National Mapping Program
Technical Instructions

Part 3
Quality Control

Standards for
Digital Elevation Models

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

CONTENTS

Page

3. Quality Control 3-1
3.1 Accuracy Verification 3-1
3.1.1 Statistical Testing 3-1
3.1.2 Water Bodies (DEM levels 1 and 2) 3-1
3.1.3 Hydrography (DEM level 3 only) 3-3
3.1.4 Slopes 3-4
3.2 Logical and Physical Format Verification 3-5
3.3 Visual Verification 3-6
3.4 Editing 3-7

LIST OF PAGES

A complete and current copy of part 3 of "Standards for Digital Elevation Models" consists of the pages (and most recent creation or revision dates) listed below.

Page	Date	Page	Date	Page	Date
3-ii	12/92				
3-iii	12/92				
3-1	12/92				
3-2	12/92				
3-3	12/92				
3-4	12/92				
3-5	12/92				
3-6	12/92				
3-7	12/92				

3 QUALITY CONTROL

Quality control is an integral part of the production process and includes project planning and the use of proper hardware, software, and procedures. It is the responsibility of each mapping center to employ techniques and procedures necessary to comply with all standards specified in this document. Only techniques and procedures approved by the Office of Technical Management are to be used for testing, editing, manipulating, or filtering DEM data. The following tests, inspections, and corrective actions are mandatory to ensure the accuracy and format of the DEM.

3.1 ACCURACY VERIFICATION

3.1.1 Statistical Testing

A representative sampling of test points is used to verify the accuracy of a DEM. A minimum number of 28 test points per DEM is required (20 interior points and 8 edge points). Specific standards regarding statistical accuracy and related testing criteria are described in this document, part 2, Specifications, section 2.1.4.

3.1.2 Water Bodies (level 1 & 2 DEM)

Water bodies contained in DEM data are edited when they conform to the following criteria:

- Type
  - Ponds, lakes, reservoirs, and double-line drainage.

- Size
  - Ponds, lakes and reservoirs that exceed approximately 1/2 inch at map scale (1000 feet at 1:24,000 scale, 4167 feet at 1:100,000 scale) along the major axis.

  - Double-line drainage exceeding 1/4 inch (500 feet at 1:24,000 scale, 2087 feet at 1:100,000 scale) in width. The drainage limits will be represented by closed polygons bounded by shorelines and contour crossings (or closure lines).

To establish the water body elevation of each of the individual polygons of a double-line drain, assign the elevation of the contour crossing (or closure line) representing the lowest elevation of the polygon.

Determine the correct horizontal and vertical position or elevation from published products or other office sources by procedures established by the mapping centers. Edit water body data using the map or orthophoto containing the most current water body information. Horizontal position and shape are as important as the elevation.

Water bodies meeting type and size criteria but lacking a published elevation are assigned an interpolated elevation not to exceed the highest contour that closely approximates the shoreline of the water body. To derive this elevation interpolate one half the contour interval subtracted from the next higher naturally occurring contour elevation above the water body or substitute an elevation derived from various water control structures such as spillways and embankments. For reservoirs that have been drained or otherwise altered at the time of the photograph, the normal pool elevation is used as the standard.

Sea level is set as an arbitrary value of zero in the DEM. The shoreline is defined as mean high tide as delineated on standard USGS quadrangle maps. Local variations of tides are rarely tied to or coincide with absolute datums; therefore, as derived within the DEM, neither sea level or mean high tide are assumed to be related to NGVD 29 or other datums. For those DEM's collected under MOU exchange agreement with the DMA, shoreline and coastline elevation values must be higher than the adjacent water elevations. Extremely shallow land just interior to coastlines but not classified as swamp or otherwise inundated must have + 1 meter or foot (depending on the units of elevation of the DEM) elevation to force land boundary portrayal.

As indicated in section 2.2.2, Vertical Accuracy, water bodies must be depicted as flat and generally lower than the surrounding terrain and must have shorelines clearly delineated. Where water bodies

join or merge with swamps or other areas that are inundated at the same elevation, the swamp or other area must be brought to conform to approximatly the same elevation as the water body. Water bodies must not have striations or benches of any kind. Areas such as swamps that are normally inundated must be free of artifacts such as striations or benches so that the surface is interpretable as a hydrographic feature.

3.1.3 Hydrography (level 3 DEM's only)

For level 3 DEM's, the grid is constrained by all major hydrographic features contained within a DLG hydrography category, including drainage, lakes, swamps, and shorelines. Elevations of hydrographic features are determined through interpolation of contours using a registered DLG hypsography file. DEM surfaces constrained to drains are treated as a special case of hypsographic faulting where the DEM surface is simply creased along the track line of the drain. Additionally, all 30-meter grid cells are tilted consistent with the direction of stream flow, along the track line of the drain. There must not be any unsupported breaks or discontinuities in the rate of slope of the drain.

3.1.4 Slopes

The intent of DEM production processes is to produce DEM data sets that are accurate representations of slope as well as elevation. Slope data are more critical to certain scientific applications than are elevation data. For this reason the DEM should be smooth within the grid and continuous from node to node except at natural break points such as streams, cliffs, and craters. Level 2 and level 3 DEM data derived from contours generally represent slope more accurately than level 1 DEM data.

3.2 LOGICAL AND PHYSICAL FORMAT VERIFICATION

The computer program, DEM VERIFY, is the standard software used to verify the logical and physical format as part of the data base entry procedure. Validation by this software applies to all DEM software systems of the USGS and other government agencies or contractors whose data are intended for submission to the NDCDB. In all cases where the integrity of the logical or physical DEM structure is in question, DEM VERIFY is the standard software for format verification.

3.3 VISUAL VERIFICATION

Additional testing is performed using a DEM Editing System (DES) to aid in the identification of blunders such as irregularly gridded data, mistagging of tops and depressions, and spikes. These blunders are generally identified by displaying the DEM with the aid of DES options, which include color banding of elevation gradients, stereoscopic viewing using anaglyphic filters, and shaded-relief enhancement. An elevation matrix is analyzed in suspect areas and corrected as required.

Verification includes:

1. Identification of the maximum and minimum elevations contained in the DEM and comparison with the maximum and minimum values represented by contours or spot elevations on the best available map product of the area. The maximum and minimum grid points must be within the stated error tolerances (section 2.3). The data and map should be examined to determine the reason for any discrepancy and the data edited.

2. Verification of all elevations below sea level according to the best available map product of the area and, if unsupported, adjustment to the surrounding terrain.

3.4 EDITING

If it is judged economically feasible, the mapping centers will edit the DEM data set or reprocess the raw data. These edited or reprocessed DEM's will be resubmitted for quality review and entry to the NDCDB. If it is judged that the DEM is not repairable or fails to meet the accuracy requirements or pass both the visual and software tests then the DEM will be rejected and deleted from the NDCDB.