UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

# LAND USE AND LAND COVER DIGITAL DATA FROM 1:250,000- AND 1:100,000-SCALE MAPS

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Data Users Guide 4

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## LAND USE AND LAND COVER DIGITAL DATA FROM 1:250,000- AND 1:100,000-SCALE MAPS

### INTRODUCTION

The National Cartographic Information Center (NCIC) distributes digital cartographic/geographic data files produced by the U.S. Geological Survey (USGS) as part of the National Mapping Program. Digital cartographic data files may be grouped into four basic types. The first of these, called a Digital Line Graph (DLG), is line map information in digital form. These data files include information on planimetric base categories, such as transportation, hydrography, and boundaries. The second form, called a Digital Elevation Model (DEM), consists of a sampled array of elevations for ground positions that are usually, but not always, at regularly spaced intervals. The third type is Land Use and Land Cover digital data which provides information on nine major classes of land use such as urban, agricultural, or forest as well as associated map data such as political units and Federal land ownership. The fourth type, the Geographic Names Information System, provides primary information for known places, features, and areas in the United States identified by a proper name.

The digital cartographic data files from selected quadrangles currently available from NCIC include the following:

- Digital Line Graphs (DLG)
  - --1:2,000,000-scale maps
  - --7.5- and 15-minute topographic quadrangle series
  - --1:100,000-scale quadrangle series
- Digital Elevation Models (DEM)
  - --7.5-minute topographic quadrangle series
  - --1:250,000-scale Defense Mapping Agency digital terrain series
- Land Use and Land Cover digital data
  - --1:250,000- and 1:100,000-scale Land Use and Land Cover and associated maps
  - --1:250,000-scale Alaska Interim Land Cover Maps
- Geographic Names

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This document describes the Land Use and Land Cover digital data prepared from 1:250,000- or 1:100,000-scale Land Use and Land Cover and associated maps. This program will eventually result in complete national coverage.

## DATA CONTENT

The set of Land Use and Land Cover and associated maps consists of Land Use and Land Cover, political units, hydrologic units, census county subdivisions, Federal land ownership, and State land ownership (optional).

The Land Use and Land Cover map is compiled to portray the Level II categories of the Land Use and Land Cover classification system documented by Anderson and others (1976). The Level II categories of this Land Use and Land Cover classification system provide the user with a basic framework to which third- and fourth-level categories may be added.

The associated maps portray either natural or administrative information. They provide the user with the opportunity to utilize the Land Use and Land Cover maps and data, either individually or collectively, to produce graphic or tabular data for the areas portrayed on the associated maps. This mapping system is constructed in such a way that the Land Use and Land Cover data can be related to other resource fields such as soils, geology, hydrology, and demography.

To provide the data in digital form, the Geographic Information Retrieval and Analysis System (GIRAS) has been developed (Mitchell and others, 1977). The data structure used in GIRAS to store the information is the result of a series of evolving structures and, as such, reflects the judgment by the USGS concerning the presentation and format of polygonal data. For those users better able to handle data in a grid cell form, data are also provided in a Composite Theme Grid (CTG) format.

## SOURCE DATA CHARACTERISTICS

The characteristics of the digital cartographic data base for Land Use and Land Cover and associated maps reflect the parameters used in compiling the maps. The Land Use and Land Cover mapping program is designed so that standard topographic maps at a scale of 1:250,000 can be used as a base for compilation and reproduction. In a few cases, USGS has prepared Land Use and Land Cover and associated maps at a scale of 1:100,000 when the 1:100,000-scale topographic map base was available.

The 1:250,000-scale mapping format is usually a quadrangle unit of 1° of latitude x 2° of longitude. The 1:100,000-scale mapping format has been established as a 30' x 60' quadrangle, normally a quarter of a 1:250,000-scale quadrangle. Both series are based on the Universal Transverse Mercator projection.

## Land Use and Land Cover Map

Land Use and Land Cover maps provide data to be used either by themselves or in combination with the other data sets produced in the program. The basic sources of land use compilation data are NASA high-altitude aerial photographs, and National High-Altitude Photography (NHAP) program photographs, usually at scales smaller than 1:60,000. The 1:250,000-scale topographic map series is generally used as the base map for the compilation of the Land Use and Land Cover maps and the associated overlays; 1:100,000-scale topographic map bases have been used on rare occasions. Although compilation of Land Use and Land Cover data is performed on a film-positive base usually enlarged to a scale of approximately 1:125,000, the associated overlays are both compiled and digitized at a scale of 1:250,000.

Land Use and Land Cover data compilation is based upon the classification system and definitions of Level II Land Use and Land Cover shown in table 1.

All features are delineated by curved or straight lines that depict the actual boundaries of the areas (polygons) being described. The minimum size of polygons depicting all Urban or Built-up Land (categories 11-17), Water (51-54), Confined Feeding Operations (23), Other Agricultural Land (24), Strip Mines, Quarries, and Gravel Pits (75) and urban Transitional areas (76), is 4 hectares (ha). All other categories of Land Use and Land Cover have a minimum polygon size of 16 ha. (Those sizes also are considered the minimum sizes to which polygons are digitized.) In the Urban or Built-up Land and Water categories, the minimum width of a feature to be shown is 200 m; (that is, if a square with sides 200 m in length is delineated, the area will be 4 ha.). Although the minimum-width consideration precludes the delineation of very narrow and very long 4-ha polygons, triangles or other polygons are acceptable if the base of the triangle or minimum width of the polygon is 200 m in length and if the area of the polygon is 4 ha. Exceptions to this specification are limited access highways (14) and all double line rivers (51) on the 1:250,000-scale base which shall have a minimum width of 92 m. For categories other than Urban or Built-up Land and Water, the 16-ha minimum size for delineation requires a minimum width polygon of 400 m. Line weight for delineating Land Use and Land Cover polygons and for neatlines is 0.10 mm at the production scale of 1:250,000.

## Political Unit Map

The political unit map provides a graphic portrayal of county, independent city and State boundaries and numerical codes and is compiled on a base map at a scale of either 1:250,000 or 1:100,000. Source materials for political unit map boundaries are the 1:250,000- or 1:100,000-scale base map and the 1970 Bureau of the Census unpublished maps entitled "County Subdivisions--Townships and Places" or 1980 County Subdivision Maps (U.S. Bureau of the Census, 1983e). State and county political units (including independent cities in Maryland, Missouri, Nevada, and Virginia)

Table 1.--U.S. Geological Survey Land Use and Land Cover Classification System for Use with Remote Sensor Data

| | LEVEL I | | LEVEL II |
|---|---|---|---|
| 1 | Urban or Built-up Land | 11 | Residential |
| | | 12 | Commercial and Services |
| | | 13 | Industrial |
| | | 14 | Transportation, Communications and Utilities |
| | | 15 | Industrial and Commercial Complexes |
| | | 16 | Mixed Urban or Built-up Land |
| | | 17 | Other Urban or Built-up Land |
| 2 | Agricultural Land | 21 | Cropland and Pasture |
| | | 22 | Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas |
| | | 23 | Confined Feeding Operations |
| | | 24 | Other Agricultural Land |
| 3 | Rangeland | 31 | Herbaceous Rangeland |
| | | 32 | Shrub and Brush Rangeland |
| | | 33 | Mixed Rangeland |
| 4 | Forest Land | 41 | Deciduous Forest Land |
| | | 42 | Evergreen Forest Land |
| | | 43 | Mixed Forest Land |
| 5 | Water | 51 | Streams and Canals |
| | | 52 | Lakes |
| | | 53 | Reservoirs |
| | | 54 | Bays and Estuaries |
| 6 | Wetland | 61 | Forested Wetland |
| | | 62 | Nonforested Wetland |
| 7 | Barren Land | 71 | Dry Salt Flats |
| | | 72 | Beaches |
| | | 73 | Sandy Areas Other than Beaches |
| | | 74 | Bare Exposed Rock |
| | | 75 | Strip Mines, Quarries, and Gravel Pits |
| | | 76 | Transitional Areas |
| | | 77 | Mixed Barren Land |
| 8 | Tundra | 81 | Shrub and Brush Tundra |
| | | 82 | Herbaceous Tundra |
| | | 83 | Bare Ground |
| | | 84 | Wet Tundra |
| | | 85 | Mixed Tundra |
| 9 | Perennial Snow or Ice | 91 | Perennial Snowfields |
| | | 92 | Glaciers |

are encoded with a five-digit number in accordance with the 1970 Geographic Identification Code Scheme (U.S. Bureau of the Census, 1972b) or 1980 Geographic Identification Code Scheme (U.S. Bureau of the Census, 1983f) and the County and City Data Book (U.S. Bureau of the Census, 1972a) or County and City Data Book (U.S. Bureau of the Census, 1983d).

## Census County Subdivision Map

The census county subdivision map depicts boundaries and numerical codes for either census tracts in Standard Metropolitan Statistical Area (SMSA) counties before June 1983, Metropolitan or Primary Metropolitan Statistical Area (MSA/PMSA) counties since June 1983, or minor civil divisions (or equivalent divisions) in non-SMSA/MSA/PMSA counties. Boundaries and codes for census tracts in SMSA counties are based on map data in Census Tracts reports (U.S. Bureau of the Census, 1972) or on the Census Tracts maps (U.S. Bureau of the Census, 1983c). Boundaries for minor civil divisions are from the 1970 Bureau of the Census unpublished maps entitled "County Subdivisions--Townships and Places" or 1980 County Subdivision Maps (U.S. Bureau of the Census, 1983e). Each SMSA/MSA/PMSA is encoded with a four-digit number and each census tract is encoded with a one-to four-digit number, with a possible two-digit number extension, that is unique for each census tract within a given SMSA/MSA. Minor civil divisions are encoded with an eight-digit number in accordance with the 1970 Geographic Identification Code Scheme (U.S. Bureau of the Census, 1972b) or 1980 Geographic Identification Code Scheme (U.S. Bureau of the Census, 1983f): the first two digits are the State code, the next three are the county code, and the last three are the minor civil division identifier.

## Hydrologic Unit Map

The hydrologic unit map is based on the Hydrologic Unit Maps published by the USGS Office of Water Data Coordination, together with the list "Boundary descriptions and name of region, subregion, accounting units, and cataloging unit" or USGS Circular 878-A, Codes for the Identification of Hydrologic Units in the United States and the Caribbean Outlying Areas (U.S. Geological Survey, 1982). The hydrologic units are encoded with an eight-digit number that indicates the hydrologic region (first two digits), hydrologic subregion (second two digits), accounting unit (third two digits), and cataloging unit (fourth two digits).

## Federal Land Ownership Map

The USGS has the responsibility for researching, obtaining, and formatting maps, plots, and other descriptive data related to Federal land ownership. Minimum size for the delineation is 16 ha. Ownership is encoded according to the agencies listed in table 2.

## State Land Ownership Map

In instances in which the USGS has a cost-sharing cooperative agreement with a specific State, a map overlay showing an inventory of State-owned land is produced from data furnished by the State. This overlay is compiled on the same map base used for the other overlays. The polygons are encoded according to the referencing system used by the State.

Table 2.--Federal Land Ownership

| Code | Agency |
|---|---|
| | DEPARTMENT OF AGRICULTURE |
| 11 | Agricultural Research Service |
| 12 | Forest Service (National Forest) |
| 13 | Forest Service (National Grassland) |
| | DEPARTMENT OF COMMERCE |
| 21 | National Oceanic and Atmospheric Administration |
| | DEPARTMENT OF DEFENSE |
| 31 | Air Force |
| 32 | Army |
| 33 | Army (Corps of Engineers - Civil Works) |
| 34 | Navy |
| | DEPARTMENT OF THE INTERIOR |
| 41 | Bonneville Power Administration |
| 42 | Bureau of Indian Affairs (does not include Indian lands held in trust) |
| 43 | Bureau of Land Management |
| 44 | Bureau of Mines |
| 45 | Bureau of Reclamation |
| 46 | Fish and Wildlife Service (National Wildlife Refuge) |
| 47 | National Park Service (National Monument, Seashore, and Recreation Area) |
| 48 | National Park Service (National Park) |
| | DEPARTMENT OF JUSTICE |
| 51 | Bureau of Prisons |
| | DEPARTMENT OF STATE |
| 61 | International Boundary and Water Commission, U.S. and Mexico |
| | DEPARTMENT OF TRANSPORTATION |
| 71 | Federal Aviation Administration |
| 72 | Federal Railroad Administration |
| 73 | U.S. Coast Guard |
| | OTHER AGENCIES |
| 81 | Energy Research and Development Administration |
| 82 | General Services Administration |
| 83 | National Aeronautics and Space Administration |
| 84 | Tennessee Valley Authority |
| 85 | Veteran's Administration |

## GIRAS DATA STRUCTURE ELEMENTS

The GIRAS digital data structure was designed to handle large quantities of map data of the polygon type. The topological elements associated with polygon maps are shown in figure 1. A polygon is an area that is homogeneous in the characteristic (for example, Land Use and Land Cover)

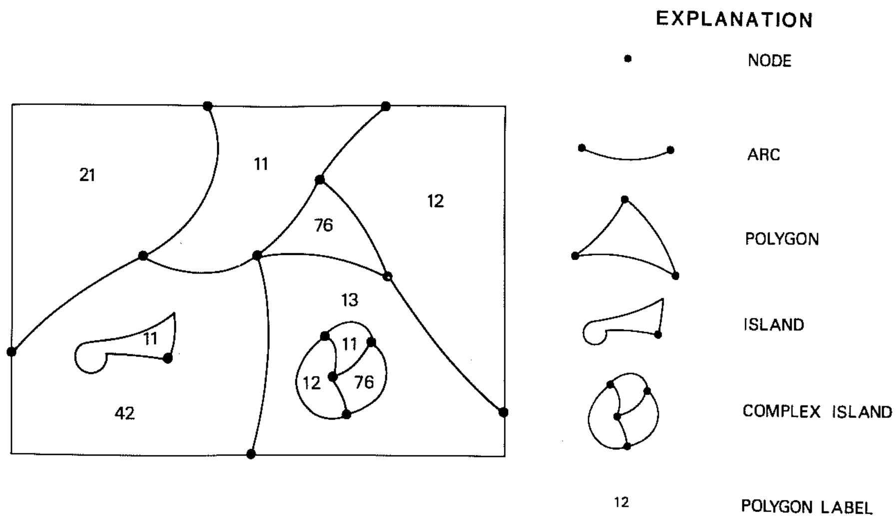



Figure 1.--Topological elements of a polygon map.

being mapped. An arc describes a boundary either between two polygons or between a polygon and the outside of the map. Further defined, an arc begins at one node, or point common to three or more arcs (that is, an intersection), and ends at another node but does not pass through any node. A special case is a simple island polygon totally surrounded by a larger polygon. For purposes of digitizing, an arbitrary point on the boundary of the island is chosen as the beginning and ending node of the arc. In the GIRAS structure, the common boundaries, or arcs, are digitized only once. The arcs are then linked together by editing software to form polygons.

Each polygon label on the map is an integer code, not necessarily unique, that identifies or describes the polygon in which it is placed or to which it points. Note that the GIRAS format has one and only one 4-byte attribute code associated with each polygon. As a rule, each GIRAS polygon attribute is a direct copy of a polygon label from the source Land Use and Land Cover or associated map overlay. There are three exceptions to this rule: (1) an attribute code of zero (0) is associated with the outside of the map; (2) special attribute codes are associated with the unlabeled polygons (see page 23 and table 5); and (3) attributes for census tracts are all 10-digit codes, of the form "laaatttss," where "l" is always the first digit and is an indication that the code is for a census tract rather than a minor civil division, "aaa" are the first three digits of the SMSA number (the fourth digit is assumed to be zero), "tttt" is the tract number (justified with leading zeros), and "ss" is the two-digit split tract extension, if any, or "00" if there is no extension.

Within the GIRAS data structure, the basic topological elements of a polygon map (arcs, nodes, and polygons) are all uniquely identified and cross-referenced to one another. The spatial location of an arc is given by a string of x,y points; the first point is its beginning (from) node, and the last point is its ending (to) node. The sequence of points of an arc defines a direction that, since the arc separates two polygons, determines a polygon to the right and a polygon to the left. A single node is the end-point (first and (or) last) of three or more arcs (or the first and last end-point of a one-arc island). A given polygon is spatially defined as the sequence of arcs that constitute its boundary, both external perimeter and any internal islands.

## CREATION OF THE GIRAS FILES

The data capture procedure involves the conversion of the source material into a digital format. As defined by GIRAS, the digitization process includes not only the initial conversion to digital form, but also the editing process by which clean or logically correct data files are produced.

In digitizing, lines are not tagged in any way, and all that is required is the capability to recognize line intersections (nodes) during computer processing. Since Land Use and Land Cover maps consist entirely of polygons, the map is completely defined when each arc, including the arcs that are the boundaries of the map, has been digitized. Along with the line data, a file that contains at least one attribute and a point inside the polygon (represented by an x,y coordinate pair) for each polygon of the map must be entered into the system. These data are not in the GIRAS format at the end of the digitizing process. Data are converted to the GIRAS format only when editing is finished.

After the necessary data have been captured, the following steps are used to produce a GIRAS file:

1. Conversion of the data file to the standard editing format;
2. Data reduction, by elimination of points not needed to define lines within a specified tolerance;
3. Splitting of data sets into sections, if necessary;
4. Limited automatic editing and error detection for the arc data;
5. Manual batch editing of line data, with returns to step 4 until data are error free;
6. Merging of labeled polygon points with the arc data resulting in either further error detection or clean files;
7. Manual batch editing of polygon labels data with returns to steps 5, 6, or 7, if necessary;
8. Edge matching of each section with neighboring sections and of each map with every available adjoining map;
9. Conversion of data files to standard GIRAS format; and
10. Transformation of data from table coordinates to the UTM coordinate system.

## APPLICATIONS

### Manipulation and Analysis

Spatial data in the GIRAS format can be applied to individual problems through manipulation and analysis procedures such as:

1. Rotation, translation, and scaling of the coordinates;
2. Conversion to geographic coordinates and from geographic coordinates to specified map projections;
3. Conversion from arc-segment polygon structure to grid cells of a specified size;
4. Conversion to standard polygon format;
5. Production of area summary statistics from polygon or grid cell data;
6. Production of border (perimeter) and adjacency lengths of particular polygon types from the polygon data; and
7. Selection of a portion of a map for closer consideration by using procedures 1 through 6.

The first two procedures in the list deal with coordinate conversion. To apply the data to needs of various users, it is often necessary to be able to rotate and translate the coordinate system and scale it to the desired size. Similarly, a facility to transform the data to another map projection is desirable, particularly when supplemental data exist on a different projection.

A number of existing data systems utilize data stored in grid cells. Thus, the ability to convert the polygon structure to a grid-cell format can be very useful.

The Land Use and Land Cover and associated map data files are converted to grid cells of a specific size and orientation to permit their addition to a existing data base. This permits GIRAS data to be used where the GIRAS data structure is inappropriate. GIRAS's capability to produce data in both polygon and grid-cell formats provides a flexibility whereby the needs of more users can be met.

Area summaries for a GIRAS data set may be obtained directly from the file. However, if a further breakdown of the information (for example, land use within each political unit for a data set) is wanted, it may be derived more easily from grid-cell formatted information than from an arc-segment file. Once all associated maps as well as the Land Use and Land Cover map for a 1:250,000-scale quadrangle sheet are in GIRAS format, they may be converted to one file of grid-cell information (an explanation of the CTG data file format begins on page 25) from which the more detailed summary described above may be obtained. For example, with the grid-cell (CTG) file, summaries of Land Use and Land Cover by county within a given drainage basin can be produced.

As with the grid-cell format data, the GIRAS format data facilitate production of certain types of information. An environmental study might require that the length of the border between two noncompatible types of

Land Use or Land Cover (procedure 6) be known. For example, if an area of industrial land borders a lake under study, the amount of lakeshore occupied by the industrial site might be of interest. This type of information can be derived easily from the arc-segment GIRAS files.

While GIRAS stores polygons as the arcs of which they are composed, many information systems that deal with polygon data store those polygons as complete entities. To bridge the gap between the two formats, conversion to a standard polygon format is necessary. Although this requires more storage than GIRAS's format, it allows the use of a simpler set of software for plotting, perimeter calculation, and area calculation.

Another technique for extracting information from the GIRAS files is the selection of an area smaller than the standard 1° x 2° map data file (procedure 7). It is often helpful to select data from the files for closer consideration. This windowing process reduces the amount of information handled by eliminating the portions of the map that are of no interest to the study. Once this smaller portion has been selected, any of procedures 1 through 6 may be applied.

### Display

Computer-generated graphics may be used to augment the manipulations and analyses described previously. A computer-generated shaded color plot of the Level II Land Use and Land Cover for a data set along with a summary of the land use gives the investigator a spatial perspective of the distribution of Land Use and Land Cover over the area mapped. If it would be more helpful to see only one or more of the land uses displayed, they can be specially selected. If the lengths of borders between two specific Land Uses or Land Covers are under study, a plot showing only those two Land Uses or Land Covers would be helpful.

The detailed summary of Land Use and Land Cover by county might be illustrated by placing the outline of the county over the Land Use and Land Cover map. The pattern of Land Use and Land Cover for that county can be seen with the areas of the different land uses computed and displayed.

## DATA VOLUMES

Large sets of complex spatial data, such as those handled by GIRAS, necessitate an efficient data structure. Table 3 shows some measure of GIRAS data volumes derived from records of data editing procedures. The numbers of coordinates (two coordinates, x and y, per point) are those defining the arcs and reflect the minimum number of points needed; straight two-point line segments have replaced multipoint curves within the spatial resolution tolerance of the original graphic map. The actual physical size of a GIRAS file is basically a function of the numbers of arcs (NA), coordinates (NC), and polygons (NP): approximately (36NA + 2NC + 32NP) bytes, plus identifying and descriptive data as specified in the map header and text subfile sections. The greater complexity of Land Use and Land Cover maps results in a large number of arcs and polygons recorded as compared to the number recorded for the associated maps.

Table 3.--Sample GIRAS data volumes from 1:250,000-scale map overlays

| | Sample size | Average | Maximum |
|---|---|---|---|
| Land Use and Land Cover, | 239 quads: | | |
| Number of arcs | | 9,434 | 31,739 |
| Number of coordinates | | 226,408 | 714,530 |
| Number of polygons | | 4,238 | 13,135 |
| Political units, | 221 quads: | | |
| Number of arcs | | 48 | 143 |
| Number of coordinates | | 4,912 | 29,248 |
| Number of polygons | | 18 | 51 |
| Census county subdivisions, | 221 quads: | | |
| Number of arcs | | 605 | 7,581 |
| Number of coordinates | | 18,706 | 68,386 |
| Number of polygons | | 221 | 2,793 |
| Hydrologic units, | 220 quads: | | |
| Number of arcs | | 35 | 68 |
| Number of coordinates | | 7,181 | 17,428 |
| Number of polygons | | 13 | 25 |
| Federal land ownership, | 102 quads: | | |
| Number of arcs | | 103 | 981 |
| Number of coordinates | | 7,847 | 62,280 |
| Number of polygons | | 69 | 636 |

## GIRAS FILE FORMAT

As indicated earlier, Land Use and Land Cover and associated map data are available in two physical file formats, GIRAS and CTG (Composite Theme Grid). The CTG file format is explained beginning on page 25. The GIRAS file format is a specific physical implementation of the logical GIRAS data structure. The format was designed to optimize storage requirements, transfer operations, and sequential processing. A standard character-formatted (usually ASCII-coded) GIRAS file consists of fixed-length 80-character (card-image) logical records. Each 80-character logical record may consist of anywhere from 1 to 16 data-element fields, depending upon where, within the file, it is located. Each data-element field may contain only one of three types of data elements: (1) a 16-bit binary integer, (2) a 32-bit binary integer, or (3) a string of text characters. Each integer is coded as one or more digits with a possible leading minus sign and leading blanks (i.e. right-justified) within a fixed field of either five characters (for 16-bit integers) or ten characters (for 32-bit integers).

In some cases a binary-formatted GIRAS file can be made available. A GIRAS binary file consists of fixed-length 32-byte (8 bits per byte) logical records. For integer data, each 32-byte GIRAS binary record is equivalent to an 80-character GIRAS card image; each 16-bit (5-digit) integer is stored in a 2-byte binary integer (two's complement notation) field, and each 32-bit (10-digit) integer is stored in a 4-byte binary integer field. Each card image record with text data is represented as two sequentially adjacent 32-byte records with EBCDIC coded characters (the last 16 characters of the card-image record are always blank). A GIRAS file, either in binary or character format, logically consists of six or more subfiles. The general structure of a GIRAS file is shown in figure 2; details are shown in figures 3-8. The first six subfiles always exist (in the order shown in figure 2); the seventh, the text subfile, may or may not exist for data released by the National Cartographic Information Center (NCIC); the eighth, the associated data subfile, is meant for user-attached data and is never present in NCIC-released data. A map data file may need to be divided spatially into several parts (sections) for processing purposes. For this reason, the second through sixth subfiles (fig. 2, B through F) may be repeated, one set of five subfiles per section. A text subfile (only one per GIRAS file) may follow the final section subfile.

## The Standard Local UTM Coordinate Frame of Reference

A GIRAS file contains a number of different types of data elements--text, codes, identifiers, counters, pointers, and some derived measurement data. Most of these data elements will be explained under the descriptions of the various subfiles below. However, one type of data, the coordinate data, needs further explanation here. All coordinates stored within a GIRAS file are coded as 2-byte (16-bit) integers. The coordinate frame of reference is defined in the map header of the file by a projection code (MPJ, see fig. 3) and six control points. The control points usually define the 1° x 2° (for 1:250,000-scale base maps) or 30' x 1° (for 1:100,000-scale base maps) quadrangle on which the overlay data are based. The latitude and longitude values are given as positive integers of the form DDDMMSS, where DDD is degrees, MM is minutes, and SS is seconds. West longitude values are given as positive numbers, increasing in value from east to west. For each of the control points, the internal x,y coordinates are equated with the geographic (latitude and longitude) coordinates of the point. The resolution of an internal coordinate unit is indicated by the map scale (MSC) value in the map header. This value is the scale denominator of a graphic plot of the GIRAS file, if the data were plotted at one internal coordinate unit per mil (0.001 in.) on the plot.

A GIRAS file containing data based on a standard USGS 1:250,000- or 1:100,000-scale quadrangle (such as the Land Use and Land Cover and associated map series) is routinely stored in a local (to the map) UTM coordinate system (MPJ = "1" for UTM). Since 16 bits are not enough to store full UTM coordinates (which may exceed 4,000,000 m), the nearest 100,000-m UTM grid intersection, which is both west and south of all map control points, is used as a local origin (x,y = 0,0). Further, the

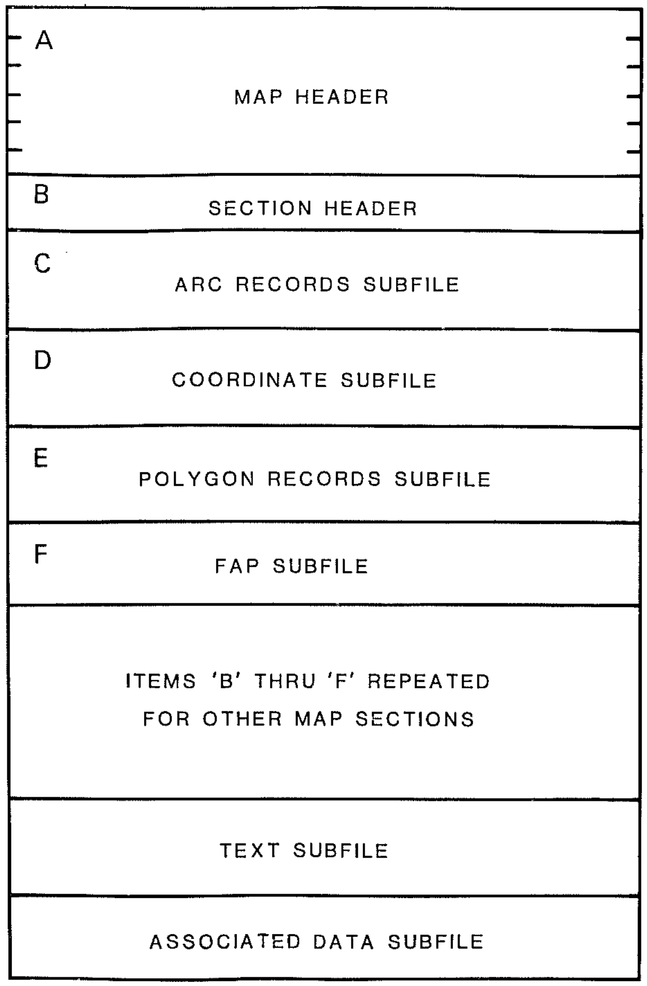
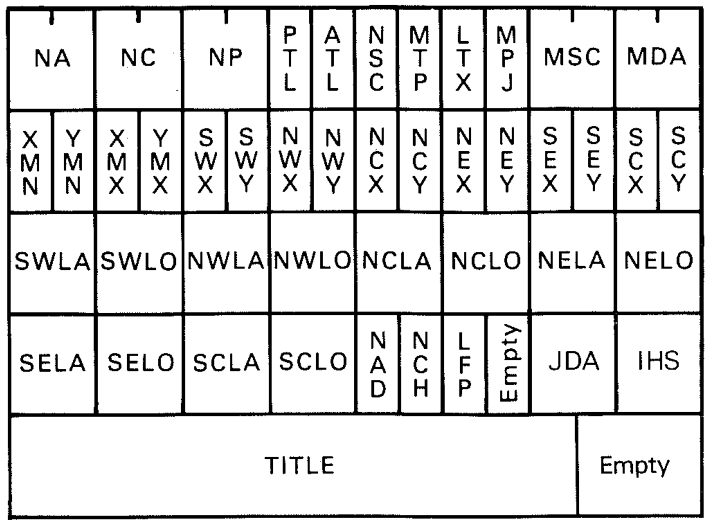



Figure 2.--GIRAS file structure.

resolution of an internal coordinate unit is set to 10 m (the MSC value = "393,701"). Using this coordinate referencing system, a GIRAS file may store data covering a 327,680-m square, more than enough for 1:250,000- and 1:100,000-scale quadrangle-based data.




| Name | Length (digits) | Description |
|---|---|---|
| NA | 10 | Number of arc records in map. |
| NC | 10 | Number of arc coordinates in map. |
| NP | 10 | Number of polygon records in map. |
| PTL | 5 | Point tolerance (in coordinate units). |
| ATL | 5 | Arc length tolerance (in coordinate units). |
| NSC | 5 | Number of map sections. |
| MTP | 5 | Map type code. |
| LTX | 5 | Length of text subfile. |
| MPJ | 5 | Map projection code. |
| MSC | 10 | Map scale denominator (1 coordinate unit per 1 mil). |
| MDA | 10 | Source map date. |
| XMN to YMX | 5 ea. | Minimum and maximum x,y coordinates for map. |
| SWX to SCY | 5 ea. | x,y coordinates of control points. |
| SWLA to SCLO | 10 ea. | Latitude and longitude of control points. |
| NAD | 5 | Number of records of associated data. |
| NCH | 5 | Number of characters in TITLE. |
| LFP | 5 | Length of FAP subfile(s). |
| JDA | 10 | Julian Date of file creation. |
| IHS | 10 | Time of file creation, in hundredths of a second. |
| TITLE | 64 | Title of up to 64 characters. |

Figure 3.--GIRAS map header.

## Map Header

The map header (fig. 3) contains a substantial amount of information, including the amount of data in the file, the date of the source material, title information, and ground control information. The values in variables NA, NC, NP, and LFP represent totals of the corresponding values for each section of the map data file. For example, NA is the sum of the

NAS (number of arcs in a section) values for all sections of the map data file. These values can be used to estimate the length of the file before analysis. Note that since the value of LFP is stored as a 16-bit integer, LFP values exceeding 32,767 will be represented by a spurious number. The point tolerance (PTL) and arc length tolerance (ATL) are values used during processing and editing of the data to eliminate spurious or unneeded data. PTL is the width, in internal coordinate units, of a corridor that was used to delete unnecessary points from each arc of the map and reflects the relative accuracy of the digital data with respect to the original graphic lines. ATL is the minimum allowable length (in internal coordinate units) of any arc on the map. The possible map type codes (MTP) are listed in table 4.

The map date (MDA) is the year of the source material used to make the map, which is usually not the same as the year the map or data set is published. The number of characters (NCH) in the title is meant to indicate that the map title (TITLE) occupies the first NCH bytes of the final two records of the map header. Because the value of NCH has been manually input and not verified, it may be spurious.

Table 4.--Map type codes for GIRAS data base

| Code | Map type |
|---|---|
| 1 | Land Use and Land Cover |
| 2 | political units |
| 4 | census county subdivisions |
| 10 | hydrologic units |
| 20 | Federal land ownership (optional) |
| 40 | State land ownership (optional) |

## Section Header

Because of previous computer constraints, the number of x,y coordinates (twice the number of arc points) of a section of a map data file is held to 32,000; the number of arcs, to 2,500; the number of polygons, to 1,500; and the total length of a FAP (file of arcs by polygon) subfile, to 6,000. Where these limits are exceeded within one map data file, the map area is broken into more than one section.

Four elements near the end of the section header (fig. 4; XMNS, YMNS, XMXS, and YMXS) are the coordinate limits of the section, and indicate the minimum and maximum x and y coordinate values within the section.

## Arc Records Subfile

Each record of the arc records subfile (fig. 5) contains a pointer (PLC) to the x,y coordinates that represent the arc in the coordinate subfile. There is one PLC value for each arc, and it represents the position

| SEC | NAS | NCS | NPS | LFS | MARK | XMNS | YMNS | XMXS | YMXS | NN | Empty |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Name | Length (digits) | Description |
|---|---|---|
| SEC | 5 | Section number. |
| NAS | 5 | Number of arcs in section. |
| NCS | 5 | Number of arc coordinates in section. |
| NPS | 5 | Number of polygons in section. |
| LFS | 5 | Length of subfile assigning arcs to polygons. |
| MARK | 5 | Indicates processing history. |
| XMNS, YMNS | 5 ea. | Minimum x,y coordinates in section. |
| XMXS, YMXS | 5 ea. | Maximum x,y coordinates in section. |
| NN | 5 | Number of nodes in section. |

Figure 4.--GIRAS section header.

| AID | PLC | PL | PR | PAL | PAR | XMNA | YMNA | XMXA | YMXA | ALEN | SN | FN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

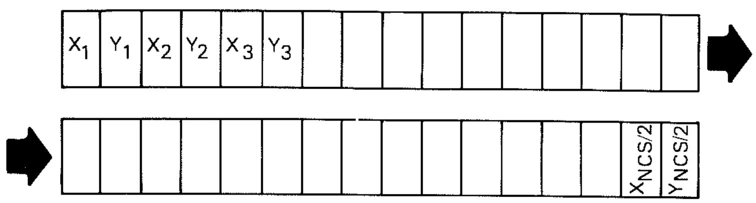
| Name | Length (digits) | Description |
|---|---|---|
| AID | 5 | Arc number. |
| PLC | 5 | Position of last arc coordinate in COORDINATE subfile. |
| PL | 5 | Polygon number of polygon to left of arc. |
| PR | 5 | Polygon number of polygon to right of arc. |
| PAL | 10 | Attribute of polygon to left of arc. |
| PAR | 10 | Attribute of polygon to right of arc. |
| XMNA, YMNA | 5 ea. | Minimum x,y coordinates in arc. |
| XMXA, YMXA | 5 ea. | Maximum x,y coordinates in arc. |
| ALEN | 10 | Arc length in coordinate units. |
| SN | 5 | Node number at beginning of arc. |
| FN | 5 | Node number at end of arc. |

Figure 5.--A GIRAS arc record.

within the coordinate subfile of the last coordinate of that arc. For example, if the first arc contained 6 points (12 coordinates), its PLC value would be 12, and if the second arc contained 8 points (16 coordinates), the PLC value would be 28 (12+16). Following this pattern, the last arc would have a PLC value equal to the total number (NCS) of coordinates in the coordinate subfile. Along with the PLC value, each record in the arc records subfile contains the unique numbers (PL and PR) of the polygons that each arc separates and the attributes (PAL and PAR) of those polygons. The outside of the map or map section is referred to as polygon number "0" (zero) with attribute "0" (zero).

## Coordinate Subfile

The coordinate subfile (fig. 6) is simply a sequential listing of every x,y coordinate needed to represent the arcs of the map section. When a map is digitized, a series of x,y coordinates is recorded for each arc of the map. Although the choice of direction taken by the digitizer during recording is not significant, that direction--once determined by digitizing--becomes important in the data structure. The direction of recording is referred to as the positive direction for the arc, and each arc can be referred to by a positive or negative representation of its




| Variable | Length (digits) | Description |
|---|---|---|
| $x_n$ | 5 | x integer coordinate value of point n |
| $y_n$ | 5 | y integer coordinate value of point n |

COORDINATE (PLC(I−1)+1) is the x coordinate value of the first point of arc I. [PLC(0)=0]

COORDINATE (PLC(I)) is the y coordinate value of the last point of arc I.

The order within the COORDINATE subfile of the (x,y) points of a given arc determines the direction of the arc, and therefore the right and left of the arc. The first point in an arc (x,y) string is its "FROM" or "START" node; the last point in an arc (x,y) string is its "TO" or "END" node.

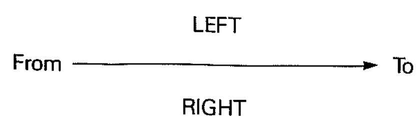



Figure 6.--GIRAS coordinate subfile.

arc identification number (AID). For example, if arc 1 is read from its starting node (SN) to the node (FN) at the end of the arc, it is represented as "+1" or 1. If the arc is to be read from FN to SN (in reverse order from that stored in the coordinate subfile), it may be represented by "-1." The need for this will become apparent when the FAP subfile is described.

To repeat, the order in which the arcs are recorded is not significant, but their order, once established, is important to the GIRAS structure. The order allows each arc to be accessed by using only the unique arc number (AID) and its PLC value. No pointers to the beginning coordinate of an arc exist in the coordinate subfile. For example, if the PLC for arc 1 is 16, then the 17th element of the coordinate subfile will be the first coordinate of arc number 2. This permits storage of the x,y coordinates in the smallest possible space.

## Polygon Records Subfile

The polygon records subfile (fig. 7) describes each polygon of the map section. The polygon identification number (PID) is the unique number by which each polygon may be referenced. The PLA value (equivalent in purpose to PLC in an arc record) points to a list, in the FAP subfile, of the arcs that comprise that polygon's borders. As with the coordinate subfile (referenced by PLC), the FAP subfile is a sequential list of information. For each polygon it contains the list of the numbers (AID's) of the arcs needed to create the boundary of the polygon. These values are listed first for polygon 1, second for polygon 2, and so on for each polygon. If polygon 1 of a section were the three-sided polygon with attribute 76 in figure 1, it would be composed of three arcs, and the PLA value for it would be "3." If polygon 2 were the polygon in figure 1 labeled 42, the situation would be slightly more complex because the FAP subfile entry for this polygon must also include the arcs that make up the outside boundary of the island within polygon 2. In this case, the value of PLA would be the number of arcs it takes to enclose the polygon (4) plus one place for a zero (indicating that what follows is a list of arcs making up an island) and one place for an arc number to represent the island (2) plus the PLA of the previous polygon (3). The PLA value for polygon 2 would then be 9. It also follows that the PLA value for the last polygon will equal the total length of the FAP subfile (LFS in the section header). A detailed explanation of the FAP subfile begins on page 19.

The next entries in the polygon record are the x,y coordinates (CX and CY) of a random point inside the polygon. These coordinates do not represent a centroid or center of mass. They define a point inside the boundary of the polygon that was recorded during the digitizing process and used during the editing process to tie the arcs together to form the polygon. The polygon attribute (ATT) and polygon area (AREA) also are included, as well as the minimum and maximum x and y coordinates (XMNP, YMNP, XMXP, YMXP) of the polygon. The area of a polygon is useful information and is stored to avoid recalculation. The limits of the polygon allow the user to--in a simple way--isolate a polygon from much

| P I D | P L A | C X | C Y | ATT | AREA | X M N P | Y M N P | X M X P | Y M X P | PERL | N I W | N I P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

| Name | Length (digits) | Description |
|---|---|---|
| PID | 5 | Polygon number. |
| PLA | 5 | Position of last arc number of polygon in FAB subfile. |
| CX, CY | 5 ea. | x,y coordinates of an interior point (arbitrarily positioned). |
| ATT | 10 | Polygon attribute. |
| AREA | 10 | Area of polygon in coordinate units squared. |
| XMNP, YMNP | 5 ea. | Minimum x,y coordinates of polygon. |
| XMXP, YMXP | 5 ea. | Maximum x,y coordinates of polygon. |
| PERL | 10 | Perimeter length of polygon in coordinate units. |
| NIW | 5 | Number of islands contained within polygon. |
| NIP | 5 | Number of the polygon containing this polygon, if it is an island. |

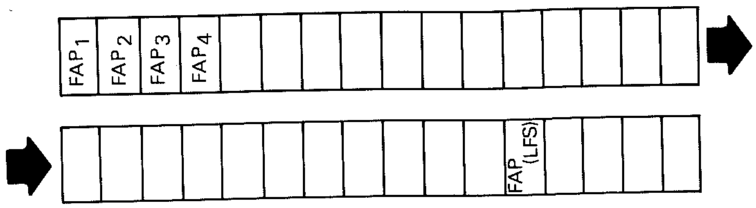
Figure 7.--A GIRAS polygon record.

of the rest of the map section. The perimeter length (PERL) of the polygon can be used along with the total area occupied by the polygon to compute measures of the compactness of the polygon.

The final two entries in the polygon record are the number of islands (NIW) contained within the polygon and the number (NIP) of the polygon that contains another polygon as an island. The number of islands is helpful when used along with PLA to read the island entries in the FAP subfile. The NIP entry identifies another polygon which totally surrounds the polygon. The attribute of the surrounding polygon can easily be obtained by looking at the value of ATT in the record for polygon number NIP. If the data were to be compressed and small polygons to be eliminated or combined with larger surrounding polygons, NIP would show quickly which polygon number and type that small island would become.

## FAP Subfile

The FAP (file of arcs by polygon) subfile (fig. 8) is the last subfile. that exists separately for each map section. It is accessed by way of an entry (PLA) in the polygon records subfile. The total length (LFS) of the FAP subfile is stored in the section header. To understand the contents of the FAP subfile, it is helpful to know how its contents are used to construct a polygon. The FAP subfile consists of lists of arcs, one arc-list per polygon. The arcs for a polygon with no islands are listed in clockwise order around the polygon from an arbitrary starting point. This starting point can be either the starting node (SN) or final node (FN) of the first arc in the list. If the starting point is SN for the arc (the polygon to the right of the arc), then the number of that arc is recorded in FAP as "+AID" or "AID." If the starting point is FN (the polygon is to the left of the arc), then that arc is recorded as "-AID." In figure 9, the direction in which the arcs of a polygon were digitized (positive direction) is indicated by the filled arrows. The list of arcs composing the polygon begins at the node closest to the internal point (CX, CY), and the FAP entry for this polygon is "-1 4 3 -2."




Each record of the FAP subfile consists of 16 elements (5 digits each) for the FAP array.

Each element contains an arc identification number pointing to the arcs that make up a specific polygon.

FAP (PLA(I−1)+1) is the first arc bordering polygon I.
[PLA(0)=0]

FAP (PLA(I)) is the last arc bordering polygon I.

Within the FAP subfile, the identification numbers of the arcs constituting a given polygon are ordered clockwise around the perimeter of the polygon and counterclockwise around interior islands of the polygon.

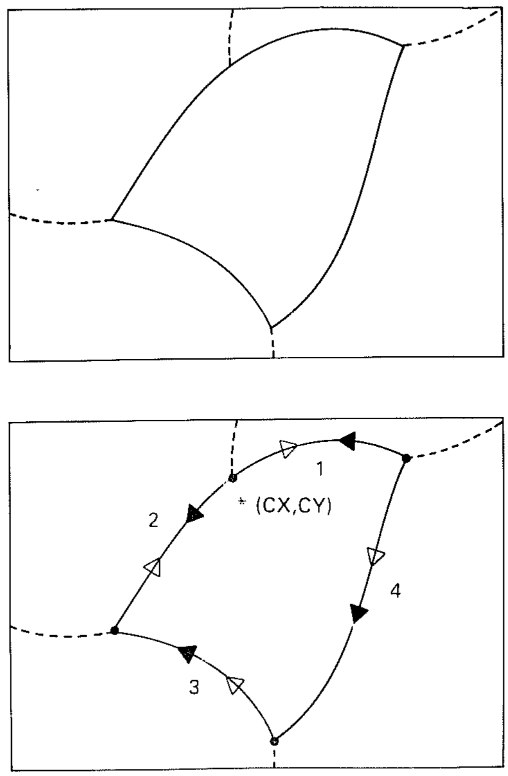
A positive arc identification number indicates the polygon is to the right of the arc.

A negative arc identification number indicates the polygon is to the left of the arc.

A zero FAP element indicates that the arc identification numbers following it, and before the next zero in the subfile or the end of the FAP list, point to the arcs that constitute an interior island of the polygon.

Figure 8.--GIRAS FAP subfile.

The FAP subfile contains a series of elements for each polygon whether or not that polygon is an island. If the polygon is an island, a list of the arcs that make up its outside boundary will also be listed in counterclockwise order in the FAP entry for the surrounding polygon in which it is an island.




EXPLANATION

| | |
|---|---|
| • | NODE |
| —▷— | FAP DIRECTION |
| —▶— | ARC DIRECTION |
| 1,2,3,4 | ARC NUMBERS |
| * (CX,CY) | INTERIOR POINT |
| ---- | REMAINDER OF MAP |

Figure 9.--GIRAS FAP subfile creation.

This points out one factor not yet mentioned in describing the FAP subfile. In many maps there may be two types of islands--simple and complex. Examples of both island types can be seen in figure 1. A simple island is a polygon that stands alone, totally surrounded by one other polygon and directly bordered by only that polygon. A complex island is a cluster of adjacent polygons that, as a group, are totally surrounded by one other polygon. When the arcs that make up a complex island are listed--in counterclockwise order--in the FAP subfile, only the arcs that compose the outside boundary of the entire cluster are recorded. The individual identities of the polygons that make up the cluster are not maintained because the cluster is considered to be an area to exclude from the polygon being described.

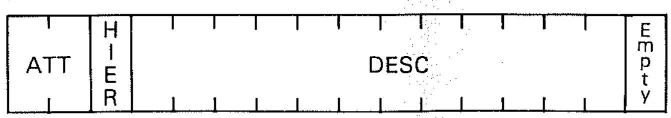
The FAP subfile is crucial to the GIRAS data structure because it is the way individual arcs can be described as part of the polygons they compose. From this file the entire outline of a polygon can be obtained, including island areas within its boundary that are to be excluded. This information is used, for example, when computer-generated shaded color plots are made.

## Text Subfile

The text subfile in a GIRAS file is reserved as a place where numerical polygon attribute codes are assigned textual labels. An individual GIRAS file includes only a single text subfile that physically follows the data for the various map sections.

Every record in the text subfile consists of three elements--an attribute code, a hierarchy code, and a descriptor (fig. 10).

A text subfile record format of (I10, I5, 58A1, 8X) was designed to be compatible with the standard binary representation of GIRAS files. Each logical text subfile entry consists of one GIRAS 80-character record.




| Name | Length (digits) | Description |
|---|---|---|
| ATT | 10 | Polygon code, right justified in a 10-digit field. |
| HIER | 5 | A 5-digit parameter to indicate polygon code type (that is, specific, general, or special). |
| DESC | 58 | A label or descriptor defining the polygon code, left justified, in a 58-character field. |

Figure 10.--A GIRAS text record.

Included in the text subfile are records for general codes that provide labels or descriptors for the more general categories under which specific polygon codes come. Consider references made to Level I and Level II Land Use and Land Cover categories. A polygon coded as "13" is known to be Industrial. The digit '1' indicates that it falls under a broader category of Urban and Built-up Land. General code records also appear in the text subfile to provide definitions for these more general categories. For the above example, a text subfile record with "10" in the polygon code (ATT) field would have the descriptor Urban and Built-up Land. (The "0" is for positional purposes only and can be considered insignificant.)

The hierarchy code (HIER) indicates the degree of generality of a text subfile polygon code (classification level). Specifically, the hierarchy code is defined as the number of insignificant digits on the right-hand side of the polygon code. Our sample Land Use and Land Cover text subfile records would thus appear:

_______10____1URBAN AND BUILT-UP LAND

_______13____0INDUSTRIAL

The role of the hierarchy code is more appreciated when dealing with other classification schemes utilized by GIRAS that involve multiple levels.

Text subfile records are arranged in ascending order by polygon code. Consequently, more general codes precede general codes of greater detail, which in turn precede codes explicitly referenced in the file. This ordering can be considered an indentation-type structure, as illustrated in table 5 for a sample census unit subfile.

Special polygon codes are required where available codes are not suitable. The set of special codes used in GIRAS is defined at the end of the subfile, as also shown in table 5. Special polygon codes were intentionally assigned extreme values (greater than 2,000,000,000) to force them to the bottom of the text subfile.

The type of map stored in a GIRAS file has an impact on the nature of the text subfile. Land Use and Land Cover and Federal ownership maps reference classification schemes that are attribute in nature. That is, there are a relatively limited number of possible codes (37 for Land Use and Land Cover and 26 for Federal ownership), and many polygons may have the same codes. The text subfiles for these types of GIRAS files list text records for all codes in the classification scheme. Consequently, all Land Use and Land Cover text subfiles are identical, as are Federal ownership text subfiles.

Census unit files, political unit files, and hydrologic unit files, alternatively, utilize codes that serve as unique identifiers. Two polygons rarely have the same code. Furthermore, it would not be feasible to list all possible codes. Consequently, only codes explicitly referenced in the file (and respective general and special codes) are defined in these types of GIRAS text subfiles.

Table 5.--Sample text subfile for a Census County Subdivision GIRAS file

| | |
|---|---|
| 42000000 | 6PENNSYLVANIA |
| 42051000 | 3FAYETTE COUNTY |
| 42051095 | 0LURERENE |
| 42059000 | 3GREEN COUNTY |
| 42059005 | 0ALEPPO |
| . | |
| . | |
| . | |
| . | |
| 42059127 | 0WAYNE |
| 42059130 | 0WHITELEY |
| 54000000 | 6WEST VIRGINIA |
| 54001000 | 3BARBOUR COUNTY |
| 54001005 | 0BAKER |
| 54001015 | 0ELK |
| 54001025 | 0PHILIPPI |
| . | |
| . | |
| . | |
| 1628000000 | 6PITTSBURGH |
| 1628732000 | 2WASHINGTON |
| 1628732000 | 0WASHINGTON |
| 1628762000 | 2WASHINGTON |
| 1628762000 | 0WASHINGTON |
| . | |
| . | |
| .. | |
| 1900000000 | 6WHEELING |
| 1900020100 | 2MARSHALL |
| 1900020100 | 0MARSHALL |
| 1900020200 | 2MARSHALL |
| 1900020200 | 0MARSHALL |
| . | |
| . | |
| . | |
| 1900020900 | 0.......... |
| 2000000000 | 9SPECIAL CODES |
| 2000000100 | 2AREA UNDEFINED BY CODING SCHEME |
| 2000000101 | 0LAND AREA UNDEFINED BY CODING SCHEME |
| 2000000102 | 0WATER AREA UNDEFINED BY CODING SCHEME |
| 2000000200 | 2UNMAPPED AREA |
| 2000000201 | 0UNMAPPED U.S. AREA |
| 2000000202 | 0UNMAPPED NON-U.S. AREA |

The text subfiles for State ownership maps are not processed because coding schemes vary from situation to situation.

The length of the text subfile is given by the LTX parameter in the GIRAS map header. LTX refers to the number of logical text subfile records (that is, polygon code definitions) and includes general and special polygon codes.

### ASSOCIATED DATA SUBFILE

The final GIRAS subfile is the associated data subfile that allows the user to store information of his own that pertains to the file (for example, population information that pertains to a particular census map). A pointer (NAD) to this subfile provides a place in the map header subfile to store the number of records in the associated data file once it is created.

## COMPOSITE THEME GRID (CTG) DATA FILE FORMAT

Digital data from all the overlays of a given quadrangle also are combined in a raster or grid-cell format as a Composite Theme Grid (CTG) file.

CTG files are sequential and consist of fixed-length logical records, and with the exception of header records, all records are of identical internal format, one grid cell per logical record. The grid cells are actually a regular point sample. The attribute codes at the center point of each cell are recorded from each overlay. The points are oriented to the UTM projection and are usually spaced 200 m apart in both east-west and north-south directions. The cell records are first ordered in the file by row from north to south, then within each row, by column west to east.

### CHARACTER COMPOSITE THEME GRID (CTG) FILE FORMAT

A character-formatted (usually ASCII) CTG file consists of fixed-length 80-character (card-image) logical records. There are two parts to the CTG file, first a header then cell records. All records, except the last header record with one text field, consist of fixed-length integer fields; each integer is coded as digits with leading blanks (i.e. right-justified). The first five logical records of the file comprise the CTG map header. The header is followed by cell records, one grid cell per 80-character logical record.

In some cases a CTG file may be released without the map header contained in the file. In this case all records in the file are individual grid cell records, and the header information is supplied as a printed listing.

## Character CTG Map Header

Record 1:

```
Bytes 1-10 = Number of rows;
     11-20 = Total number of cells x 2;
     21-30 = Number of columns;
     31-35 = Meaningless field;
     36-40 = Cell size (width and length) in meters;
     41-45 = Number of overlays merged;
     46-50 = Map type code (see below);
     51-55 = Projection zone number;
     56-60 = Map projection code (should be "1" for UTM);
     61-70 = Scale of a plot at one mil per cell width; and
     71-80 = Source date of the land use overlay.
```

Record 2:

```
Bytes 1-5  = Minimum column index;
      6-10 = Minimum row index;
     11-15 = Maximum column index;
     16-20 = Maximum row index;
     21-25 = Column index for SW control point;
     26-30 = Row index for SW control point;
     31-35 = Column index for NW control point;
     36-40 = Row index for NW control point;
     41-45 = Column index for NC control point;
     46-50 = Row index for NC control point;
     51-55 = Column index for NE control point;
     56-60 = Row index for NE control point;
     61-65 = Column index for SE control point;
     66-70 = Row index for SE control point;
     71-75 = Column index for SC control point; and
     76-80 = Row index for SC control point.
```

Record 3:

```
Bytes 1-10 = Latitude of SW control point;
     11-20 = Longitude of SW control point;
     21-30 = Latitude of NW control point;
     31-40 = Longitude of NW control point;
     41-50 = Latitude of NC control point;
     51-60 = Longitude of NC control point;
     61-70 = Latitude of NE control point; and
     71-80 = Longitude of NE control point.
```

Record 4:

```
Bytes 1-10 = Latitude of SE control point;
     11-20 = Longitude of SE control point;
     21-30 = Latitude of SC control point;
     31-40 = Longitude of SC control point;
     41-50 = UTM Easting value of west edge of cells;
     51-60 = UTM Northing value of north edge of cells;
     61-70 = File creation date (a Julian date); and
     71-80 = Meaningless field.
```

Record 5:
Bytes 1-64 = Title (text characters); and
Bytes 65-80 Blank.

Some further explanation is needed for some of the elements in the CTG map header:

1. The map type code (in bytes 46-50 of the first record) indicates which overlays have been included in the CTG data file. The code is formed by the addition (in base 10) of the separate GIRAS map type codes for each of the overlays:

01 = Land Use and Land Cover;
02 = Political units;
04 = Census county subdivisions and SMSA tracts;
10 = Hydrologic units;
20 = Federal land ownership; and
40 = State land ownership.

For example, the map type code for a combination of the first four overlays above would be 17; all six overlays combined have a map type code of 77.

2. The UTM Easting and Northing values given in the fourth record (bytes 41-60) are in whole meters and are values for the west and north edges of the cells, rather than the center point of the first (northwest corner) cell. The Easting and Northing values for a given cell may be calculated thus:

Easting = (XORG-CW/2) + (column index)*CW
Northing = (YORG+CW/2) -(row index)*CW

where XORG and YORG are the Easting and Northing values in bytes 41-60 of the fourth header record, and CW is the cell width in bytes 36-40 of the first header record.

3. The control points usually define the 1° x 2° (for 1:250,000-scale base maps) or 30' x 1° (for 1:100,000-scale base maps) quadrangle on which the overlay data are based. The latitude and longitude values are given as positive integers of the form DDDMMSS, where DDD is degrees, MM is minutes, and SS is seconds. West longitude values are given as positive numbers, increasing in value from east to west. The row and column values given for the control points are the indices for the cell whose center point is closest to the true position of the control point.

## CTG Grid Cell Records

Each grid cell logical record of a standard character-formatted CTG data file is 80 characters in length and consists of nine decimal integers, right justified (with leading blanks) within fixed-length fields:

Bytes 1–3 = UTM zone number (this value should be the same in every record of a given CTG file); the first byte will always be a blank for zones in the northern hemisphere; 4–11 = UTM Easting value, in whole meters, for the sample point of the cell; 12–19 = UTM Northing value, in whole meters, for the sample point of the cell;

20 = Blank;
21–30 = Land Use and Land Cover attribute code;
31–40 = Political unit (FIPS State/county) code;
41–50 = USGS hydrologic unit code;
51–60 = Census county subdivision or SMSA tract code;
61–70 = Federal land ownership agency code; and
71–80 = State land ownership code.

If a given overlay category has not been included within the file, the codes for that category will be zero (0). Since some misregistration of map overlays occurs, some of the cells along the edges of the 1:250,000- or 1:100,000-scale quadrangle may have codes for some overlays, but not others (the "other" code(s) will be zero). The standard character CTG data file will have only those cell records for which at least one of the categories is coded. This means that, since the 1:250,000-and 1:100,000-scale quadrangles do not form perfect rectangles in the UTM projection (lines of latitude curve and lines of longitude converge), a variable number of cell records will exist for any given row or column.

## BINARY CTG DATA FILE FORMAT

Each logical record of a binary CTG file is either 32 or 52 bytes in length. A record consists of eight 32-bit (4-byte) binary integers in the following order:

Bytes 1–4 = Row index, where 1 is the index of the northern-most row and index numbers increase by one for each row moving south (NOTE, due to a processing error, CTG files in which the State ownership is not coded will have all zero row index numbers; the row index is then a function of the sequential position of the record within the file);

5–8 = Column index, where 1 is the index of the western-most column and index numbers increase by one for each column moving east;
9–12 = Land Use and Land Cover code;
13–16 = Political unit code;
17–20 = Hydrologic unit code;
21–24 = Census county subdivision or SMSA tract code;
25–28 = Federal land ownership code;
29–32 = State land ownership code; and
33–52 = Null (binary zeros) field, if present.

If a given overlay has not been digitized, the codes for that overlay will all be zero. To be sure that a regular grid of cells (forming a UTM rectangle) covers the entire base map quadrangle, a "buffer zone" of cells with all zero attributes has been included in the binary CTG data file.

## Binary CTG Map Header

The CTG map header associated with a binary CTG data file is stored in a physically separate sequential file. The header consists of six, 32-byte logical records. For the first four records, each 32-byte binary record is equivalent to an 80-character CTG map header card image; each integer in a 5-digit character field is stored in a 2-byte binary integer field, and each integer in a 10-digit character field is stored in a 4-byte binary integer field. The fifth card-image header record (with text data) is represented as the fifth and sixth 32-byte binary records with EBCDIC coded characters (the last 16 characters of the card-image record are always blank).

## REFERENCES


Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. E., 1976, A Land Use and Land Cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p.

Mitchell, W. B., Guptill, S. C., Anderson, K. E., Fegeas, R. G., and Hallam, C. A., 1977, GIRAS--A geographic information retrieval and analysis system for handling Land Use and Land Cover data: U.S. Geological Survey Professional Paper 1059, 16 p.

U.S. Bureau of the Census, 1972, Census tracts--1970 census of population and housing: U.S. Bureau of the Census Final Reports PHC(1)-1 through PHC(1)-241. (One volume for each SMSA.)

__________ 1972a, County and city data book, 1972: U.S. Bureau of the Census, 1020 p.

__________ 1972b, Geographic identification code scheme--1970 census of population and housing: U.S. Bureau of the Census Final Reports PHC(R)-3 Northeast Region, North Central Region, South Region, and West Region. (One volume for each region.)

__________ 1983c, Census tracts--1980 census of population and housing: U.S. Bureau of the Census Final Maps PHC80-2-58 through PHC80-2-380. (One map for each SMSA.)

__________ 1983d, County and city data book, 1983: U.S. Bureau of the Census, 1060 p.

__________ 1983e, 1980 County subdivision maps: U.S. Bureau of the Census. (One map for each State.)

__________ 1983f, Geographic identification code scheme--1980 census of population and housing: U.S. Bureau of the Census Final Report PHC80-R5.

U.S. Geological Survey, 1982, Codes for the identification of hydrologic units in the United States and the Caribbean outlying areas: U.S. Geological Survey Circular 878-A.

APPENDIX A.--Listing of Sample GIRAS Map Header Data

```
TITLE: KEY WEST, FL 1:250000 QUAD POLITICAL

FILE CREATION DATE: 83004    TIME 21:56

MAP TYPE:    2    PROJECTION:  1    SCALE 1: 393700    SOURCE DATE: 1972

NUMBERS OF FILE ELEMENTS:
            ARC      COORD-    POLYGON    FAP       TEXT    ASS. DATA  TITLE
SECTIONS  RECORDS    INATES    RECORDS  ELEMENTS  RECORDS   RECORDS    CHARS
   1         27       4350        24        71        0         0        50

DUPLICATE POINT TOLERANCE =  3      MINIMUM ARC LENGTH =  10

MINIMUM X = 8130  MINIMUM Y = 5403  MAXIMUM X = 28478  MAXIMUM Y = 16523

   CONTROL POINT INFORMATION:
             LONGITUDE  LATITUDE     X        Y
SOUTH-WEST       821000    240000    8130     5462
NORTH-WEST       821000    250000    8227    16523
NORTH-CENTRAL    811000    250000   18318    16479
NORTH-EAST       801000    250000   28410    16510
SOUTH-EAST       801000    240000   28478     5429
SOUTH-CENTRAL    811000    240000   18304     5409

SECTION HEADER INFORMATION FOR SECTION  1:
NUMBER OF ARCS  =        27           NUMBER OF COORDINATES =  4350
NUMBER OF POLYGONS =     24           NUMBER OF FAP ELEMENTS =    71
NUMBER OF NODES  =       25           CURRENT MARK STATUS  =      50
MINIMUM X = 8130  MINIMUM Y = 5403  MAXIMUM X = 28478  MAXIMUM Y = 16523
```

## APPENDIX B.--Sample Character-Formatted GIRAS Data File

```
       27       4350         24     3   10     1     2     0     1    393700       1972
8130 54032847816523 8130 5462 82271652318318164792841016510284 78 542918304 5409
   240000     821000     250000     821000     250000     811000     250000     801000
   240000     801000     240000     811000     0    50    71           83004
KEY WEST, FL 1:250000 QUAD POLITICAL
   1    27 4350    24    71    50 8130 54032847816523    25
   1    10     0    23          02000000102 8182116592458916523     21225     1     2
   2    14     0    20          0       12087245891648624716 16487       127     2     3
   3    30     0    23          02000000102 8130 54032847816510     41299     3     4
   4    34     0     1          0       12087 818211638 818211659       22     4     1
   5   108    23     12000000102        12087 818211523 827411722      552     1     4
   6   280    23     22000000102        12087 838211527 885912073     2154     5     5
   7   320    23     32000000102        12087 976611290 987811402      356     6     6
   8   350    23     42000000102        12087100781123610193 11273      263     7     7
   9   380     5    23      120872000000102106021127010704 11513      570     8     8
  10   410    22    23      120872000000102109641162211013 11672      162     9     9
  11   436    21    23      120872000000102106431209810690 12165      186    10    10
  12   512     6    23      120872000000102122371239312705 12673     1373    11    11
  13  2492    23     92000000102        12087117441146617674 14298    26907    12    12
  14  2582    23     72000000102        12087139291311614329 13491     1267    13    13
  15  2626    23     82000000102        12087142151373414349 13830      402    14    14
  16  2690    23    102000000102        12087149721358215046 13767      456    15    15
  17  2724    23    112000000102        12087162231393416284 14020      237    16    16
  18  2842    23    122000000102        12087165441331716968 13888     1647    17    17
  19  2892    23    132000000102        12087170271390817114 14039      357    18    18
  20  2928    23    242000000102        12087176611397717711 14056      210    19    19
  21  3544    23    142000000102        12087187481302620923 14003     6399    20    20
  22  3568    23    152000000102        12087210851410621136 14137      133    21    21
  23  3760    23    162000000102        12087215041426922143 14730     2247    22    22
  24  3898    23    172000000102        12087225901478423126 15459     2010    23    23
  25  3920    23    182000000102        12087221381577122185 15819      154    24    24
  26  3952    23    192000000102        12087233791626523554 16422      501    25    25
  27  4350    20    23      120872000000102233181533124725 16487     4780     2     3
 818211659 822716523134751649218804164732458916487245891648724716164862471616486
284101651028478 542922551 540418227 540311066 5437 8130 5462 818211638 818211638
 818211659 818211659 819011671 819511687 819811696 822511722 823211722 823811721
 824011713 824011700 822111675 820711649 820511626 820411595 820511588 821511566

[ 265 records of the Coordinate Subfile are removed from this listing here ...]

24420160722447216106244991613224511161532453116189245461620324550162192455816234
24597162672460316283246321630724641163392465516358246801637224700163822470616395
2470116412247091642724720164332472516448247201645924717164672471616486
```

```
     1     2 818511656      12087      6117 818211523 827411722      574     0     0
     2     3 861911544      12087     54753 838211527 885912073     2154     0    23
     3     4 978011396      12087      8374 976611290 987811402      356     0    23
     4     51013311243      12087      317810078112361019311273      263     0    23
     5     61069911481      12087     1354610602112701070411513      570     0    23
     6     71254712605      12087     5691312237123931270512673     1373     0    23
     7     81415613366      12087     3678213929131161432913491     1267     0    23
     8     91423613802      12087      419914215137341434913830      402     0    23
     9    101175411653      12087   365911711744114661767414298    26907     0    23
    10    111502413589      12087      812014972135821504613767      456     0    23
    11    121624314017      12087      317816223139341628414020      237     0    23
    12    131678113799      12087    10720116544133171696813888     1647     0    23
    13    141710013914      12087      588717027139081711414039      357     0    23
    14    151975513330      12087    30062418748130262092314003     6399     0    23
    15    162110214111      12087      103421085141062113614137      133     0    23
    16    172179514396      12087     5627521504142692214314730     2247     0    23
    17    182310915186      12087     6600622590147842312615459     2010     0    23
    18    192216015774      12087      170822138157712218515819      154     0    23
    19    202349916271      12087     1585523379162652355416422      501     0    23
    20    222459616482      12087    18878023318153312472516487     4907     0     0
    21    231067312147      12087      226910643120981069012165      186     0    23
    22    241099211661      12087      163910964116221101311672      162     0    23
    23    702472416480200000102 219786908 8130 5403284781 6523   115849    21     0
    24    711770613984      12087      201517661139771771114056      210     0    23
     5     4     6     7     8    -9   -12    14    15    13    16    17    18    19    21    22
    23    24    25    26     2   -27   -11   -10     3    -5     1    27     0    -6     0    -7
     0    -8     0     9     0    12     0   -14     0   -15     0   -13     0   -16     0   -17
     0   -18     0   -19     0   -21     0   -22     0   -23     0   -24     0   -25     0   -26
     0    11     0    10     0   -20    20
[ END OF DATA ]
```

## APPENDIX C.--Listing of CTG Map Header Data

COMPOSITE THEME GRID CHARACTER DATA OUTPUT:

C T G B T A   RUN:  JUNE 3, 1982     TIME 19:23:06

GRID CELL MAP HEADER INFORMATION:

TITLE: LAWRENCE, MO KS 1:250,000 QUAD LU PB CN HU FO SO

FILE CREATION DATE: 81084   TIME  0: 0

MAP TYPE:  77   PROJECTION:  1   SCALE 1:  7874016   MAP DATE: 1973

NUMBERS OF FILE ELEMENTS:

| CATEGORIES | CELLS | ROWS | COLUMNS | ZONE NUMBER | WEST & NORTH EDGES: EASTING | NORTHING |
|---|---|---|---|---|---|---|
| 6 | 485368 | 575 | 884 | 15 | 236900 | 4321100 |

DUPLICATE POINT TOLERANCE =   0   CELL SIZE IN METERS =   200

MIN COL =  1   MIN ROW =   1   MAX COL =  884   MAX ROW =  575

CONTROL POINT INFORMATION:

| | LONGITUDE | LATITUDE | COL | ROW |
|---|---|---|---|---|
| SOUTH WEST | 960000 | 380000 | -1 | 557 |
| NORTH WEST | 960000 | 390000 | 17 | 2 |
| NORTH EAST | 940000 | 390000 | 883 | 21 |
| SOUTH EAST | 940000 | 380000 | 877 | 576 |

CHARACTERISTICS OF THE CHARACTER CTG FILE:

THE FILE CONTAINS ONLY GRID CELL (AND NO HEADER) RECORDS.

THE FILE CONSISTS OF 80 CHARACTER RECORDS, ONE GRID CELL PER RECORD.

UTM ZONE, EASTING, AND NORTHING VALUES ARE PART OF EACH CTG DATA RECORD AS THE FIRST THREE INTEGERS, RIGHT JUSTIFIED IN BYTES 1-3, 4-11, AND 12-19.

BYTES 21-80 OF EACH RECORD CONTAIN THE USGS 10-DIGIT INTEGER CODES, RIGHT JUSTIFIED WITHIN 10-BYTE FIELDS, FROM THE FOLLOWING OVERLAYS, IN ORDER:

LAND USE/LAND COVER, POLITICAL UNIT, HYDROLOGIC UNIT, CENSUS SUBDIVISION/TRACT,
FEDERAL LAND OWNERSHIP, AND STATE LAND OWNERSHIP.

ONLY RECORDS WITH AT LEAST ONE NON-ZERO ATTRIBUTE ARE PART OF THE FILE. (A VARIABLE NUMBER OF RECORDS EXIST FOR A GIVEN ROW OR COLUMN.)

APPENDIX D.--Sample "Standard" Character-Formated CTG Data File (without header)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 15 | 240200 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 240400 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 240600 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 240800 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 241000 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 241200 | 4321000 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 240200 | 4320800 | 21 | 20197 | 10270102 | 0 | 2099 | 2099 |
| 15 | 240400 | 4320800 | 21 | 20197 | 10270102 | 0 | 2099 | 2099 |
| 15 | 240600 | 4320800 | 21 | 20197 | 10270102 | 0 | 0 | 2099 |
| 15 | 240800 | 4320800 | 21 | 20197 | 10270102 | 0 | 0 | 2099 |
| 15 | 241000 | 4320800 | 21 | 20197 | 10270102 | 0 | 0 | 2099 |
| 15 | 241200 | 4320800 | 21 | 20197 | 10270102 | 0 | 0 | 2099 |
| 15 | 241400 | 4320800 | 21 | 20197 | 10270102 | 0 | 0 | 2099 |
| 15 | 241600 | 4320800 | 21 | 0 | 0 | 0 | 0 | 2099 |
| 15 | 241800 | 4320800 | 21 | 0 | 0 | 0 | 0 | 2099 |
| 15 | 242000 | 4320800 | 21 | 0 | 0 | 0 | 0 | 2099 |
| 15 | 242200 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 242400 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 242600 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 242800 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 243000 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 243200 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 243400 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 243600 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 243800 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 244000 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 244200 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 244400 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 244600 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 244800 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 245000 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 245200 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 245400 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 245600 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 245800 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 246000 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 246200 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 246400 | 4320800 | 31 | 0 | 0 | 0 | 0 | 0 |
| 15 | 246600 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 246800 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 247000 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 247200 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 247400 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 247600 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 247800 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 248000 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 248200 | 4320800 | 21 | 0 | 0 | 0 | 0 | 0 |
| 15 | 240200 | 4320600 | 21 | 20197 | 10270102 | 20197025 | 2099 | 2099 |
| 15 | 240400 | 4320600 | 21 | 20197 | 10270102 | 20197025 | 2099 | 2099 |
| 15 | 240600 | 4320600 | 21 | 20197 | 10270102 | 20197025 | 2099 | 2099 |
| 15 | 240800 | 4320600 | 21 | 20197 | 10270102 | 20197025 | 2099 | 2099 |
| 15 | 241000 | 4320600 | 21 | 20197 | 10270102 | 20197025 | 2099 | 2099 |

[ etc. ... ]



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