National Mapping Program
Technical Instructions

Part 1
General

Standards for
Digital Line Graphs

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

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1. GENERAL

The U.S. Geological Survey (USGS) serves as the lead Federal agency for the collection and distribution of digital cartographic data. The standards specified in this document pertain to the collection, processing, revision, and quality control of Digital Line Graph (DLG) data intended for entry into the National Digital Cartographic Data Base (NDCDB).

These standards are intended to facilitate the interchange and use of DLG data. DLG collection and processing systems must produce data that are compatible with other production systems not only within the Federal sector but also within other government and private sector organizations. Due to rapidly changing technologies in the mapping industries, these DLG standards cover a broad range of collection and processing systems. It is not the intent of this standard to inhibit usage of any procedure, but to set common standards which will allow data to be acceptable for entry into the NDCDB.

This document also provides the NDCDB manager and the quality control units within the USGS with standards for testing DLG data. Data generated by National Mapping Division (NMD) production units are collected according to the standards set forth in this document. DLG data collected by other Federal agencies or acquired through procurement from the private sector will be accepted for entry into the NDCDB after verification according to these same standards.

1.1 SERIES DESCRIPTION

One form of digital cartographic data produced for and distributed from the NDCDB is the Digital Line Graph (DLG). Three distinct types of DLG data are archived in the NDCDB: (1) large-scale DLG data digitized primarily from 1:24,000-scale USGS topographic quadrangles, (2) intermediate-scale DLG data digitized from 1:100,000-scale USGS quadrangles, and (3) small-scale DLG data digitized from the 1:2,000,000-scale sectional maps of The National Atlas of the United States of America. The basic applications of DLG data are to support automation of cartographic processes and automated spatial data analysis.

The DLG file structure is designed to accommodate all categories of spatial data represented on a conventional line map. Node, line, and area data types are accepted. The attribute coding scheme is designed to accommodate basic cartographic data categories such as hypsography, hydrography, or political and cultural features, as well as additional thematic data categories.

1.2 DATA SOURCES

Digital Line Graph data are currently derived by digitizing map features as line graph elements from cartographic source materials. The scale of the source materials is contained in the file header. The scale is also reflected in the resolution field, which states the ground length in meters of the smallest data collection unit (0.001 inch) for each scale.

1.2.1 Large-Scale Digital Line Graphs

The large-scale DLG data files are derived primarily from USGS topographic maps published as 7.5-minute quadrangles at 1:24,000 or 1:25,000 scale. Where 7.5-minute coverage is not available, the following sources are used, in order of preference:

- Advance manuscripts for 7.5-minute maps.
- Published 15-minute quadrangles at 1:62,500 scale (1:63,360 scale in Alaska).
- Archival compilation materials for 15-minute quadrangles, if available at a larger scale than the published map, such as 1:48,000 scale.

1.2.2 Intermediate-Scale Digital Line Graphs

The intermediate-scale DLG data files are derived from USGS topographic maps published as 30- by 60-minute quadrangles at 1:100,000 scale. Where 1:100,000-scale coverage is not available, the following sources are used, in order of preference:

- Bureau of Land Management planimetric editions of 1:100,000-scale maps.
- Archival compilation materials, if available.

1.2.3 Small-Scale Digital Line Graphs

The small-scale DLG data files were derived from the 1:2,000,000-scale sectional maps of the 1970 National Atlas of the United States of America. Alaskan hydrography data were collected at 1:1,000,000-scale. Selective updating of the sectional maps was conducted prior to digitizing.

1.2.4 Digital Line Graph Revision

Sources for revision of digital data archived in the NDCDB may include aerial photographs, orthorectified or other imagery, other agency graphic and digital data, and field data.

1.3 DATA CONTENT

The DLG files derived from the 1:24,000- and 1:100,000-scale maps contain selected categories of cartographic data in digital form; these data categories do not necessarily correspond to the traditional feature separates associated with the maps.

The following categories are valid for large- and intermediate-scale DLG files:

- Hypsography -- This category of data consists of information on topographic relief (primarily contour data) and supplementary spot elevations.

- Hydrography -- This category of data consists of all flowing water, standing water, and wetlands.

- Vegetative Surface Cover -- This category of data consists of information about vegetative surface cover such as woods, scrub, orchards, and vineyards. Vegetative features associated with wetlands, such as marshes and swamps, are collected under Hydrography.

- Non-Vegetative Features -- This category of data consists of information about the natural surface of the Earth as symbolized on the map such as lava, sand, and gravel features. This category is not all-inclusive, as other non-vegetative surface features, such as glaciers, are found in the category of Hydrography.

- Boundaries -- This category of data consists of (1) political boundaries that identify States, counties, cities, and other municipalities, and (2) administrative boundaries that identify areas such as national and State forests. Political and administrative boundaries are always collected as a single data set.

- Survey Control and Markers -- This category of data consists of information about points of established horizontal position and third-order or better elevations that are used as fixed references in positioning and correlating map features.

- Transportation -- This category of data includes major transportation systems collected in three separate overlays labeled: (1) Roads and Trails, (2) Railroads, and (3) Pipelines, Transmission Lines, and Miscellaneous Transportation Features.

- Manmade Features -- This category of data includes cultural features not included in the other major data categories, such as buildings and other related industrial, commercial, and residential features.

- U.S. Public Land Survey System (PLSS) -- This category of data describes the rectangular system of land surveys which is administered by the U.S. Bureau of Land Management. PLSS data exist only for areas falling solely, or in part, within the States which were formed from the public domain. The PLSS subdivides the public domain and represents property boundaries or references to property boundaries. These DLG data are not intended to be official or authoritative. They are presented as cartographic reference information. The only legal basis for determining land boundaries remains the original survey.

A standardized naming convention is required to ensure uniformity of DLG files and to conform with the requirements of the National Digital Cartographic Data Base (see table 1-1).

Table 1-1
Formal and abbreviated forms of the DLG category/overlay names

Long Form	Short Form	Abbreviation
Hypsography	HYPSOGRAPHY	HP
Hydrography	HYDROGRAPHY	HY
Vegetative Surface Cover	VEG SURFACE COVER	SC
Non-Vegetative Features	NON-VEG FEATURES	NV
Boundaries	BOUNDARIES	BD
Survey Control and Markers	SURVEY CONTROL	SM
Roads and Trails	ROADS AND TRAILS	RD
Railroads	RAILROADS	RR
Pipelines, Transmission Lines, and Miscellaneous Transportation Features	PIPE & TRANS LINES	MT
Manmade Features	MANMADE FEATURES	MS
U.S. Public Land Survey System	PUBLIC LAND SURVEYS	PL

The long form is the proper form of the overlay name and is used in DLG documentation and other NMD documentation and publications referencing DLG category names. The short form is used in the DLG overlay record. The first four characters of the short form are used by NMD DLG processing software to verify the proper use of the short form. The abbreviation is used in accordance with the instructions in Supplemental Topographic Instruction 85-1-D.

All DLG data are collected, processed, and archived as single topologically structured files for the above categories or overlays.

The 1:2,000,000-scale map series was digitized to produce files of data grouped into the following categories:

- Political Boundaries
- Administrative Boundaries
- Roads and Trails
- Railroads
- Streams
- Water Bodies
- Cultural Features (airports, Alaska pipeline)
- Hypsography (Continental Divide only)

1.4 DATA STRUCTURE

The structure of the DLG data will be described by considering the following subject areas: levels of structuring, topology, topological elements and graph theory.

1.4.1 Levels of Structuring

The term Digital Line Graph (DLG) is used by the USGS to describe a digital map data set in vector form. Originally, three levels of DLG data (DLG-1, DLG-2, and DLG-3) were envisioned; these levels were differentiated by their positional accuracy, level of attribute coding, and relational spatial information. It was found, however, that the widest user community would be served by producing DLG-3 data, which have the full range of attribute codes, are topologically structured, and have passed certain quality-control checks. These three properties are required by users whose work includes both graphic and analytic applications. Level 2 DLG's are not topologically structured and usually have less than the full range of attribute codes.

1.4.2 Topology

Current data collection is directed toward producing topologically structured level-3 DLG data, referred to as DLG-3. The DLG-3 concept is based on graph theory in which a two-dimensional diagram is expressed as a directed graph composed of a set of nodes (topologically significant points), lines, and areas in a manner that explicitly expresses logical relationships. Applied to a map, this concept is used to encode the digital data with the spatial relationships between map elements that are

obvious when the map is examined visually. The spatial relationships include such concepts as adjacency and connectivity between features on the map. The abstraction of the map data according to the rules of graph theory preserves the spatial relationships inherent in the map graphic and creates a logical and consistent data file structure for computer processing. A digital file of cartographic or geographic data that maintains the spatial relationships inherent in the map is called a topologically structured data file. A topologically structured data file can support simple graphic applications, such as plotting streams and roads for base maps, as well as more advanced applications, such as computations and analysis involving areas and lines and their spatial relationships.

1.4.3 Topological Elements

A DLG-3 file is composed of three separate, but related, elements: nodes, lines, and areas. Nodes define the location of the endpoints of every line, and a single node may mark the start or end of one or more lines. Thus, nodes occur at intersections of linear features and at other places on linear features where the feature is subdivided into separate line segments.

A line is an ordered set of points that describes the position and shape of a linear feature on the map. Each line starts at a node and ends at a node, has an area to the left of its direction of travel, and has an area to the right of its direction of travel. The direction of travel is arbitrarily determined at the time of data capture. Lines connect to each other at nodes, and a line

does not cross itself or any other line. A line may describe the boundary between two areal map features, such as counties, or may define a map feature by itself, such as a road. A special line, called a degenerate line, is used to define features symbolized as isolated (nonconnecting) point features on a map. A degenerate line starts and ends at the same node, has two identical coordinate pairs, has zero length, and has the same area to the left and right of the direction of travel; that is, it is totally enclosed inside one map area. Topologically, a degenerate line is considered to be a fully connected line, since the attached node has a node-line list count of two. Topological symmetry would require a 'degenerate area' element; however, the node-area linkage can be determined through the line topology.

An area is a continuous, unbroken region of the map bounded by lines. In older DLG files, each area is identified in a DLG-3 data file by an arbitrary point chosen to represent the characteristics of the area; the point was not required to be inside the area it represents. However, files processed using the DLG Production System (PROSYS) have unique area points located inside the area they represent. Also, every DLG data file will have at least two areas identified: one representing the area covered by the file and the other representing the area outside the coverage of the file. Polygons as unique features are not defined explicitly in a DLG file. However, polygons can be constructed using line-area linkages built into the DLG data structure.

1.4.4 Graph Theory

The digital line graph concept is based on graph theory, in which a diagram can be expressed as a set of elements (nodes, areas, and lines) in a manner that shows logical spatial relationships with minimal redundancy. Historically, there were three ways to implement the line graph concept in DLG files: the area case, the network case, and the area-hybrid case. These cases were differentiated by the nature of the information contained in the categories. All NMD files are now collected and processed as area or area-hybrid case DLG's.

Area line graphs can be used to represent areal features such as political entities or the U.S. Public Land Survey System. In the area case, all closed circuits of lines form unique areas. All line elements bound two different area elements. Line elements for area line graphs are not normally assigned primary attributes. The characteristics of lines in these categories can usually be derived by examining the attributes of the area elements on each side of the line.

Network line graphs were used to represent linear features such as roads or streams. The network case differs from the area case in that, irrespective of the number of closed areas forming the graphs, only two area elements were encoded: (1) the area outside the domain, termed the outside area; and, (2) the area within the domain, termed the background area. All lines except the graph boundary, or neatline, were considered to be contained within the background area. The major topological relationship expressed by network data is that of connectivity. In the pure network case the lines themselves have the identity and carry the appropriate attribute codes. Data encoded in network line graph form are suitable for various forms of network analysis, such as minimum path computations.

In the area-hybrid case, network and area type information are gathered in a single DLG file. In this approach, all closed circuits of lines define unique areas, some of which have a cartographic identity. Some lines may exist which do not form the boundaries between two areas. The unique areas which represent features for the overlay are given attribute codes. For example, in the hydrography category there are areal features, such as lakes, reservoirs, and swamps that are represented by unique attributed area elements. There are also linear features, such as single-line streams and aqueducts, that are significant in themselves and are also assigned attribute codes. These features may occupy a position in an area of no other hydrographic significance, that is, an unattributed background area.