

National Geospatial Program

Standards for Scanned U.S. Geological Survey Historical Topographic Quadrangle Collection



Techniques and Methods 11–B3

Cover:

Cartographers in the Field This Depression-era oil painting, created by Hal Shelton in 1940, depicts mapping techniques used in the early days of cartography, including an alidade and stadia rod for determining distances and elevations and a plane-table for sketching contour lines. This 4-by-6 foot painting is on display in the USGS library in Menlo Park, California. Photograph by Terry Carr, USGS.

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By Gregory J. Allord and Kristin A. Fishburn

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

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

English to Metric

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
Area		
square mile (mi ²)	2.590	square kilometer (km ²)

Metric to English

Multiply	By	To obtain
Length		
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
Area		
square kilometer (km ²)	0.3861	square mile (mi ²)

A U.S. Survey Foot is defined as: 1 meter = 39.37 inches. Dividing 39.37 inches by 12 (12 inches per foot), the resulting conversion factor is 1 meter = 3.280833333. U.S. Survey Feet (reference www.ngs.noaa.gov/faq.shtml).

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Introduction

The U.S. Geological Survey (USGS) is scanning all scales and all editions of about 200,000 topographic maps published by the USGS since the inception of the topographic mapping program in 1884. This scanning provides a comprehensive digital repository of USGS topographic maps that are easily discovered, browsed, and downloaded by the public at no cost. Each map image is scanned “as is” and captures the current content and condition of each one. The project provides ready access to maps that are either no longer available for distribution in print, or are being updated by the new generation of US Topo maps. John Wesley Powell gained authorization from the U.S. Congress to begin systematic topographic mapping of the United States in December 1884, and the USGS created and printed topographic maps using traditional cartographic methods and lithographic processes up until 2006 (U.S. Geological Survey, 2010a, 2010b). Thus, all topographic maps and special purpose maps produced between 1884 and 2006 are included in the project. See the project web site (<http://nationalmap.gov/historical/>) for more detailed information that describes the large scope of the project, including production status and numbers.

The USGS is accurately cataloging and creating metadata (complete information about each map) to accompany high-resolution, georeferenced digital files representing the lithographic maps. Digital maps are georeferenced (tied to a known earth coordinate system) to provide for basic map analysis, such as distance and area calculation, and coordinate readouts.

Two digital formats are used for distribution of the maps: 1) Portable Document Format (PDF) with a geospatial extension that is called Georeferenced PDF (GeoPDF®); and 2) Tagged Image File Format (TIFF) with an accompanying transformation file in Extensible Markup Language (XML) readable by open-source and proprietary Geographic Information Systems (GIS). This XML file contains the transformation parameters necessary to georeference the unprocessed TIFF image. Georeferenced TIFFs then can be integrated into a GIS with geospatial data from other sources, such as *The National Map (TNM)* (<http://nationalmap.gov/index.html>).

Background

Topographic maps originally were produced to support minerals exploration, but they quickly became popular with many other disciplines and with the general public because of their usefulness for viewing and studying the Nation’s vast landscape (U.S. Geological Survey, 2010a, 2010b).

Technological capability in the early days constrained broad distribution of maps, and although there were map libraries for published paper maps, they were lending libraries, not archives. Nor was a catalog developed or published to document a list of all maps produced since 1884. Over time, some maps have been lost from USGS libraries, and therefore no single complete set of USGS historical maps is known to exist. Part of the challenge of this project is to find those maps that are not readily available in USGS map warehouses and archives. The USGS is working closely with Library of Congress to discover maps in its Archives collection. There are many interested parties that may be able to donate historical USGS maps that cannot be found elsewhere, including local libraries, university geological collections and libraries, and state geological surveys. Map contributions can be made by contacting the USGS via <http://nationalmap.gov/historical/contact.html>.

Advances in GIS technology motivated the USGS to produce a scanned, georeferenced map series in the mid-1990’s that could be easily integrated into a GIS. These Digital Raster Graphics (DRGs) initially were produced from 1995 to 1998 in partnership with Land Information Technology Company, Ltd. About 1,000 new DRGs were added during the next several years. The objective of this program was to scan and georeference the most recent published version of the USGS standard quadrangle maps for the 7.5-minute, 30x60-minute, and 1x2-degree series (U.S. Geological Survey, 2001a, 2001b). The scanned historical topographic quadrangle collection uses a higher resolution and more advanced color model than the DRGs, and provides both the TIFF and GeoPDF delivery formats. A more extensive set of metadata is captured and catalogued, and the project provides a permanent digital archive of historical maps that includes all printings and all series produced by the USGS.

Applicability

When physical and cultural features change over time, maps are updated, revised, and new editions are printed. Although they are out of date, these historic maps are often useful to scientists, historians, environmentalists, genealogists, and others who are researching a particular geographic location or area. A series of maps of the same area published over time can show how some areas looked as early as 1884, before current development, and provide a detailed view of changes.

In digital form, and with the added benefit of georeferencing, the maps become a versatile document that can be viewed individually, or viewed together across large areal extents. The digital maps provide the capability to zoom, pan, readout coordinates, measure map distances and areas, and print any desired portion of the map. By publishing the maps in two formats, the USGS satisfies conventional users who can use the GeoPDF without GIS equipment or expertise, and advanced users who can integrate the TIFF with other data and maps in a GIS.

Maintenance

The National Geospatial Program (NGP) of the USGS maintains standards for *The National Map*. Submit questions and comments concerning this document through the National Geospatial Program Standards and Specifications website at <http://nationalmap.gov/standards> or email nmpstds@usgs.gov.

Product Overview

The general characteristics of the scanned historical maps are as follows:

- The digital maps are produced by scanning an entire paper map, including the complete map collar (such as, legend, dates, sources, overedge data, and insets).
- The maps are produced in two physical formats intended for distribution:
 - A GeoPDF is produced for users in the general public who wish to have reference maps.
 - An unprocessed TIFF is produced for GIS users. The TIFF is not georeferenced, but it is accompanied by an XML file that provides the transformation parameters necessary to georeference the unprocessed TIFF image.
- Scan resolution typically is 600 pixels per inch (PPI) (although some maps are scanned at 400 PPI).
- File sizes generally are less than 20 megabytes (MB) for the GeoPDF, and the TIFFs range from 500 MB

to 1.4 gigabytes (GB), depending on the original map sheet size.

- The TIFF file has a color bit-depth of 8 bits per Red, Green, Blue (RGB) color channel.
- The TIFF file is not compressed.
- The GeoPDF is produced using Joint Photographic Experts Group (JPEG) compression with a quality setting of 25 percent.
- For the GeoPDF, the image inside the map frame (map collar is excluded) is georeferenced to the native datum and projection of the original map.
- At full resolution, the digital maps preserve the accuracy of the original map, but do not improve it.
- Maps are scanned “as is,” meaning no extraneous notes, marks, or paper background discolorations have been adjusted or removed.
- Each map geographic location and extent are defined according to standard USGS topographic cells. These cells are defined in the Geographic Cell Names Database (GCNDB) as part of the Geographic Names Information System (GNIS).
- Metadata is captured in an XML file that complies with the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM) (Federal Geographic Data Committee, 1998).

Data Sources

All editions of all USGS standard topographic maps at all published scales series are included in the scanning project. Every printing (that is, restock and/or update) of each historical quadrangle is being scanned. Each map image is scanned “as is,” no enhancements or restorations are made.

The information in the map collar varies depending on the original product, but may include USGS and U.S. Department of Interior logos, map title, map date, source notes, projection, horizontal and vertical datum and coordinate system information, quadrangle location and adjoining quadrangle diagrams, scale bars and map scale, accuracy statements, north arrow and magnetic declination diagram. Much of this information is captured as metadata for cataloguing purposes. The USGS initially captures this data and stores it in a database, a subset of which is used to populate the XML FGDC compliant metadata file that accompanies the GeoPDF and TIFF maps. A link to the complete metadata database is provided at <http://nationalmap.gov/historical/>, where a user may export and download data from the database into a Comma-Separated Variable (CSV) formatted file readable in many database or spreadsheet software packages.

Distribution and Supporting File Formats

The product defined by this standard is a digital file distributed in two formats.

The first is a single-layered GeoPDF. Although this standard is driven in part by the capabilities of specific commercial software systems, it is notable that Adobe Systems, Inc. released the PDF1.7 specification to be published by the International Organization for Standardization (ISO). The document is now available as ISO 32000-1 (see <http://www.iso.org/iso/pressrelease.htm?refid=Ref1141>) (International Organization for Standardization, 2008). Adobe continues to document extended features that are based upon ISO 32000-1 (PDF1.7), including geospatial encoding, and has submitted these extensions to the ISO for inclusion in future ISO specification revisions (http://www.adobe.com/devnet/pdf/pdf_reference.html) (Adobe Systems Inc., 2009). TerraGo Technologies developed and patented the GeoPDF georegistration technique and holds the implementation rights. This geospatial extension to PDF has been published as an Open Geospatial Consortium (OGC®) Best Practices specification, PDF Georegistration Encoding Best Practice Version 2.2, OGC 08-139r3, 2011-1-17. Note that an OGC Best Practice is “a technique or methodology that, through experience and research, has proven to reliably lead to a desired result.” An OGC Best Practice is not a standard, but is a means to recognize stable and reliable technological practices (see <http://www.opengeospatial.org/standards/bp>) (Demmy and Reed, 2011).

The GeoPDF lets individuals use georeferenced maps and data, providing spatially correct information. It specifically provides a scalable display of the digital map or image with crisp, clear delineation of roads, rivers, contour lines, and other features as the user zooms in for a closer look. PDF maps can be viewed and printed with any conforming PDF viewing or editing software. Adobe® Reader® versions 9.x and 10.x are known to read and display the functions implemented by USGS datasets correctly, and the software may be downloaded for free at <http://get.adobe.com/reader/>. Adobe Acrobat® software may be used in lieu of Adobe Reader, if available. The TerraGo® Toolbar™ is a plug-in that enhances the capabilities of Adobe Reader and Acrobat by taking advantage of the PDF geospatial extensions to allow (for example) reading ground coordinates and measuring ground distances. This plug-in also is available for free and may be downloaded from <http://usgs.terragotech.com/home/> (TerraGo Technologies Inc., 2011). At this time (2011) it is only available for Microsoft® Windows® operating system versions of Reader and Acrobat.

Supporting files for the GeoPDF maps include an integrated metadata file in XML format that conforms to the FGDC CSDGM and a thumbnail image of the scanned historical topographic quadrangle in JPEG format. The XML format provides a set of rules for encoding documents in computer-readable text form. These metadata documents, which are

open-source and can be accessed by a variety of text reading software programs, provide information to a user about the data and products they are using. The thumbnail image is very low resolution / small file size that allows the user to quickly obtain a big picture view of the map scene. Users may be able to distinguish water, land and vegetated areas, but text and individual features are not discernible. The thumbnail is used to allow the user to preview a map prior to downloading the larger GeoPDF.

The second distribution format is a full resolution TIFF file for storing images as scanned by USGS, contractor or contracting partner. No sacrifices in image quality are made to reduce the space requirements of the image. The only change to the original scanned file is that the page size is clipped to eliminate extraneous white space. This change creates consistency in the page size and more closely matches the original printed size. Adobe holds the copyright to the TIFF specification (<http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf>) (Adobe Systems Inc., 1992).

Supporting files for the TIFF maps also include an XML metadata file conforming to the FGDC CSDGM. In addition, the TIFFs are accompanied by an XML file that contains parameter values for transformation that can be used to convert the scanned image into a new image file whose pixels are georeferenced. This XML file can be used by open-source as well as proprietary geographic information systems to automatically georeference the TIFF. It is compatible with the Geospatial Data Abstraction Library (GDAL), a free and open source translator library for raster geospatial data formats released by the Open Source Geospatial Foundation (see <http://www.gdal.org>). An example of the content contained in the transformation file can be seen in Appendix A. It includes parameters and information for the datum, spheroid, prime meridian, and coordinates. Last, a browse image of the scanned historical topographic quadrangle in JPEG format is included to provide the user with a preview of the map, but at a higher resolution and file size than the thumbnail. The browse image allows the user to identify in more detail the overall trends of the mapped area. Large individual features, such as urban areas, rivers and lakes, are visible, but the user may not be able to discern smaller map features and most text.

The TIFF, text georeference, and metadata files are packaged using the BagIt file packaging format (<http://tools.ietf.org/pdf/draft-kunze-bagit-06.pdf>) (Boyko and others, 2011). BagIt is a hierarchical file packaging format that is used when storing and transferring digital content. Included are the actual content or “bag” and then metadata “tags” that document the storage and transfer of that content. These file formats are ideal for digital content that is part of a collection of files and are well-suited for exporting and archiving because they use ordinary transferring and filing tools that are familiar and available cross-platform. It also is widely adopted in digital libraries, such as the Library of Congress.

Resolution, Bit Depth, File Size, and Compression

Scanner optical resolution refers to the number of pixels per inch that the scanner actually samples. The minimum requirement for scanning resolution is 400 PPI. However, 600 PPI results in higher image quality without resulting in an unmanageable file size. Thus, the majority of the maps are scanned at 600 PPI. This resolution maintains the visual integrity of the maps as printed and supports a high level of accuracy when the scanned TIFF images are georeferenced.

Bit depth represents the precision with which colors are specified in an image. For example, an 8-bit image (alternatively called a 24-bit image) stores 8 bits per pixel for each of the three primary color channels (Red, Green, and Blue), or 256 intensity values for each primary color. Higher bit depth results in a larger file size. An 8-bit image is a true-color image appropriate for high quality printing, and thus is required for the historical topographic quadrangle collection.

For the GeoPDF, the objective is to produce a digital map that supports high quality printing and yet is a manageable file size for storage, view, and manipulation in its native digital format. The goal is to produce a GeoPDF with a file size less than 20 MB. This is a goal, not a hard requirement, because the source map sheet size varies. This file size is small enough for optimal performance, and large enough to maintain high quality for printing. The GeoPDF is produced by first georeferencing the unprocessed TIFF. JPEG compression then is used to produce the GeoPDF, which provides smaller file sizes and maintains the image quality. Note that compression is achieved with built-in features of commercial software for which precise algorithms are proprietary. Displaying and printing requires decompressing the data, which is done automatically by Adobe Reader software.

The TIFF is produced specifically for GIS users who have hardware and software that can handle large file sizes for zooming and panning through the data and running complex analysis tools. High quality viewing and printing also is a goal for the TIFF. Typically the TIFF maps will range from 500 MB to 1.4 GB, again depending primarily on the original map sheet size.

Datums, Projections and Coordinate Systems

The georeferencing process requires that the original datum of the paper map be used. This information normally is found in the map collar, although with some of the older maps, the map datum is not stated or only the ellipsoid (typically Clarke 1866) is included. In those cases, the North American Datum of 1927 (NAD 27) is used, as georeferencing results meet accuracy requirements. See Appendix A for further discussion about the history of datums used by the USGS.

GeoPDF maps are georeferenced to the original datum and are also re-projected to the original map projection. The intent is to provide the user with a map that may be printed in

its original form. The transformation XML file that accompanies the TIFF contains the parameters required to georeference the TIFF to the datum and projection used in the original map. GIS software provides the capability for the user to project the scanned map as required for integration with other geospatial data.

Note that the TerraGo Toolbar used with the GeoPDF provides a coordinate readout capability and also allows the user to change the datum and projection, as required. GIS applications provide more advanced capabilities for converting and re-projecting the TIFFs.

Georeferencing

The Georeferencing tool used by the USGS for the scanned historical topographic quadrangle collection was developed by the University of Wisconsin in Madison. A user guide for the process and software used to georeference the scanned TIFF images may be found at: <http://www.geography.wisc.edu/research/projects/QUAD-G/> (Burt and others, 2011).

USGS has built the georeferencing tool into the production process to create a fully georeferenced GeoPDF and to create the XML file, with the transformation parameters that accompany the TIFF. The process uses all corner and graticule tick coordinates available in the map to maintain the accuracy of the original map. Each of the historical map series and the associated number of graticule corners and ticks used in the georeferencing process are listed in table 1.

Table 1. Map scale (series) and graticule ticks.

Map scale (series)	Number of graticule ticks used for georeferencing
1:24,000 (7.5 x 7.5 minutes)	16
1:25,000 (7.5 x 7.5 minutes)	16
1:24,000 (7.5 x 15 minutes)	28
1:31,680 (7.5 x 7.5 minutes)	16
1:48,000 (15 x 15 minutes)	16
1:62,500 (15 x 15 minutes)	16
1:63,360 (15 x 15 minutes)	16
1:63,360 (Alaska)	Varies
1:100,000 (30 x 60 minutes)	45
1:125,000 (30 x 30 minutes)	16
1:250,000 (1 x 2 degrees)	45

Data Quality

Components of data quality typically include currency, consistency, completeness, and accuracy. Since the objective of this project is to create a digital archive and dissemination capability for *historical* maps, the standards for currency,

consistency, and completeness vary according to the standards that were used to produce the original map. Scanning does not affect these characteristics of data quality.

Regarding positional accuracy, however, the historical map product was compiled to meet National Map Accuracy Standards (NMAS) of the era when the map was originally published. The high-scanning resolution ensures the TIFF image is an excellent facsimile of the paper map. Even the thinnest of lines are several pixels wide in the image. The georeferencing procedure requires that transformed image control marks be within the lineweight of the graticule tick as shown on the original map. If stretching or other physical degradation of the paper map made this impossible, the image was not included in the archive, or it was rescanned to obtain acceptable results.

Metadata

An FGDC compliant metadata file in XML format is integrated with each GeoPDF and accompanies each TIFF. The metadata file will contain the same information as the map collar, plus additional information as required by the FGDC CSDGM. The benefit of duplicating collar information is that the XML file can be parsed by software.

See Appendix A for a list of the fields and corresponding definitions that are captured from the map collar, and how they are captured in the FGDC XML metadata file.

File Names

Files are named using the following convention:

state_mapname_scanID_year_scale_geo.xxx

For example: NM_Escoba_14525_1990_24000_geo.pdf where

- *state* is the 2-letter abbreviation of the U.S. State in which the majority of the mapped area exists on the ground.
- *mapname* is the printed name on the specific quadrangle map.
- *scanID* is a unique 6-digit integer assigned to the scanned quadrangle.
- *year* is the four-digit date in the lower portion of the map collar that is the year the map was created.
- *scale* is the denominator of the ration of paper map units to ground units.
- *geo* is the indicator that the file is georeferenced.
- *xxx* is the filename extension associated with the filetype (for example, *pdf*, *tif*, and *xml*).

No requirements are specified for letter case. Filenames may use any combination of uppercase and lowercase letters.

A naming convention is not dictated for transfer or distribution files. For example, a zip file containing the TIFF and associated XML metadata and text files need not conform to any particular naming convention.

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Glossary

National Geospatial Program (NGP, <http://www.usgs.gov/ngpo/>) An administrative unit of the U.S. Geological Survey responsible for mapping and Geographic Information System (GIS) activities. The NGP is under the USGS Core Science Systems.

Metadata Information (<http://geology.usgs.gov/tools/metadata/>) Information about a map or other geospatial product that describes how the product was made, the sources of data, and other relevant information. The FGDC's Content Standard for Digital Geospatial Metadata (version 2.0), FGDC-STD-001-1998, defines content and organization of metadata files.

Standard cell Geographic quadrangle that aligns with appropriate increments of latitude and longitude (see table 1). These cells, their official names, and other attributes are stored in the Geographic Cell Names Database (GCNDB), a part of the Geographic Names Information System (GNIS).

USGS Mapping Program An umbrella term that encompasses most of the activities of the NGP, including all aspects of *The National Map* and the National Atlas.

Useful Websites

<http://geology.usgs.gov/tools/metadata/> This site provides useful information about how to implement the FGDC metadata standard.

<http://geonames.usgs.gov/> This is the USGS home page for the U.S. Board on Geographic Names.

<http://get.adobe.com/reader/> The free Adobe Reader software may be downloaded from this site.

<http://nationalmap.gov/> This is the USGS home page for The National Map.

<http://nationalmap.gov/historical/> This is the USGS home page for the scanned historical topographic quadrangle collection.

<http://nationalmap.gov/historical/contact.html> Contact information for the scanned historical topographic quadrangle collection can be obtained from this site.

<http://nationalmap.gov/standards/> Feedback for the scanned historical topographic quadrangle collection standard can be submitted via this site.

<http://nationalmap.gov/ustopo/> This is the USGS home page for the US Topo maps.

http://nationalmap.gov/ustopo/ustopo_feedback.html Feedback for the US Topo products can be submitted via this site.

<http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf> This is the website for obtaining the TIFF specification.

<http://store.usgs.gov/> USGS products may be downloaded from this site.

<http://usgs.terragotech.com/home/> The free TerraGo Toolbar extension may be downloaded from this site.

<http://www.fgdc.gov/> This is the home page for the Federal Geographic Data Committee.

<http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/> The FGDC Content Standard for Digital Geospatial Metadata may be downloaded from this site.

<http://www.fgdc.gov/usng/> This is the FGDC site for the United States National Grid standard.

<http://www.gdal.org/> This is the home page for the Geospatial Data Abstraction Library (GDAL).

<http://www.geography.wisc.edu/research/projects/QUAD-G/> This site provides a user guide for the georeferencing tool used by the USGS for the scanned historical topographic quadrangle collection developed by the University of Wisconsin in Madison.

<http://www.iso.org/> This is the home page for the International Organization for Standardization.

<http://www.ngs.noaa.gov/> This is the home page for the U.S. National Oceanic and Atmospheric Administration National Geodetic Survey.

<http://www.opengeospatial.org/> This is the home page for the Open Geospatial Consortium.

<http://www.osgeo.org/> This is the home page for the Open Source Geospatial Foundation.

<http://www.usgs.gov/ngpo/> This is the home page for the USGS National Geospatial Program.

<http://www.usgs.gov/pubprod/reference.html#standards/> This is the home page for the USGS Maps, Imagery, and Publications.

Acronyms and Abbreviations

CSDGM	Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata
CSV	Comma-Separated Variable
DRG	Digital Raster Graphic
FGDC	Federal Geographic Data Committee
GB	Gigabyte
GCNDB	Geographic Cell Names Database (part of GNIS)
GDAL	Geospatial Data Abstraction Library
GeoPDF	Portable Document format with geospatial extensions produced by TerraGo Technologies software.
GIS	Geographic Information System
GNIS	Geographic Names Information System
ISO	International Organization for Standardization
JPEG	Joint Photographic Experts Group
MB	Megabyte
NAD27	North American Datum of 1927
NGP	National Geospatial Program
NMAS	National Map Accuracy Standards
OGC	Open Geospatial Consortium
PDF	Portable Document Format
PPI	Pixels per inch
RGB	Red Green Blue (Image Color Channels)
TIFF	Tagged Image File Format
TNM	The National Map
USGS	United States Geological Survey
XML	Extensible Markup Language

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Appendix A: Notes and Discussion

TIFF Transformation File

The following XML-formatted text is an example of the information contained in the transformation file that accompanies the TIFF image. The transformation file contains the parameters necessary to convert the scanned TIFF into a new image file whose pixels are georeferenced.

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<PAMDataset>
  <Metadata />
  <Metadata domain="xml:ESRI" format="xml">
    <GeodataXform xsi:type="typens:PolynomialXform"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xmlns:xs="http://www.w3.org/2001/XMLSchema"
      xmlns:typens="http://www.esri.com/schemas/ArcGIS/10.0">
      <PolynomialOrder>2</PolynomialOrder>
      <SpatialReference xsi:type="typens:GeographicCoordinateSystem">
        <WKT>GEOGCS["GCS_North_American_1927",DATUM["D_North_American_1927",SPHEROID["
          Clarke_1866",6378206.4,294.9786982]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.01745329251994
          33],AUTHORITY["EPSG",4267]]</WKT>
      </SpatialReference>
      <SourceGCPs xsi:type="typens:ArrayOfDouble">
        <Double>2.580833333333</Double>
        <Double>2.9775</Double>
        <Double>7.914166666667</Double>
        <Double>2.9825</Double>
        <Double>13.2625</Double>
        <Double>2.990833333333</Double>
        <Double>18.615833333333</Double>
        <Double>2.999166666667</Double>
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        <Double>13.254166666667</Double>
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        <Double>18.604166666667</Double>
        <Double>10.6025</Double>
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        <Double>18.179166666667</Double>
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        <Double>18.189166666667</Double>
        <Double>18.5925</Double>
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        <Double>2.574166666667</Double>
        <Double>25.779166666667</Double>
        <Double>7.8975</Double>
        <Double>25.789166666667</Double>
        <Double>13.234166666667</Double>
        <Double>25.799166666667</Double>
        <Double>18.575833333333</Double>
        <Double>25.810833333333</Double>
      </SourceGCPs>
    </GeodataXform>
  </Metadata>
</PAMDataset>
```

```

</SourceGCPs>
<TargetGCPs xsi:type="typens:ArrayOfDouble">
  <Double>-83.750000001</Double>
  <Double>45.375</Double>
  <Double>-83.708333334</Double>
  <Double>45.375</Double>
  <Double>-83.666666667</Double>
  <Double>45.375</Double>
  <Double>-83.625</Double>
  <Double>45.375</Double>
  <Double>-83.750000001</Double>
  <Double>45.416666667</Double>
  <Double>-83.708333334</Double>
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  <Double>45.416666667</Double>
  <Double>-83.625</Double>
  <Double>45.416666667</Double>
  <Double>-83.750000001</Double>
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  <Double>-83.708333334</Double>
  <Double>45.458333334</Double>
  <Double>-83.666666667</Double>
  <Double>45.458333334</Double>
  <Double>-83.625</Double>
  <Double>45.458333334</Double>
  <Double>-83.750000001</Double>
  <Double>45.500000001</Double>
  <Double>-83.708333334</Double>
  <Double>45.500000001</Double>
  <Double>-83.666666667</Double>
  <Double>45.500000001</Double>
  <Double>-83.625</Double>
  <Double>45.500000001</Double>
</TargetGCPs>
</GeodataXform>
</Metadata>
</PAMDataset>

```

Historical Datums

The following excerpt was originally quoted from a National Academy of Sciences (1971, p. 7) report titled “North American Datum.”

“The first official geodetic datum in the United States was the New England Datum, adopted in 1879. It was based on surveys in the eastern and northeastern states and referenced to the Clarke Spheroid of 1866, with triangulation station Principio, in Maryland, as the origin. The first transcontinental arc of triangulation was completed in 1899, connecting independent surveys along the Pacific Coast. In the intervening years, other surveys were extended to the Gulf of Mexico. The New England Datum was thus extended to the south and west without major readjustment of the surveys in the east. In 1901, this expanded network was officially designated the United States Standard Datum, and triangulation station Meades Ranch, in Kansas, was the origin. In 1913, after the geodetic organizations of Canada and Mexico formally agreed to base their triangulation networks on the United States network, the datum was renamed the North American Datum.

By the mid-1920's, the problems of adjusting new surveys to fit into the existing network were acute. Therefore, during the 5-year period 1927–1932 all available primary data were adjusted into a system now known as the North American 1927 Datum.

The coordinates of station Meades Ranch were not changed but the revised coordinates of the network comprised the North American 1927 Datum.”

(Snyder, 1987, p. 13)

NAD27 is used in the scanned historical topographic quadrangle collection because the difference between NAD27 and the older datums is negligible as compared to error inherent in the older maps.

Map Collar Metadata

Table 2 identifies the fields that are collected from the map collar, field definitions, and the FGDC metadata tags used to capture these fields in the FGDC XML metadata file.

Table 2. Map collar metadata fields and definitions.

[FGDC, Federal Geographic Data Committee]

Map collar metadata field	Definition	FGDC metadata tag(s)
Scan File Name	The filename of the scanned map.	<supplinf>
Map Name	The printed name of a specific map.	<title>, <supplinf>, <othercit>
Map Scale	The ratio of paper map units to ground units.	<srscscale>
Primary State	The geographic jurisdiction (U.S. State) in which the majority of the mapped area exists on the ground. In border areas showing more than one state (or country), this is the first state (area) listed directly along with the Map Name.	<placekey>
Date on Map	The 4-digit (YYYY) date for the year the map was created.	<procdesc>, <procdat>
Imprint Year	The 4-digit (YYYY) date for the year the map was printed.	<procdesc>, <procdat>
Woodland Tint	A flag that indicates whether or not the map included Woodland Tint.	<othercit>
Scan Quality	Value for recording the quality of the completed scans. The only value that is captured in the FGDC metadata is “Not Optimal.”	<supplinf>
Keywords	Words or phrases associated with the map that enhance catalogue search capability.	<keywords>, <themekey>, <placekey>
Aerial Photo Year	The 4-digit (YYYY) date of the aerial photography used in the creation of the map.	<procdesc>, <procdat>
Field Check Year	The 4-digit (YYYY) date representing the year the map content was last verified in the field.	<procdesc>, <procdat>
Edit Year	The 4-digit (YYYY) date representing the year the map was last globally edited or revised.	<procdesc>, <procdat>
Photo Inspection Year	The 4-digit (YYYY) date representing the year when a photo inspection was last done on the map.	<procdesc>, <procdat>
Photo Revision Year	The 4-digit (YYYY) date representing the year when new photos were used to revise a map.	<procdesc>, <procdat>
Survey Year	The 4-digit (YYYY) date representing the year when a field survey was completed for the mapped area (used generally before the 1950’s).	<procdesc>, <procdat>
Datum	A mathematical model that approximates the size and shape of the earth. This field is used to identify the specific datum used to create the map.	<horizdn>
Projection	A mathematical model used to represent the spherical shape of the earth’s surface on a flat surface (paper map). This field is used to identify the specific projection used to create the map.	<mapprojn>
Advance	A flag that identifies the map as an advance copy or sheet.	<themekey>
Preliminary	A flag that identifies the map as a preliminary sheet or edition.	<themekey>
Provisional	A flag that identifies the map as a provisional copy or sheet.	<themekey>
Interim	A flag that identifies the map as an interim edition.	<themekey>
Topographic	A flag that identifies the map as one that has elevation contours.	<themekey>
Planimetric	A flag that identifies the map as one that has no elevation contours.	<themekey>

Table 2. Map collar metadata fields and definitions.—Continued

[FGDC, Federal Geographic Data Committee]

Map collar metadata field	Definition	FGDC metadata tag(s)
Special Printing	A flag that identifies the map as one that has no Woodland Tint and no elevation contours.	<themekey>
Special Map	A flag that identifies the map as an oddly sized or off-grid map that was created for a special purpose.	<themekey>
Shaded Relief	A flag that identifies the map as one that includes a 3-dimensional shadow effect enhancing visualization of terrain relief.	<themekey>
Orthophoto	A flag that identifies the map as one that includes an orthophoto.	<themekey>
Pub USGS	A flag that identifies the U.S. Geological Survey as the Federal agency that produced or cooperated in the production of the map.	<origin>
Pub Army Corp Eng	A flag that identifies the U.S. Army Corps of Engineers as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Army Map	A flag that identifies the U.S. Army Map Service as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub War Dept	A flag that identifies the U.S. War Department as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Military Other	A flag that identifies Other Military Agencies as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Forest Serv	A flag that identifies the U.S. Forest Service as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Reclamation	A flag that identifies the Bureau of Reclamation as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Bur Land Mgmt	A flag that identifies the Bureau of Land Management as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Natl Park Serv	A flag that identifies the National Park Service as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Indian Affairs	A flag that identifies the Bureau of Indian Affairs as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub EPA	A flag that identifies the U.S. Environmental Protection Agency as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub Tenn Valley Auth	A flag that identifies the Tennessee Valley Authority as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
Pub USCommerce	A flag that identifies the U.S. Department of Commerce as the Federal agency that produced or cooperated in the production of the map.	<lineage>, <origin>
GNIS Cell ID	The Geographic Names Information System permanent, unique identifier for geographic quadrangles.	<supplinf>
Scan Contributor	The organization that scanned the map.	<srctr>
Scanner Resolution	The optical resolution used to scan the map. This is the number of pixels per inch that the scanning hardware samples.	<supplinf>
Bounding Coordinates	The maximum north and south latitudes, and the maximum east and west longitudes included in the map extents.	<westbc>, <eastbc>, <northbc>, <southbc>

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