NATIONAL
CARTOGRAPHIC
INFORMATION
CENTER

DIGITAL TERRAIN TAPES

NCIC User Guide

U.S. Department of the Interior
Geological Survey

National Cartographic
Information Center

Digital Terrain Tapes

Introduction

The National Cartographic Information Center (NCIC) handles public distribution of digital terrain tapes produced by the Defense Mapping Agency Topographic Center (DMATC) from the 1:250,000-scale series of maps. The tapes, digital representations of terrain elevations, are an invaluable yet relatively inexpensive aid for regional terrain and land use studies.

Development of digital terrain tapes

DMATC's digital terrain tapes are a by-product of the agency's efforts to streamline the production of raised-relief maps. In the early 1960's DMATC developed the Digital Graphics Recorder (DGR) system that introduced new digitizing techniques and processing methods into the field of three-dimensional mapping. The DGR system consisted of an automatic digitizing table and a computer system that recorded a grid of terrain elevations from traces of the contour lines on standard topographic maps. A sequence of computer accuracy checks was performed and then the elevations of grid points not intersected by contour lines were interpolated. The DGR system produced computer magnetic tapes which controlled the carving of plaster forms used to mold raised-relief maps.

It was realized almost immediately that this relatively simple tool for carving plaster molds had enormous potential for storing, manipulating, and selectively displaying (either graphically or numerically) a vast number of terrain elevations. As the demand for the digital terrain tapes increased, DMATC began developing increasingly advanced digitizing systems and now operates the Digital Topographic Data Collection System (DTDCS). With DTDCS, two types of data--elevations as contour lines and points, and stream and ridge lines--are sorted, matched, and resorted to obtain a grid of elevation values for every 0.01 inch on each map (approximately 200 feet on the ground). Undefined points on the grid are found by either linear or or planar interpolation.

Accuracy

The accuracy of the digital terrain tapes is no better than the accuracy of the stable-base 1:250,000-scale map sheets from which they were digitized. Neither the maps nor the tapes have been completely tested for vertical accuracy. However, the computer interpolation between contours on the map to produce a matrix of equally spaced elevation values is more consistent than manual interpolation. The Geological Survey does not assume any responsibility for the accuracy of the tapes but information on the expected accuracy of specific tapes can be obtained from NCIC.

Applications

Current applications of digital terrain tapes include the generation of graphics displaying slope, direction of slope, and terrain profiles between designated points. Terrain elevation data have been used in combination with stream location points and weather data to aid in planning forest fire control. Many nongraphic applications have developed, such as modeling terrain and gravity data for use in the search for energy resources. Applications of digital terrain data are still in the early stages of development and their usefulness to researchers is limited only by the amount and quality of creative study invested in them. NCIC does not distribute applications software but can direct users to organizations that do.

Format

Since 1:250,000-scale quadrangle maps generally cover one by two degrees of longitude and latitude, DMATC prepares two one-degree matrices for each quadrangle. Labeled either east or west, each block of data is stored on one seven-track UNIVAC 1108 computer tape. Before coming to NCIC the tapes are evaluated for accuracy and redigitized where necessary. For easier handling on NCIC's IBM 370/155 computer, eight one-degree matrices are stored on each nine-track, 1600 byte-per-inch tape.

Additional technical information, such as how the data are organized on the tapes, is included in the Appendix. For additional information or answers to technical questions, contact the Geological Survey's Office of Research and

Technical Standards, 519 National Center, Reston, Virginia 22092, telephone 703-860-6291.

Ordering Instructions

Because NCIC stores several one-degree blocks on each tape, copies prepared for our customers may require the manipulation and copying of many setup tapes to produce one output tape, depending on whether one-degree areas ordered are consecutively stored or scattered over several tapes. For its customers, NCIC will store up to eight one-degree quadrangles of latitude and longitude on each nine-track, 1600 byte-per-inch tape (four using 800 bpi storage). The cost of each block decreases as more blocks are ordered. Standard prices are:

Sales Price	Regular Processing	Priority Processing*
per tape	$15.00	$15.00
per one-degree block	$6.00	$10.00

For example, an order for eight blocks, regular processing will cost:

on 1600 bpi tape, $15 for one tape plus 8 x $6 = $63
on 800 bpi tape, $30 for two tapes plus 8 x $6 = $78

To order tapes from NCIC, identify the blocks you need by latitude and longitude or by quad name or number and east or west half. Unless you state a preference, a 1600 bpi tape will be sent. Prepayment is required. Send your check, made out to the U.S. Geological Survey, to: The National Cartographic Information Center, U.S. Geological Survey, 507 National Center, Reston, Virginia 22092.

Questions about ordering tapes can be answered by NCIC's User Services Section, telephone 703-860-6045.

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*Priority processing guarantees two day turnaround on the computer but NCIC cannot guarantee shipping time. Capacity may not be available for priority processing of large orders (over 25 tapes).

Appendix

I. Logical Organization of NCIC Digital Terrain Files

The digital terrain data in NCIC's library is recorded on multifile 9-track magnetic tape volumes. The recording is done in odd parity at 1600 bpi. Each data file represents elevations for a planimetric grid of points covering part (usually one half) of a 1:250,000-scale map sheet.

Within each file, data are arranged in sequential logical records. Three types of logical record formats are used. The following is a description of data content and arrangement for each record type.

A. Type A logical record:

The first logical record in a digital terrain model file is a type A record. It contains general characteristic information about the digital model. Figure 1 is a schematic layout of the 78 bytes which constitute the record and an explanation of their contents. Table 1 is a description of each data field in the record. Unless otherwise specified, all data fields represent binary integer numbers.

B. Type B logical record

A type B record is a variable length record which is used for elevation profiles. Figure 2 is a schematic layout of this variable length record and Table 2 describes its data content.

C. Type C logical record

Type C record is the last logical record in a digital terrain file. Figure 3 is a schematic layout of the record's 12 bytes, and Table 3 contains a description of its data content.

Figure 1

Type A logical record

Type A record	Byte positions	Content
	1-12	sheet number *(EBCDIC)
	13-18	series ID (EBCDIC)
	19-24	edition ID (EBCDIC)
	25-26	map projection code
	27-28	projection zone no.
	29-30	elevation units' code
	31-32	X_{sw}
	33-34	Y_{sw}
	35-36	X_{nw}
	37-38	Y_{nw}
	39-40	X_{ne}
	41-42	Y_{ne}
	43-44	X_{se}
	45-46	Y_{se}
	47-50	λ_{sw}
	51-54	ϕ_{sw}
	55-58	λ_{sw}
	59-62	ϕ_{nw}
	63-66	λ_{ne}
	67-70	ϕ_{ne}
	71-74	λ_{se}
	75-78	ϕ_{se}

* Extended Binary Coded Decimal Interchange Code

Table 1

Type A logical record

Bytes		Contents
1-12	....	sheet number (EBCDIC)
13-18	....	map series (EBCDIC)
19-24	....	map edition (EBCDIC)
25-26	....	map projection code number, code 1 is for UTM projection
27-28	....	map projection zone number
29-30	....	code no. for elevation-data units = 0 for meters = 1 for feet
31-32	.. (X_{sw}) ..	*X-coordinate of south west map corner
33-34	.. (Y_{sw}) ..	Y-coordinate of south west map corner
35-36	.. (X_{nw}) ..	X-coordinate of north west map corner
37-38	.. (Y_{nw}) ..	Y-coordinate of north west map corner
39-40	.. (X_{ne}) ..	X-coordinate of north east map corner
41-42	.. (Y_{ne}) ..	Y-coordinate of north east map corner
43-44	.. (X_{se}) ..	X-coordinate of south east map corner
45-46	.. (Y_{se}) ..	Y-coordinate of south east map corner
47-50	.. (λ_{sw}) ..	**longitude of south west map corner
51-54	.. (ϕ_{sw}) ..	latitude of south west map corner
55-58	.. (λ_{nw}) ..	longitude of north west map corner
59-62	.. (ϕ_{nw}) ..	latitude of north west map corner
63-66	.. (λ_{ne}) ..	longitude of north east map corner
67-70	.. (ϕ_{ne}) ..	latitude of north east map corner
71-74	.. (λ_{se}) ..	longitude of south east map corner
75-78	.. (ϕ_{se}) ..	latitude of south east map corner

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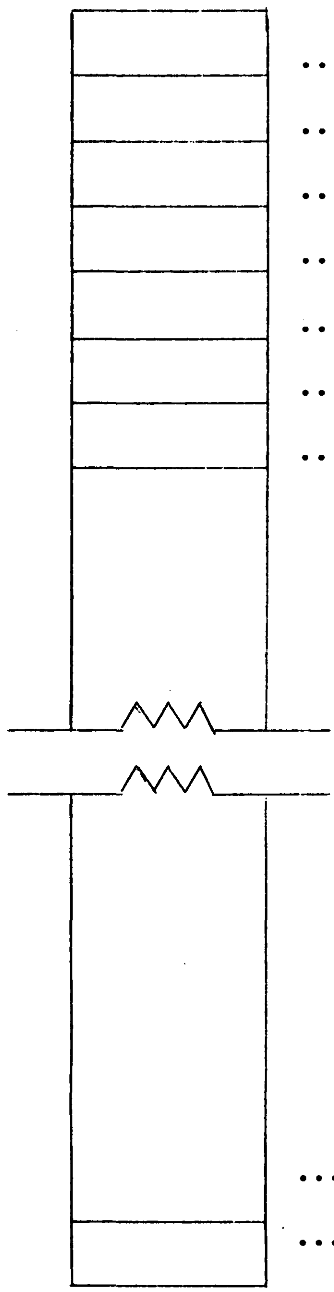
* all X and Y coordinates are on one-hundredth of inch units

** all longitudes and latitudes are in arc second units

Figure 2

<u>Type B logical record</u>



Type B record	Byte position	Contents
	1-2	X
	3-4	Y
	5-6	ΔX
	7-8	ΔY
	9-10	M
	11-12	H_1
	13-14	H_2
	.	.
	.	.
	.	.
	.	.
	.	.
	.	.
	.	.
	.	.
	.	.
	.	.
	(2m+9) – (2m+10)	$H_{(m-1)}$
	(2m+9) – (2m+10)	H_m

Table 2

Bytes	Contents
1-2	map X-coordinate of the first point in the profile (X_0) in one-hundredths of inch
3-4	map Y-coordinate of the first point in the profile (Y_0) in one-hundredths of inch
5-6	X-component of map step between profile elevation points (ΔX) in one-hundredths of inch always equals 0
7-8	Y-component of map step between profile elevation points (ΔY) in one-hundredths of inch always equals 1
9-10	number of elevation points (m) in the profile
11-12	elevation of first profile point (H_1)
13-14	elevation of second profile point (H_2)
.	
.	
.	
.	
.	
.	
.	
.	
.	
(2m+9) - (2m+10)....	elevation of m^{th} profile point (H_m)

Figure 3

Type C logical record

Type C record	Byte positions	Content
	1-2	'1111 1111 1111 1111B'
	3-4	'1111 1111 1111 1111B'
	5-6	'1111 1111 1111 1111B'
	7-8	'1111 1111 1111 1111B'
	9-10	1
	11-12	number of profiles

Table 3

Type C logical record

Byte	Content
1-2	a string of 16 '1' bits
3-4	a string of 16 '1' bits
5-6	a string of 16 '1' bits
7-8	a string of 16 '1' bits
9-10	the number 1
11-12	no. of profiles (type B logical records) in the digital terrain file.

II. Physical Organization of NCIC Digital Terrain Files

This section is included for those who plan to use NCIC digital terrain files on other than IBM computers. For IBM computer users, it is sufficient to know that the data tapes are 9-track, 1600 bpi, variable blocked (VB) physical records, and block size = 32,756 bytes.

For all other users, Figure 4 shows a schematic layout of a physical record. The first four bytes contain a Block Descriptor Word (BDW). The high-order two bytes of BDW contain the total length of the physical record (including four bytes for BDW) in bytes. The low-order two bytes of BDW contain zero (see Figure 5). The maximum length of a physical record is 32,760.

The rest of the physical record contains a variable number (n) of segments. Each one of the segments starts with a four bytes Segment Descriptor Word (SDW), followed by one of three types of logical records previously described. The SDW contains the number of bytes in the segment (including four bytes for SDW) in the high-order two bytes and zero in the low-order two bytes (see Figure 6). If the length of the i^{th} logical record is L bytes then:

Content of high-order two bytes of BDW =

$$[4 + \sum_{i=1}^{n} (4+L_i)] \leq 32,760$$

Content of high-order two bytes of i^{th} SDW = $(4+L_i) < 32,760$

Figure 4

Layout of variable blocked (VB) physical record

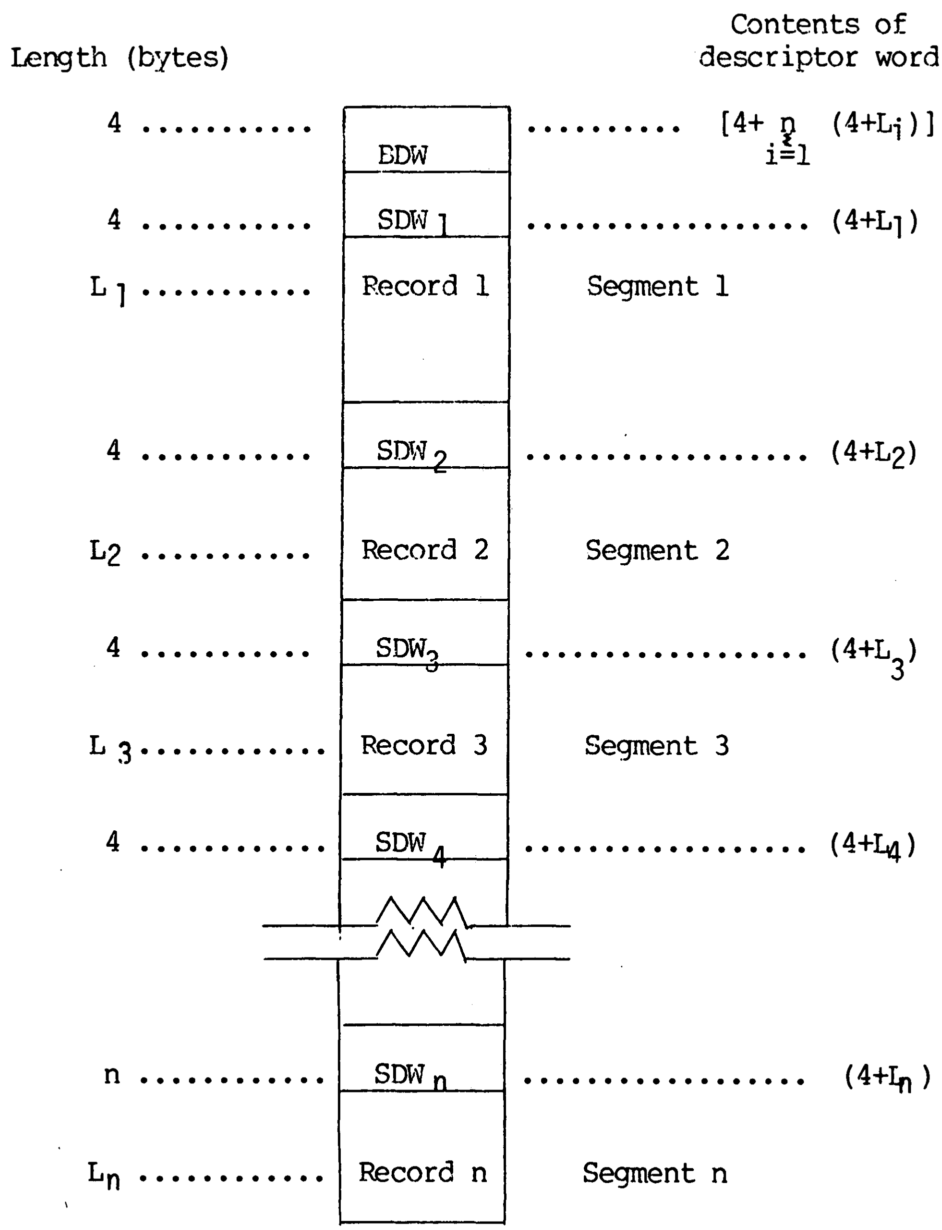


Figure 5

Block Descriptor Word (BDW)

Byte

1	2	3	4
		0	0

Bytes 1–2: Length of physical record ($\leq$ 32,760 bytes)

Figure 6

Segment Descriptor Word (SDW)

Byte

1	2	3	4
		0	0

Bytes 1–2: Length of block segment ($\leq$ 32,760 bytes)