USGS science for a changing world

The National Map

Digital Map – Beta

7.5-Minute Quadrangle Maps in GeoPDF

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U.S. Geological Survey

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U.S. Department of the Interior
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Notes on this document release

This document is still in technical review and is not yet an official publication of the U.S. Geological Survey. Because this standard represents significant changes in USGS mapping procedures, products, and policies, draft versions will be released for review and comment before the document has been through the USGS standards editorial review processes.

Technical developments and policy decisions have caused significant changes to the product design in each new version of this document. All earlier versions are invalid and should be discarded.

For more information, see http://nationalmap.gov/digital_map/index.html

Comments regarding this document can be submitted through the web page http://nationalmap.gov/digital_map/digitalmap_feedback.html

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1 Image-Based 7.5-Minute Quadrangle Maps

1.1 Objective

This document defines a U.S. Geological Survey (USGS) quadrangle map that uses an orthophoto image as its primary content. This product makes current orthophoto images available to traditional map users by packaging images in standard 7.5-minute cells with traditional map collars and grids, and by enhancing the image with some interpreted map linework and place names. It also provides a technical foundation for building a more complete topographic line map. This product is intended to serve map users who are not Geographic Information System (GIS) specialists.

This standard is supported by several other documents:

- A PDF-format style sheet is a full-size template for a quadrangle map that defines placement of map elements, fonts and text styles, and symbols.
- A XML-format file is a template for FGDC-compliant metadata associated with this product, along with an associated .dtd file.

These, and other technical documents internal to the USGS, constitute technical specifications for implementing this standard, but are not part of the standard.

1.2 Scope

The USGS intends to use this standard to create a national map series of 7.5-minute digital orthophoto image maps. National coverage on a 3-year production cycle is an objective of this program. Adding layers of interpreted cartographic features is also an objective.

1.3 Applicability

Maps based on images are easier and cheaper to make than traditional topographic line maps. Production speed and data currentness partially compensate for other shortcomings of the product, such as the lack of elevation data. The USGS believes that pre-packaged image maps, on standard coordinate systems, with full U.S. National Grid lines, are particularly valuable for emergency first response operations.

1.4 Referenced and Related Publications

The following documents were used to prepare this standard. At the time of publication, the editions were valid.

Federal Geographic Data Committee, 2001, United States National Grid (USNG), FDGC-STD-011-2001, accessed August 2007 at *http://www.fgdc.gov/standards/standards_publications/*

Federal Geographic Data Committee, 2001, Content Standard for Digital Geospatial Metadata (version 2.0), FGDC-STD-001-1998, accessed January 2008 at *http://www.fgdc.gov/standards/standards_publications/*

Federal Register, Vol. 60, No. 157, August 15, 1995, Use of the NAD 83/GWS 84 Datum Tag on Mapping Products, accessed May 2009 at *http://origin.www.gpoaccess.gov/fr/index.html*

The National Agriculture Imagery Program (NAIP). Accessed October 2008 at http://165.221.201.14/NAIP.html.

Orth, Donald J. Principles, Policies, and Procedures: Domestic Geographic Names. U.S. Board of Geographic Names, Reston, VA. 1997. 2003 online edition available at *http://geonames.usgs.gov/docs/pro_pol_pro.pdf*

U.S. Geological Survey, National Hydrography Dataset, accessed November, 2008 at http://nhd.usgs.gov/

U.S. Geological Survey, National Elevation Dataset, accessed November, 2008 at http://ned.usgs.gov/

U.S. Geological Survey, 2002, Standards for Revised Primary Series Quadrangle Maps, Part 1: General, National Mapping Program Technical Instructions: online edition, 18 p., accessed August, 2007, at *http://rockyweb.cr.usgs.gov/nmpstds/qmapstds.html*

U.S. Geological Survey, 2002, Standards for Revised Primary Series Quadrangle Maps, Part 2: Specifications, National Mapping Program Technical Instructions: online edition, 262 p., accessed August, 2007, at *http://rockyweb.cr.usgs.gov/nmpstds/acrodocs/qmaps/2rqm1202.pdf*

U.S. Geological Survey, 2005, Standards for Preparing *The National Map* Standards, National Mapping Program Technical Instructions: internal draft manuscript.

1.5 Standards Development Procedures

This document was prepared according to the USGS Fundamental Science Practice guidelines.

1.6 Publishing Authority

The Associate Director for Geospatial Information of the USGS has authorized this publication.

1.7 Maintenance Authority

The National Geospatial Program (NGP) of the USGS maintains standards for *The National Map*. Submit questions and comments concerning this draft document through http://nationalmap.gov/digital_map/digitalmap_feedback.html.

1.8 Definitions

The following definitions apply to this standard:

National Geospatial Program (NGP) – An administrative unit of the U.S. Geological Survey responsible for mapping and Geographic Information System (GIS) activities. The NGP is under the Associate Director for Geographic Information.

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.

7.5-minute standard cell – Geographic squares that align with even 7.5-minute boundaries. 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 Graphics Project – A sub-activity of the USGS Mapping Program that is focused on the definition and creation of 1:24,000-scale quadrangle map products, including the image map that is the subject of this standard.

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

U.S. National Grid – The official grid coordinate system of the U.S. Government. See http://www.fgdc.gov/usng for information and specifications.

1.9 Abbreviations and Acronyms

FGDC – Federal Geographic Data Committee

GCNDB – Geographic Cell Names Database (part of GNIS)

GeoPDF – Portable Document Format with georeferencing tags

GIO – Geographic Information Office

GIS – Geographic Information System

GNIS – Geographic Names Information System

NAD 83 – North American Datum of 1983

NGP – National Geospatial Program

PDF – Portable Document Format

PPI – Pixels Per Inch

USGS – United States Geological Survey

URL – Uniform Resource Locator (or Internet address)

USNG – U.S. National Grid.

WGS 84 – World Geodetic System of 1984

XML – Extensible Markup Language

2 Product Overview

This section is an executive summary of the product standard. Sections 3-6 comprise the detailed product description.

The philosophy of this product design is:

1. The basic quadrangle layout of the traditional USGS 7.5-minute topographic map has value. Maps with standard cell extent, full map collars, and standard grids are useful, in part, because of their standard format and layout. For these advantages to be realized, the layout and design of the product must conform to editorial standards.
2. In at least the government communities of emergency response and national security, there is a need for medium scale, general purpose maps that can be easily printed at a known and standard map scale.
3. Similarly, there is a need for a national map series that can be used without specialized geographic information system (GIS) software and expertise.
4. Image maps, enhanced with some cartographic linework and labels, are useful in their own right, but also provide a base for building a topographic line map.

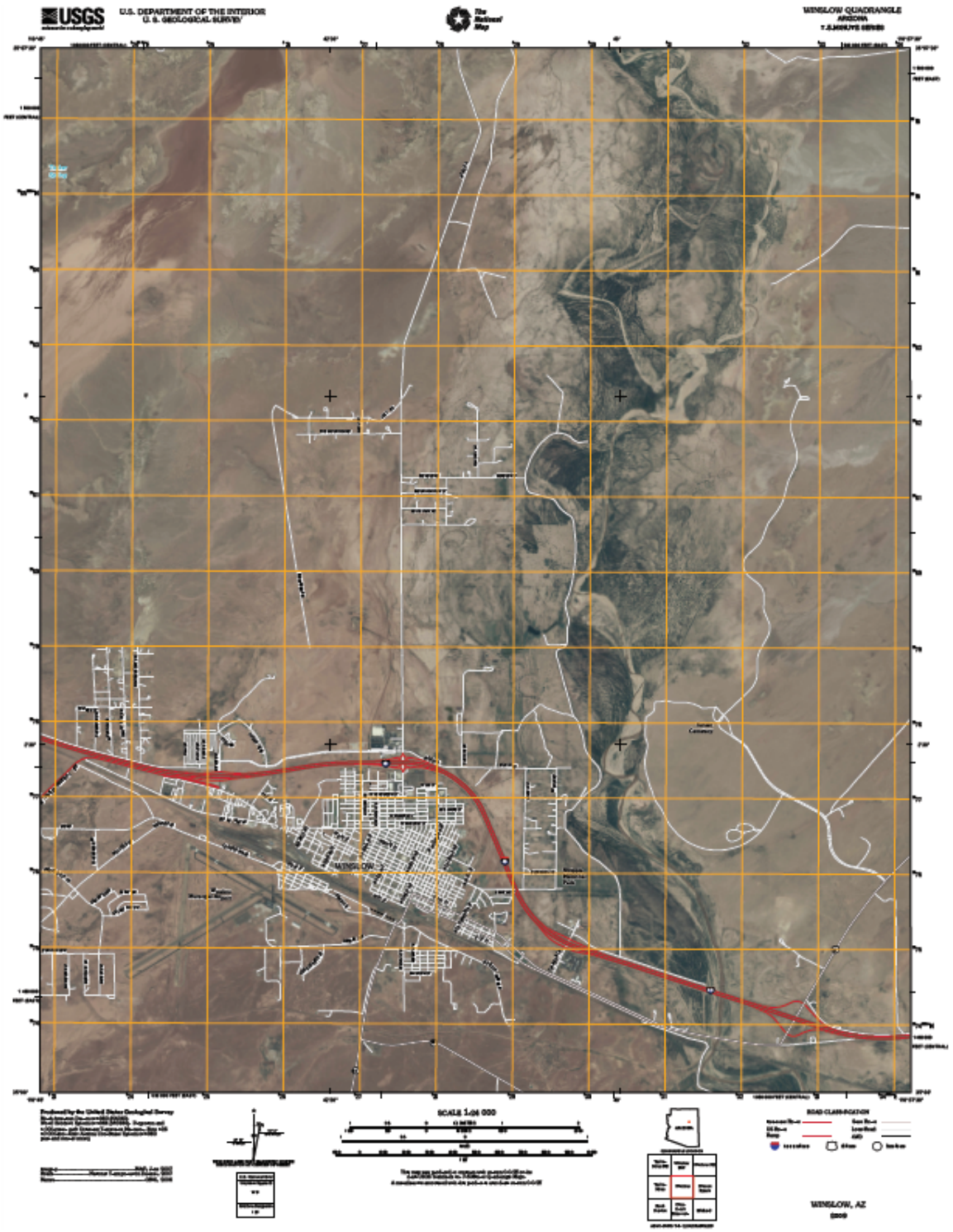

Figure 1. Browse image of a Image-Based Quadrangle map.

2.1 Files and Formats

The product defined by this standard is a layered GeoPDF. A metadata file conforming to the FGDC Metadata Content Standard, with XML as the physical format, will be bundled with (or attached to) the PDF file.

2.2 Scale, Extent, Projection, and Coordinate System

This document defines quadrangle maps with standard 7.5-minute extent at 1:24,000 scale. The standard does not prohibit other extent sizes, domains, and scales, but neither does it specifically address them. This may change in future versions of this standard.

All maps are cast on the Transverse Mercator projection with Universal Transverse Mercator (UTM) parameters. All maps are cast on NAD 83/WGS 84 datum.

All maps include a 1,000-meter UTM grid. This grid is drawn and labeled in conformance with the U.S. National Grid (USNG) standard. Corner coordinate labels and 2.5-minute ticks and labels are shown. State plane coordinate ticks are usually, but not necessarily always, shown.

2.3 Map Collar and Metadata

Every map has a traditional map collar. The collar is defined by the style sheet that accompanies this standard.

An FGDC-compliant metadata file in XML format will be attached to each GeoPDF. The metadata file will contain the same information as the map collar, plus additional information as required by the FGDC metadata content standard. The benefit of duplicating collar information is that the XML file can be parsed with software.

2.4 Feature Content, Data Sources

All geospatial content is taken from national geospatial databases under the stewardship of USGS data programs. This normally means data owned and hosted by the USGS, but does not preclude using data sources owned and hosted by other organizations, provided that these sources have been approved by a USGS data program.

The accuracy – both positional and attribute accuracy – of these data is the responsibility of the data sources, not the map production process. Cartographic editing to insure readability of the final product is the responsibility of the map production process.

In addition to the orthophoto image, this product includes some interpreted cartographic features, including:

- Roads, with street names and route numbers as appropriate.
- Geographic names (including hydrography names), populated places, other significant names, major cultural features, and national boundaries.

This product is freely distributable. This does not necessarily mean that all the data in the product are public domain; this standard does not preclude the use of licensed data. Relevant license information will be documented in the product metadata.

3 Digital File Organization

Traditional printed quadrangle maps were designed for ease of use by a person viewing a paper map. The product defined by this standard is a digital product. It is still intended primarily for human viewing, but this includes softcopy viewing and limited manipulation in addition to hardcopy plots.

3.1 GeoPDF Format Product

GeoPDF is a copyrighted format, with implementation rights held exclusively by TerraGo Technologies. This standard is therefore driven in part by the capabilities of specific commercial software systems.

3.1.1 GeoPDF Folder and Layer Organization

The layer structures of the GeoPDF file contains, at a minimum, the following folders or layers:

Map Collar

Map Frame

Projection and Grids

Geographic Names

Boundaries

Transportation

Images

Orthoimage

See Section 5 for details about the content of the collar, and Section 6 for details about the content of the map interior.

"Map Collar, "Map Frame," and "Images" must be folders, with at least the listed subfolders or layers. The other entries in this list may be either folders or layers.

Every folder or layer is "clickable" – that is, the folder or layer may be turned off by the user. All data in the file belongs to a folder or layer. It is therefore possible to remove everything from the display.

The folders and layers listed above will be present in every GeoPDF file, and will use exactly the names shown here. Other folders and layers may be added without violating this standard. As this product matures, more required folders and layers may be added to this standard.

Cartographic content (geographic names, boundaries, transportation, and orthoimage folders) may be cut exactly to the 7.5-minute cell extent, or may include overedge data. Overedge data, if present, will be hidden by a mask layer in the Map Collar folder.

3.1.2 Startup Conditions

A GeoPDF file can specify many of its initial view characteristics. Specifying software behavior is unusual for a USGS product standard, but is justified in this case because of the tight coupling between GeoPDF, the commercial software tools that can read a GeoPDF, and this product standard.

The following behaviors depend on the Acrobat reader and the TerraGo toolbar, which the USGS does not control. The requirements therefore must be considered perpetually provisional.

When the GeoPDF file is opened in a current version of Acrobat reader that has the TerraGo toolbar installed, the following behaviors will be exhibited:

- The image is fit to the view page.
- The folder structure is collapsed, showing only top-level folders and layers.
- All folders and layers are turned on.
- Measurement units are meters

Additional startup conditions are desirable, but are not technically feasible at this time.

The USGS recognizes that it is desirable to allow user-created markup in the GeoPDF file through the TerraGo GeoMark feature. However, the licensing issues behind this feature are complex, currently unresolved, and possibly very expensive. Pending resolution of these issues, GeoMark enabling is not required by this standard.

3.2 Companion Data Files in Open Formats

GeoPDF is a proprietary, unpublished format. It is unprecedented for the USGS to use such a format as the exclusive distribution format of a geospatial product, and it is desirable to distribute content-equivalent data products in open formats. However, the technical problems behind defining such companion products are severe enough that the USGS has decided to defer this issue until later. At this time, the GeoPDF format is the only distribution format for this product.

3.3 Metadata Files

An FGDC-compliant metadata file in XML format will be attached to each GeoPDF. The metadata file will contain the same information as the map collar, plus additional information as required by the FGDC metadata content standard. The benefit of duplicating collar information is that the XML file can be parsed with software.

3.4 Projection Line Orientation and Page Size

The orientation of the projection line to the internal coordinate system of the GeoPDF image space will be that traditionally used on USGS quadrangle maps. The central meridian of the quadrangle (not to be confused with the central meridian of the projection zone) will be set parallel to the left and right edges of the image file. The west and east edges of the projection line will therefore be almost, but not exactly, parallel to the left and right edges of the image file (or, on a rectangular paper plot, to the edges of the paper).

No standard page size for the image is specified. The image is not required to be trimmed to the extent of the map content as with traditional paper maps; excess white space on the right and bottom margins is acceptable.

3.5 Off-Grid and Oversize Maps

Approximately 400 of the original 7.5-minute topographic maps did not precisely match the domain of a standard 7.5-minute cell. Exceptions included extensions beyond the projection line to include a finger of land mass, extending the projection line to match a State boundary, and shifting the entire projection line to center the quad over an island.

USGS cell-based digital products, such as Digital Line Graphs and Digital Elevation models, did not allow such exceptions. Every product had the geographic domain of an on-grid 7.5-minute cell.

Quadrangle image maps made to the current standard conform to the latter convention. There are no overedge areas on any map, and all maps precisely fit the standard 7.5-minute cell grid. See further discussion in Appendix A about oversize and off-grid maps.

3.6 File Names

Layered GeoPDF files are named using the following convention:

state_cellname_timestamp_OM_geo.pdf

For example: SC_Charleston_20071204_OM_geo.pdf

Where:

- *state* is the 2-letter abbreviation of the primary State

- *cellname* is the GCNDB name for this standard cell. If the cell name consists of multiple words, words are delimited with the underbar (_) character, not spaces.
- *timestamp* is the system-generated date and time of PDF file creation. Its primary purpose is to make each file name unique, regardless of how many instances of the same product are created for one cell. It also carries information that might be valuable to a human reader in some circumstances. The timestamp string is a concatenation of year:month:day, where year has four digits and the other two fields have exactly two digits (padded with zeros as necessary). No delimiters are used in the timestamp, so December 4, 2009 is expressed as 20091204.
- *OM* is a string literal to indicate the map type (**O**rtho **M**ap)
- *geo* is a string literal that indicates the PDF is georeferenced. If the file is a non-georeferenced PDF, this string is omitted.

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

Because metadata files are bundled with the GeoPDF file as file attachments, no naming convention for the metadata file is dictated.

4 Scale, Projection, Datum , Coordinate System, Grids

This standard focuses on 1:24,000-scale maps. The USGS has in the past also produced medium scale maps at 1:20,000, 1:25,000, and1:63,360. This standard does not prohibit other scales, but neither does it completely define maps at other scales. Future enhancements to the standard might include such definitions.

All maps are projected to the Transverse Mercator projection with correct Universal Transverse Mercator (UTM) parameters.

All maps are cast on the North American Datum of 1983 (NAD 83), or the World Geodetic System of 1984 (WGS 84), and the credit note includes the phrase “Horizontal Datum NAD 83/WGS 84” or equivalent. See Appendix A for further discussion about the relationship between NAD 83 and WGS 84.

4.1 Geographic Coordinate Labels

Geographic coordinate labels are shown outside the projection line. The full latitude and longitude values in degrees-minutes-seconds (DMS) format are shown at the corners of the projection. The 2.5-minute values are shown at every 2.5-minute tick. Corner coordinate labels, 2.5-minute ticks and labels are required and must conform to the style sheet.

4.2 USNG Grid Lines and Labels

All maps include a 1,000-meter UTM grid drawn and labeled in conformance with the U.S. National Grid (USNG) standard. A USNG grid reference box is required.

As dictated by the USNG standard, full UTM values are shown for the first grid lines in from the northwest and southeast corners of the projection and truncated values are shown for the rest of the grid lines. The USNG standard has several options for representing the 1,000-meter grid labels. Products that conform to this Image-Based Map standard use the following options.

- Except for the corner coordinates that show full UTM values, grid lines are labeled with the USNG principle digits in regular type, the preceding UTM digits in superscript type, and the post digits not shown. For example, ^{2}81 or ^{32}95
- If the map includes two 100,000-meter zones, the zone letters are printed in both margins. If the map includes a corner between four 100,000-meter zones, the zone letters are printed in the

margins and also at the intersection in the interior of the map. (These are the only two cases of multiple 100,000-meter zones that can occur on a 7.5-minute on-grid map.)

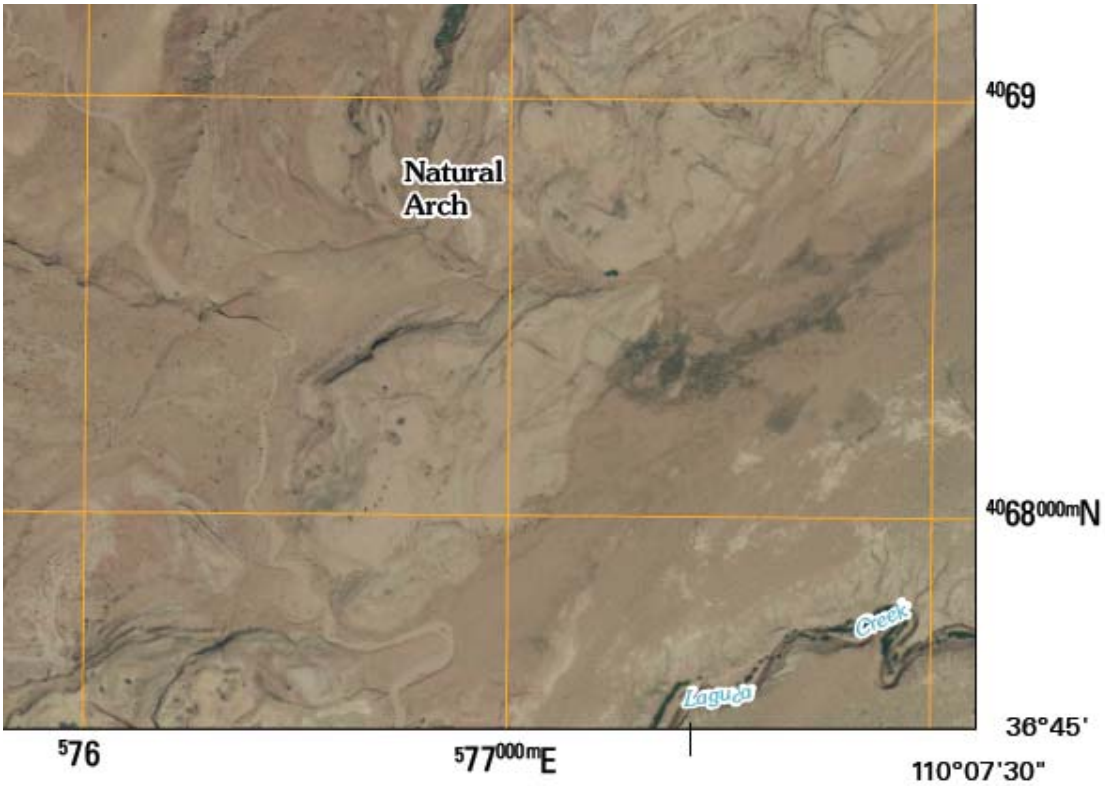

Figure 2. Detail of southeast quad corner, showing correct style for geographic and USNG coordinate values. SPCS ticks are also shown elsewhere on the quadrangle.

4.3 State Plane Ticks and Labels

State Plane Coordinate System (SPCS) ticks and labels are normally shown, though they may be omitted at the discretion of project managers. Placement and fonts are as shown on the product style sheet.

5 Map Collar

The map collar is defined as the area outside the projection line and all text, diagrams, and other information that appears in this area, **except** tick marks and number values of cartographic coordinate systems. Tick marks and coordinate values are logically associated with the projection line and grids, and are defined in Section 4. The map collar is also called the map margin.

The general layout of the map collar is similar to that of traditional 7.5-minute topographic maps. The following information is shown in the collar. Precise content, positions, colors, fonts, and lineweights are defined by USGS technical specifications that are not part of this standard.

1. USGS Visual Identity Logo
2. U.S. Department of Interior and Bureau Identifier
3. The National Map Visual Identity Logo
4. Title Block, upper right.

5. Title Block, lower right.
6. Map Generation Date, lower right. This is the year the map product was created, not the date of any source material
7. Highway Route Legend.
8. Map Credit Legend, consisting of four parts:
    a. The note "Produced by the United States Geological Survey". If applicable, the name of the cooperating State, Commonwealth, or Country is also shown.
    b. The map projection, horizontal datum, UTM grid spacing, UTM zone, and State Plane zone.
    c. A list of data layers with sources and currency dates.
    d. Disclaimer notes as appropriate. For example: "Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government."
9. Quadrangle Location Diagram.
10. Adjoining Quadrangle Diagram.
11. Map Scale Note, with scale expressed as a representative fraction.
12. Bar Scales.
13. Distribution Note. No distribution note will be shown until distribution details are defined. When appropriate, a distribution note will be added below the bar scale.
14. Accuracy Statement. An accuracy statement is shown only when all data displayed in the map interior are USGS data that has been accepted as part of a quality assurance program.
15. A statement about the standard version number and the metadata file version number is required. URL pointers will not be included, only titles and version numbers.
16. North arrow and declination diagram.
17. A USNG grid reference box. The grid reference box is logically associated with grids and coordinate systems (section 4.2), but is positioned in the map collar area.
18. No imprint note is shown on this product, as there is no date of printing.

6 Map Interior

6.1 Image Background

An orthorectified image is a layer in every product. Spatial resolution of 600 or 300 pixels per inch (ppi), 1 and 2 meters respectively at 1:24,000-scale, is desirable. Spatial resolution of at least 150 ppi (4 meters at 1:24,000 scale) is required. See Appendix A for further discussion of spatial resolution, compression, and file sizes.

The normal image source will be the National Agricultural Imagery Program (NAIP). Other recent USGS orthoimagery may be used as circumstances warrant. Factors to be considered when multiple image sources are available include:

1. Currency of imagery. More recent is better. Using images captured within 3 years of the map publication date is a high priority.
2. Full-quad coverage from a single source is preferable to a mosaic of images with different dates or tonal characteristics.

3. Tonal quality. Color is preferable to black and white. True color is preferable to false color. Tonal consistency within a quadrangle is important, but tonal consistency between quadrangles is of only minor importance. Even within a quadrangle, complete tonal seamlessness is not always possible; tonal consistency is not an absolute requirement of this standard.

No single factor is decisive in selecting one image source from multiple options. The objective is to make the overall best product.

7.5-minute tiles of 1- or 2-meter imagery are very large, and must be compressed to achieve acceptable file sizes. Any compression method supported by PDF, Adobe Acrobat, and TerraGo software may be used. There is no obligation to use the same compression method for all product instances. Because compression methods for PDF tend to be proprietary and not well documented, there is no obligation to fully explain the compression method in the product metadata.

6.2 Interpreted Cartographic Features

The image map defined by this standard is a transition product. It is intended to fill a need for static, plottable, 7.5-minute quadrangle maps in the absence of the set of interpreted data needed to make a complete and consistent topographic line map. Images are inherently complete and consistent, and serve to fill in significant gaps in interpreted data. (However, combining images and interpreted features may introduce inconsistencies because of temporal, scale, or resolution differences.)

Interpreted cartographic point, line, and area features will be taken from databases maintained or approved by the USGS data programs. These databases are multi-purpose GIS databases, and are not necessarily complete or consistent in the same sense that a traditional topographic map is complete and consistent. The databases are compiled from multiple primary and secondary sources, and therefore have no single currency date.

The quadrangle map defined by this standard therefore has different characteristics of currency, consistency, and completeness than a traditional topographic map. The data will tend to be more current than on a traditional map, but will also tend to be less consistent between quadrangles. The overall quality of the cartographic data depends directly on the quality of the source GIS databases.

See Appendix A for additional discussion of completeness and consistency.

6.2.1 Transportation

6.2.1.1 Roads

The standards defined by *Part 3: Transportation, Standards for USGS and USDA Forest Service Single Edition Quadrangle Maps* (**Road** and **Route**; pages 3-25 through 3-43) is the maximal standard road feature set for this product.

This product will use road data from the USGS transportation database, which is mostly derived from Census Bureau transportation data. The following guidelines will be used to portray and symbolize road data:

- Interstate highways and Federal highways are critical features. Symbolized lines are shown and annotated with road shields in all cases. Every effort should be made to achieve completeness for these features.

  If the road data are older than the image and fail to show changes in Interstates and Federal highways that are clearly visible on the image, features are edited to achieve consistency between these road features and the image. This is the only case for which roads are edited.

- State routes are important features, and are shown with symbolized lines and road shields. Route numbers should be placed unambiguously on the product, but effort need not be made to make the interpreted features fully consistent with the image.
- In urban areas, local roads are shown as available data and cartographic considerations permit. Residential streets may be filtered if necessary to achieve scale-appropriate detail. Labeling major streets with names is desirable, subject to label crowding and other cartographic considerations. There is not a requirement to label all, or even a majority of, streets and roads.
- In rural areas all available roads are shown. Rural road data tends to be lower quality than urban road data, but these data will not be edited solely for the purpose of making this product. Therefore, roads in rural areas will be shown as provided by the source national datasets. Improving the data sources is a management and policy issue outside the scope of this product standard.
- County route numbers or other local names and route designations are not required. These may be shown if, in the judgment of the map compilers and editors, the scarcity of Federal and State roads makes local roads important features.

6.2.1.2 Airports

Airport names from GNIS will be shown. Airport outlines, runways, and terminals will be shown if appropriate data are available. The lack of such data will not prevent or delay the publication of a product instance.

6.2.1.3 Other Transportation Features

No railroads or other transportation features will be shown at this time, pending availability of national datasets with appropriate scale and currency.

6.2.2 Geographic Features and Populated Places from GNIS

The Geographic Names Information System (GNIS) is the official Federal Government repository of geographic names. "Geographic names" comprises a subset of all feature names that might be shown on a map. The following guidelines will be used for image maps; see Appendix A for further discussion.

- GNIS is the definitive authority for the spelling and general location of "natural features of the land, unincorporated localities, and populated places…"(Orth, 1997). GNIS is normally the sole source for these names.
- The National Hydrography Dataset (NHD) is an exception to the above rule, because the USGS hydrography program and names program have coordinated their activities. Names of hydrography features may be taken from NHD. The same principle applies to any other USGS geospatial database that is coordinated with GNIS.

  Although the hydrography and names programs are coordinated, their databases are not identical. NHD contains label placement information not in GNIS. GNIS contains ocean features not included in NHD. GNIS is the primary source for natural feature names. NHD may be used as convenient.
- There is no obligation for the map to show all the geographic features provided by GNIS. Feature names may be omitted at the discretion of map compilers and editors. This is necessary to reduce feature and label crowding or to remove labels not appropriate for a 1:24,000-scale product.

- GNIS is not a cartographic database, and is **not** the final authority on the cartographic location of a feature or the placement of a feature name. Other sources may be used to aid placement of GNIS features. Copyrighted sources may not be used without appropriate license agreements.

6.2.3 Other Names

Names other than "natural features of the land, unincorporated localities, and populated places…" may be obtained from both GNIS and other "appropriate administrative agency" sources (Orth, 1997). For the purposes of this standard, this means geodatabases that have been approved by the USGS geographic names data program. In most cases these databases are owned and hosted by USGS, but USGS ownership is not strictly necessary.

What constitutes a mapworthy name depends on data availability and cartographic considerations, and is left to the discretion of the map compilers and editors. Examples of things that might be worth labeling include: State Capitals and other government buildings, universities, sports stadiums, parks.

6.2.4 Boundaries

National boundaries are shown. Cartographic content on the foreign side of the border follows these guidelines:

- The full 1,000-meter U.S. National grid covers the full quad extent
- Orthoimagery covers the full quad extent if available. Any area for which no images are available is left blank except for grids and coordinate information.
- With the exception of the country name, no interpreted cartographic features or names are shown outside U.S. territory, except in the following case.
- If an international agreement has been negotiated for cooperative production of maps along the border, then the content guidelines of that agreement take precedence over this standard.

State and county boundaries are not required at this time, pending resolution of policy and technical issues about data sources and accuracy. It is the intention of the USGS to add these features to the product in the future.

Boundary features, if present in the dataset, will be placed in their own folder or layer on the same level with the folders for Projections and Grids, Transportation, etc. (see Section 3.1.1).

6.2.5 Contour lines and hydrography linework

Contour lines and hydrography features are not required by this version of the standard. The USGS intends to add these features to the product in the near future.

Contour lines will be derived from the National Elevation Dataset (NED), and hydrography linework will be derived from the National Hydrography Dataset (NHD). Contour and hydrography features will be integrated to achieve reasonable visual consistency. Policies and procedures are in development.

Contours and hydrography features, if present in the dataset, will each be placed in their own folder or layer on the same level with the folders for Projections and Grids, Transportation, etc. (see Section 3.1.1).

6.2.6 Other Feature Classes

Structures are not included in this standard as a separate feature category because there is no national database of structures suitable for 1:24,000-scale mapping. GNIS contains some structure features. For example, schools and hospitals are GNIS feature types. Because these are not natural features of the land, GNIS is not necessarily the best or sole source of these names for USGS maps. Nor is GNIS a complete source of structures data for USGS maps. This standard therefore permits the inclusion of structures, at the discretion of compilers and editors, as major cultural features, but does not impose requirements for

including any particular structure class. This will change as sufficient national databases of structures become available.

6.2.7 Feature Labels

The details of text style are outside the scope of this standard, and are defined in separate technical specifications. Text styles for this product are different than on traditional USGS topographic maps. For example, most text labels in this image map have white halos. This is to insure that text strings will be visible both against the dark background of an orthoimage or against the light background of a display or plot with the image turned off.

Text placement standards will evolve with this product. At this time, placement guidelines are:

- It is never acceptable for two text strings in the same layer to overprint or interfere with each other. Overprints between labels in different layers should be avoided to the fullest extent possible.
- Text labels must be placed and rotated in such a way that the text can be reasonably associated with the feature it refers to. For example, placing a stream name perpendicular to and several centimeters away from the stream it labels is not acceptable. However, production speed and automation are important considerations for this product, and achieving strict compliance with traditional cartographic standards is not a requirement. For example, stream names are not required to curve to closely follow the course of the stream.
- Because the layer structure of the product allows feature classes to be turned on and off, higher densities of labels and features than traditionally allowed for a 1:24,000-scale product are acceptable.

6.2.8 Symbol Standards

Symbol conventions and requirements are outside the scope of this standard, and are defined in separate technical specifications. At this writing, most symbols are not rigorously defined, and will probably change over the coming years.

The nature of this product – various layers of both image and vector data – presents particular problems for symbol and text definition. Colors and lineweights are defined primarily to insure that lines will be visible against both light and dark backgrounds. Some colors are therefore different than those used in the original 7.5-minute topographic map series.

The USGS recognizes that point symbols, especially those for emergency response facilities such as hospitals and firestations, should conform to standards that are recognized throughout the map user community. Several efforts are underway to define such symbol standards, but none are yet mature.

The overall result is that colors, fonts, and symbol sets for this product are not yet well defined or stable.

Appendix A: Notes and discussion issues

This appendix contains additional discussion about several of the design decisions for this image map product.

Completeness and Consistency

Feature **completeness** means that for some predefined feature set, if a feature exists in the real world, it is shown on the map. **Consistency** means that the same feature set is used everywhere. Completeness and consistency are extremely difficult to maintain over continental areas. The original 7.5-minute topographic maps were impressively complete and consistent, but at a huge cost in both time and money. The results were possible only because the maps were compiled from primary sources such as new aerial photography, specialized field work, direct contact with local sources, and official survey plats.

General-purpose maps of the present and the foreseeable future are not compiled from primary sources, and should not aspire to the same levels of completeness and consistency. Raising all datasets to a high level of completeness and consistency would be slow and prohibitively expensive, while lowering content guidelines to a level where completeness and consistency are achieved "naturally" would make most maps artificially low quality.

For any given small area (such as a city or county), the "best available" data is often very good. But data between cities and counties tends not to be consistent. The use of secondary, best-available sources will, somewhat paradoxically, tend to make maps that might be very high quality, while at the same time being less complete relative to any specific content standard and less consistent relative to each other than traditional maps.

New models may be needed to express these realities in map content standards. Pending such developments, and pending the development of more mature national geospatial databases, it is the intention of the USGS to strike a reasonable balance between these factors, but to lean toward the "best available data" model, even if this leads to inconsistency between map sheets.

Oversize and Off-Grid Maps

The policy of not allowing oversize or off-grid maps has several implications:

- The development and maintenance of map production software and procedures is much easier. This is the primary reason the current standard dictates only on-grid, standard size products. Building production systems to accommodate the special cases of off-grid products is so difficult, and the number of cells involved so small, that it cannot be considered a high priority. The issue will be readdressed in the future as part of the more general problem of user-defined map extent.
- Softcopy map users will probably not be inconvenienced in any significant way by this policy, and might even consider the higher level of regularity and standardization to be a benefit.
- The primary cost of this policy is to users who rely on paper maps. There will be some instances of quadrangles that are covered almost completely by water, and instances of small islands or chains broken up into several pieces. Users who print their own maps will use more ink and paper to print very little additional information in these cases.

Datums: NAD 83 and WGS 84

The following is from the Federal Register: August 15, 1995 (Volume 60, Number 157), "Use of the NAD 83/WGS 84 Datum Tag on Mapping Products"

This article is online, but must be searched for from the Federal Register main page, http://origin.www.gpoaccess.gov/fr/

> SUMMARY: The Office of National Geodetic Survey, redefined and readjusted the North American Datum of 1927 (NAD 27), creating the North American Datum of 1983 (NAD 83). The World Geodetic System of 1984 (WGS 84) was defined by the Defense Mapping Agency (DMA). The interagency Federal Geodetic Control Subcommittee (FGCS) at its meeting on December 7, 1994, recommended that **"All maps and charts produced for North America, at scales of 1:5,000 or smaller, that are based on either the North American Datum of 1983 (NAD 83) or the World Geodetic System of 1984 (WGS 84), should have the horizontal datum labeled as NAD 83/WGS 84."** *[Emphasis added]*
>
> SUPPLEMENTARY INFORMATION: The following supplementary information was reviewed by FGCS membership. A Federal Register notice published on June 29, 1979 (44 FR 37969), by the National Oceanic and Atmospheric Administration (NOAA) provided notification of the establishment of a new Datum (NAD 83) to which the geographic and plane coordinate values for the National Network of Horizontal Geodetic Control would be referenced. A Federal Register notice published on June 14, 1989 (54 FR 25318), by NOAA affirmed NAD 83 as the official horizontal datum for all future U.S. surveying and mapping activities performed or financed by the Federal Government. Furthermore, this notice said that to the extent practicable and feasible, all Federal agencies using coordinate information should provide for an orderly transition to NAD 83. Both NAD 83 and WGS 84 were originally defined (in words) to be geocentric and oriented as the Bureau International de l'Heure (BIH) Terrestrial System. In principle, the three-dimensional coordinates of a single physical point should therefore be the same in both NAD 83 and WGS 84 systems; in practice, small differences are sometimes found. The original intent was that both systems would use the Geodetic Reference System of 1980 (GRS 80) as a reference ellipsoid. As it happened, the WGS 84 ellipsoid differs very slightly from GRS 80. The difference is 0.0001 meters in the semi-minor axis. Effective January 2, 1994, the WGS 84 reference system was realigned to be compatible with the International Earth Rotation Service's Terrestrial Reference Frame (ITRF).

Spatial Resolution and File Size of Images

Ortho-rectified imagery typically has ground resolutions between 6 inches and 1 meter, though even higher resolutions are sometimes seen. This standard calls for images to be 1- or 2-meter resolution, considerably lower than most current data collection.

This is a compromise between several factors:

- A 7.5-minute quadrangle is an extremely large image tile. Most high-resolution digital aerial photographs are packaged in tiles of around 1500 meters, about 1/50 of a 7.5-minute cell.
- Two meters at 1:24,000 corresponds to 300 PPI, which is an appropriate resolution for high-quality printing.

A 7.5-minute tile at 300 PPI contains around 35 million pixels, or over 100 Mb of RGB image data. The same tile at 600 PPI (1 meter) is four times as big. After appropriate compression, the total file size of a GeoPDF with 1 meter imagery and conforming to this standard is typically smaller than 20 Mb. This compression is achieved with built-in features of commercial software; the precise algorithms are proprietary. Displaying and printing requires decompressing the data; this is done automatically by software, but the memory management of decompression is implementation-dependent.

Geographic and Cultural Features, their Names and Labels

The U.S. Board on Geographic Names (BGN) publication *Principles, Policies, and Procedures: Domestic Geographic Names*, says (page 5):

> "It is the policy of the Federal Government that only official domestic geographic names are to be used on Federal maps and in other publications. An official name is…approved by the U.S. Board on Geographic Names or the appropriate administrative agency…By law, the Board is responsible for all geographic names except those applying to offices or establishments of Federal agencies…Practically, however, the Board decides primarily on the names of natural features of the land, unincorporated localities, and populated places in the United States, and its territories and outlying areas. Unless asked to do so, the Board does not rule on the names of cultural features such as roads, streets, shopping centers, churches, schools, hospitals, and airports…"

Applying these and other principles of the BGN guidelines to specific map production systems can be difficult and controversial. This product standard interprets the BGN guidelines to mean that GNIS is the sole authority for natural features and populated places; that other authoritative sources can be used for the names of other feature types not contained in GNIS; and that databases coordinated with GNIS can also be authoritative.

The database table gnis.feature_classes defines 65 feature types. Whether or not these should be further classified for graphic map purposes (for example: show all instances all the time, never show any instances, etc.) is not within the scope of this standard and is left to implementation specifications.

airport	cape	forest	mine	sea
arch	cave	gap	oilfield	slope
area	cemetery	glacier	park	spring
arroyo	census	gut	pillar	stream
bar	channel	harbor	plain	summit
basin	church	hospital	post office	swamp
bay	civil	island	populated place	tower
beach	cliff	isthmus	range	trail
bench	crater	lake	rapids	tunnel
bend	crossing	lava	reserve	unknown
bridge	dam	levee	reservoir	valley
building	falls	locale	ridge	well
canal	flat	military	school	woods

Structures and Building Footprints

Traditional USGS topographic maps show the precise footprint of oversized structures. Portraying correct sizes and shapes of features like stadiums, airport terminals, and large manufacturing facilities is a hallmark characteristic of traditional topographic maps.

The fact that no national database of building footprints currently exists is a major justification for creating a quadrangle image map. A line map that shows (for example) a major airport with just a point-feature label looks very different than the same map that shows the footprints of the terminals and hangers. The lack of building outlines is in this case a serious deficiency on a general-purpose, medium-scale map. In the absence of a database of interpreted building footprints, a background image provides the missing information.

This is also an example of how requirements differ between GIS systems and traditional symbolized maps. A GIS database of structures normally has little need for a polygon footprint; attributes such as square footage, number of floors, and building use are more relevant.