To contour flat areas satisfactorily from aerial photographs, some of the techniques of planetable sketching should be adopted. In particular, the use of many spot height readings will aid in drawing the contours in their proper position. Also, the contact prints should be used to get a better perspective of the shape of the land and a panoramic view of the overall land form. Instead of perceiving and drawing the contour as a continuous line, one should concentrate on contour segments and even trace these segments from opposite directions. In planetable sketching, the field person would frequently reshape contours after moving to a different vantage point.

Because flat terrain provides a less distinct relief model, there may be a zone of elevation where the ground is level or where there is only a slight change of elevation. In these areas, the tracing of the contours may be stopped frequently in order to look ahead to get a better idea of where the contour may be heading and the general shape of the land. The starting and stopping of the contour lines causes the lines to be drawn less smoothly than they would be in higher relief terrain. Therefore, when utilizing modern stereoplotting technology to compile flat land, shaping and adjusting the contours may be more significant than it would be in higher relief areas.

7A.4.4.3 Flatland Characteristics

There are several types of flatland topography and each has its own character; river flood plains, coastal plains, marshes and hummocks, glacial drifts, deserts, dry lake beds, and so forth. Some terrain may be similar in shape to higher relief topography, the only difference being that the contours are further apart. Frequently there are tops, depressions and uneven slopes. As in higher relief areas, some of these features will not be adequately portrayed by the basic contours and the use of "topographic license" in the adjustment of contours will need to be employed.

Some characteristics of flatland terrain are seldom found in higher relief topography. Re-entrants are more rounded and may not seem to "track" the course of a drain. The drainage may seem to change in configuration. There may also be shapes that resemble a **broom handle** (smooth, relatively parallel, not necessarily straight, and/or with a rounded end), a **bottle neck** (constricted on the open end, like a depression open to the main contour), or a **banana** (in river bottom areas, produced by alternate erosion and deposition along a bend in the river). There may be depressions that have a saddle on one or both ends. The ends of ridges may have a very similar profile to a re-entrant. In all of these cases, the contours should be allowed to represent the topography as it is and should not be forced into conforming to shapes found in high relief areas.

The unique character of a flatland area creates a tendency, when contouring, to create negative/wrong-side-out/reverse-image topography, especially in glacial drift areas. The re-entrants and ridge ends have a tendency to look similar in shape. The drainage may appear to be flowing in the opposite direction from its true flow or one may not be able to determine which contour has a higher elevation without using the contour labels. By slightly shaping the contours, the correct ground representation can be produced, making interpretation of the contours easier without any sacrifice of accuracy.

7A.4.4.4 Drainage in Flatlands

Because the relief in flat terrain is sometimes inconspicuous, drainage patterns assume greater importance as a means of deducing the topography. The photogrammetrist has an advantage over the planetable topographer because the stereo view of the drainage is more complete and detailed than the ground view. However, more care must be taken when interpreting the drainage in flatland areas than in areas of greater relief. Generally, the drainage and channels are not as deep or as well developed because of the lesser gradient and younger age of topography. Particular care should be taken not to exaggerate rudimentary drainage that appears on the photographs as dark streaks (due to the increased moisture content of the soil), as the lack of definition within these dark streaks tends to give a misleading impression of the depth of the drainage features. Neither should they be ignored as they provide an excellent indication of the relief.

Wide valleys that have been formed by stream action often have old stream beds that can be useful in the interpretation of the relief. Abandoned channels are common and their contoured appearance is sometimes similar to that of a river, even though they do not contain water. Fragments of scarp banks frequently mark the course of an old river bed or indicate the shoreline of an ancient lake. Often there is a natural levee formed along the bank by deposition of sediment during flood stage. It may be possible to indicate these topographic features by the use of topographic license if the basic contours do not adequately portray them.

7A.5 RELIEF TREATMENT OF SPECIAL FEATURES

7A.5.1 Roads and Railroads

Special treatment of contours along roads and railroads is needed to show the route grades as accurately as possible and to accommodate the transportation symbols, which are generally wider than the actual width of the features.

7A.5.1.1 Contour Crossings

Contours are drawn across class 1 and 2 roads, railways, and paved runways as straight lines at right angles to the alignment. When the contour runs along a graded road, it should be 0.005 inch (10 feet at 1:24,000 scale) from the edge of the transportation symbol. Contour crossings at class 3, 4, and 5 roads are delineated as if the road did not exist, but contours should not be carried within the road symbol for more than 0.1" (200 feet at 1:24,000 scale).

When contours cross a graded road, especially on hillsides, they should not be distorted when displacement is caused by the transportation symbol. The contour should align on both sides of the road and appear to be a continuous smooth line, as though the road didn't interrupt the contour. The elevation of the center line of the road is indicated by contour crossings. In areas of moderate and low relief, it is also important to have the contours align on both sides of the road, unless there is an actual nonconformity.

The median strip of a divided highway is not contoured unless there is $\geq$ 0.035" (70 feet at 1:24,000 scale) separation. Instead, the contour is shown straight across the road. If the road surfaces on either side of the median are at different elevations, the accuracy of the road crossings should be maintained.

7A.5.1.2 Grades

The contour spacing that indicates the grade or slope of roads and railroads should be more accurate than for other ground slopes. Along the more important roads, accuracy can be assured by field inspection, or, if necessary, by traversing during field completion. However, the photogrammetrist should give special attention to the spacing of contour crossings. Except for steep mountain roads, a major road will seldom have a grade that is greater than 10 percent, and most grades will be less than 5 percent. Grades of well constructed railroads will seldom exceed 0.6 percent, except in mountainous areas where grades of 3 percent or more may sometimes be found.

Percent grade (amount of incline) is an engineering term used in defining slope. It is a ratio of x/100, where x is the amount of rise or fall in the road bed in relation to 100 horizontal units of measure; for example, a 3 percent grade means 3 feet of rise per 100 feet of horizontal distance.

7A.5.1.3 Cuts and Fills

Cuts and fills are contoured by two methods. Where the face of the slope is not too steep, all the contours are shown. When the face of the slope is too steep to show all the contours, the contours are connected by a carrying contour parallel to the road or railroad. Fills are distinguished from cuts by ticks on the straight line sections of the contour that parallel the road alignment. Depressions formed by fills are not shown by depression contours. Cut and fill contours should not be feathered. If not all contours can be shown they should be banded.

In depicting a cut or fill, the contours should conform across the feature as though it did not exist. Contour lines are drawn parallel to the route, connecting the ends of each interrupted contour of like elevation. These parallel lines are often referred to as "trapped" contours. Where a road or railway has been abandoned, the fill or cut is shown as if the feature was still there. Because there is no symbol for the feature, the parallel contour lines do not need to be displaced. As with other fills, fill ticks instead of depression ticks are shown.

If more than one contour is trapped by a fill, the fill ticks should be staggered so that they do not line up with the ticks on the adjacent contours and the ticks should not extend beyond the adjacent contour. Ticks for the equivalent contour on opposite sides of the fill should align with each other.

On some fills the ticks will not align well. An offset may be created because the low area (drain) crosses the fill at an angle, so the trapped contour is not opposite its associated contour on the other side of the fill (this is frequently true for wide fills or dual highways). In these cases, the trapped contour should be shown with depression ticks.

When a road and railway, or dual roads are parallel and there is a fill on both sides and a contour is trapped between the features, the contours are not shown if the space between the symbols is < 0.035" (70 feet at 1:24,000 scale). If the spacing is ≥ 0.035", the trapped contour is shown and each fill is ticked separately, with the ticks staggered.

Do not show small fills that provide access across streams or ditches for farm field roads which are not mapped.

7A.5.2 Bridges and Nonearthen Shoreline

Contours are extended into a nonearthen shore or bridge abutment symbol and dropped where they are coincident with the other symbol. One or more contours may be coincident with the abutment or nonearthen shore. If the bridge is not symbolized, the contours cross the end of the road or railway fill abutment as a straight line. If there are multiple contours, they are banded.

7A.5.3 Dam/Weirs and Spillways

Earthen dams are treated in the same manner as road fills, even if they do not have a coincident transportation feature. The contour on the face of the dam is straight lined and multiple contours are parallel. If a contour is trapped behind the dam, the fill tick symbolization is used on each side of the dam, instead of using depression ticks on the contour(s) trapped behind the dam.

Masonry dam/weirs are treated differently. If the contour is above the water line, it is continued through the dam/weir as though the dam/weir did not exist. If the contour on the downstream side of the dam/weir is below the water line, it is drawn to the dam/weir symbol and dropped.

Earthen spillways are contoured. Masonry spillways that are large enough to be symbolized and are not an integral part of a masonry dam/weir are not contoured. The contours are drawn to the edge of the spillway symbol and dropped.

7A.5.4 Levees and Spoil Banks

A spoil bank is waste excavation material piled along a linear hydrographic feature and left in irregular sized mounds and ridges. Often there will be gaps between the piles. A symbolized spoil bank is considered to be a continuous feature, in relationship to the contours, unless the gap between piles is ≥ 0.03" (60 feet at 1:24,000 scale) or there is a stream or ditch channel passing through the gap.

Symbolized levees and spoil banks are not contoured. The contour is dropped 0.005" (10 feet at 1:24,000 scale) from the symbol. If a levee or spoil bank is too small to be symbolized, it is also not contoured. Contours that are trapped behind levees and spoil banks are ticked like depressions.

If a symbolized levee or spoil bank is adjacent to and parallel with another feature such as a stream, ditch, road, railway, and so forth, and a contour is between the other feature and the levee or spoil bank, the contour is always dropped.

Levees and spoil banks wider than 0.04" (80 feet at 1:24,000 scale) at the base are contoured. The contours on a levee are always straight and parallel. The contours on a spoil bank are rarely straight. Spoil banks that have been cut down and smoothed are always contoured as normal terrain even though there may be a slight rise in the elevation. Contours trapped behind a contoured levee or spoil bank are shown as depressions.

7A.5.5 Canals and Ditches

Treatment of canals and ditches is dependent on whether they are for navigation, irrigation, or drainage.

7A.5.5.1 Navigational Canals and Locks

Navigational canals are always contoured. The water surface is practically level from lock to lock and is usually maintained, within narrow limits, at a constant elevation. Contours cross the canal only at the lock or lock and dam. If the lock is in contact with the shore and a contour crosses the lock, then the contour is drawn to the lock symbol and dropped. The contour is considered to have crossed the lock at the downstream gate.

7A.5.5.2 Drainage Ditches

All ditches that are a part of a drainage system (as opposed to irrigation) are contoured in their entirety. The only exception to this is when there is a levee or spoil bank closely paralleling the ditch. Even in this situation, all of the re-entrants must be shown. If multiple contours are in the bank, they are banded. Often, if a ditch is not a channelized natural drain, there will be little or no taper of the contour into the bank, and one or both sides of the entry will be abrupt. The minimum distance between the contour lines on each side of the ditch, and within the banks, is 0.02" (40 feet at 1:24,000 scale). The contour lines are shown smooth and parallel to the ditch symbol, unless there are places where the banks exceed the minimum spacing of the contours. The re-entrants are rounded off.

Road and railway ditches are not contoured, even in flat terrain, unless the ditch is an integral part of the drainage system. The contours are shown to the road or railways symbol as though the ditch did not exist. If the contour of the natural terrain closely parallels the road, it should not be turned abruptly into the road or railway to keep from showing a narrow space between the road and the contour.

7A.5.5.3 Irrigation Canals and Ditches

Irrigation canals/ditches and open aqueducts are distinctly different from drainage features. Although they are sometimes adjacent to or connected to a drainage feature, they are usually isolated. An experienced photointerpreter can distinguish between irrigation and drainage ditches. Field investigation is a sure means of accurate identification.

Irrigation features are often difficult and confusing to contour. They are frequently in flat terrain and have a very low gradient. The controlling agency may fluctuate the water level, causing the potential re-entrant to vary considerably. There are often embankments, normally too small to be symbolized, on one or both sides of the feature, to contain or elevate the feature and to maintain gravity flow. The water level is sometimes slightly higher than the natural ground level. Also, the direction of flow is often difficult to determine because of the low gradient.

In contouring irrigation channels, it is difficult to obtain uniform treatment even on the same quadrangle. Because of this, contours representing the natural ground surface are drawn to the feature on each side and dropped 0.005" (10 feet at 1:24,000 scale) short of the feature (in the same manner as used with levees). The contours are drawn through only where a siphon or flume interrupts the feature.

If the feature is elevated above the natural ground, the embankment that supports and/or impounds the feature is symbolized if it is < 0.04" (80 feet at 1:24,000 scale) wide at the base. If it is ≥ 0.04" wide at the base, it is contoured. The contours are not shown within the banks of the feature and no re-entrants are determined or shown. No effort is made to determine the direction of flow.

7A.5.6 Built-up Areas

Built-up areas are often difficult to contour because of the congestion of cultural features, manmade changes in the topography, and buildings and trees that obscure the ground. The contours should represent, as nearly as practicable, the ground surface. Contours should be plotted across building symbols on the assumption that the ground was not disturbed in constructing the buildings. The convention that contours cross roads and streets at right angles also applies in urban areas.

Where the network of streets is intricate, or terracing and grading is extensive, stereo-contouring might be unreliable. Lower flight-height photography may be required.

7A.5.7 Intricate Surface Areas

Where the ground surface is irregular and intricate (in areas of sand dunes, sand washes, lava, rocky coasts or outcrops, and so forth), contouring may not provide satisfactory representation of the terrain. The area is contoured only as accurately as need be to show the general form and characteristic pattern of the surface. In some of these areas the contours are augmented by an area fill. The use of area fills is dependent on the feature and the area size.

7A.5.8 Mines

All surface mine features such as pits, open pits, quarries and strip mines, are fully contoured, although some generalization may be required for the intricate surfaces.

Because they are temporary, the storage piles of mine products, such as coal, gravel, sulfur, or ore are not mapped or contoured. Contours are compiled along the natural ground surface as though the storage piles did not cover the area.

7A.5.9 Mine Dumps, Tailings, and Tailings Ponds

Mine dumps are non-ore-bearing rock material extracted from a mine in conjunction with the extraction of the ore-bearing rock. This material is usually dumped in irregular piles near the mine site. On some maps, these dumps have not been contoured and the extent dump site has been indicated by some other symbolization, such as hachures around the perimeter or an area fill.

Tailings are the discarded material from the ore treatment processes which are usually piled in random heaps and piles. The area covered with this material has been shown with various area patterns, and usually the contours have been omitted.

In some ore-treatment processes, the waste material in aqueous suspension is disposed of in tailings ponds. Tailings ponds are similar to a reservoir and usually have an embankment encompassing and impounding them. If there are multiple ponds at different levels, the perimeter line is shown between each pond. In the past, tailings ponds have not been contoured.

All of these will be fully contoured, in order to provide complete contour data for derivative products. The area fill will continue to be used in conjunction with the contours. The area is contoured only as accurately as needed to show the general form and characteristic pattern of the surface. Because the surface changes, as more material is added to the deposit, the map representation only reflects the topography at the date of photography.

7A.5.10 Washes

For washes that are ≥ 0.04" (80 feet at 1:24,000 scale) wide the contours are compiled straight across from bank to bank. Re-entrants are not symbolized for individual channels within the wash. The entire feature is viewed as one channel, because individual channels within the sand area are temporary.

7A.5.11 Coastal Beaches

Only the backshore area of a beach is contoured. The backshore is defined as the zone extending inland from the mean high water line (shoreline). No contours are mapped below the delineated shoreline, even though that area is above the mean sea level and is exposed at low tide.

7A.5.12 Lakes and Ponds

If the shoreline of a lake/pond is at the same elevation as a contour, the shoreline represents the contour and the next higher contour is the first one shown.

When the perimeter line of an area subject to inundation is at the same elevation as a contour, the area perimeter line represents the contour. Any contours between the perimeter line of the inundation area and the average water elevation are compiled and shown.

7A.5.13 Underwater Contours

Contours that were compiled before an area was inundated are retained and shown in conjunction with the blue area fill. These contours may be obtained from a previous edition of the same quadrangle, a quadrangle at a different scale, or another agency. The contour interval may be the same or different from the above-water interval depending on the source that is used. It is preferable that the underwater contour interval be appropriate for the terrain, but when this is not possible, any available interval will be helpful to the map user. The use of underwater contours is restricted to lakes that are ≥ 5.28 square inches (¾ square mile at 1:24,000 scale).

7A.5.14 Ice Masses

Ice masses are fully contoured, although the contours may be generalized. These surfaces are often irregular and intricate, having many ridges and crevasses. At the actual time of contouring, the correct elevation is of secondary significance to the portrayal of the form of the surface. Being in a state of flux, the surface configuration changes from year to year, so that even precisely drawn contours quickly become out of date. Contours that extend across an ice mass are a continuation of the ground contours, but they are shown blue rather than brown. In the past a formline symbolization has sometimes been used for ice masses. This symbolization has been discontinued.