State Cartographer's Office

One of a series of guides covering various mapping topics in Wisconsin

Wisconsin TOPOGRAPHIC MAPPING

Guide 1, 2nd edition June 1998

Despite recent trends toward computerized mapping, the concept of the multipurpose topographic (topo) map remains strong. The look and value of traditional printed topo maps have been accepted by users for years, and the recent interest in a scanned image format indicates that people continue to use what is familiar.

Topo maps are now **available as computer images** that look much like the original. They also have become sources for several **statewide thematic GIS data layers**. These derivative products represent a continuing benefit stream from the multi-million dollar public investments made in earlier years to produce the maps.

The scanned topo maps available from the U.S. Geological Survey (USGS) are called *Digital Raster Graphics* (**DRGs**). Similar computer files are available from private companies. Our web site has an extensive explanation.

Particular features are often digitized (captured in computerized form) from topo maps. One common approach is to digitize a thematic "layer" such as all water features, or the terrain contours. Federal programs in this regard develop Digital Line Graphs (**DLGs**) and Digital Elevation Models (**DEMs**), both of which are explained at our web site.

While computerizing of topo maps garners the limelight, traditional topo mapping continues to decline, limited mostly to minimal revisions of the maps already published.

Highlights of this guide....

Tight budgets and competition from other desirable mapping products such as digital orthophotos and GIS databases combine to push the traditional product lower on the priority list. As a result, **Wisconsin's topo map series have continued to age**..

What a Topo Map Shows

Designed to be a multi-purpose base map, the typical topo map is a depiction of a **variety of features on the landscape**. The most commonly used and widely available topo maps are produced by the USGS following a standard national model. Many features shown on USGS topo maps—terrain, forest vegetation, roads, lakes, buildings, and geographic names—are familiar to most people. Others—geodetic control points, mine entrances, Public Land Survey System sections, and map coordinate grids—are of more specialized interest.

In order to map the entire country in a practical manner, even the most detailed USGS topo map series covers a moderately large area per sheet—about 60 square miles in Wisconsin. Yet those 1154 maps do depict much of our state's important natural and cultural detai.

Much more detailed topographic mapping is also commonly done by other organizations in support of specific construction projects. Particularly **in urbanized areas, a detailed topo map series may be developed** to support a wide variety of engineering, planning, and management purposes. We don't discuss this kind of topo mapping here, but please contact us if you want more information.

Planimetric construction

Features are positioned on a topo map in very specific fashion. In order for the map to meet accuracy standards, all of the **features have to be placed on an imaginary flat surface** over which a rectangular mapping coordinate system grid is placed. The mapping plane is formed by projecting the earth's curved surface onto a flat surface. This process results in a planimetric map.

New Edition

The first edition of this guide appeared in 1992, and was 12 pages long. Now six years later, updates to much of that publication's content, and more, is available routinely over the Internet or in other electronic forms.

As a result, we have reduced this second edition to cover background information. We invite you to visit our web site (see page 4) where you will find much more detail and links to many useful sites.

The 12-page first edition (1992) of this guide is available to download from our website in .PDF format. This second edition is also available in .PDF as well as paper. See the SCO contact information on page 4.

Contours

Local variation in the earth's surface is depicted on the flat topo map as contour lines which follow constant elevations on the landscape. In steeper terrain the interval between contour lines often needs to be greater (e.g., 40 feet rather than 20 feet) in order to maintain contour legibility. The **patterns of contour lines convey a sense of the terrain** and allow estimation: of slope—both steepness as well as the direction a slope faces; and of elevation at a given point.

Through a scanning process followed by computerized sampling, previously mapped topographic contours can be converted to a grid a elevation points. These are available for all of Wisconsin as DEMs. Actually, most new mapping of terrain now first develops a computer model from which contours can be calculated as needed.

Map symbols

The USGS uses a standardized symbol set nationwide for its topo maps. A key to help interpret these symbols is available by fax, in print, or over the Internet.

Grids and coordinates

Latitude and longitude comprise a reference system globally, and appear on typical topo

maps. In addition, one or more rectangular mapping coordinate grids may be shown. State Plane and Universal Transverse Mercator (UTM) coordinate systems are the most common. These coordinate systems as well as those developed more recently for individual counties are explained in the SCO's 91-page guide *Wisconsin Coordinate Systems*.

The PLSS

Almost all of Wisconsin's lands were originally surveyed under the federal Public Land Survey System (PLSS). The section corners and lines, and the numbers of the sections, towns, and ranges are all shown on USGS topo maps.

This topo map representation of the PLSS is available as a DLG layer, and in Wisconsin has further been developed into a GIS layer called the **Landnet** which contains approximate subdivisions down to 1/4-1/4 sections (nominally 40 acres each).

Boundaries

In addition to the PLSS, the USGS maps civil boundaries such as municipalities, counties, and park and forest land. In some cases these boundaries have changed since the maps were published. This "layer" is available in DLG format.

Geodetic control

High accuracy surveying relies on a network of monuments for which precise elevations and/or latitude and longitude have been determined. Some of these geodetic control points are shown on topo maps, although various indexes and databases are currently a more complete and up-to-date source of reliable information. The SCO serves as a clearinghouse of geodetic control for Wisconsin.

Map Scale

The scale of a map influences the amount of local detail or generalization inherent in the map as well as the size of the area covered. Scale is most often reported on a topo map as a "unitless" ratio where the first number (or numerator) represents the map distance, and the second number represents the corresponding ground distance.

For instance, on a map with a scale of 1:24,000, one unit of map distance represents 24,000 ground units. Therefore, one inch on the map equals 24,000 inches (or 2,000 feet) on the ground.

Large-scale vs. small-scale

A large-scale map shows a small area in great detail. This may seem backwards, but if you think in terms of ratios (or fractions) it becomes clearer. For instance, 1:5,000 is larger scale than 1:250,000.

Digital map scale

When printed maps are converted to digital form, the resulting computer files no longer have a map scale because they can be displayed at any size. This opens the door to potential misuse, as features may be misconstrued to be more precisely depicted and/or positioned than they actually are. A user needs to rely on a metadata description of digital files to understand these limitations, whether when using single files or when combining them into a view or analysis.

Geographic Names

The names of places and features found on USGS maps are also catalogued in the Geographic Names Information System (GNIS) which is available on CD-ROM or over the Internet.

Wisconsin's Topo Map Series

Since 1886, the USGS has been producing topo maps over Wisconsin. These maps are mostly grouped into series where each sheet is the same scale and covers a standard area. The table on page 2 carries the distinguishing characteristics of these series. Map indexes showing the coverage and map names for each series are on the web or on paper.

Small-scale coverage

USGS mapped the state on a single sheet at 1:1 million-scale, and also at 1:500,000-scale (which is about 4 x 4 feet). At 1:250,000-scale the state becomes too large for a single sheet so it is divided into blocks of 1 x 2 degrees of latitude x longitude. These types of blocks are sometimes called *quadrangles* or "quads" for short.

Series	Ratio Scale	Inch Scale	Mile Scale	Approx. Sheet Size	Approx. Image Size	Ground Area *(sq. miles)*	Contour Interval	# sheets in state	# maps completed	Current revision program	Years
7.5'	1:24,000	1"=2000'	2.64"=1 mi	22" x 27"	15-17" x 23"	50 - 55*	10 or 20 ft	1154	1154	yes	1944-95
15'**	1:62,500	1"= .99mi	1.01" = 1 mi	17" x 21"	12.8" x 17.5"	197-282	20 ft	323	230	no	1943-80
15'*◆	1:48,000	1" = .76 mi	1.32" = 1 mi	21" x 27"	16" x 23"	197-282	none	323	139	no	1904-59
15' metric	1:50,000	1" = .79 mi	1.27" = 1 mi	22.5" x 29.4"	17" x 21.9"	197-282	10 m	323	12	yes	1976-86
County	1:100,000	1" = 1.58 mi	0.63" = 1 mi	varies	varies	varies	20, 40 or 80 ft	72	72	yes	1985-86
30' x 60'	1:100,000	1" = 1.58 mi	0.63" = 1 mi	29" x 40"	22" x 32"	1578 - 2167	10 m	49	49	yes	1976-90
1⑤ x 2⑤	1:250,000	1" = 3.95 mi	0.25" = 1 mi	22" x 32"	18" x 25-27"	7200-7800	50 ft	18	18	yes	1963-82

** A few non-standard sheets cover upwards of 60 square miles.*

*** The 15-minute map series are no longer updated or reprinted; however film separations are still available.*

◆ *The 15-minute, 1:48,000-scale maps do not include contours, and thus are not truly topographic maps.*

Intermediate-scale coverage

A typical Wisconsin county at a scale of 1:100,000 is a convenient sheet size. For this reason, the state worked with USGS to produce a series of 72 such maps. Since the counties vary in size, so do the maps.

The national standard at this scale is quadrangles that are 30 x 60 minutes in size. However, those maps often split counties onto adjoining sheets. **Wisconsin has coverage of both the county and the quadrangle series at 1:100,000-scale.** Joined into a single statewide coverage, either set occupies about 17 x 17 feet.

The 1:100,000-scale topo map series was primarily compiled from the next more detailed series available nationwide, the 1:24,000-scale series (see below). It was also the linework basis of much of the digital TIGER file products developed to support the 1990 Census.

A number of DLG layers have also been developed from this series, most of which are available statewide in 30 x 30 minute units, or further enhanced and restructured in various GIS data layers.

Minor areas of the state have been mapped at other intermediate scales. Around Fort McCoy there are 14 map sheets (each a 15-minute quad) at 1:50,000-scale. An older series at 1:62,500 (also 15-minute quads) was halted before statewide completion.

Large-scale coverage

Probably **the best known USGS topo map series is published at 1:24,000-scale**. Each sheet is a quadrangle covering 7.5 minutes of latitude and longitude.

Although begun several decades earlier, this series was developed primarily in the 1970s and 1980s. **Since completion in 1985, only a small fraction of the sheets have been updated** and as a result the series overall is aging quite rapidly. In developing urban centers this poses a problem for some uses even though primary physical features such as the terrain and the major water features may remain essentially unchanged.

Map sheet names

When a series of quadrangles are prepared over an area, each sheet is given a name taken from a settlement or physical feature within the area. Within Wisconsin, these names are unique.

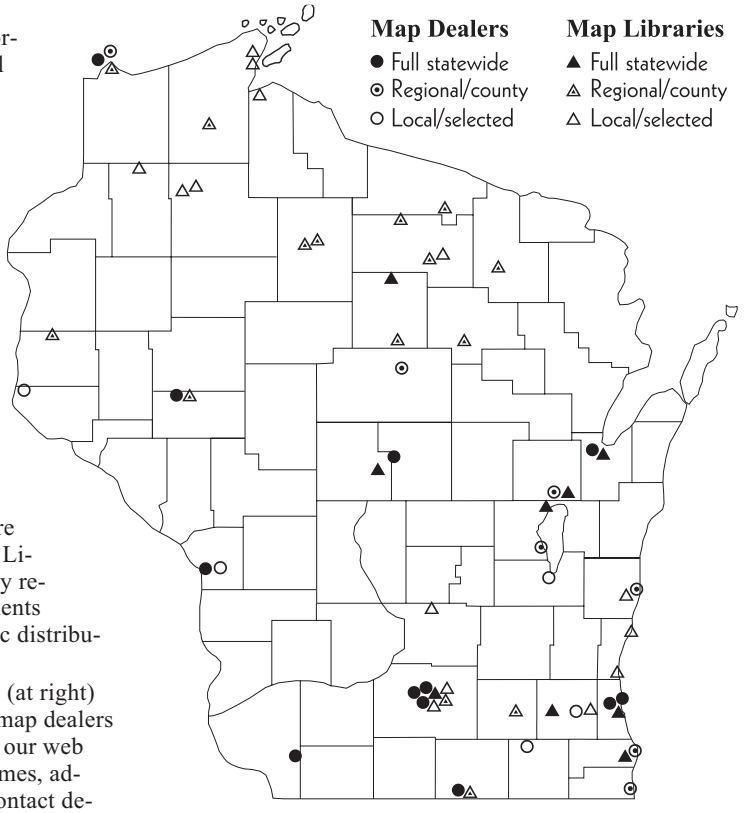
Sources for Topo Maps

There are dozens of outlets in Wisconsin where you can buy copies of USGS topo maps. At most of these locations, the dealers carry only maps of the local area and/or the 1:24,000-scale quads. However, **there are a number of dealers who stock statewide coverage**, and some will also service mail, telephone, and fax orders. We do not sell USGS maps at the SCO.

Dealers are free to set the prices they charge for USGS topo maps, as well as for shipping/handling. Quantity discounts may be available.

Certain libraries also have map collections for on-site viewing and/or borrowing. Some are termed "Depository Libraries" because they receive federal documents through an automatic distribution.

Consult the map (at right) for locations of the map dealers and libraries. Visit our web site or call us for names, addresses, and other contact details.



Sites for buying and viewing USGS topo maps.

Digital Versions of Quads

Computerizing of topo map contents has been very popular in the 1990's. The concepts, computer file specifics, and status are too complex to report here. Following is a very brief introduction.

Digital Raster Graphics (DRGs)

Beginning in 1995, the USGS began a program to scan paper copies of currently maintained topo maps series into DRG files (raster TIFF images). This work was **completed by 1997** with 50% state coordinated cost-sharing, and further funds underwrote **enhancements that help make the images more usable in a GIS context.** Neither the paper maps, the standard DRGs, nor the enhanced products are copyrighted.

The DRGs represent a low cost alternative to buying paper copies, but their image quality isn't as high as the original maps. Also, few people have color plotters big enough to print a copy at the same scale as the original, and some plotter inks may fade. Clipped sections can be pasted into computer documents easily.

Several private companies have also scanned USGS quads and some offer customized viewing software.

To learn much more about all of these aspects of scanned topos, visit our website.

Digital Elevation Models (DEMs)

Derived from topographic contour lines, DEMs are another form of terrain information. These are grids of elevation values over an area. The grid spacing, and the elevation value accuracy are different depending on which map source was used. DEMs from the most detailed USGS topo map series are available statewide. For a tour of the DEM world, visit our website.

The Digital Line Graphs (DLGs)

Another form of computerized topo maps are the DLGs. These use a vector format where map features become encoded as points, lines, and/or areas.

Typically, a "layer" of information is limited to a single class of features: water bodies, roads, etc. DLG files are often converted to GIS layers to which various feature attributes are attached; they may then be enhanced by encoding spatial relationships between features. A number of DLG layers are available, but a full complement of all layers is not available from each topo map series.

Coordination and Funding

By state statute, responsibility for administering and coordinating Wisconsin's topographic mapping by federal agencies is assigned to the **state geologist** who directs the Wisconsin Geological and Natural History Survey (WGNHS).

Most of the USGS topo maps for Wisconsin were funded under 50:50 cost sharing arrangements. **Wisconsin's funding for the**

1:24,000-scale series, mostly provided by our state departments of transportation (DOT) and natural resources (DNR) in addition to the WGNHS, **totaled $4.9 million.** Beyond matching that amount, additional federal funds were allocated, bringing the total investment to $11.9 million (not adjusted for inflation).

After the 1:24,000-scale series was completed in 1985, the WGNHS maintained a $20,000 annual state program to fund quad revision, but even that modest amount fell victim to budget cuts in 1995.

Conversion of existing topo mapping to various digital forms has been coordinated and funded by a variety of other mechanisms, although the DNR, DOT, and WGNHS, and other in-state organizations have all been involved in these efforts.

Revisions to the USGS topo series

Less than 10% of Wisconsin's coverage of the USGS topo maps have been revised since 1980. None of this work has been full replacement mapping (the most costly alternative) but has involved updates to selected features. An block of 42 quads surrounding Lake Winnebago were updated in the mid-1990s (with federal funds) using a computerized process and a modified symbol scheme. A new economical raster edit process may encourage more revision activity.

How Topo Maps are Produced

The initial edition of a topo map is compiled primarily from aerial photographs using a complex process based on **photogrammetry**. For features not visible in the photographs, though, information is collected from other sources.

Recent aerial photography is the primary source for map revision. **Orthophotos**, which are digitally scanned aerial photographs but are accurate like a map, **have become an important revision tool.**

USGS topo maps are printed using a special set of ink colors, and features are separated by color. For instance, blue is reserved for water, green for forest, and only contour lines are brown. However, boundaries, text, and geodetic control points are all printed in black. Maps are printed using offset (lithographic) presses.

Map separates

Film copies of certain classes of topo map features can be acquired from the USGS. These "separates" are useful for subsequent printing projects or as a digitizing source. As a federal agency, none of USGS's products are copyrighted.

Map Accuracy

USGS topo maps adhere to vertical and horizontal accuracy standards. The *National Map Accuracy Standards* (NMAS), likely will be replaced by the *National Standard for Spatial Data Accuracy.* To put horizontal accuracy into perspective, the 1:24,000-scale topo maps are constructed so that at least 90% of features that are "well-defined" in the landscape are positioned within 40 feet (1/30th of an inch at map scale) of their true location. At 1:100,000-scale, this standard equates to 167 feet.

However, this is an absolute standard, based on comparing map position to true latitude and longitude, feature by feature. In practice, relative accuracy based on mapped distances between nearby features is much higher.

Vertical accuracy is described for contour lines, where the actual elevation for at least 90% of test points must not differ by more than ½ the contour interval.

Non-spatial accuracy encompasses issues such as completeness *(are any features missing?)*, classification *(are features shown with the correct symbol?)*, and names. While changes on the land can render a map inaccurate, this is different than errors embedded at publication time. In either case, there are no specific standards for these types of accuracy.

If you come across questionable features, elevations, or positions on topo maps, please contact the SCO. Also, if you believe that a name of a feature warrants being changed, we can advise you on the process involved (which includes making a formal request to the Wisconsin Geographic Names Council).

Map Projections

Lambert Conformal Conic, and Transverse Mercator are the commonly used projections used in USGS topo maps. In earlier years, the Polyconic projection was used, too. **In order for map sheets to fit together over an area, they must all be built on the same map projection.** After conversion to digital form, however, it is relatively easy to switch between different coordinate systems which often are based on different projections.

Datums

Prior to the 1980s there was only one horizontal datum and one vertical datum used widely in U.S. topo mapping to provide consistent reference surfaces for mapping. However, the arrival of NAD 83 and NAVD 88 changed that situation. Existing topo mapping is rarely changed to these newer datums due to the cost involved. However, it is easy to apply datum conversion formulas to computerized map files, although the resulting products shouldn't be thought of as being more accurate than the originals.

Magnetic North and Grid North

The direction a compass needle points is rarely exactly toward the north geographic pole, although in Wisconsin the differences are relatively small. However, **the earth's magnetic field changes over time,** so the direction of magnetic north shown on many Wisconsin topo maps has changed by several degrees since they were published. Contact us for details.

Grid north is a third type of "north". It is aligned with the grid of a plane coordinate system, and usually will not be quite the same as geographic north and further will often vary across a mapped area. However, it will not change over time.

To Find Out More...

We invite you to visit our Internet web site to learn more about this topic:

feature.geography.wisc.edu/sco/

This guide is a very abbreviated treatment, and **on our web site you will find more detailed information plus samples and examples.** There we also **point you toward a wide variety of books, guides, pamphlets, and other web pages** which will help you better understand topo maps and their development, including a number of computerized products derived from USGS maps of Wisconsin. From our web site you can also post questions to us.

If you don't have Internet access, please contact us directly.

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This guide is published by the Wisconsin State Cartographer's Office and distributed free of charge.

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