science for a changing world

National Mapping Program Technical Instructions

Part 2
Specifications

Standards for Digital Raster Graphics

U.S. Department of the Interior
U.S. Geological Survey

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A complete and current copy of Part 2 of the Standards for Digital Raster Graphics consists of the pages (and most recent creation or revision dates) listed below.

2. SPECIFICATIONS

This part of the standard provides specific information on the production of digital raster graphics (DRGs).

2.1 FILE FORMATS

A USGS DRG is comprised of two physical files, an image file and a metadata file. No specific convention for naming either of these files is required.

Tagged Image File Format (TIFF) 6.0 contains no convenient and standard mechanism for explicitly referencing companion files. Keeping the image file and the metadata file correctly associated with each other is a data management and distribution issue; many solutions are possible, but none are defined by this DRG product standard.

USGS DRGs are usually distributed with a third file, called a world file, used by some commercial GISs for georeferencing. World files are not required.

2.1.1 Image File

2.1.1.1 TIFF Requirements

The Tagged Image File Format is a copyrighted standard of Adobe Systems, Inc. See figure 2-1 for an example of the interpreted output of the tifflib utility tiffinfo for an original coverage DRG.

```
TIFF Directory at offset 0x85c1d2
       Subfile Type: (0 = 0x0)
       Image Width: 5287 Image Length: 6764
       Resolution: 250, 250 pixels/inch
       Bits/Sample: 8
       Compression Scheme: PackBits
       Photometric Interpretation: palette color (RGB from colormap)
       Date & Time: "1996:11:01 08:49:01"
       Software: "USGS CD Archiver program tif2usgsdrg v.1.0"
       Image Description: "USGS GeoTIFF DRG 1:24000 Quad of Dillon.
       Product:478363"

       Samples/Pixel: 1
       Rows/Strip: 1
       Planar Configuration: single image plane
       Color Map: (present)
```

Figure 2-1
Sample DRG TIFF tag content.

A DRG image file is required to conform to the TIFF standard, version 6.0. The DRG image must have the following characteristics, which are restrictions of the TIFF standard:

(1) A DRG must be an 8-bit palette-color image. The PhotometricInterpretation tag (262.d, 106.h) must have a value of 3, the BitsPerSample tag (258.d, 102.h) must have a value of 8, and the ColorMap tag (320.d, 140.h) must have a value of 768 (=3*(2**8)). Palette-color requirements are defined in section 5 of the TIFF 6.0 standard.

(2) The Xresolution (282.d, 11a.h) and Yresolution (283.d, 11b.h) TIFF tags must be equal to each other (pixels must be square) and must contain the correct output pixel resolution. If the image is printed at the resolution specified by these tags, the printout will be at the map scale intended by the data producer.

(3) Although the TIFF standard supports five types of data compression, only PackBits compression (run length encoding) is allowed in a DRG. The Compression tag (259.d, 103.h) will therefore have a value of either 1 (no compression) or 32,773 (PackBits).

(4) The color map must be organized in one of the two ways specified in section 2.7, referred to as "Color Model 1" and "Color Model 2." A specific color map organization is an unusual requirement for a TIFF image. Specialized software may be needed to implement this requirement.

(5) The DateTime tag (306.d, 132.h) is required. The contents of this tag should be obtained from the system clock to guarantee that DRG images created at different times will have different time stamps.

(6) The ImageDescription tag (270.d, 10e.h) of original coverage DRGs has the form "USGS GeoTIFF DRG <scale> Quad of <quad name>. Product:<product_id>". Images made to conform with the current version of the standard must contain this string plus two additional pieces of information: the version number of the DRG product standard and the color model used for the file. The tag contents will have the following form:

USGS GeoTIFF DRG <scale> quad of <quad name>. Product:<product_id>; Standard: V<version>; Color model:<model_number>

where

<product_id> is an arbitrary identifier

<version> is the number of the DRG product standard to which the image conforms. The standard version number is printed in the preface of the preliminary pages of this standard.

<model_number> is 1 or 2, indicating sections 2.7.1 and 2.7.2, respectively

For example, if the DRG described in figure 2-1 was remade according to this version (V2.0) of the standard, the ImageDescription tag might be as follows:

USGS GeoTIFF DRG 1:24000 quad of Dillon. Product: 987654; Standard: V2.0; Color model: 1.

2.1.1.2 GEOTIFF Requirements

GeoTIFF is a public domain extension of TIFF that provides a robust and flexible method of storing georeferencing information in a TIFF file. GeoTIFF was defined by a consortium of private companies and government agencies in 1994-95. The USGS did not play a significant role in defining this standard, but the DRG program was one of the first large GeoTIFF implementations.

GEOTIFF-Specific TIFF Tags

The following four TIFF tags are required to be present and correctly populated in a USGS DRG. These are registered TIFF tags. Although they are part of the standard TIFF Image File Directory (IFD), they are defined by the GeoTIFF standard, not the base TIFF standard:

(1) ModelPixelScaleTag (33550.d, 830e.h). The X and Y values in a DRG must be equal to each other (pixels must be square) and to the ground distance of one DRG pixel. For 1:24,000-scale DRGs at 250 lines per inch scan resolution, these values are both 2.4384 (meters). See section 2.6.1 of the GeoTIFF standard.

(2) ModelTiepointTag (33922.d, 8482.h). This tag specifies the (X,Y) ground coordinates of the (0,0) image pixel, by convention the upper left corner of the image. In most USGS DRGs, the UTM is the ground coordinate system. GeoTIFF allows considerable flexibility in how an image is tied to the ground, but this DRG standard requires the tie to be to the (0,0) pixel and the Z coordinate values to be set equal to 0. See section 2.6.1 of the GeoTIFF standard.

(3) GeoAsciiParamsTag (34737.d, 87b1.h). This tag is used to store all the ASCII-valued GeoKeys. For the most part, the only keys that are ASCII valued are citation keys. See section 2.4 of the GeoTIFF standard.

(4) GeoKeyDirectoryTag (34735.d, 87af.h). This tag references all non-ASCII GeoKeys. All projection and datum information is stored in GeoKeys. See the next section of this standard and section 2.4 of the GeoTIFF standard.

GEOKEYS

GeoKeys are structurally similar to TIFF tags, but at one lower level of abstraction. The following GeoKeys are required in a USGS DRG:

(1) GTModelTypeGeoKey (1024.d, 400.h). The required value is 1 (ModelTypeProjected) for USGS DRGs.

(2) GTRasterTypeGeoKey (1025.d, 401.h). The required value is 1 (RasterPixelIsArea) for USGS DRGs.

(3) ProjectedCSTypeGeoKey (3072.d, c00.h). This key contains a coded value for the projection, datum, and possibly plane coordinate zone. USGS DRGs may use only the values explicitly listed in section 6.3.3 of the GeoTIFF standard. User-defined values, though allowed by the GeoTIFF standard, are not permitted in USGS DRGs.

(4) PCSCitationGeoKey (3073.d, c01.h). This is a free text field for describing the projection and datum. Most USGS DRGs are projected on the UTM and use this field to describe the projection, zone, and datum. In these cases, the GeoKey contents are required to be of the form "**UTM Zone <number> <N/S> with <datum>**", where

<number> is the UTM zone number, and

<datum> is the common datum abbreviation, such as NAD27 or NAD83.

See figure 2-2 for an example.

Contents of the PCSCitationGeoKey are for descriptive purposes only. Application software may display this key as simple metadata but should depend on the ProjectedCSTypeGeoKey for precise coordinate system information. Applications should not attempt to parse the PCSCitationGeoKey to obtain projection or datum information.

Other GeoKeys may be populated at the data producer's option, provided that all additional keys are consistent with these four required keys.

```
Geotiff_Information:
      Version: 1
      Key_Revision: 0.2
      Tagged_Information:
            ModelTiepointTag (2,3):
               0                 0                 0
               608981.286        4207278.14        0
            ModelPixelScaleTag (1,3):
               2.4384            2.4384            0
            End_Of_Tags.
      Keyed_Information:
            GTModelTypeGeoKey (Short,1): ModelTypeProjected
            GTRasterTypeGeoKey (Short,1): RasterPixelIsArea
            ProjectedCSTypeGeoKey (Short,1): PCS_NAD27_UTM_zone_15N
            PCSCitationGeoKey (Ascii,25): "UTM Zone 15 N with NAD27"
            End_Of_Keys.
      End_Of_Geotiff.

PCS = 26715 (NAD27 / UTM zone 15N)
Projection = 16015 (UTM zone 15N)
Projection Method: CT_TransverseMercator
      ProjNatOriginLatGeoKey: 0.000000 (  0d 0' 0.00"N)
      ProjNatOriginLongGeoKey: -93.000000 ( 93d 0' 0.00"W)
      ProjScaleAtNatOriginGeoKey: 0.999600
      ProjFalseEastingGeoKey: 500000.000000
      ProjFalseNorthingGeoKey: 0.000000
GCS: 4267/NAD27
Datum: 6267/North American Datum 1927
Ellipsoid: 7008/Clarke 1866 (6378206.40,6356583.80)
Prime Meridian: 8901/Greenwich (0.000000/  0d 0' 0.00"E)
Projection Linear Units: 9001/meter (1.000000m)

Corner Coordinates:
Upper Left     (608981.286,4207278.139)
Lower Left     (608981.286,4190784.802)
Upper Right    (621873.106,4207278.139)
Lower Right    (621873.106,4190784.802)
```

Figure 2-2
Sample DRG GeoTIFF tag content.

The listing in figure 2-2 is interpreted output of the libgeotiff utility listgeo, not a literal dump of GeoTIFF tags and keys. Projection information below the line "End_Of_Geotiff" is implied by the standard projection and is not stored explicitly in the data file. The descriptions are retrieved from libgeotiff look-up tables in the listgeo application. Similarly, only the first of the four image corner coordinates is stored explicitly; the rest are computed by the application. Note that these coordinates are the UTM values of the corners of the image, not of the map neatline. Note also that this application shows only two GeoTIFF-specific TIFF tags, even though four are present in the file. The other two (GeoASCIIParamsTag and GeoKeyDirectoryTag) contain pointers to GeoKeys, not actual data.

2.1.2 Metadata File

Each DRG image must be accompanied by exactly one companion file of metadata. The metadata file is based on the Federal Geographic Data Committee (FGDC) Content Standard For Digital Geospatial Metadata. See section 2.9 for information about the content of this file.

The FGDC standard is a content standard only and does not specify any physical format for metadata files. Original coverage DRGs used an ad hoc, plain text format for the metadata files. The text was organized to reflect the organization of the content standard document.

DRGs made since 1999 use a plain text format that is similar but adheres to additional rules for text syntax and organization. DRG metadata files are now required to be consistent with the FGDC metadata parser (MP) software system.

Neither of these physical file formats conforms to any formal specification. Writing parsing software against examples of these files is not recommended.

2.2 DATA SOURCES

Original coverage DRGs were made by scanning paper maps. New version DRGs are made from several data sources:

(1) From scans of paper maps.

(2) From the outputs of digital map revision processes. These data are digital feature separates, used to plot negatives for printing new maps. The digital separates can be combined directly to make a DRG. These revision processes can be either vector based or raster based; in both cases, the final outputs are symbolized raster separates.

(3) From scans of the original map materials. This is similar to using the outputs of digital revision; digital feature separates are combined to make a DRG.

Original coverage DRGs were almost all of standard topographic quadrangles. Since the completion of the original data program, an increasing number of non-standard DRGs have been made from other maps, including National Park maps, historical maps, and Antarctica maps. In most cases, these DRGs were made by scanning paper copies of the published map sheets. Many of these DRGs did not conform to the original product standard because it was not possible to reduce the number of colors to 13. The changes to section 2.7 should make it possible to make a compliant DRG from any map.

2.3 COVERAGE

The standard area of coverage of a DRG is the entire area printed on a USGS map, including the map collar, any overedge areas, and insets. Original coverage DRG sources include the following:

- 1:10,000- or 1:12,000-scale maps of some islands in the Pacific Ocean
- 1:20,000- or 1:30,000-scale maps of Puerto Rico
- 1:24,000- or 1:25,000-scale maps of the conterminous United States, Alaska, Hawaii, and U.S. Territories
- 1:63,360-scale maps of Alaska
- 1:100,000-scale maps of the conterminous United States and Hawaii
- 1:250,000-scale maps of the conterminous United States, Alaska, and Hawaii

2.4 DRG RESOLUTION

2.4.1 Scan Resolution

DRG source materials are scanned on a high-quality, multicolor scanner capable of resolutions of at least 500 dpi. Scanner limitations, large image file sizes, processing times, and intended use of the data are considerations in the choice of a scanning resolution.

DRGs produced under the current standard must be scanned at a real scan resolution of at least 500 dpi. The final product may be downsampled to 250 dpi at the data producer's option. Experience has shown that downsampling from a 500 dpi scan produces a higher quality image than scanning at 250 dpi.

Earlier versions of this standard did not contain this requirement. Most original coverage DRGs were scanned at 250 dpi.

2.4.2 Output Resolution

The final output resolution of a DRG must be at least 250 dpi, but not more than 1,000 dpi.

Though any output resolution in this range is permissible, the USGS recommends resolutions of 250 and 500 dpi be used for most data. Tests show very little improvement in quality, especially when scanning paper maps, at resolutions higher than 500. The minor quality improvement rarely justifies the greatly increased file sizes.

The original DRG product standard allowed only one output resolution, 250 dpi. All original coverage DRGs are at this resolution.

The output resolution of the DRG image will be stored in the TIFF tags Xresolution (282.d, 11a.h) and Yresolution (283.d, 11b.h). DRG pixels must be square, so these two tag values must be equal. The value of these tags should be such that an application that uses this value to print the image will print the map at correct scale.

2.5 GEOREFERENCING

DRGs must be georeferenced; that is, the data must contain all information needed to transform image coordinates to a ground coordinate system. This information is carried primarily in the image file's GeoTIFF tags (section 2.1.1.2) and secondarily in the FGDC metadata file (sections 2.1.2 and 2.9).

USGS DRGs are georeferenced by fitting computed UTM values to each latitude and longitude tick on the source map. These ticks include the corners of the map neatline. Table 2-1 shows the number of ticks georeferenced for each map series.

Table 2-1
Georeferenced ticks for standard series maps

Scale	**Area of Coverage**	**Tick Spacing**	**Ticks Referenced**
1:24,000 and 1:25,000	7.5- X 7.5-min	2.5 min	16
1:25,000	7.5- X 15-min	2.5 min	28
1:100,000	30- X 60-min	15 min	15
1:250,000	1 deg X 2 deg	15 min	45

No particular image tranformation is required. Various commercial and custom software packages have been tested for DRG production, and found to produce nearly identical results. Variations between tested transformation implementations were less than the size of 1 DRG pixel at 250 dpi. Although some transformation differences could become measurable at finer resolutions, it is doubtful they will ever be significant.

2.5.1 Projections and Horizontal Datums

As stated in section 2.1.1.2, a DRG is required to use the ProjectedCSTypeGeoKey to specify the projected coordinate system of the image. Allowed values for this GeoKey are listed in section 6.3.3.1 of the GeoTIFF standard.

This requirement essentially means that a DRG must use relatively common combinations of standard projections, coordinate systems, and horizontal datums. Although the GeoTIFF standard allows user-defined projections and datums, these are not permitted in USGS DRGs. Only projected coordinate systems explicitly listed in section 6.3.3.1 of the GeoTIFF standard are allowed.

The USGS attempts to use the UTM projection and coordinate system for most DRGs.

Changing the map projection in the DRG creates a conflict between the DRG metadata and the printed map collar that is part of the DRG image. The map collar contains metadata for the printed map. The DRG is not required to use the same projection or coordinate systems.

The USGS also attempts to retain the datum of the published map. However, the requirement to use only GeoTIFF-standard coordinate systems means that this is not always possible. Two examples of horizontal datums used on USGS maps that are not included in the GeoTIFF standard are the Old Hawaiian and Guam datums.

Changing the datum also creates a conflict between the map collar and the DRG image and metadata. Changing the datum of the scanned map image changes the coordinate values of the neatlines and grids, which means that coordinate values printed in the map margins will not match software readouts. DRG producers should be aware that this can be very confusing for end users.

2.5.2 Overedge and Map Insets

Georeferencing of overedge areas and map insets is optional, because of its technical difficulty. Specialized software, advanced GIS expertise, or both are usually needed. Some transformations commonly used for DRG georeferencing require control points to be evenly spaced. The 2.5-minute tick marks meet this requirement for standard cells, but slivers outside the standard cell boundary cannot be included. Similarly, insets are maps within maps and can be very complicated to georeference without creating separate image files.

USGS DRGs do not georeference overedge areas or map insets. Although software may display ground coordinates for these areas, the coordinate values are simple extensions of the image plane and will not necessarily have a meaningful relationship to the Earth’s surface.

2.6 HORIZONTAL ACCURACY

DRG production processes are designed to preserve the accuracy of the source materials. Although it is not possible to improve the accuracy of a map significantly by scanning it, it is possible to retain the accuracy of the source map. In practice, small errors tend to be introduced by inexact point selection during georeferencing. In general, these errors from DRG production tend to be smaller than errors present in the source map.

See section 2.8.3 for horizontal accuracy evaluation techniques and tolerances.

2.7 COLORS

The original version of this standard specified exactly one color model. This model was designed to retain the linework character of a typical USGS topographic quadrangle by requiring DRG colors to match standard ink colors.

The original model has advantages, particularly for GIS users of the data. However, it is very difficult to apply to maps other than normal USGS topographic quadrangles. For this reason, the current version of the standard introduces a second acceptable color model.

Both color models are required to conform to the base TIFF standard for 8-bit palette-color images (see section 5 of the TIFF 6.0 standard).

The ImageDescription tag (270.d, 10e.h) is required to specify which of these two color models is used. See section 2.1.1.1.

2.7.1 Color Model 1: Standard Colors in a Reduced Color Map

Although only six inks are used on a USGS topographic map, halftone screening normally simulates up to six more colors (and sometimes more). The white background of the map is one additional color. Original coverage USGS DRGs required a color map, or look-up table, consisting of 13 colors.

In addition to meeting the requirements of TIFF, a DRG color map is required to contain specific RGB values, and the colors themselves must be arranged in a specific order. These values and their order are listed in table 2-2.

These requirements for predefined RGB values and color map index order are unusual for a TIFF file and are specified as a convenience for GIS users. Because colors on USGS maps correspond to feature types, it is useful for many map applications to know color values and ordering in advance.

Table 2-2
The USGS DRG color map

Digital Number	**Color**	**Red**	**Green**	**Blue**
0	Black	0	0	0
1	White	255	255	255
2	Blue	0	151	164
3	Red	203	0	23
4	Brown	131	66	37
5	Green	201	234	157
6	Purple	137	51	128
7	Yellow	255	234	0
8	Light Blue	167	226	226
9	Light Red	255	184	184
10	Light Purple	218	179	214
11	Light Gray	209	209	209
12	Light Brown	207	164	142

The colors listed in table 2-2 are chosen to represent as closely as possible the colors of the printed map. However, variations in the colors of printed maps caused by different brands of ink, different presses, map age, and other factors make it difficult to completely standardize DRG colors. Most DRGs contain moderate amounts of color "noise" caused by incorrect color mappings.

2.7.2 Color Model 2: Non-Standard Color Map

At the option of the data producer, a DRG may be made with the following color characteristics instead of those described in section 2.7.1

Color slot 1 will designate the map background. This is usually the color of the paper, and in the normal case will be white (255,255,255). However, these exact RGB values are not required. Production procedures should use appropriate scanning or data processing techniques to ensure that most pixels in the map background are mapped to color slot 1. The purpose of this requirement is to allow GIS applications to render the map background transparent.

The remaining 255 colors may be used in any way the data producer deems appropriate. Colors may be in any order, with any RGB values.

Data producers are encouraged to use this model only when the nature of the source data makes the reduced color map specified in section 2.7.1 impractical. The USGS anticipates using this new model for Forest Service single-edition topographic maps, orthophotomaps, some standard topographic maps with unusual tints (for example, lava flows and water depth), and most thematic, geologic, and hydrologic maps.

2.8 DATA QUALITY

Because of the large number of DRG's produced in a short time, quality control for original coverage DRGs was done in part by sampling selected attributes of each image. Occasional errors are still found in some of these data.

In general, the goal of DRG production is to duplicate the quality of the published map. Errors in the original map can only be fixed by revising the map, a process that is always much more expensive and time consuming than fixing a DRG error.

2.8.1 Image Completeness and Quality

Image completeness is checked by visually inspecting each DRG image. Different parts of the image are inspected for gaps, color errors, and other visual artifacts. There is no absolute, quantitative standard for acceptable image quality, but there are qualitative guidelines.

2.8.1.1 All DRGs

The following two quality guidelines apply to all DRGs:

(1) Preserving the spatial information present in map linework is top priority. Unbroken lines on the map should remain unbroken in the DRG. Any significant amount of introduced linework breakage or dropout makes an image unacceptable.

(2) Preserving text information is also top priority. Illegible feature names, for example, make an image unacceptable. Text information in the map collar, though also important, is less important than text inside the neatline. This lower priority is because of the technical difficuties of preserving collar information through the georeferencing process. Nevertheless, most of the collar must be readable.

2.8.1.2 DRGs That Use Color Model 1

The following three quality guidelines apply only to DRGs that use color model 1 (see section 2.7.1) and are made by scanning paper maps or color composite source materials:

(1) Preserving the color of map linework is medium priority. It is desirable for all lines of like color on the map to be of consistent color in the DRG. However, this is not as critical as preserving unbroken lines. Moderate amounts of color misclassification are tolerated in linework, particularly in lines that are difficult to scan because of light color, fine lineweight, or both (contours on older maps, for example). "Moderate" means in the range of 5 percent-10 percent pixel misclassification for black lines, up to the range of 10 percent-30 percent for contours, depending on the condition of the scan materials.

(2) Correct classification of the map background color is medium priority. This is important to GIS applications that need to make the map background transparent to other data.

(3) Area fill tints (timber, urban fill, water bodies, and so on) are lowest priority. The "information/ink" ratio of fill tint is relatively low. Further, it is technically difficult to scan lithographic screen dots. Image processing techniques can and should be used to improve the consistency of screened areas (see section 2.8.2), but relatively large amounts of color noise and pixel misclassification can be tolerated in areas with fill tints. It is critical that fill tints not obliterate the linework that runs through them. Guidelines 1 and 2 for all DRGs above apply equally to areas with and without fill tint.

2.8.1.3 DRGs That Use Color Model 2

DRGs made with color model 2 (see section 2.7.2) must faithfully reproduce the visual appearance of the printed map. This includes preserving the information of all fill tints. Color model 2 will usually be used for thematic maps, where fill tints contain more information than tints on standard topographic quadrangles.

2.8.1.4 DRGs From Digital Data

When a standard topographic quadrangle is revised by the USGS or its contractors, a new DRG is made by using digital feature separates or by scanning stable-base feature separates. In either case, the resulting DRG is expected to have much higher image quality than a DRG made by scanning a paper map:

(1) The image must be almost completely free of line breaks and color noise.

(2) No lithographic screens will be used. Area fills will be of a uniform color. Area fill will not interfere with any linework.

2.8.2 <u>Descreening and Color Noise Reduction</u>

DRGs made from paper map scans are descreened whenever technically practical. Descreening removes the lithographic dots of area fill tints and replaces them with a smooth color fill. The success of this process depends on several things, including the quality of the source materials, time and effort spent on scanner calibration, and types of image processing techniques available.

Image processing techniques are also used whenever practical to remove extraneous misclassified pixels. Descreening and noise reduction procedures are more art than science, and there is no absolute or quantified quality standard by which to judge their success.

The procedures are generally considered worthwhile if both these conditions are true:

(1) File size is reduced by replacing many small lithographic dots with larger, "smooth" color areas.

(2) The visual appearance of the image is made better (or at least not made worse) when judged by the guidelines in section 2.8.1.

Screens and color noise are issues only for DRGs made by scanning paper maps. DRGs made from digital data do not use lithographic screens and therefore do not require descreening. The color noise in such data is usually extremely low.

2.8.3 Positional Accuracy

DRG accuracy is measured by comparing the grid ticks used for control points with their theoretically correct positions. The average displacement must be less than 4 pixels and the maximum displacement must be less than 8 pixels.

Note that this comparison is with theortically correct corner positions, not with positions of the original map. The printed map graticule usually contains small errors caused by the original plotting and scribing or introduced by material deformation. These errors tend to be removed by DRG georeferencing.

Some original coverage DRGs do not meet this accuracy standard. When found, these data sets are placed in a queue for reprocessing and are corrected as time and resources permit.

2.8.4 Georeferencing

The georeferencing of each DRG is confirmed by viewing the image in GIS software other than the software used to make the image.

Occasional errors are still discovered in the georeferencing of original coverage DRGs. When found, these data sets are placed in a queue for reprocessing. Georeferencing errors are assigned the highest priority in this correction queue.

2.9 METADATA

Federal agencies are required by Executive Order 12906 (April 11, 1994) to include metadata with all digital geospatial data. Executive Order 12906 established the National Spatial Data Infrastructure and adopted the FGDC's Content Standard for Digital Geospatial Metadata to provide a consistent approach and format for the description of data characteristics. Each DRG has an associated metadata file that complies with this standard.

The USGS has a separate implementation standard for metadata, Standards for the Preparation of Digital Geospatial Metadata. Part 5 of the standard defines DRG metadata. The DRG metadata implementation is relatively simple:

- "Series level" metadata about both the source maps and the DRG are written in a small number of text "templates." Each template covers a large number of similar maps.

- "Quadrangle level" metadata are extracted from USGS databases and inserted into the templates by software. Examples of quadrangle level metadata are the name and publication date of a particular map.

The templates are filled in automatically for each DRG by software. This makes the metadata relatively consistent and very inexpensive, but it also means that errors present in any of the source databases are propagated to the DRG metadata file. Some additional errors were introduced through software bugs early in the DRG program. When metadata errors are found, the DRG is placed in a queue for replacement, though with a relatively low priority.

Refer to section 2.1.2 for information about the physical format of DRG metadata files.