National Mapping Program
Technical Instructions

Part 1
Digital Line Graph Revision

Miscellaneous Instruction
Technical Criteria for Digital Revision and Product Generation

1:24,000-Scale Digital Line Graphs and Quadrangle Maps

U.S. Department of the Interior
U.S. Geological Survey
National Mapping Division

Technical Criteria for Digital Revision and Product Generation
1:24,000-Scale Digital Line Graphs and Quadrangle Maps
Part 1: Digital Line Graph Revision

CONTENTS

LIST OF PAGES

A complete and current copy of Part 1 of Miscellaneous Instruction, Technical Criteria for Digital Revision and Product Generation, 1:24,000-Scale Digital Line Graphs and Quadrangle Maps consists of the pages (and most recent creation or revision dates) listed below.

Technical Criteria for Digital Revision and Product Generation
1:24,000-Scale Digital Line Graphs and Quadrangle Maps
Part 1: Digital Line Graph Revision

1. DIGITAL LINE GRAPH REVISION

This part provides technical instructions to support revision of 1:20,000- through 1:63,360-scale digital line graphs (DLG). These instructions apply only to the digital methods of revision. Refer to Supplemental Technical Instruction 93-2-C, issued February 26, 1993, for traditional (that is, analog) revision information. Terms used in this document are defined in appendix 1-A.

1.1 LIMITED UPDATE

Limited update is performed when there is a critical time requirement or resource limitation that precludes standard update. A limited update is unlike a standard update in that the National Mapping Division (NMD) does no field checking of feature content. The goal for a limited update is that feature content will be current, but will include only: (1) those feature types that are photoidentifiable on a monoscopic source, supplemented with available stereo project photographs and limited ancillary sources, and (2) those feature types from existing DLG's that are not photoidentifiable but are not particularly prone to change, for example, gaging stations, windmills, and trails. Stereo compilation is allowed, but only if monoscopic sources are unavailable or if it is necessary to make the best use of equipment and personnel without delaying standard update projects. The intent is to maintain the accuracy of the existing data sets or graphic maps used as sources during digital limited update. In some areas, such as in heavily timbered areas or areas with extensive photorevision from a non-rectified source, the positional accuracy of the revised data set may not meet NMAS.

The products of digital limited update are level 3 DLG's that meet current standards. Not all categories of data are revised during a limited update. Section 1.1.3.2 provides details about which categories are revised. In this document, the term "revised" applies to the process by which data are updated to reflect changes that have occurred since the date of the existing DLG. Data whose positions are modified by datum conversion or systematic adjustments (for example, Systematic Horizontal Adjustment of Positional Error System (SHAPES)) are not considered revised.

All DLG categories, both revised and nonrevised, are converted to the North American Datum of 1983 (NAD83). If discrepancies and

offsets exist among the data merged as a result of the shift, resolve them by using the guidelines in section 1.1.2.1.

The intent of a digital limited update is to produce DLG's and a map with features that match in position and content. However, problems that require corrections on the map may not be discovered until the data have reached the product generation stage. If the problem discovered during product generation adversely affects the meaning and usefulness of the data, modify the DLG. If a problem does not require modifying the DLG, but a correction would have to be repeated each time the map is made from the DLG, document the correction in the digital correction file for DLG correction at the time of the next revision.

1.1.1 Planning and Preparation

Production planning activities provide information on all phases of work needed for a specific project area and an assessment of resources required. This includes planning and investigating names and boundaries and obtaining ancillary sources.

1.1.1.1 Preliminary Evaluation of Existing Data and Positional Accuracy

Results of previous accuracy tests show that most DLG's and source maps meet NMAS. However, preliminary evaluations of DLG content currentness and accuracy are necessary for planning production activities. Use sources such as quadrangle reports, DLG status and header information, the Primary Map Inventory (PRIM) data base, correction files, and a comparison of the existing DLG's with the 3.75-minute digital orthophoto quadrangle (DOQ) to evaluate compliance with current content and positional accuracy standards. Include photorevised features in this evaluation.

→ During preliminary reviews and later during revision procedures, extensive areas (for example, areas that were photorevised using a nonrectified source)may be found that exceed the digital limited update delineation tolerance. (The delineation tolerance is defined in Appendix 1-A). If efforts to correct and reposition these areas impact pre-determined production schedules, confer with the appropriate program or project manager to determine how to proceed. ←

Automated methods exist for evaluating horizontal accuracy and for applying mathematical transformations to remove systematic horizontal error (for example, SHAPES). These methods may be used at the center's discretion.

1.1.1.2 Names

All names that were previously on the map will be included on the new map if they are still valid and if the features to which the names apply are shown. Modify names that have been identified as errors in the correction files. Collect only new names that are identified during the boundary update. Notify the Branch of Geographic Names of all recommended changes or additions to the Geographic Names Information System (GNIS) content. Check new names

against approved GNIS sources before the final plotting of map materials.

1.1.2 Datums

1.1.2.1 Horizontal Datum

Convert all DLG categories, **including** nonrevised categories, to NAD 83. (See policy 93-PO-8, "Implementation of North American Datum of 1983 (NAD 83) on National Mapping Division (NMD) Standard Digital and Graphic Products," dated August 24, 1993, and supplemental technical instruction (STI 93-4-D), "Horizontal Datum Use and Reference on National Mapping Division (NMD) Map and Digital Products," dated August 24, 1993.)

Where DLG data exist, fill the void created by the shift to NAD 83 by extracting the missing features from the adjoining DLG. If DLG data do not exist for the void caused by the shift or if it is more cost-effective to do so, collect the additional information from image and (or) ancillary sources, such as a scanned copy of the adjoining map. Resolve all gaps and mismatches in content, attribution, and position between existing data and data that must be added to the file.

For hypsography, if the adjoining DLG has a larger contour interval, extract the contours from the adjoining DLG and create the missing contours by using logical contouring techniques. If relative positioning and shape relationships cannot be maintained or if the contour accuracy cannot be maintained within one-half of the contour interval (or one-fourth of the contour interval in areas with a slope of 10 feet or less per mile), do not logically compile the missing contours. Allow the existing contours to end at the old

(NAD 27) neatline. Identify the file as requiring standard update at the time of the next revision.

If the adjoining DLG has an incompatible contour interval (for example, 20 feet versus 25 feet or 5 meters versus 25 feet), then extract matching contours from the adjoining DLG or a scanned copy of the adjacent map and allow other contours to end at the old (NAD 27) neatline.

If the adjoining DLG or adjacent map has a smaller contour interval, incorporate only those contours that match the existing contours; delete the additional contours.

1.1.2.2 Vertical Datum

Maintain DLG's on the National Geodetic Vertical Datum of 1929 (NGVD 29) until instructions for converting to the North American Vertical Datum of 1988 (NAVD 88) are issued.

1.1.3 Compilation of Feature Content

Compile and modify content-worthy feature types using 3.75-minute digital orthophoto quadrangles, supplemented by available stereo project photographs.

1.1.3.1 Verification of Existing Feature Content

Unless otherwise indicated by the preliminary evaluation (see section 1.1.1.1), assume that the original DLG accurately depicts the features and their attributes as shown on the source map. A systematic quality review of the existing DLG is not necessary, because the DLG successfully completed a quality review process at the time of collection. However, if errors are identified during the revision process or if errors that affect the meaning and

usefulness of the data are found during the product generation process, correct them.

1.1.3.2 Content

A subset of standard product content is revised and validated during limited update. Limited update feature content is restricted to: (1) feature types that are photoidentifiable on a monoscopic source, supplemented by a limited ancillary source, and (2) feature types from existing DLG's that are not photoidentifiable but are not particularly prone to change. Feature types from existing DLG's that are not photoidentifiable and are prone to change are deleted.[1]

The Standards for 1:24,000-Scale Digital Line Graphs and Quadrangle Maps defines content-worthy feature types and associated attributes and provides the criteria used to determine if a feature instance should be captured. The standards are composed of feature templates. The revision portion of the feature templates provides special instructions for collecting and revising feature types during limited update. Special instructions include whether feature types from existing DLG's are retained or deleted, what characteristics of a feature type are not described, and when an ancillary source is required to value certain characteristics.

Feature types are revised unless the feature template states specifically that the feature type is not to be revised during limited update. If a feature type is revised, the section on limited update in the revision section of the template will provide

[1] The information in this standard does not apply to FS/USGS Single Edition Products. Some information that is not normally revised during a limited update will be supplied by the FS from information gathered in the field.

any special instructions on the capture and attribution of feature instances. Information will also be provided on whether an ancillary source is required to correctly capture or attribute the feature type. If there is no information in this section, then the feature type is revised using all of the rules found in the body of the template.

If a feature type is not revised during limited update, then the feature template will state that it is not revised and whether existing feature instances are to be retained or deleted from the existing DLG data set. If an existing feature instance is retained, it will be deleted only when it is replaced by another instance of a feature type that is revised in limited update.

The criteria for when to revise (or not revise) will be applied uniformly in all cases. The fact that an individual feature instance can be determined does not override the global decision not to collect a feature type. The fact that characteristics can sometimes be determined does not override the global decision not to describe that characteristic.

→ Special instructions for collecting and revising feature types during a limited update are provided in the Standards for 1:24,000-Scale Digital Line Graphs and Quadrangle Maps. ←

Apply the following general criteria for each category.

Hypsography

Revise contours using nonstereoscopic, logical contouring techniques
→ when the results will meet NMAS. Contours that are not revised and ←
that conflict with planimetric features are identified with an OBSOLETE CONTOUR code.

Public Land Survey System

Revise the Public Land Survey System (PLSS) only in areas where new surveys have been performed where there have been no previous surveys and the information is available from the Bureau of Land Management's Geographic Coordinate Data Base (GCDB). Ensure that the PLSS is continuous internal to the DLG and the project boundary. Revise existing survey lines only to connect to the new survey lines.

Boundaries

Revise by using ancillary sources and the delineations of features that define the location of the boundary, including the PLSS.

Survey Control and Markers

Do not revise survey control and markers.

Hydrography

Revise hydrographic features by adding new bodies of water, such as lakes and reservoirs, and by modifying existing shorelines around bodies of water. Do not add streams and small ditches and do not modify shorelines defining streams unless there is obvious evidence of a change in channel. Do not modify coastal shorelines, except to capture portions modified by construction.

All other DLG categories are revised.

Use Part 3: Attribute Coding of Standards for Digital Line Graphs to determine the correct codes to assign to the features.

1.1.3.3 Feature Positioning

Do not adjust the position of existing and photorevised DLG features if:

(1) they are within the delineation tolerance of source position as defined for limited update. (The terms “source position” and “delineation tolerance” are defined in Appendix 1-A). The tolerance for DLG features is ± 73 feet of their location on the source imagery (refer to Appendix 1-B for detailed information on the derivation of this tolerance); and

(2) they adequately represent the shape of the feature and the feature's connectivity with and position relative to other features; and

(3) they do not conflict with existing, modified, or new features when all features are fully symbolized for product generation.

If the existing features do not meet these criteria, delete, move, or recollect them. See section 1.1.1.1 for exceptions.

Collect or reposition **new** and **positionally modified** features in source position, unless there is a conflict with an existing feature. Collect only the level of detail needed to represent the characteristic shape of a feature, consistent with the level of detail that can be symbolized on the map. In most cases, if conflicts with an existing feature occur, displace the feature of lesser priority[2] so that:

[2] A feature hierarchy document will be compiled for review at a later date. Until then, continue using existing criteria that have been applied to analog mapping.

(1) it does not conflict with existing, modified, or new features when fully symbolized; and

(2) it adequately represents the shape of the real-world feature and its connectivity with and position relative to other features; and

(3) it falls within the delineation tolerance defined for limited update. Move the feature of higher priority only if it is significantly more efficient to do so and if the impact on quality will be minimal. For example: If a third- or fourth-class road is modified so that the new position places the road on top of numerous previously digitized buildings, move the road relative to the buildings within the limited update delineation tolerance. If the road is first or second class, move the buildings, within the limited update delineation tolerance, to clear the road's symbolized source position.

Resolve all feature position issues before DLG archiving, taking into account map symbolization specified in policy 93-NMD-7 (formerly 93-PO-4), "Feature Content and Position During Digital Revision." Displace features as necessary to conform to graphic symbolization, generalization, and conflict resolution specifications.

1.1.3.4 Vertical Registration

Ensure that all DLG data in the revised categories (see PLSS exceptions below) are vertically registered, as defined in Appendix 1-A, so that each feature is in its correct position relative to other features and there are no unauthorized conflicts between symbolized features. Refer to part 2 of this instruction for guidelines on acceptable symbol conflicts.

Accomplish vertical registration through automated means where possible or through interactive editing.

Vertically register areas that are logically contoured in hypsography.

Do not vertically register the nonrevised survey control and markers with other categories.

Do not vertically register the nonrevised PLSS or the PLSS obtained from the GCDB. If a boundary is legally defined as following a PLSS line, register the boundary to the PLSS.

→ 1.1.3.5 Vertical Alignment

Vertical alignment (defined in Appendix 1-A) is encouraged when an efficient means of collecting or revising features is to copy geometry from one category to another. However, it is not a requirement for digital limited update to expend additional resources to ensure that all coincident features are vertically aligned. ←

1.1.4 Processing

Produce a DLG level 3 that meets current standards.

1.1.4.1 DLG Header

Use the following guidelines to modify the DLG header:

Date Information

→ Dates will vary from category to category depending on the type of source used, the vintage of source, and whether or not the category is authorized for revision during limited update. Modify the DATE and COLLECTION PROCEDURE QUALIFIER according to the following criteria.

- For revised categories, delete the COLLECTION PROCEDURE QUALIFIER (formerly the DATE QUALIFIER).

- If the category is not authorized for revision or datum conversion, do not modify the DATE or the COLLECTION PROCEDURE QUALIFIER.

- The DATE element contains only one date.

- For Hydrography, Transportation, Manmade Features, Vegetative Surface Cover, and Non-Vegetative Features, use the date of the oldest image source or ancillary source material used to evaluate and collect new feature information. If the sources have a range of dates, use the oldest date.

  Do not use the date shown on Digital Raster Graphics (DRGs) which are used as supplemental information during revision.

- For Boundaries, use the date NMD verified sources and incorporated the information as part of the revision process.

- For PLSS, use the date of the most recent field check or the date NMD verified Geographic Coordinate Data Base (GCDB) data provided by the Bureau of Land Management for the revision.

- For Hypsography, use the date of the original source compilation. This is generally the date of the imagery used to originally compile the data. For topography originally compiled by planetable methods, the date corresponds to the date of the planetable survey.

- o If Survey Control and Markers are authorized for conversion to NAD 83, use the date of the most recent field check. If this category is not authorized for conversion to NAD 83, do not change the header date.

Refer to part 2, "Specifications," Standards for Digital Line Graphs, for more information.

Horizontal Datum

For all categories (**including** nonrevised categories) modify the datum field to reflect the change to NAD 83.

1.1.4.2 Edge Matching[3]

Use the edge-align software to match and process all edges internal to a project area. Correct mismatches by using revision source materials so that data internal to the DLG domain are continuous in content, position, and attribution. This includes preexisting mismatches that are incorporated into the DLG domain when a DLG is converted from NAD 27 to NAD 83. The following mismatches cannot be corrected:

(1) Mismatches may occur if the content varies on adjoining DOQ's with different source dates.

(2) Mismatches may occur between hypsography DLG's revised in a limited update because the mismatches cannot be resolved by

[3] Except where identified as unique to digital limited updates, all of the following edge matching guidelines apply to standard updates also.

logical contouring; the adjoining DLG may be on a different vertical datum; the DLG may have a different contour interval that is not a multiple of the adjoining contour interval, or the one quadrangle may have metric contours while the other quadrangle has English contours.

(3) Mismatches will occur on bathymetric quadrangles matched to nonbathymetric quadrangles in the areas where no bathymetric data exist. The topographic data on these quadrangles will be matched and aligned.

(4) Mismatches will occur if an adjoining file has been segmented because of the size limitations for the processing software. Where data exist, features will be matched and aligned.

Use edge-align software to process all edges external to a project area where adjoining DLG's exist. Do not investigate or correct mismatches. Do not process external edges with edge-align software in the following cases:

(1) For adjoining DLG's on different horizontal datums

2) For hypsography and hydrography, when the adjoining DLG is on a different vertical datum

(3) For hypsography, when the adjoining DLG has a different contour interval that is not a multiple of the adjoining contour interval or when the adjoining quadrangles have metric and English contours

(4) When adjoining data have not been processed successfully to a level 3 DLG using software developed after 1986, such as all Unified Cartographic Line Graph Encoding System (UCLGES) data (pre-1987) and some TRANCON data.

APPENDIX 1-A

Definitions

SOURCE POSITION = The position of features as they exist on source materials, such as digital orthophotos.

GEOGRAPHIC POSITION = The position of features as they exist on the ground, as best approximated by high-precision surveys.

TRUE POSITION = The "exact" position of features as they exist on the ground.

CARTOGRAPHIC POSITION = The position of a feature after it has been displaced or modified to permit legible symbolization on a map. Example: The displacement of a linear feature that closely parallels another feature to allow for symbol separation.

CONTENT-WORTHY FEATURES = Feature content specified for collection in product standards. The standards which are derived from objective analysis of user requirements, consider programmatic commitments and the availability of NMD resources. (Feature content beyond that specified in product standards may be obtainable from a DOQ or other sources, but the additional features are not content worthy. The fact that a feature is collectible from a source does not [in and of itself] justify its capture.**)**

GEOGRAPHIC CONTENT = The representation of content-worthy features with no generalizations for map symbolization.

CARTOGRAPHIC CONTENT = The representation of only those content-worthy features that can be symbolized, taking into account the space and legibility constraints of the map. Cartographic content criteria may be applied to digital products as well as graphic products, even though the same space and legibility concerns do not exist for digital feature

representation. Example: The deletion of one or more minimum-size point symbols, such as those for buildings, when all content-worthy features cannot be symbolized in the available map area.

CARTOGRAPHIC GENERALIZATIONS = Methods of limiting the amount of information symbolized on a map, taking into consideration space and legibility issues. Methods include simplification, exaggeration, selection/elimination, and suppression.

VERTICAL REGISTRATION = The process by which feature(s) from one DLG category are placed in correct relative position to feature(s) in other categories within the same quadrangle area.

VERTICAL ALIGNMENT = The process by which feature(s) from one DLG category are represented by the same numeric coordinates as feature(s) from an overlapping DLG category, thereby preserving true ground coincidence.

VERTICAL INTEGRATION = The process by which all DLG category data for a quadrangle are merged into the same DLG file, requiring the resolution of spatial, attributional, topological and content differences.

DELINEATION TOLERANCE = An allowable threshold of source position for previously existing and photorevised features. The positions of existing and photorevised features which do not exceed the delineation tolerance are not modified or adjusted during limited update.

FEATURE TYPE = A class of entities defined by common attributes and relationships. Bridge is an example of a feature type.

FEATURE INSTANCE = An occurrence in a data set of a feature type defined by a unique set of attribute and relationship values. For example, the Roosevelt Bridge is a particular occurrence of the feature type BRIDGE.

APPENDIX 1-B
Derivation of the Delineation Tolerance for Digital Limited Update

Derivation of the Delineation Tolerance for Digital Limited Update

→ When a digital data set of existing and photorevised features is compared with newer imagery or superimposed on a digital orthophoto, it is possible that the vectors will not match corresponding feature images. The delineation tolerance provides a threshold for accepting some of the positional discrepancies of existing and photorevised features relative to their image source position. There are several reasons for having a delineation tolerance for limited update.

(1) The intent for limited update is to maintain the existing accuracy of the source map and to not necessarily improve smaller positional discrepancies, some of which occur from cartographic symbol displacements on graphic products.

(2) The tolerance prevents attempts to improve perceived positional inaccuracies which may be present due to the overall error budget of source materials, map control solutions, and previous production processes. Correcting inherent systematic errors during revision does not necessarily improve overall positional accuracy. In future revisions, image sources may have different control solutions which could negate small positional adjustments made during current projects.

(3) The delineation tolerance promotes optimum production time and efficiencies for revising limited update feature content.

Data sets having a large number of existing feature elements located between source position and the delineation tolerance may fail NMAS. However, the delineation tolerance supports the intent and goal for limited update, whether or not the revised data set meets NMAS.

The delineation tolerance is not used to define the overall positional accuracy of a data set or a graphic map. Also, the delineation tolerance is not used for applying the NMAS statement. Overall positional accuracy and the application of the NMAS statement are verified through accuracy testing procedures. During accuracy testing procedures, errors in the geodetic base of a map are computed from differences between surveyed coordinates of ground control and coordinates of the same control scaled on the map. The NMAS (90 percent of well-defined features are within 40 feet of true position) implies a linear one-dimensional expression of accuracy so that a standard error[1] is calculated from the measured positional differences. However, the resulting errors are in latitude and longitude which implies a two-dimensional expression of accuracy. Since these errors are assumed to follow a circular distribution, the linear standard error is converted so that map accuracy can be better expressed as a two-dimensional circular error. According to principles of error theory and stated in terms of circular error, the NMAS statement represents a 90 percent probability that true error positions will not be larger than the computed circular error[2].

The derivation of the delineation tolerance incorporates the conversion of the linear map accuracy standard to a circular map accuracy standard (based on a two-dimensional circular distribution of errors).

---

[1] The standard error (also known as the root-mean-square error) is defined for x-axis measurements as:

$$x = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 \ldots e_n^2}{N}}$$

Where:
e_1 = discrepancy (observed value minus true value) in the x-component
e_n = discrepancy in the x component, test point number n
N = total number of test points for the x component

[2] U.S. Air Force, "Principles of Error Theory and Cartographic Applications", *Aeronautical Chart and Information Center*, Technical Report No. 96, June 1968, pp. 54-59.

The NMD makes the assumption that the error in a product consists of a combination of random errors in the product source and the position of features in the digital file. The delineation tolerance for the error in the position of features can be computed through propagation of errors. The following equation and assumptions are used to calculate the tolerance.

$$F_{tolerance} = \sqrt{F^2_{map} - F^2_{source}}$$

Assumptions:

- F (sigma) represents the limit for the standard error of ground-scale measurements in metric units.

- NMAS requires that not more than 10 percent of tested points shall be in error by more than 1/50 inch.

- A major source for limited update is a 1:12,000-scale digital orthophoto quadrangle (DOQ). The NMAS allow a larger error limit (1/30 inch) for products having scales larger than 1:20,000; however, for determining the delineation tolerance, F_{source} is calculated using the smaller 1/50 inch error limit.

- Multiplying a linear standard error by the statistically derived constant of 2.146 converts the linear error to a circular error at the 90 percent probability level[3].

- To convert inches to millimeters, multiply by 25.4 mm/in.

- To convert meters to feet, divide by 0.3048 m/ft.

[3] U.S. Air Force, "Principles of Error Theory and Cartographic Applications", *Aeronautical Chart and Information Center*, Technical Report No. 96, June 1968, pp. 31-32.

Thus:

(1) Convert 1/50 inch to millimeters

$$1/50'' = 0.02''$$

$$\frac{0.02''}{X\ mm} = \frac{1''}{25.4\ mm}$$

$$X = 0.5\ mm$$

(2) Calculate F for both the source and the map

Source

$$F_{source} = \left(\frac{0.5\ mm}{Y\ m} * \frac{1000\ mm}{1\ m} \right) \frac{1}{12000}$$

$$F_{source} = 6.0\ m$$

Map

$$F_{map} = \left(\frac{0.5\ mm}{Z\ m} * \frac{1000\ mm}{1\ m} \right) \frac{1}{24000}$$

$$F_{map} = 12.0\ m$$

(3) Calculate $F_{tolerance}$ using F_{source} and F_{map}

$$F_{tolerance} = \sqrt{12.0^2\ m - 6.0^2\ m}$$

$$F_{tolerance} = \sqrt{108.0\ m}$$

$$F_{tolerance} = 10.4\ m$$

(4) Convert $F_{tolerance}$ to a two-dimensional circular error (ϵ)

$$\epsilon_{circular} = 10.4\ m * 2.146$$

$$\epsilon_{circular} = 22.3\ m$$

Therefore, converting to units in feet:

$$\epsilon'_{circular} = \frac{22.3\ m}{0.3048\ m/ft}$$

$$Delineation\ Tolerance = \epsilon_{circular} = 73.2\ ft$$

For ease of use and application during limited update, the delineation tolerance is rounded to the nearest foot. ←