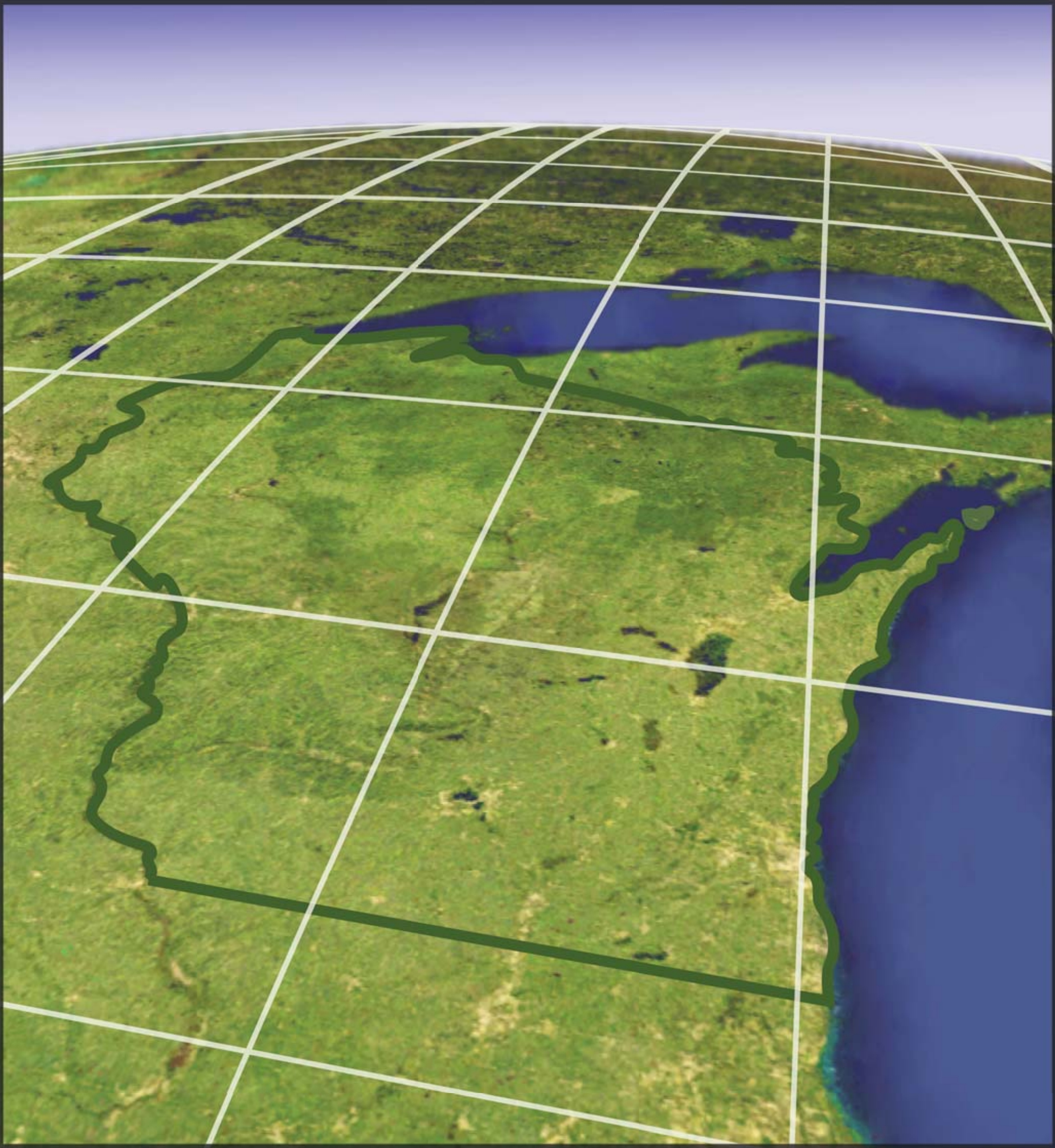
Wisconsin
Coordinate Reference Systems

Second Edition



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State Cartographer's Office

THE UNIVERSITY of WISCONSIN MADISON

Wisconsin
Coordinate Reference Systems

Second Edition

Wisconsin State Cartographer's Office — Madison, WI

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About the State Cartographer's Office

Operating from the University of Wisconsin-Madison campus since 1974, the State Cartographer's Office (SCO) provides direct assistance to the state's professional mapping, surveying, and GIS/LIS communities through print and Web publications, presentations, and educational workshops. Our staff work closely with regional and national professional organizations on a wide range of initiatives that promote and support geospatial information technologies and standards. Additionally, we serve as liaisons between the many private and public organizations that produce geospatial data in Wisconsin.

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The contents of the *Wisconsin Coordinate Reference Systems* (2nd edition) handbook are made available by the Wisconsin State Cartographer's office at the University of Wisconsin-Madison (University) for the convenience of the reader. This handbook is provided on an "as is" basis without any warranties of any kind.

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Revisions

Wisconsin Coordinate Reference Systems (2nd edition) is a digital publication, and as such, we occasionally make minor revisions to this document. For a complete list of updates made since the original publication in April 2009, please see page 112.

Acknowledgements

We would like to thank the many individuals, organizations and agencies who provided support and materials for this publication. This edition, an update to *Wisconsin Coordinate Systems*, published in 1995, was guided by the Wisconsin Coordinate Systems Task Force of the Wisconsin Land Information Association (WLIA). Dr. Alan P. Vonderohe, the Wisconsin Department of Transportation, and the Jackson County Land Information Office contributed information, analysis and administrative support related to Wisconsin's county-based coordinate systems. The National Geodetic Survey provided illustrations and technical support. The cover image was developed in NASA World Wind. We are grateful to the Wisconsin Coordinate Systems Task Force and other members of the Wisconsin land information community for their very valuable review of this handbook, and to the Wisconsin County Surveyors Association for their financial support to offset production costs.

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Dedication

This publication is dedicated to the many years of surveying and mapping education at the University of Wisconsin-Madison and the exceptionally talented faculty of those programs.

Foreword

Wisconsin Coordinate Reference Systems (2nd edition) is a technical guide and resource for those who work with geospatial information in Wisconsin. This handbook provides a brief overview of the history, evolution, and basics of Wisconsin's coordinate reference systems, and compiles in one place the technical specifications for coordinate reference systems most commonly used here.

An overview of Wisconsin coordinate systems was first published in 1995 by the State Cartographer's Office. The first handbook provided background material on map projections and coordinate reference systems and compiled, for the first time, information about the most commonly used systems in Wisconsin. The current edition provides updated information about Wisconsin coordinate reference systems, adds information about the geodetic systems that support coordinate reference systems, and includes information on the 2006 County Coordinate Systems redesign project and the new Wisconsin Coordinate Reference Systems (WISCRS).

This handbook is intended to be a coordinate reference systems user manual, therefore we assume some knowledge and prior exposure to basic concepts of map projections and coordinate reference systems. The "References and Resources" section in this handbook provides additional references for readers requiring more detailed background information.

Contents

Introduction

Note: words in italics are defined in the Glossary (beginning on page 106)

The explosion in the use of geospatial technologies – in particular, global positioning systems (GPS), imaging systems, and geographic information systems (GIS) – have made a sound understanding of *spatial reference systems* critical to successful use of these technologies.

Thanks to advances in the usability and sophistication of many common GIS and computer mapping programs, *coordinate reference systems* and *coordinate* values can be stored, computed, and transformed with relative ease. But, without an understanding of basic concepts, system designs, and limitations, erroneous data can easily result.

This handbook describes coordinate reference systems commonly used in the state of Wisconsin, the rationale behind these systems, the parameters used to define them and data *conversion* and *transformation* among systems. The remainder of this section summarizes the fundamentals required to understand more complex concepts described later.

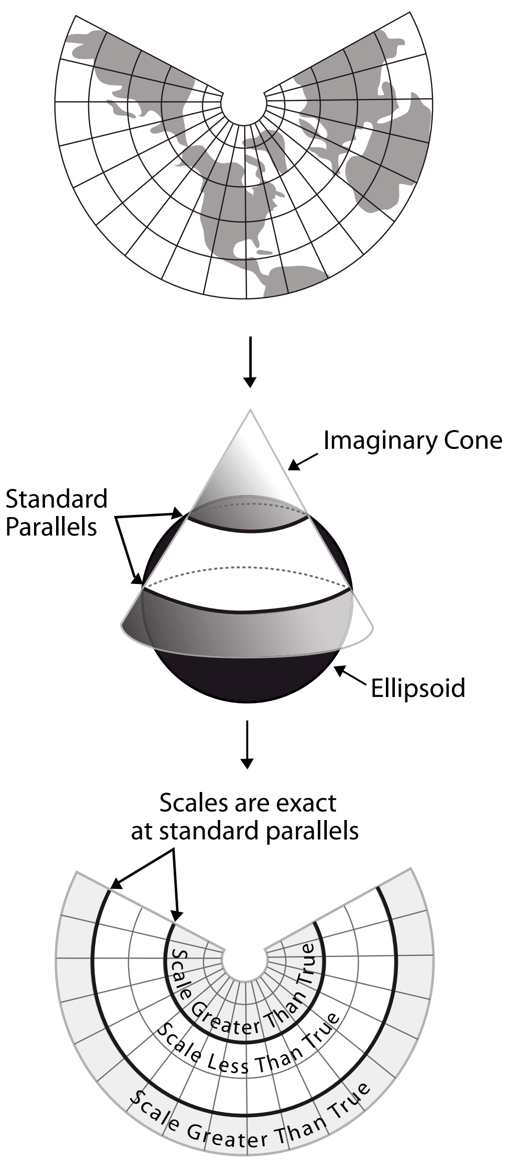


Figure 1: The Lambert conformal conic projection

Map Projections and Coordinate Reference Systems

Geographic coordinates (latitude and longitude) are perhaps the best known method for describing a horizontal position on the surface of the Earth. Latitude and longitude are expressed in angular units, typically degrees, minutes and seconds (e.g., 90° 45' 15'') or decimal degrees (e.g., 90.75416667°).

Measurements, computations and computer applications are more difficult to manage using angular units, thus, latitude and longitude values are commonly converted to a *rectangular coordinate system* of "northings" (Y-axis) and "eastings" (X-axis) that can be expressed and easily understood in linear units such as meters or feet.

Converting a position from geographic to rectangular coordinate values requires the point to be projected from an *ellipsoid* (a mathematical representation of the Earth) to a *"developable"* map *projection* that can be made into a flat surface.

The earth's spherical surface cannot be transformed to a flat map without creating significant distortions. Distortion can affect shape, area, scale (distance), or direction depending upon the projection used. Many unique map projections exist, each intended to minimize a particular distortion. The *conic projection* and *cylindrical projection* are examples. However, no single projection can give an exact representation of the surface of the Earth.

The two most common projections used as reference surfaces for rectangular coordinate systems are the Lambert conformal conic *(see Figure 1)* and the transverse Mercator *(see Figure 2)*.

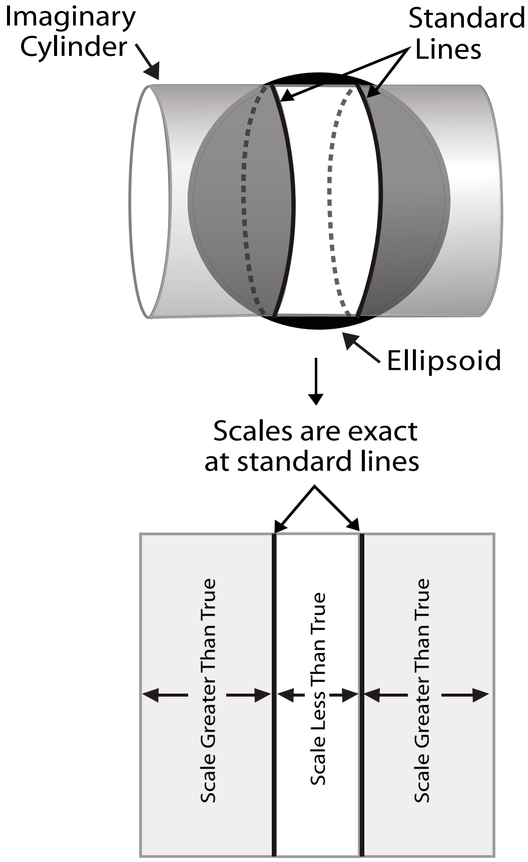


Figure 2: The transverse Mercator projection

These projections are designed to have varying scale, but retain the correct shape of the mapped area. Scale variation is greatest in north-south directions for Lambert conformal conic projections, and in east-west directions for transverse Mercator projections. For these reasons, Lambert conformal conic projections are typically used for geographic areas having larger east-west extents, while transverse Mercator projections are used for areas with larger north-south extents.

Principles of Rectangular Coordinate Reference Systems

A map projection simply defines how the ellipsoid model of the earth is transformed to a flat surface. By comparison, a rectangular coordinate reference system is defined by three elements:

1. A geodetic *datum* (and any adjustments to that datum) *(see pages 5-8)*
2. Map projection referenced to the specified datum by a point of origin and orientation
3. *Unit of measurement*

Note that a map projection makes up only one part of the definition of a rectangular coordinate reference system. Also, a coordinate reference system may use more than one map projection. The State Plane Coordinate System, for example, uses both the transverse Mercator and Lambert conformal conic projections in the 48 conterminous states.

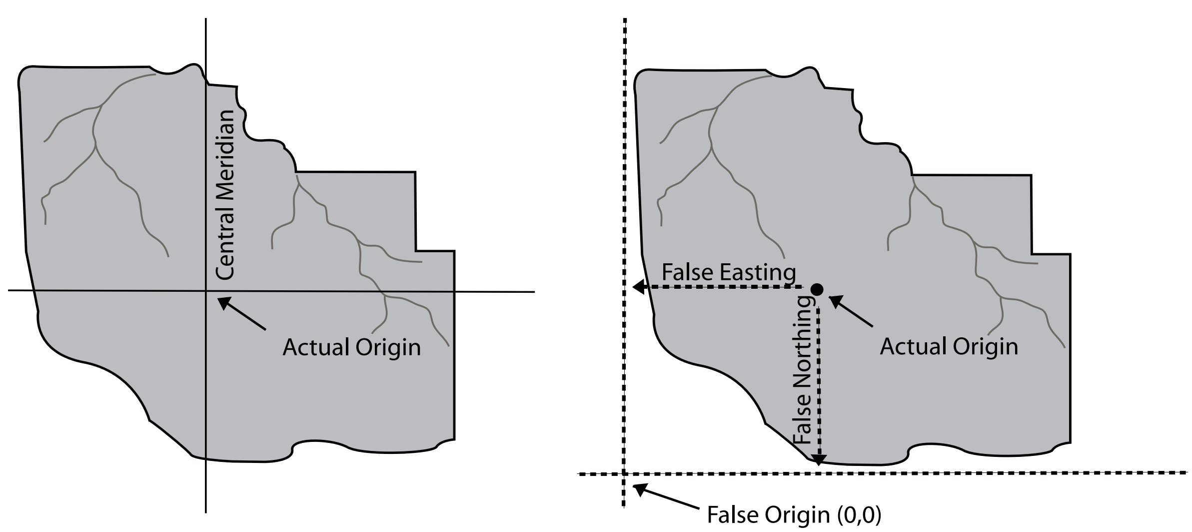


Figure 3: Shifting a rectangular coordinate system's origin, by false easting and northing to produce a false origin

Origin and Orientation

All coordinate reference systems must have a point of origin, typically expressed as a latitude and longitude coordinate pair. The true origin of a rectangular coordinate system is often shifted by applying a *"false" easting and/or northing* assuring that all points within the region covered by the system will have positive coordinate values. This results in a *"false origin"*, which is typically located west and south of the projection area, and has a coordinate value of 0,0 *(see Figure 3).*

The orientation of the most common coordinate reference systems is established through a *central meridian*. Only at the central meridian does a coordinate reference system's "grid north" line coincide with true north. Unlike the latitude-longitude system, the north-south lines of a grid system never converge toward the poles *(see Figure 4).* The angular difference between grid and true north is known as the convergence angle. The convergence angle is typically a factor only for land surveying applications requiring a high degree of accuracy over long distances.

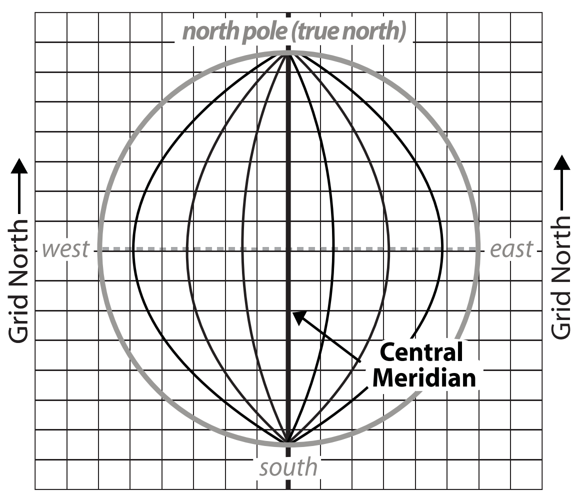


Figure 4: Relationship of true north and map coordinate grid north

Unit of Measurement

Another key piece of coordinate system information is the linear unit of measurement applied to the system. While the definition of the coordinate system requires formal specification of linear units, users often convert coordinate values to other units of measure that better match the information with which they are working.

Rectangular coordinate systems typically use the meter, international foot, or U.S. Survey Foot as the unit of measurement. Most surveying and mapping work conducted at the local level in the United States is based on the U.S. Survey Foot.

When a conversion from one of these units to the other is performed, it is important to determine which standard foot is involved. The international foot, based upon a redefinition of the meter in 1959, is equivalent to exactly 0.3048 meters. The U.S. Survey Foot is equivalent to exactly 1200/3937 meters, or 0.30480061 meters when rounded to 8 digits.

Additional Considerations

Scale Factor

Distances on the ellipsoid surface, called "geodetic distances", differ from corresponding grid distances projected onto the map projection surface. The ratio of projected distance to geodetic distance is known as the *scale factor*.

The design of a map projection often results in one or more places where the scale factor is held constant – equal to 1.0 – and geodetic distances are the same as grid distances. The scale factor is equal to 1.0 along *"standard lines"*. When project data does not lie at a point where the scale factor is 1.0, scale factors must be applied to obtain accurate grid distance values *(see Figure 5).*

Ground-to-Grid Ratio

A limitation of coordinate systems covering large areas is that distances computed on the grid surface are not equivalent to actual ground distances *(see Figure 6).* Surveying measurements are made on the surface of the earth, while engineering designs and computer applications are referenced to the rectangular grid surface. Understanding the *ground-to-grid ratio* is crucial. To properly relate ground and grid distances, the scale factor and *elevation factor,* (together known as the "combined factor") must be applied.

Ground-to-grid conversions are dependent on *elevation*, with differences between ground and grid values being more significant in areas of higher elevation *(see Figure 6).* In Wisconsin, grid distances and ground distances can vary by as much as one foot per mile when using the State Plane Coordinate System and by more than twice that amount when using the Wisconsin transverse Mercator coordinate system. Ground-to-grid differences are negligible in the Wisconsin County Coordinate Reference Systems.

Specifying whether coordinate values are grid or ground-based is another critical piece of coordinate system information.

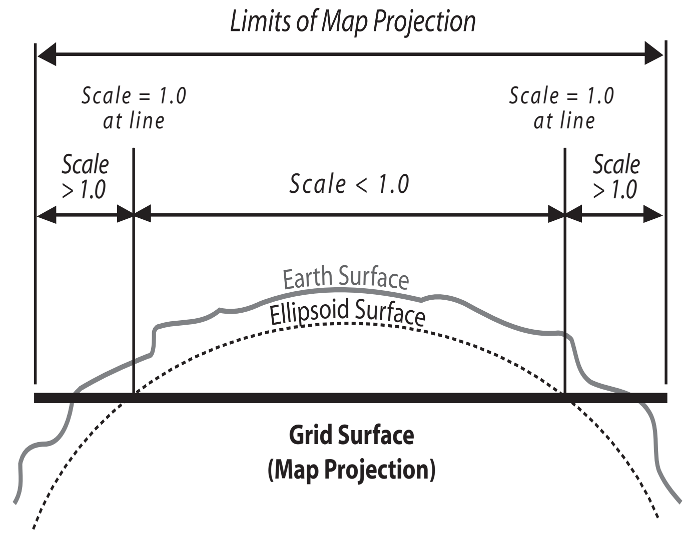


Figure 5: Scale relationship between the ellipsoid and map projection

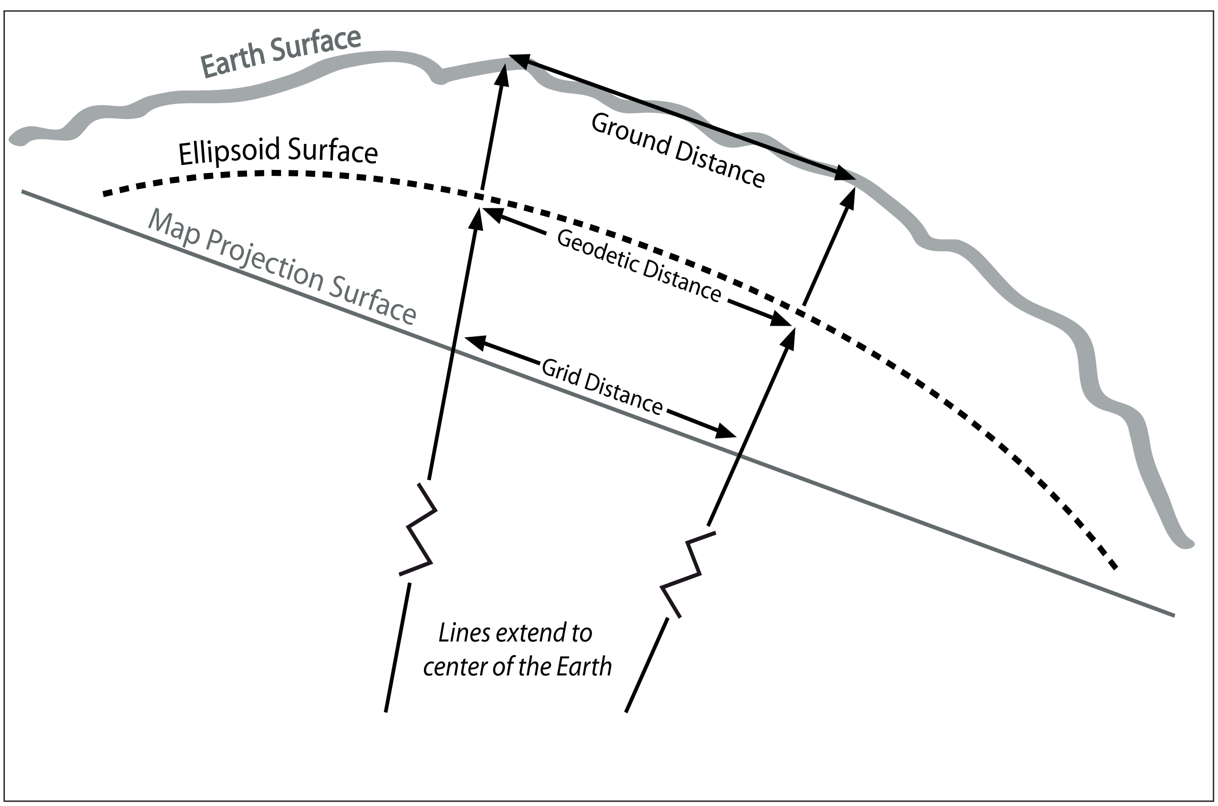


Figure 6: The relationship of ground distance, geodetic distance, and grid distance

Horizontal Geodetic Systems

Introduction

Geodetic systems describe the size and shape of the Earth, and are used to translate real positions on the Earth to positions shown on maps and in survey records. Geodetic systems are also referred to as "geodetic datums." A horizontal geodetic datum is a mathematical model approximately representing the surface of the Earth that is physically referenced through a network of *monumented survey points* with precisely known coordinate positions.

A horizontal geodetic datum is used to locate and measure positions on the Earth. It is the basis for two-dimensional referencing in latitude/longitude or other (north/south and east/west) coordinate systems. Depending on the horizontal datum, a position on the Earth can have very different coordinates. Literally hundreds of different horizontal geodetic datums exist around the world.

These systems range from simple "flat-earth" models where the dynamics and curvature of the Earth are ignored due to the small geographic area covered by the system, to very complex systems that are intended to support global applications.

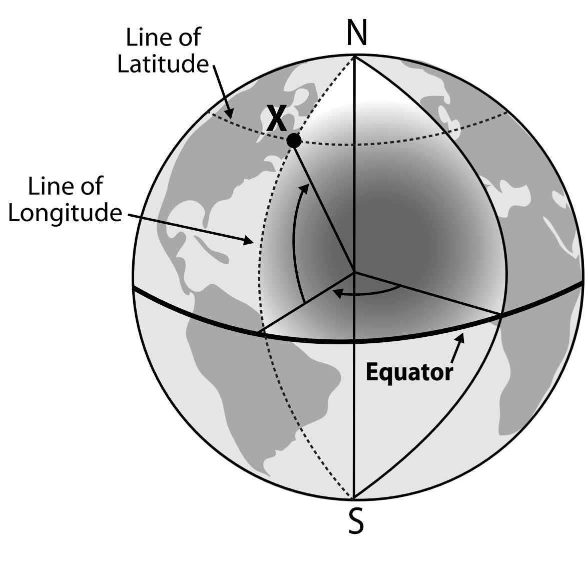


Figure 7: Location of point X shown as a latitude/longitude coordinate point

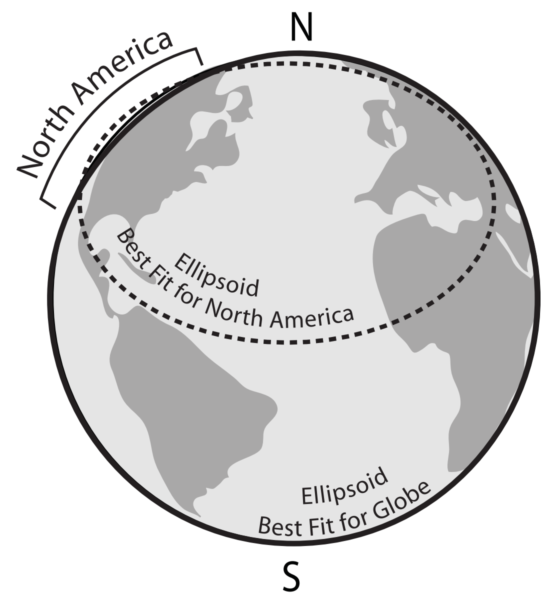


Figure 8: "Best fit" ellipsoids

Positions, Models, and Datums

The most basic expression of a horizontal position is through latitude and longitude, also known as geographic coordinates. These coordinates, are expressed in the angular units of degrees, minutes and seconds (for example, 45° 15' 00"), or may be expressed in decimal degrees (for example, 45.25°) and are referenced to an approximate mathematical model (ellipsoid) of the surface of the Earth *(see Figure 7)*.

When the ellipsoid model is oriented and positioned in space, it forms a "horizontal geodetic datum." The datum is physically referenced through a geodetic network of measurement and monumented points that are recoverable and usable for field applications, and for which formally adjusted and published coordinate values are available.

Horizontal geodetic datums are designed and established differently depending on use and the extent of coverage. The selection of a particular ellipsoid as the Earth model and the fixation of that ellipsoid with respect to the Earth's surface are key elements in defining a horizontal geodetic datum. Ellipsoids are generally chosen to "best fit" the area of the Earth that the horizontal geodetic datum will cover *(see Figure 8).*

Following are brief descriptions of commonly used horizontal geodetic datums in the United States.

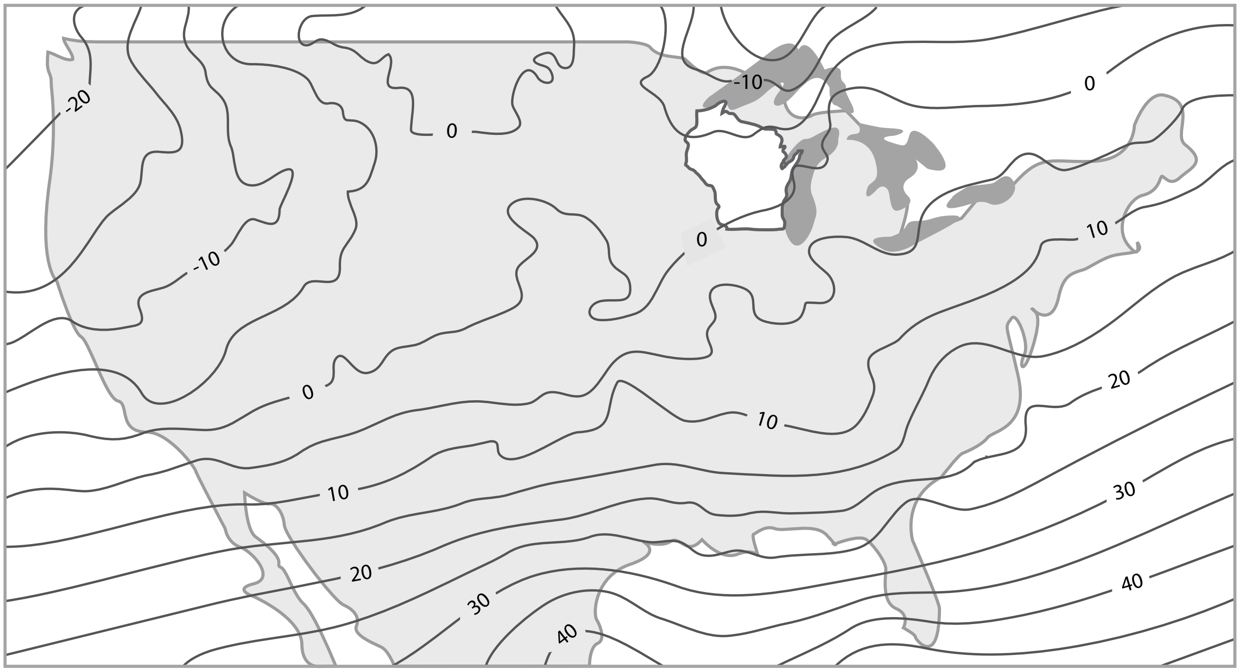


Figure 9: Latitude datum shift in meters [NAD 83 (1986) minus NAD 27]

North American Datum of 1927

The North American Datum of 1927 (NAD 27) is a national geodetic control network published in the 1920s and based on the Clarke 1866 ellipsoid. This ellipsoid model "best fit" the United States and Canada. The origin of this datum which fixes it with respect to the surface of the Earth is a single point, Station Meades Ranch in Kansas.

Over the decades, massive amounts of measurements and mapping by local, state and federal agencies, and the private sector, have been referenced to NAD 27. In Wisconsin, eight counties continue to base their digital geospatial data and mapping on NAD 27.

Over the years, subsequent geodetic control work was "made to fit" the horizontal network as it existed in 1927. This, coupled with improved technology and expanded knowledge of the shape of the Earth, caused measurement differences to accumulate resulting in a lesser quality system overall. Eventually, this led to the decision by the *National Geodetic Survey* (NGS) to redefine and readjust the datum.

North American Datum of 1983

The North American Datum of 1983 (NAD 83), a fundamentally different datum, has for the most part replaced NAD 27. It is based on a *geocentric* Geodetic Reference System of 1980 (GRS 80) ellipsoid rather than the older Clark 1866 ellipsoid used in NAD 27. The completion of NAD 83 removed significant local distortions that had accumulated over the years in NAD 27, making NAD 83 much more compatible with modern survey technologies and practices.

Since NAD 27 and NAD 83 were computed from differing sets of measurements referenced to different ellipsoids, there is no exact mathematical correlation between them. However, transformation software has been developed based upon models that can interpolate differences and apply that information to other data. The federal government has officially adopted NAD 83 as the nation's legal horizontal datum, and NAD 83 is likewise recognized in legislation in nearly all states, including Wisconsin.

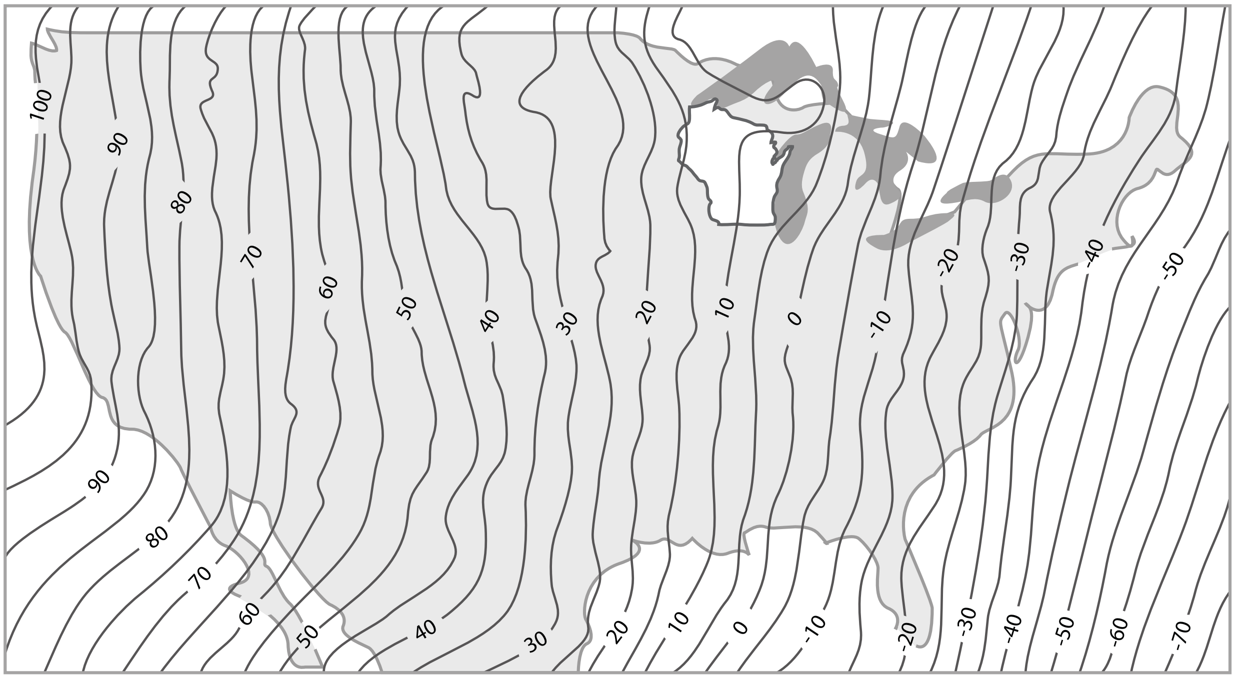


Figure 10: Longitude datum shift in meters [NAD83 (1986) minus NAD 27]

North American Datum of 1983 (1986)
Data related to the North American Datum of 1983 were generally published and made available in 1986, thus the published adjustment is referred to as NAD 83 (1986). In Wisconsin, shifts between the NAD 27 and NAD 83 (1986) datums range between -8 to +2 meters in latitude, and between +5 to +15 meters in longitude. *(see Figures 9 and 10)* Several datum adjustments have been applied to the NAD 83 datum since its initial 1986 definition and adjustment.

North American Datum of 1983 (1991)
The NAD 83 (1986) adjustment was published just as Global Positioning System (GPS) technology was coming into wide use. The National Geodetic Survey (NGS) realized the potential for increased network accuracy through the use of GPS and undertook an effort to use the technology to establish a *High Accuracy Reference Network (HARN)* in each state, beginning with Wisconsin in 1991. The establishment of Wisconsin's HARN resulted in the NAD 83 (1991) datum readjustment. As a result, this adjustment has been the most prevalently used datum by local and state agencies in Wisconsin. The NAD 83 (1991) adjustment compared to the NAD 83 (1986) adjustment for Wisconsin resulted in datum shifts ranging from -4 to +1 meters in latitude and from -0.3 to +0.3 meters in longitude.

North American Datum of 1983 (1997)
In 1997, the Wisconsin HARN was resurveyed and adjusted again, with the additional survey stations improving and strengthening the network. The NAD 83 (1997) adjustment provided a foundation for improvements to Wisconsin's vertical geodetic network through the Height Modernization Program.

In Wisconsin, the difference between NAD 83 (1991) and NAD 83 (1997) is about 4 centimeters — negligible for all but the most precise surveying and mapping applications. This difference is even smaller than the probable error in the mathematical models used by NGS in transformation software such as *NADCON and CORPSCON.* Therefore, these programs do not currently support transformation using NAD 83 (1997) data.

North American Datum of 1983 (National Spatial Reference System 2007)

Recently, NGS has completed and published the newest national horizontal geodetic datum readjustment – NAD 83 (NSRS 2007). This readjustment was undertaken to "better match" the earlier HARN networks across state borders, to take advantage of GPS technology advances with regard to *ellipsoid heights*, and to respond to national geopositioning standard requirements for individual and network accuracy estimates for all stations in the national geodetic network.

In the mid-1990s, NGS began to establish a national network of *continuously operating reference stations (CORS)* to support the use of GPS technology. Inconsistencies among neighboring state HARN network adjustments and the nationwide CORS network were resolved with the simultaneous network readjustment of 2007. A primary benefit of NAD 83 (NSRS 2007) is that for the first time since 1986, the nation has a single harmonized adjustment, reported according to current geopositioning standards.

World Geodetic System (1984)

The WGS 84 geodetic referencing system was developed by the Department of Defense and is used by military and homeland security agencies and the National Geospatial-Intelligence Agency. It is also the system used to describe orbits of GPS satellites.

When first established in 1987, WGS 84 was effectively identical to NAD 83 (1986). Subsequently, WGS 84 has undergone a number of readjustments, as has NAD 83. The readjustments of WGS 84 were based upon sets of measurements that differed from those used in the readjustments of NAD 83. Therefore, published coordinates for the same points on different adjustments of the two datums now have different values. For surveying and high-accuracy mapping, these differences can be significant and must be accounted for when collecting data with GPS. GPS receivers and associated office software compute positions using satellite orbit information broadcast by the satellites themselves or downloaded from tracking stations. As noted, these orbits are usually described with respect to the latest adjustment of WGS 84. If the desired datum for surveying and mapping applications is an adjustment of NAD 83, a transformation must be applied. Some GPS data process programs have default input and output datums that are the latest adjustments of WGS 84 and NAD 83, respectively.

Datums in State Law

Chapter 236 of Wisconsin Statutes contains the rules for land division and platting such as subdivisions. Chapter 236, Section 236.18(2) specifies legally allowable datums and related coordinate systems that may be used for subdivision platting. Chapter 236 identifies the Wisconsin Coordinate System (SPC 1986) and the use of other coordinate systems that are mathematically relatable to NAD 27 or NAD 83 or subsequent federal datum definitions and adjustments.

Vertical Geodetic Systems

Introduction

As previously discussed, a horizontal geodetic datum provides the basis for two-dimensional referencing. A vertical geodetic datum provides the basis for developing heights and depths.

Developing heights and depths involves another Earth model and reference surface critical to geodetic systems - the *geoid*. The geoid is an equipotential surface of the Earth's gravitational field that best fits the global equivalent of "mean sea level" *(see Figure 11).*

Mean Sea Level and the Geoid

Mean sea level is determined over time by averaging the level of the seas including such factors as wind-created waves, and changes due to tides. This imaginary sea level surface conforms to the Earth's gravitational field, which is similar, but much smoother, than the Earth's land surface.

The mean sea level surface can be conceptually extended under the continents, and as such, is a close approximation of the geoid. However, due to measurement inconsistencies and non-periodic changes in sea level, the relationship between the geoid and mean sea level is not exact or consistent.

Elevation and Heights

An elevation of a point is the distance the point is above or below a datum. An orthometric height of a point is the distance the point is above or below the geoid. Traditionally called "elevation," the *orthometric height* is the mathematic combination of the *ellipsoid height* minus the *geoid height* at a point *(see Figure 11).* The mathematical models of the geoid heights are continually updated and refined as additional measurements are incorporated. In Wisconsin, the geoid generally lies about 30 meters below the GRS 80 ellipsoid, the ellipsoid for NAD 83. In Wisconsin, geoid heights are always a negative value.

Modeled geoid heights vary according to the mathematics used to produce them. Some modeled heights are accurate to a few centimeters. Since geoid models vary and are frequently updated, knowing the specific model used in computations is a critical piece of elevation information.

National Geodetic Vertical Datum of 1929

Until 1973, the National Geodetic Vertical Datum of 1929 (NGVD 29) was known as the Sea Level Datum of 1929, or more commonly, "mean sea level." For this vertical datum, mean sea level was determined by continuously measuring the rise and fall of

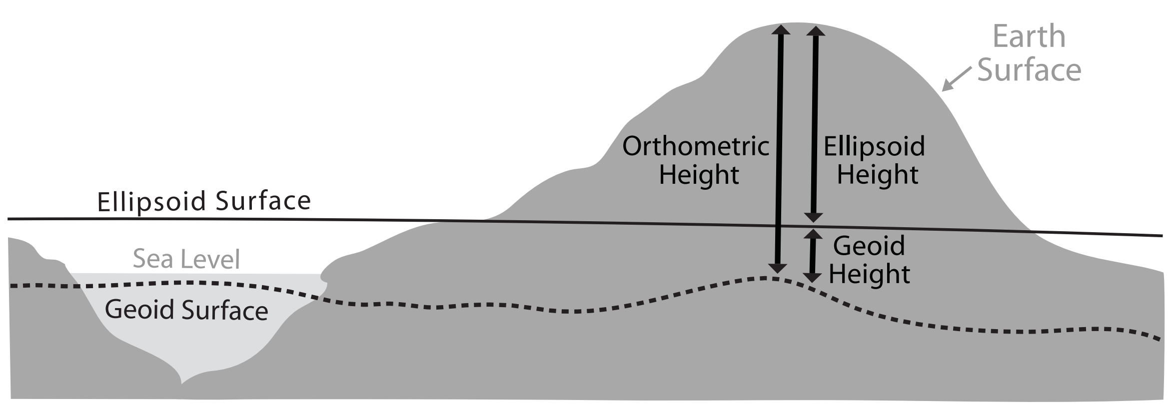


Figure 11: Relationship of the "heights" — geoid, ellipsoid, and orthometric

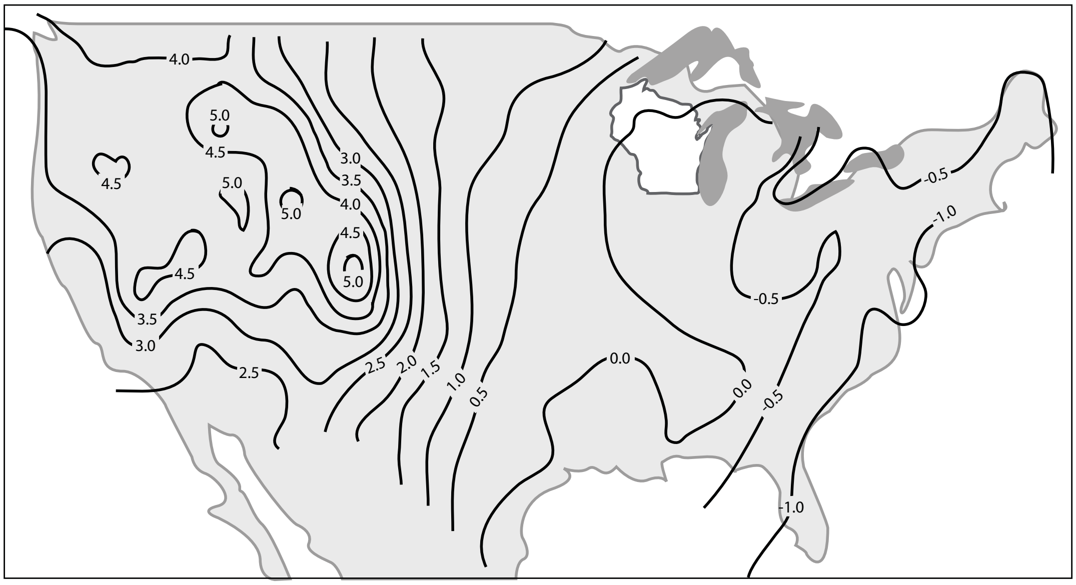


Figure 12: The difference in feet between NGVD 29 and NAVD 88 (1991)

the ocean at 26 tide gage stations along the U.S. and Canadian coastlines. Highs and lows of tides, caused by changing effects of gravitational forces from the sun and moon, are averaged out over a tidal "epoch," a period of at least 19 years. This information, together with a national network of level lines, formed NGVD 29.

North American Vertical Datum of 1988

By the 1980s, thousands of in-ground monuments (bench marks) across the nation were damaged or destroyed, thousands of new bench marks were added, and many existing bench marks had moved due to the effects of crustal motion, postglacial rebound, subsidence, or frost. Distortions of as much as two meters nationally required a need for new leveling data and a new vertical datum.

Apparent NGVD 29 distortions in Wisconsin were approximately 10 centimeters. The greatest of these were in southeastern Wisconsin.

North American Vertical Datum of 1988 (1991)

The nationwide adjustment for the North American Vertical Datum of 1988 (NAVD 88) was completed in 1991. Up to 20 percent of existing NGS bench marks were not included in the adjustment because the older network data were inconsistent with the newer data. In addition, thousands of U.S. Geological Survey third-order bench marks were not included in the adjustment because NGS did not have complete data on the marks.

The NAVD 88 (1991) nationwide adjustment was fixed on a single existing bench mark elevation at Father Point/Rimouski located in the mouth of the St. Lawrence River, Quebec, Canada. The selection of this point was made to minimize the impact of NAVD 88 (1991) on U.S. Geological Survey mapping products, such as the 7.5-minute quadrangle series.

NAVD 88 (1991) is more compatible with modern surveying and mapping technologies such as GPS and LiDAR, is more accurate than NGVD 29, and is now designated as the official vertical datum for the United States. Additionally, NGVD 29 is no longer supported by NGS, and published heights for NGVD 29 on NGS bench marks will not be updated.

The Federal Emergency Management Agency (FEMA) attempts to base all digital flood insurance map modernization projects on NAVD 88 (1991) unless there is significant local opposition to changing the mapping from the previously used NGVD 29 datum.

In Wisconsin, the difference between the NGVD 29 and NAVD 88 (1991) datums is minimal, with a zero shift line running through the northern portion of the state *(see Figure 12).* The computer programs *VERTCON* and *WISCON* are both capable of computing modeled transformations between NGVD 29 and NAVD 88 (1991) heights.

North American Vertical Datum of 1988 (2007)

Many of the Wisconsin monuments included in the NAVD 88 (1991) adjustment were surveyed in the 1930s. In using the NAVD 88 (1991) datum, the Wisconsin Department of Transportation (WisDOT) found many data inconsistencies due to poor survey methods, and monuments that had moved due to a variety of factors. Thus, the decision was made by NGS and WisDOT to proceed with a subsequent adjustment. This readjustment on the NAVD 88 (1991) datum was completed during 2007 by NGS and included several thousand selected points in Wisconsin. These were points included in field surveys conducted during the first five phases of the Height Modernization Program (HMP) in Wisconsin (for more on the HMP, see next column).

For the 2007 project, NGS agreed to readjust values for those monuments included in the HMP surveys; hence the data tag NAVD 88 (2007) was created to differentiate the data of the 2007 adjustment from data of the 1991 adjustment. Today, many monuments still exist in the state with NAVD 88 (1991) values because they were not part of the HMP survey process and therefore not part of the 2007 adjustment. It is important for users of height data to be aware of these two adjustments so that vertical data is properly used and transformed.

Within Wisconsin, elevation differences between NAVD 88 (1991) and NAVD 88 (2007) adjustments range from minus 0.60 feet to positive 0.68 feet, with an average difference of approximately 0.25 feet. As more HMP surveys are completed additional data will be adjusted to NAVD 88 (2007). Due to the nature of the HMP the NAVD 88 (2007) adjustment will exist only within Wisconsin. Other areas of the United States have received similar regional adjustment by NGS.

International Great Lakes Datums

The International Great Lakes Datums (IGLD) have been used primarily for hydraulic studies and the development of charts for the Great Lakes and connecting waterways.

The International Great Lakes Datum of 1955 (IGLD 55) was determined from readings over the period from 1941 to 1956 with zero elevation at mean sea level at Pointe-au-Pere, Quebec.

The International Great Lakes Datum of 1985 (IGLD 85) established a set of elevations consistent with one another for surveys taken between 1982 and 1988. As part of the datum readjustment, a new reference zero point location (the point to which all other elevations are referenced) was established at Rimouski, Quebec, Canada, the same point used to fix the NAVD 88 (1991) datum. The result is that IGLD 85 and NAVD 88 (1991) are now based on the same bench mark. However, because of the differences between the measurement definition of orthometric heights and dynamic heights, and because of hydraulic corrections, the values will differ.

Height Modernization Program (HMP)

To improve the density of bench marks listed in the *National Spatial Reference System (NSRS)* with accurate orthometric heights (elevations), WisDOT, in cooperation with NGS, initiated a program in 1998 to improve height data throughout the state.

The process used by WisDOT divides the state into geographic regions (phases), based on areas that can be completed each year. Region boundaries depend on both topography and pre-existing NGS level lines (a series of bench marks for which elevations have been established).

Four steps are necessary to complete each phase for HMP, with planning and recovery of existing monuments in year one, monumentation in year two, GPS and leveling field observations in year three, and reduction, adjustment, and publication of data for submission to NGS for insertion into the NSRS in year four.

Wisconsin Continuously Operating Reference Stations

WisDOT has developed a state GPS reference station network called the Wisconsin Continuously Operating Reference Systems (WISCORS), which is a part of the HMP. WISCORS consists of permanent GPS receiver sites, a communications network using the Internet, software to determine corrections, and wireless access to servers to provide correctors in real-time to mobile users. Mobile users who are properly equipped with GPS receivers and digital cellular communication can take advantage of these correctors, and can use specific survey methods in the field to achieve 2-centimeter level accuracy in real-time.

WISCORS stations also provide a bridge between horizontal geodetic systems used by civilian and defense communities since CORS data is published with both *International Terrestrial Reference System* (WGS 84) and NAD 83 (GRS 80) coordinate values. More information on WISCORS is available on the WisDOT web site at https://wiscors.wi.gov/index.htm

GRAV-D Project

In the past twenty years, use of GPS technology for determining fast and accurate ellipsoid heights has created a strong need for a similar fast and accurate determination of orthometric heights *(see Figure 11).*

Ellipsoid heights cannot be used to determine how water will flow, and therefore are not used in floodplain mapping. Orthometric heights are related to water flow and are more useful. In order to transform from ellipsoid heights to orthometric heights, an accurate model of the geoid must be determined. This is best done by recording gravity forces near the Earth's surface.

Currently, much of the gravity data collected by NGS is from the 1980s and earlier; there are imbalances in coverage and different methods of collection. To correct these and other deficiencies, and to obtain a consistent view of the entire gravity field of the United States and its territories, NGS is embarking on a 7 to 10-year multi-million dollar project to obtain a high-resolution description of the gravity surface that will be used to redefine the geoid model, used for calculating geoid heights.

Coordinate Conversion and Transformation

Introduction

The need to integrate, analyze and visualize geographically referenced information in a common coordinate reference system is often necessary. Converting or transforming data from disparate sources into a common system for analysis is a frequent requirement.

Most current mapping and survey computer programs allow for fast and easy transformation of data between rectangular coordinate systems and geographic (latitude/longitude) systems, though end users may not be aware of the subtleties involved in the storage, manipulation and presentation of the integrated data. Converting and integrating data has also become more complicated due to an increasing number of geodetic datums, adjustments, and coordinate systems in use. This reality requires the need for a basic understanding of data conversion and transformation principles, in addition to the need for quality data documentation to make the most effective use of geographically referenced information.

Geographic Data Conversion and Transformation

In the truest sense of the word, conversion refers to an exact process of moving data from one mathematical system into another (in a reproducible fashion), while transformation is used to refer to modeled or "best fit" data.

Geographic coordinates of latitude and longitude can be precisely converted into a rectangular coordinate system. Geodetic datum transformations, however, generally use interpolative models that apply approximations to the transformation. Many of these models have been encoded in standard software libraries (e.g. NADCON) and re-used in various GIS software applications.

Increasingly, positional differences between successive datum adjustments (e.g., NAD 83 (1991) and NAD 83 (1997)) may be smaller than the accuracy of the underlying transformation models. If so, these data cannot be accurately converted except by using field survey information. Also, the positional differences may be unimportant if within the accuracy requirement of a particular mapping application.

When data requires transformation to another spatial referencing system, consideration should be given to the future use or applications of the transformed data, including accuracy and quality requirements, and the limitations of the source data and the transformation methods. This requires close attention to significant digits, units of measurement, and perhaps most importantly, the details of the coordinate reference system of the source information. These and other details of data transformation should be captured and encoded in a metadata record for reference in the future.

Conversion Mechanics

Converting geographic latitude/longitude coordinates to a rectangular coordinate system such as the State Plane Coordinate System is referred to as a direct conversion, while the reverse direction – rectangular to geographic – is referred to as an inverse conversion. Direct and inverse conversions involve a series of mathematical equations that relate two sets of coordinates, the reference ellipsoid, and the map projection surface.

Coordinate conversions from one rectangular system into another on the same datum, for example, State Plane Coordinates converted into a Wisconsin County

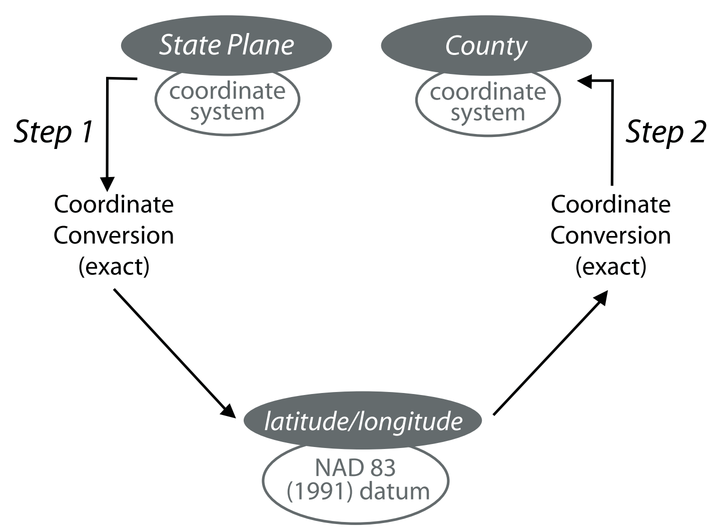


Figure 13: The process of exact conversion between the State Plane Coordinate System and a county coordinate system

Coordinate System, are done in a two step process that is generally hidden to the user by most computer programs. These two steps convert a State Plane coordinate to geographic coordinates (latitude/longitude), and then from geographic coordinates to a county coordinate system. The underlying mathematical equations of direct and inverse plane map projections are precise, so resultant data accuracy is primarily related to the positional accuracy of the source data and the inherent distortions in the target map projection. *(see Figure 13)*

It is also possible to transform geographic coordinates from one datum to another or from one adjustment of a datum to another adjustment of the same datum (e.g., NAD 83 (1986) to NAD 83 (1991)). *(see Figure 14)* The recent geodetic datum adjustments in the United States are not perfectly related to older datums (NAD 27) because the new adjustments removed errors and distortions in the geodetic network while at the same time redefining the mathematical model. The only way to perform an exact datum transformation is to recalculate the point's position using the original survey measurement observations that produced the latitude/longitude position *(see Figure 14).*

Transformation Methods

Datum transformations are performed by various methods. Some of these methods support highly accurate geodetic and surveying work, and others are approximate and more suitable for mapping, visualization, and other purposes. Datum transformation methods may be categorized as follows:

<u>Exact Transformation</u>
The only exact method of datum transformation requires the original survey measurement information, using it to geodetically recompute positions in the new reference system.

<u>Best-fit Transformation</u>
Another method of datum transformation uses a least squares approach to apply a "best fit" to the data for a region. The quality of the fit is dependent upon the number, distribution, and quality of geodetic control points in the area. Exact transformation and least squares adjustments most often require geodetic and mathematical expertise to effectively produce and analyze results.

<u>Modeled Transformation</u>
A third transformation method uses a set of gridded data models to interpolate approximate correction values, which are then applied to produce the transformed coordinate values. WISCON and federally produced software programs such as NADCON, CORPSCON, and VERTCON are based on this commonly-used method of addressing datum-to-datum transformations.

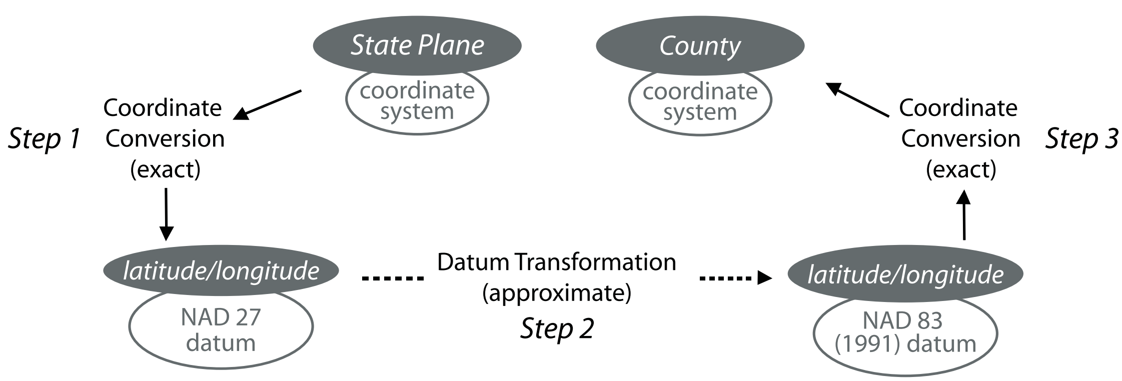


Figure 14: Coordinate transformation between the State Plane Coordinate System and a county coordinate system based on "best fit" transformation models

Transformation Considerations

Transformations of geographic data should be based on thoughtful evaluation and assessment of desired use and future applications of the data, requirements for accuracy and quality, known limitations of the source data, and appropriate transformation methods.

Back-and-forth data transformation should be avoided as this process may result in unpredictable changes in data accuracy.

When planning your approach to transforming project data, the following questions should be considered to help guide the process:

Coordinate System —

- What coordinate system is used for the source data? What coordinate system is desired for the transformed data?
- How large a geographical area does the project data cover? Does the coordinate system need to support data outside of its designed geographic extent?

  Note: small project areas may not require a geodetically-referenced coordinate system; Large project areas may exceed coordinate system design extents.

Geodetic System —

- What datum is used for the source data? What datum is desired for the transformed data?

Data —

- Does the source data meet or exceed the desired accuracy for the transformed data?

  Transformation cannot improve data accuracy.

- What are the linear and angular units of measure of the source and transformed data?

  Use standard conversion factors and the appropriate number of significant figures.

- Is the source data original or was it previously transformed?

  Data documentation (metadata) should describe how the source data was collected, adjusted, processed, and prepared for publication and use.

Transformation Tools & Process —

- Does the use of the data require it to be transformed?

  For example, the small coordinate differences between the Wisconsin County Coordinate System (WCCS) and the newer Wisconsin Coordinate Reference Systems (WISCRS) can be ignored for most applications.

- Does the accuracy of the data exceed the accuracy of the transformation method?

  Coordinate differences between same systems (ex: NAD83 (1997) and NAD83 (NSRS 2007) are smaller than the limitations of standard modeled transformation software such as NADCON.

- What is the distribution, quantity and quality of the points common to both the source and transformed data?

  Select the transformation method most appropriate for the available source data.

It is useful to point out that some current desktop GIS software packages have incorporated methods for "re-projection on the fly", allowing for integrated viewing of data in different coordinate systems in a common view. This type of transformation may be appropriate when neither high accuracy analysis nor data change is required.

Accuracy and Precision

Accuracy is defined as how well a represented feature matches the actual object on the ground and often describes the quality of both input and resultant data. Precision is the measure of the reproducibility of a given process or procedure. Precise data processing and conversion is still inherently subject to the original accuracy of the data inputs. The procedures used to produce a map may be very precise, but if the data or methods used are not accurate, the results will be inaccurate. Precise transformation processes cannot improve the accuracy of data.

Imprecise transformation can reduce the accuracy of results. Transformation methods should be evaluated for appropriateness based on data requirements and use. For example, in the past, transformation process errors were often overshadowed by the accuracy of the data and considered negligible. Today, GPS-based and sensor-based technology allow for increasingly accurate data collection and requires attention to procedures and differences that were negligible in the past.

Formal accuracy standards have been established to guide the collection and production of geographic data such as GPS surveys, aerial imagery and geodetic networks. These guidelines outline specific field methods and adjustment procedures that must be followed to assure the final data meets or exceeds a stated accuracy.

Significant Figures

Significant figures represent the number of digits in a number that can reliably be used. This is important in the context of measurements and mathematics operations because computed solutions are limited by the least accurate data items. For example, a measurement of 101 feet is significant only to the one foot level, even though computer software may display this value as 101.000 feet. Data cannot be improved after transformation, therefore attention to significant figures helps qualify the end result.

Significant figures are particularly important in coordinate systems and mapping because some software give a false sense of precision by displaying many digits to the right of the decimal point – whether significant or not – leading to a false sense of accuracy by subsequent users.

Metadata

Lack of accurate and thorough documentation (metadata) is the most common source of error or ambiguity when converting or transforming geographic data. Without good metadata, assumptions may be made about the data that are not correct.

It is important to know the lineage of source data, from collection through processing and publication for use. Data originally collected at a low accuracy level cannot be improved by integration with high quality data or coordinate system conversion. Subsequent data conversions, transformation and processing can preserve or deteriorate the quality of data depending on the methods used.

Test, then Transform

Most importantly, transformation methods and software tools should be thoroughly and independently tested before transforming project data. Software vendors implement coordinate and geodetic system algorithms slightly differently. While these implementations are based on federal standards and conversion algorithms where available, different software implementations have previously resulted in differing coordinate results. The best way to be confident in one's results is to test transformations first.

Test data for Wisconsin is available on the State Cartographer's Office Web site. It is recommended that each coordinate or datum transformation be tested with these values to establish the appropriate transformation method for a given project, data, and software version.

Coordinate Systems Registry

While no official national registry of coordinate reference systems currently exists, the OGP Surveying and Positioning Committee[1], through its geodesy sub-committee, maintains and publishes a dataset of parameters for coordinate reference system and coordinate transformation description called the EPSG Geodetic Parameter Dataset. This dataset contains worldwide information and through its distribution is often used for integration of coordinate system parameters into commercial software.

In 2004, the SCO submitted Wisconsin Transverse Mercator parameters to this database to accompany the Wisconsin State Plane Coordinate systems already present there. Registration of WISCRS parameters in this database will be pursued in 2009, allowing for more automatic inclusion in future software. For more information, see www.epsg.org.

[1]The Surveying and Positioning Committee of the International Association of Oil and Gas Producers (OGP) was formed in 2005, by the absorption into OGP of the now-defunct European Petroleum Survey Group (EPSG) which itself had been formed in 1986. The Surveying and Positioning Committee comprises specialists from OGP member companies working in the areas of surveying, geodesy, cartography and coordinate data management.

Troubleshooting Errors

The following table (on this and the next page) has been assembled to help identify systematic positional error, as well as errors in coordinate systems definition. The figures and comments shown in the "Magnitudes" column below are derived from a variety of sources, including this handbook, the National Geodetic Survey, and first-hand user experiences. Systematic errors often occur due to data mis-definition or assumed accuracies which result from insufficient documentation regarding a dataset's coordinate reference system.

Source:
Best Practices for GPS & Spatial Data Collection, Storage and Documentation - Compiled by: Joes Cusick, Andrew Balser, Scott Sexton, Jeff Freymueller and David Zezula as part of *Mapping the Common Ground Between Surveyors & GIS: Your Datum or Mine?*; GPS Best Practices Handout, Alaska Surveying & Mapping Conference, March 2007.

Positioning shifts as a result of changes in definition or transformation	Magnitudes
Geodetic datum and coordinate systems	**Typical Result**
Difference between NAD 27 and NAD 83 (1986) in Wisconsin (NAD 83 (1986) minus NAD 27 position)	-8 to +2 meters in latitude and +5 to +15 meters in longitude
Difference between NAD 83 (1986) and NAD 83 (1991) (NAD 83 (1991) minus NAD 83 (1986) position)	-4 to +1 meters in latitude and -0.3 to +0.3 meters in longitude
Difference between NAD 83 (1991) and NAD 83 (1997)	Approximately 4 centimeters
Difference between UTM 27 and UTM 83 projected positions	Approximately 200 meters in northing and less than 10 meters in easting.
Difference between WTM 27 and WTM 83 projected positions	Approximately 20,000 meters (13 miles) in northing and easting.
Difference between SPCS 27 and SPCS 83 projected positions	Approximately 6 miles in easting
Vertical datum	
Difference between NGVD 29 and NAVD 88 in Wisconsin	Difference is minimal: -0.25 meter to +0.25 meter
Using ellipsoid heights for elevations	Up to 10's of meters variation (vertical) equivalent to geoid separation

Terminology	
Listing grid coordinates (such as SPCS) as “NAD 83”	NAD 83 is a geodetic datum, not a grid coordinate system
Documenting geodetic datum as “GRS-80”	GRS-80 is a reference ellipsoid, not a datum
Documenting geodetic datum as “WGS-84” when it is not	Perpetuates confusion about “equivalence” of WGS-84 and NAD 83
Documenting vertical datum as “Mean Sea Level” (MSL)	There is no MSL datum in the US (name changed to NGVD 29)
Using precision as an accuracy estimate with data containing systematic errors (e.g., incorrect reference coordinates)	Accuracy estimate is meaningless
Reporting horizontal error using unscaled standard deviation, rather than at the 95% confidence level (as specified by the FGDC)	Gives error estimates at 39% confidence level
Reporting vertical error using unscaled standard deviation, rather than at the 95% confidence level (as specified by the FGDC)	Gives error estimates at 68% confidence level

Positional Accuracies of Control Networks			
Network	**Dates**	**Network Accuracy**[1]	**Local Accuracy**[2]
NAD 27	1927-1986	10 meters	First Order (1 part in 100,000)
NAD 83 (1986)	1986-1990	1 meter	First Order (1 part in 100,000)
NAD 83 (1991)	1990-1997	0.1 meter	B-order (1 part in 1 million) A-order (1 part in 10 million)
CORS	1996-present	0.01 meter	0.01 meter

[1]**Network Accuracy**
A value that represents the uncertainty of its coordinates with respect to the geodetic datum at the 95-percent confidence level. Datum is considered to be best expressed by the Continuous Operating Reference Stations (CORS)

[2]**Local Accuracy**
A value that represents the uncertainty of its coordinates relative to other directly connected, adjacent control points at the 95-percent confidence level. An approximate average of the individual local accuracy values between this control point and other observed control points used to establish its coordinates.

County Coordinate Systems

Evolution of County Systems

In Wisconsin, grid distances and corresponding ground distances can differ by as much as one foot per mile when using the State Plane Coordinate System, and more than twice that amount when using the Wisconsin Transverse Mercator. Eliminating the need for ground-to-grid conversion of distances was the primary reason for the development of the county coordinate systems.

County coordinate reference systems have been actively used in Wisconsin since the 1970s. The first widely adopted county-based system was developed by the Wisconsin Department of Transportation (WisDOT). This system was designed by applying a correction factor computed to best fit county areas, but was not mathematically relatable to NAD 27 except at a single point.

During the 1980s, several Wisconsin counties developed and began to use their own local coordinate system. At this sametime, WisDOT realized the need for a statewide set of standardized and mathematically-based local coordinate systems that had appropriate accuracy for large-scale mapping and roadway design.

Wisconsin County Coordinate System (WCCS)

In 1993, WisDOT contracted for the development of a unified set of county coordinate systems *(see Figure 15)* that would incorporate as many of the already-existing county systems as possible. The resulting set of county coordinate systems, known as the Wisconsin County Coordinate System (WCCS), became available for open use in 1995.

WCCS is mathematically-based on, and related to, NAD 83. This maintains the benefits of using NAD 83 while providing for the development of local rectangular coordinate systems with minimal differences between measured ground distances and projected grid distances. WCCS minimizes ground and grid difference by enlarging and elevating a local ellipsoid (the reference surface) to the median terrain elevation in the county.

Other design considerations for WCCS included: metric units, a maximum grid scale distortion of 1:30,000 in rural areas and 1:50,000 in urban areas, and a distinct numeric difference between adjacent coordinate systems to avoid confusion. The design criteria supports uses in both urban and rural areas and in transportation corridors.

WCCS has been widely adopted by state and local agencies for use in GIS, infrastructure design and construction stake out, Public Land Survey System remonumentation and measurement, and geodetic control system surveys. Its popularity is driven by the fact that distances measured on the ground are, for most applications, negligibly different from distances on the corresponding coordinate grid.

The 1995 handbook, *Wisconsin Coordinate Systems*, contains WCCS projection parameters, design notes, and other information for each of the state's 72 counties. WCCS county information also may be accessed on the SCO Web site.

Since WCCS used enlarged ellipsoids and geodetic datums are associated with specific ellipsoids, this approach led to each county coordinate system, effectively, having its own horizontal geodetic datum. Those unfamiliar with geodetic datums, map projections, and coordinate systems experienced difficulty in understanding and applying the design of the WCCS. This difficulty grew as WCCS was more widely adopted.

In 2004, the Wisconsin Land Information Association (WLIA) formed the Wisconsin Coordinate Systems Task Force with a mission to analyze existing usage problems with WCCS, and to make recommendations for correcting these problems. Following more than a year of study and analysis, the task force concluded the best solution available was to redesign the system. The redesign effort resulted in the creation of the Wisconsin Coordinate Reference Systems (WISCRS).

Wisconsin Coordinate Reference Systems (WISCRS)

Note: for WISCRS county projection parameters, see pages 23-95.

A Wisconsin Land Information Program grant funded the redesign project, and the Jackson County Land Information Office provided funding and administration of the contract. In 2006, the Wisconsin Coordinate Reference Systems (WISCRS) were published. The methodology for redesign is described in Vonderohe (2006). WISCRS is designed to:

1. Retain the number, type of projection, (except for Jackson County) and same geographic extents as WCCS;
2. Use GRS 80 as the single reference ellipsoid for all individual coordinate systems;
3. Minimize coordinate differences between WCCS and the redesigned system to be less than or equal to five millimeters.

Minimizing differences between WISCRS and WCCS was a key consideration of the design. This enables legacy GIS databases and other spatial data to be merged with newly-acquired data in the new system without a need for any transformation. That is, data referenced to either WCCS or WISCRS can be integrated without concern for coordinate discrepancies.

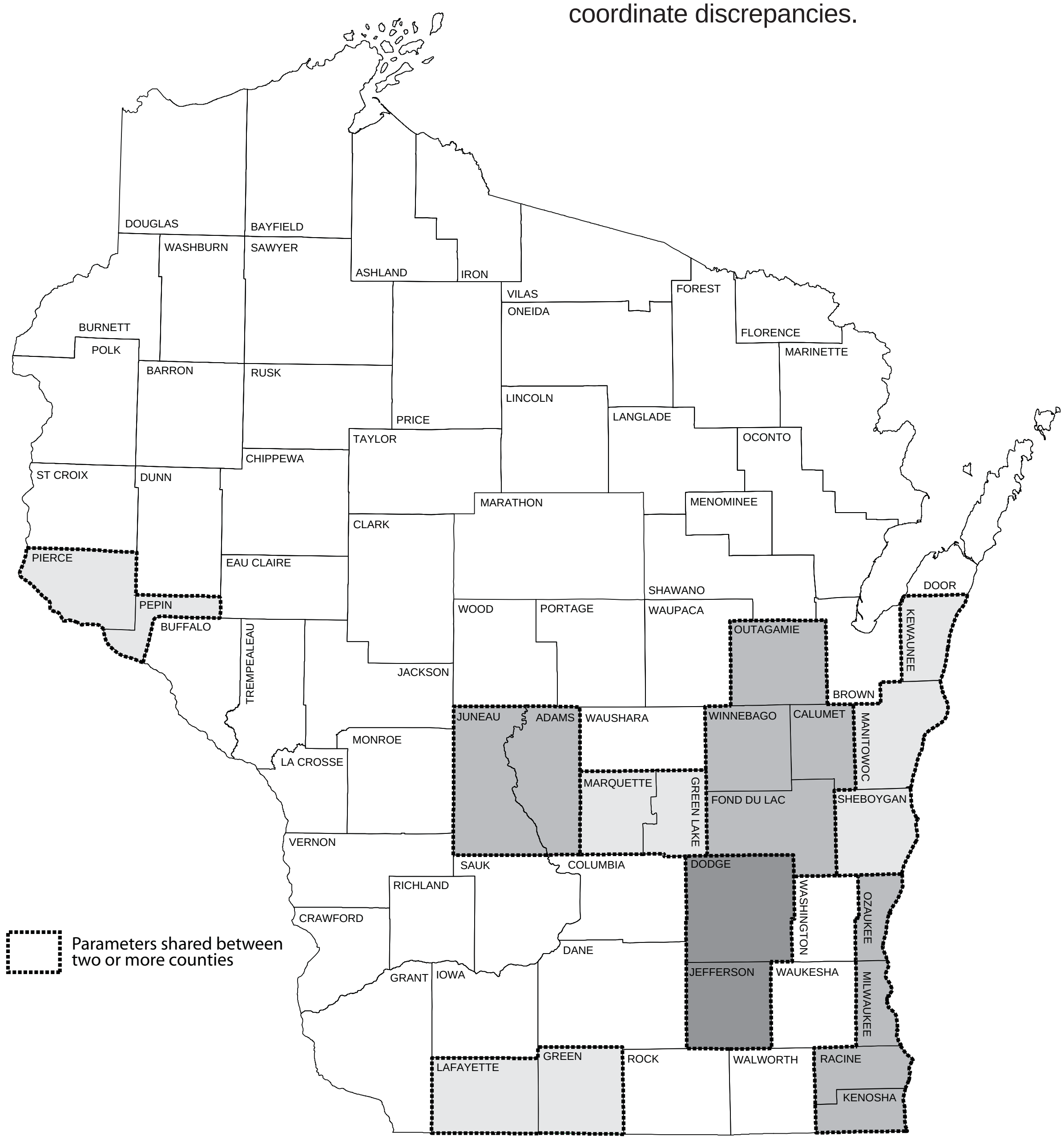


Figure 15: In both the Wisconsin County Coordinate System (WCCS), and the more recent Wisconsin Coordinate Reference Systems (WISCRS) adjoining counties shown with a common tint share the same set of projection parameters. Untinted counties each have a separate coordinate system.

The largest differences in coordinate values between WCCS and WISCRS are less than five millimeters, and that much difference only occurs in four counties. Differences between the two sets of coordinates in most other counties have maximums of three millimeters or less. Differences in northing and easting coordinate values between WCCS and WISCRS coordinates for each county can be found in Vonderohe (2006).

WISCRS offers the following improvements and advantages over previous Wisconsin county coordinate systems:

1. All county coordinate systems use the same reference ellipsoid.
2. The number of parameters for a Lambert-based system is reduced from eight to five by eliminating the design elevation and geoid height, and by moving the true origin to the intersection of the central parallel and central meridian.
3. The number of parameters for a transverse Mercator-based system is reduced from seven to five by eliminating the design elevation and geoid height.

Geographic Extents of Wisconsin County Coordinate Systems

The geographic extents of each individual WISCRS coordinate system were determined during design of WCCS, and thus are the same as WCCS.

Survey projects and mapping applications sometimes require extension of a coordinate system beyond its design. Most Lambert-based WISCRS coordinate systems can be extended 30 miles north or south of their central parallels (not county boundaries) before encountering differences larger than 1 part in 20,000 (i.e., approximately 0.25 feet in a mile) between ground distances and grid distances. Similarly, most transverse Mercator-based WISCRS coordinate systems can be extended 30 miles east or west of their central meridians (not county boundaries) before encountering differences larger than 1:20,000 between ground distances and grid distances.

Throughout the state, there are some exceptions to this rule-of-thumb. For example, if there are large elevation differences in adjacent counties, especially if an adjacent county has a much lower elevation, the differences between ground and grid distances can exceed 1:20,000 at 30 miles.

Naming Conventions

The newly-designed county coordinate systems required a name that distinguished between the original and redesigned systems while not changing what was already widely in use. While individual county WCCS names vary, they are most typically denoted as (county name) County Coordinate System" - for example, the Dane County Coordinate System.

The new county-based coordinate systems are designated as WISCRS (Wisconsin Coordinate Reference Systems). Individual coordinate systems within WISCRS are referred to as "WISCRS, *countyname* County." For example: WISCRS, Langlade County.

Official Status

While Wisconsin has not legislatively defined or mandated the adoption of county coordinate systems at the state level, some local governments do specify the use of a particular coordinate reference system and/or datum for their region through local ordinance or regulation. It is important to check with local officials and agencies for any legal requirements related to coordinate reference system and datum use.

Since the county coordinate systems are mathematically relatable to NAD 83, their use is allowed under Chapter 236 of the Wisconsin Statues.

Wisconsin Coordinate Reference Systems (WISCRS)

The following 72 pages (arranged alphabetically by county) provide the projection parameters and associated information for the Wisconsin Coordinate Reference Systems (WISCRS). This system was designed in 2006 and is an alternative to the Wisconsin County Coordinate System (WCCS) designed in 1993.

The county parameters for the WCCS are not included in this edition of the handbook. However, they were published by the Wisconsin State Cartographer's Office in the 1995 handbook, *Wisconsin Coordinate Systems.*

The largest differences in coordinate values between WCCS and WISCRS are less than five millimeters, and that much difference only occurs in four counties. Differences between the two sets of coordinates in most other counties have maximums of three millimeters or less. Considering these small differences, data referenced to either the WCCS or WISCRS can be integrated without concern for coordinate discrepancies for most applications.

Adams County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Adams and Juneau Counties share the same projection

The parameters for this projection are:

Origin Longitude:	90°00’00.000000”
Origin Latitude:	43°22’00.000000”
False Easting:	147218.6942 meters (482999.999 U.S. Survey Feet)
False Northing:	0.0037 meters (0.012 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000365285

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:60,000.............Friendship Mound

Urban .... 1:500,000...........Friendship, Adams

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

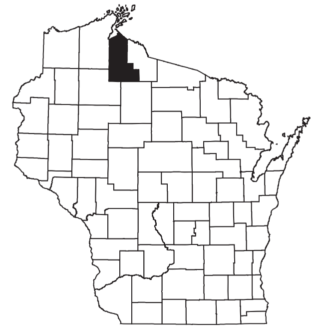
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Ashland County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°37’20.000000”
Origin Latitude:	45°42’22.000000”
False Easting:	172821.9461 meters (567000.001 U.S. Survey Feet)
False Northing:	0.0017 meters (0.006 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000495683

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:29,000..............Mt. Whittlesey
Urban ....1:30,000..............Ashland
1:144,000............Mellon
1:54,000..............Glidden
1:58,000..............Butternut

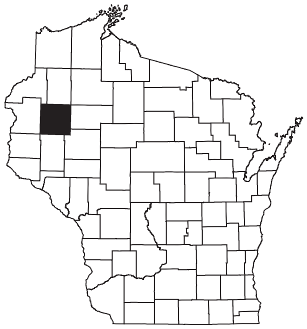
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Barron County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°51’00.000000”
Origin Latitude:	45°08’00.000000”
False Easting:	93150.0000 meters (305609.625 U.S. Survey Feet)
False Northing:	0.0029 meters (0.010 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000486665

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:57:000.............Blue Hillls (elev 1600 ft)
Urban .... 1:500,000...........Barron, Cameron, Almena, Turtle Lake
1:320,000...........Rice Lake, Dallas
1:140,000...........Chetak
1:260,000...........Cumberland
1:170,000...........Haugen

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Bayfield County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	91°09'10.000000"
Latitude of the Central Parallel and Coordinate Origin:	46°40'10.734158"
False Easting:	228600.4575 meters (750000.001 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	148551.4837 meters (487372.659 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000331195

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst)	1:31,000	Sand Island (north end)
Urban	1:99,000	Washburn
	1:75,000	Bayfield, Iron River, Cornucopia
	1:114,000	Drummond, Port Wing
	1:238,000	Cable

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 650,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Brown County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°00’00.000000”
Origin Latitude:	43°00’00.000000”
False Easting:	31600.0000 meters (103674.333 U.S. Survey Feet)
False Northing:	4600.0000 meters (15091.833 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000200000

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:45,000.............T21N, R20E, Sec 24 (high point)
Urban ....1:97,000.............Green Bay
1:120,000...........Pulaski
1:66,000.............Denmark

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 38,000 feet

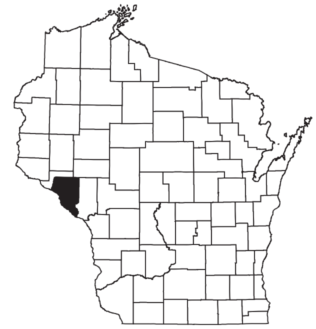
Approximate southernmost coordinate (Y) = 467,000 feet

Notes:

1. No coordinate shifts exist between the WCCS (‘95) and the WISCRS (‘06) coordinate systems. The five WISCRS design parameters are exactly equal to these same parameters in the WCCS.
2. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
3. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Buffalo County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°47’50.000000”
Origin Latitude:	43°28’53.000000”
False Easting:	175260.3502 meters (~574999.999 U.S. Survey Feet)
False Northing:	0.0048 meters (~0.016 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000382778

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:47,000..............T24N, R12W, Sec 36 (high point)

Urban ....1:90,000..............Alma

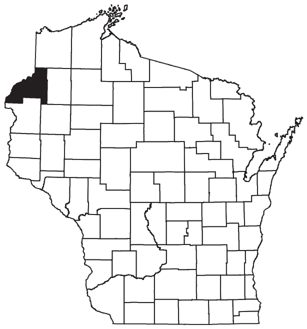
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Burnett County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	92°27’28.000000”
Latitude of the Central Parallel and Coordinate Origin:	45°53’55.373517”
False Easting:	64008.1276 meters (209999.999 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	59445.9043 meters (195032.104 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000383841

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:61,000............T37N, R14W, Sec 33, (elev 1440 ft)
Urban ....1:450,000...........Siren
1:240,000...........Webster
1:500,000...........Danbury
1:340,000...........Grantsburg

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Calumet County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Calumet, Fond du Lac, Outagamie, and Winnebago Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°30’00.000000”
Origin Latitude:	42°43’10.000000”
False Easting:	244754.8893 meters (802999.999 U.S. Survey Feet)
False Northing:	0.0049 meters (0.016 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000286569

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:63,000.............Highest point
Urban ....1:500,000...........Chilton, Gravesville
1:300,000...........Appleton
1:320,000...........New Holstein, Hilbert
1:100,000...........Brillion

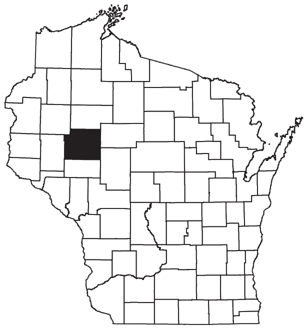
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 828,000 feet

Approximate southernmost coordinate (Y) = 427,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Chippewa County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	91°17'40.000000"
Latitude of the Central Parallel and Coordinate Origin:	44°58'40.284835"
False Easting:	60045.7200 meters (197000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	44091.4346 meters (144656.648 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000391127

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:51,000.............T29N, R10W, Sec 17 (high point)
Urban ....1:200,000...........Chippeau Falls
1:130,000...........Eau Claire
1:180,000...........Bloomer, Cornell
1:430,000...........Jim Falls, New Auburn
1:100,000...........Cadott, Stanley

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Clark County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°42'30.000000"
Origin Latitude:	43°36'00.000000"
False Easting:	199949.1989 meters (655999.997 U.S. Survey Feet)
False Northing:	0.0086 meters (0.028 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000463003

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:62,000.............Southeast corner
Urban ....1:200,000...........Neillsville
1:192,000...........Abbotsford, Loyal
1:156,000...........Thorp, Owen
1:500,000...........Colby
1:320,000...........Greenwood

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Columbia County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°23’40.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°27’45.167925”
False Easting:	169164.3381 meters (554999.999 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	111569.6134 meters (366041.307 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000349800

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:33,000.............T11N, R8E, Sec 6 (high point)
Urban ....1:250,000...........Portage
1:500,000...........Poynette, Cambria
1:158,000...........Wisconsin Dells, Lodi
1:350,000...........Columbus, Pardeeville
1:210,000...........Randolf

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

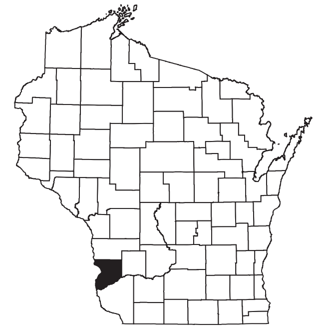
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Crawford County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°56’20.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°12’00.200178”
False Easting:	113690.6274 meters (373000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	53703.1201 meters (176190.987 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000349151

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:52,000.............Mt. Sterling
Urban ....1:70,000.............Prairie du Chien
1:80,000.............Wauzeka, Soldiers Grove
1:105,000...........Gays Mills
1:55,000.............De Soto

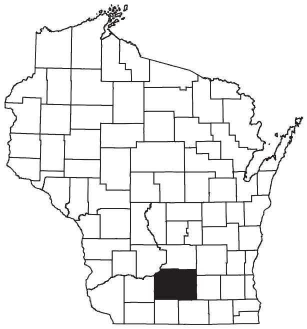
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Dane County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°25’20.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°04’10.257735”
False Easting:	247193.2944 meters (811000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	146591.9896 meters (480943.886 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000384786

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:37,000.............Blue Mounds (summit)
Urban ....1:500,000...........Oregon, Madison, Middleton, Cross Plains
1:300,000...........Waunakee, Verona, DeForest, Marshal
1:180,000...........Stoughton
1:86,000.............West Side Catholic Seminary Hill

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 400,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Dodge County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Dodge and Jefferson Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°46’30.000000”
Origin Latitude:	41°28’20.000000”
False Easting:	263347.7263 meters (863999.999 U.S. Survey Feet)
False Northing:	0.0076 meters (0.025 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000346418

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:83,000.............T13N, R16E, Sec 15 (high point)
Urban ....1:280,000...........Juneau
1:270,000...........Mayville
1:250,000...........Waupun
1:500,000...........Horicon, Beaver Dam, Watertown

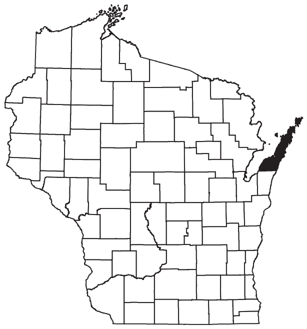
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The de facto horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Door County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	87°16’20.000000”
Origin Latitude:	44°24’00.000000”
False Easting:	158801.1176 meters (521000.000 U.S. Survey Feet)
False Northing:	0.0023 meters (0.008 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000187521

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:67,000.............5 miles North of Sturgeon Bay
Urban ....1:105,000...........Sturgeon
1:110,000...........Ephraim
1:310,000...........Egg Harbor

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Douglas County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°55’00.000000”
Origin Latitude:	45°53’00.000000”
False Easting:	59131.3183 meters (194000.000 U.S. Survey Feet)
False Northing:	0.0041 meters (0.013 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000385418

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:41,000.............Northeast corner (low point)
Urban ....1:56,000.............Superior
1:68,000.............South Superior
1:180,000...........Brule
1:90,000.............Solon Springs, Lake Nebagamon
1:50,000.............Oliver

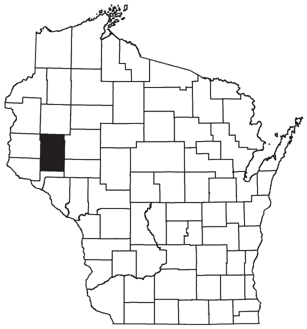
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Dunn County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°53’40.000000”
Origin Latitude:	44°24’30.000000”
False Easting:	51816.1040 meters (170000.001 U.S. Survey Feet)
False Northing:	0.0030 meters (0.010 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000410324

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:65,000.............T31N, R12W, Sec 35 (elev 1280 ft)
Urban .... 1:130,000...........Menominee
1:230,000...........Colfax, Knapp
1:470,000...........Boyceville
1:125,000...........Ridgeland

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 102,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Eau Claire County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	91°17’20.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°52’20.212055”
False Easting:	120091.4402 meters (394000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	91687.9239 meters (300812.797 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000350790

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) ....1:55,000.............T27N, R6W, Sec 17 (high point)

Urban ....1:150,000...........Eau Claire

1:500,000...........Fairchild, Augusta

1:230,000...........Fall Creek

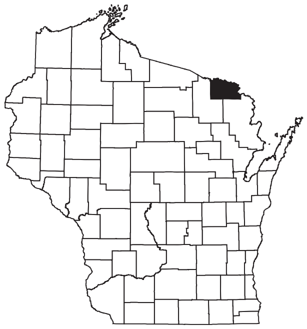
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Florence County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°08'30.000000"
Origin Latitude:	45°26'20.000000"
False Easting:	133502.6683 meters (438000.004 U.S. Survey Feet)
False Northing:	0.0063 meters (0.021 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000552095

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:81,000..............Menominee River (low point)

Urban ....1:500,000............Florence

1:150,000............Long Lake

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

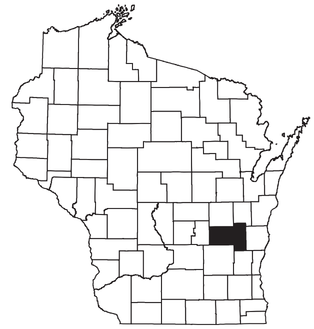
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Fond du Lac County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Transverse Mercator

Note: Calumet, Fond du Lac, Outagamie, and Winnebago Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°30’00.000000”
Origin Latitude:	42°43’10.000000”
False Easting:	244754.8893 meters (802999.999 U.S. Survey Feet)
False Northing:	0.0049 meters (0.016 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000286569

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:43,000.............T14N, R18E Sec 3 (high point)
Urban ....1:260,000...........Fond du Lac
1:220,000...........Ripon
1:260,000...........Waupon

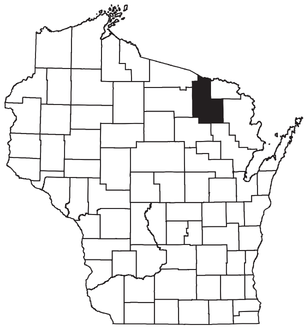
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Forest County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°38’00.000000”
Origin Latitude:	44°00’20.000000”
False Easting:	275844.5533 meters (905000.005 U.S. Survey Feet)
False Northing:	0.0157 meters (0.052 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000673004

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:56,000.............Sugarbush Hill
Urban ....1:500,000...........Wabeno
1:500,000........... Crandon
1:340,000............Laona

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 800,000 feet

Approximate southernmost coordinate (Y) = 500,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Grant County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°48’00.000000”
Origin Latitude:	41°24’40.000000”
False Easting:	242316.4841 meters (794999.998 U.S. Survey Feet)
False Northing:	0.0100 meters (0.033 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000349452

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:46,000.............Far western boundary (low points)
Urban ....1:74,000.............Lancaster, Blue River, Cassville
1:51,000.............Fennimore, Muscoda
1:142,000...........Platteville, Montfort
1:103,000...........Boscobel

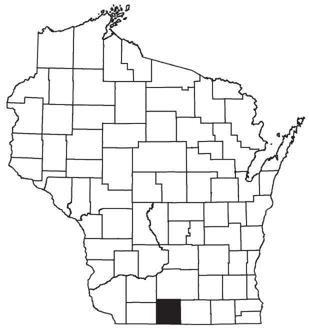
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 400,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Green County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

Note: Green and Lafayette Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	89°50’20.000000”
Latitude of the Central Parallel and Coordinate Origin:	42°38’15.224197”
False Easting:	170078.7403 meters (558000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	45830.2947 (150361.559 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000390487

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:94,000.............Sugar River (low point)
Urban .... 1:106,000...........Monroe
1:166,000...........New Glarus
1:260,000...........Brooklyn
1:130,000...........Brodhead

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 558,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Green Lake County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

Note: Green Lake and Marquette Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	89°14’30.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°48’25.200424”
False Easting:	150876.3018 meters (495000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	79170.7795 meters (259746.132 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000344057

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:84,000.............T12N, R13E, Sec 12 (high point)

Urban ....1:125,000...........Berlin

1:300,000...........Princeton

1:550,000...........Green Lake

1:210,000...........Marquette

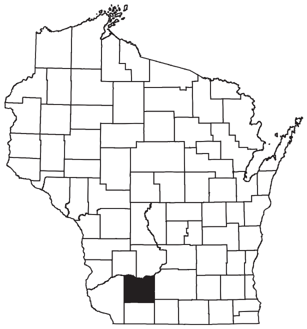
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 494,000 feet

Approximate southernmost coordinate (Y) = 196,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Iowa County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°09’40.000000”
Origin Latitude:	42°32’20.000000”
False Easting:	113081.0261 meters (371000.000 U.S. Survey Feet)
False Northing:	0.0045 meters (0.015 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000394961

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:34,000..............Blue Mound
Urban ....1:58,000..............Dodgeville, Arena
1:156,000............Mineral Point
1:114,000............Cobb
1:138,000............Barneveld
1:64,000..............Avoca

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

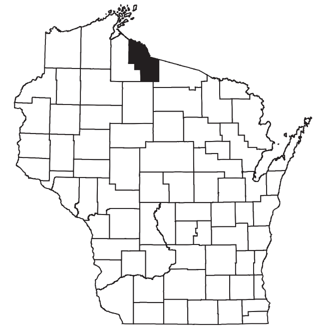
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Iron County

WISCRS (Wisconsin County Reference System)



Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°15’20.000000”
Origin Latitude:	45°26’00.000000”
False Easting:	220980.4419 meters (725000.000 U.S. Survey Feet)
False Northing:	0.0085 meters (0.028 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000677153

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:20,000.............Lake Superior (along shore line)
Urban .... 1:500,000...........Hurley, Mercer
1:83,000.............Montreal
1:380,000...........Upson

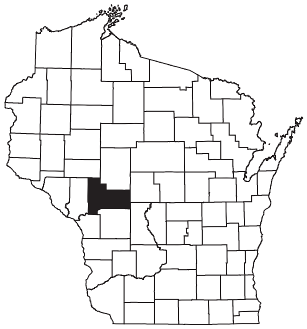
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 650,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Jackson County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°50’39.467470”
Origin Latitude:	44°15’12.006460”
False Easting:	27000.0000 meters (88582.500 U.S. Survey Feet)
False Northing:	25000.0000 meters (82020.833 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000353000

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:51,000.............Southwest corner (low point)

Urban .... 1:125,000...........Black River Falls

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 4,000 feet

Approximate southernmost coordinate (Y) = 15,000 feet

Notes:

1. The existing Jackson County official coordinate system was adopted for WISCRS, Jackson County. However, the older Wisconsin County Coordinate System (WCCS) for Jackson County was based on a different map projection. WISCRS, Jackson County and WCCS coordinates for Jackson County will not match and should not be used together.
2. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
3. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Jefferson County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Dodge and Jefferson Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°46’30.000000”
Origin Latitude:	41°28’20.000000”
False Easting:	263347.7263 meters (863999.999 U.S. Survey Feet)
False Northing:	0.0076 meters (0.025 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000346418

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

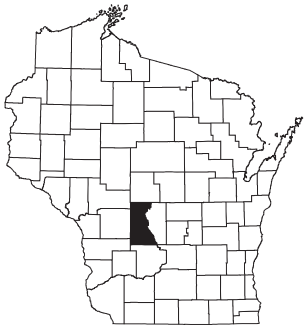
Rural (worst) .... 1:112,000.............T6N, R14E, Sec 18 (high point)
Urban ....1:320,000.............Jefferson
1:450,000.............Watertown, Whitewater
1:270,000.............Fort Atkinson
1:285,000.............Lake Mills
1:175,000.............Waterloo

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 800,000 feet
Approximate southernmost coordinate (Y) = 500,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Juneau County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Adams and Juneau Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	90°00'00.000000"
Origin Latitude:	43°22'00.000000"
False Easting:	147218.6942 meters (482999.999 U.S. Survey Feet)
False Northing:	0.0037 meters (0.012 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000365285

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:49,000.............T14N, R3E, Sec 14 (high point)

Urban ....1:500,000...........Mauston, New Lisbon

1:380,000...........Necedah

1:340,000...........Elroy

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 478,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Kenosha County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kenosha, Milwaukee, Ozaukee, and Racine Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°53’40.000000”
Origin Latitude:	42°13’00.000000”
False Easting:	185928.3728 meters (610000.003 U.S. Survey Feet)
False Northing:	0.0009 meters (0.003 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000260649

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:133,000.............T1N, R21E, Sec 35 (high point)

Urban ....1:222,000.............Kenosha

1:300,000.............Silver Lake

1:200,000.............Paddock Lake, Twin Lakes

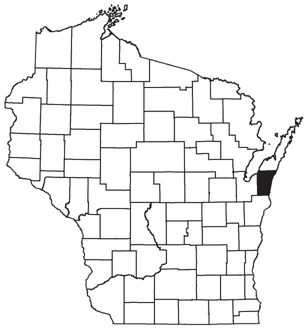
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Kewaunee County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kewaunee, Manitowoc, and Sheboygan Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°33’00.000000”
Origin Latitude:	43°16’00.000000”
False Easting:	79857.7614 meters (262000.006 U.S. Survey Feet)
False Northing:	0.0012 meters (0.004 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000233704

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:60,000.............T23N, R23E, Sec 32 (high point)
Urban ....1:200,000...........Kewaunee
1:500,000...........Algoma
1:120,000...........Luxemburg

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 205,000 feet

Approximate southernmost coordinate (Y) = 386,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

La Crosse County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°19’00.000000”
Origin Latitude:	43°27’04.000000”
False Easting:	130454.6598 meters (427999.996 U.S. Survey Feet)
False Northing:	0.0033 meters (0.011 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000319985

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:41,000.............T18N, R8W, Sec 25 (high point)
Urban ....1:150,000...........LaCrosse, Onalaska
1:175,000...........French Island, West Salem
1:108,000...........Bangor
1:340,000...........Holmen

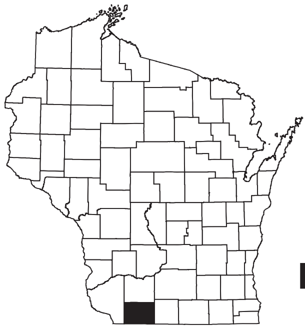
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Lafayette County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

Note: Green and Lafayette Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	89°50’20.000000”
Latitude of the Central Parallel and Coordinate Origin:	42°38’15.224197”
False Easting:	170078.7403 meters (558000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	45830.2947 meters (150361.559 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000390487

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:43,000.............Platteville Mounds
Urban ....1:147,000...........Darlington, South Wayne
1:300,000...........Shullsburg
1:166,000...........Belmont
1:123,000...........Gratiot, Argyle
1:89,000.............Blanchardville

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Langlade County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°02’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	45°09’ 15.253579”
False Easting:	198425.1970 meters (651000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	105279.7829 meters (345405.421 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000627024

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:52,000.............T32N, R13W, Sec 29 (high point)

Urban ....1:270,000............Antigo

1:500,000............Elcho

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 550,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Lincoln County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Adams and Juneau Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	89°44’00.000000”
Origin Latitude:	44°50’40.000000”
False Easting:	116129.0323 meters (381000.000 U.S. Survey Feet)
False Northing:	0.0058 meters (0.019 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000599003

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:45,000.............Lookout Mountain
Urban ....1:170,000...........Merrill
1:200,000...........Tomahawk

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

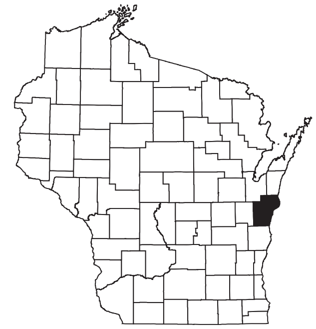
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Manitowoc County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Transverse Mercator

Note: Kewaunee, Manitowoc, and Sheboygan Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°33’00.000000”
Origin Latitude:	43°16’00.000000”
False Easting:	79857.7614 meters (262000.006 U.S. Survey Feet)
False Northing:	0.0012 meters (0.004 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000233704

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:98,000.............T18N, R22E, Sec 29 (high point)

Urban ....1:500,000...........Manitowoc, Two Rivers

1:270,000...........Kiel

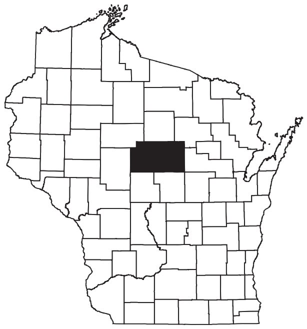
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 132,000 feet

Approximate southernmost coordinate (Y) = 228,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Marathon County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°46’12.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°54’03.255925”
False Easting:	74676.1493 meters (245000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	55049.2669 meters (180607.470 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000532890

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:30,000.............Rib Mountain Summit (elev 1920 ft)
Urban ....1:500,000...........Schofield, Rothschild, Spenser, Stratford
1:87,000.............Wausau (highest point in Wausau)
1:210,000...........Edgar
1:120,000...........Marathon City
1:170,000...........Mosinee

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 102,000 feet

Approximate southernmost coordinate (Y) = 101,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Marinette County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	87°42’40.000000”
Origin Latitude:	44°41’30.000000”
False Easting:	238658.8794 meters (783000.007 U.S. Survey Feet)
False Northing:	0.0032 meters (0.010 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000234982

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:53,000.............T37N, R20E, Sec 5 (high point)
Urban ....1:380,000...........Marinette
1:500,000...........Peshtigo, Wausaukee
1:250,000...........Crivitz, Coleman
1:140,000...........Goodman, Amberg
1:54,000.............Niagara

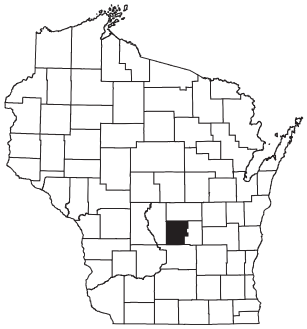
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Marquette County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

Note: Green Lake and Marquette Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	89°14'30.000000"
Latitude of the Central Parallel and Coordinate Origin:	43°48'25.200424"
False Easting:	150876.3018 meters (495000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	79170.7795 meters (259746.132 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000344057

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:53,000.............T17N, R8E, Sec 7 (high point)
Urban ....1:330,000...........Montello
1:500,000...........Oxford
1:200,000...........Westfield

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Menominee County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°25’00.000000”
Origin Latitude:	44°43’00.000000”
False Easting:	105461.0121 meters (346000.004 U.S. Survey Feet)
False Northing:	0.0029 meters (0.010 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000362499

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:71,000.............T30N, R15E, Sec 4 (high point)

Urban ....1:240,000...........Keshena

1:250,000...........Neopit

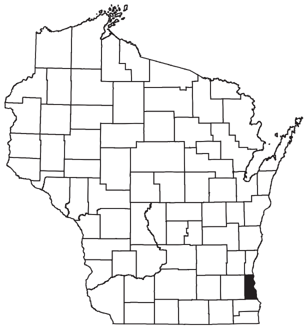
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 200,000 feet

Approximate southernmost coordinate (Y) = 50,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Milwaukee County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kenosha, Milwaukee, Ozaukee, and Racine Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°53'40.000000"
Origin Latitude:	42°13'00.000000"
False Easting:	185928.3728 meters (610000.003 U.S. Survey Feet)
False Northing:	0.0009 meters (0.003 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000260649

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:133,000.............T6N, R21E, Sec 30 (high point)
Urban .... 1:250,000.............Milwaukee - Downtown
1:1:147,000...........Greendale
1:160,000.............West Allis
1:200,000.............Wauwatosa

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 563,000 feet

Approximate southernmost coordinate (Y) = 228,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Monroe County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°38'30.000000"
Latitude of the Central Parallel and Coordinate Origin:	44°00'00.266143"
False Easting:	204521.2090 meters (671000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	121923.9861 meters (400012.278 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000434122

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:50,000.............T18N, R2W, Sec 9 (high point)
Urban ....1:84,000.............Sparta
1:250,000...........Tomah

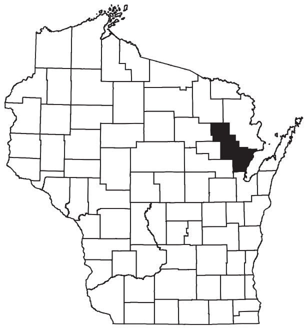
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 584,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Oconto County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	87°54’30.000000”
Origin Latitude:	44°23’50.000000”
False Easting:	182880.3676 meters (600000.006 U.S. Survey Feet)
False Northing:	0.0033 meters (0.011 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000236869

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:62,000.............T33N, R17E,Sec 25 (high point)
Urban ....1:500,000...........Oconto
1:350,000...........Oconto Falls
1:320,000...........Gillett
1:138,000...........Suring

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Oneida County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°32’40.000000”
Latitude of the Central Parallel and Coordinate Origin:	45°42’15.205573”
False Easting:	70104.1401 meters (230000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	57588.0346 meters (188936.744 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000686968

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:95,000.............T37N, R11E, Sec 13 (elev 1760 ft)
Urban ....1:470,000...........Rhinelander
1:370,000...........Woodruff
1:410,000...........Minocqua
1:280,000...........Three Lakes

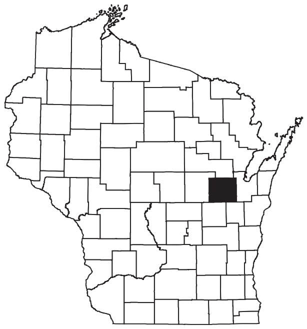
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 102,000 feet

Approximate southernmost coordinate (Y) = 101,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Outagamie County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Calumet, Fond du Lac, Outagamie, and Winnebago Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°30’00.000000”
Origin Latitude:	42°43’10.000000”
False Easting:	244754.8893 meters (802999.999 U.S. Survey Feet)
False Northing:	0.0049 meters (0.016 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000286569

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:75,000.............T22N, R16E, Sec 33 (high point)
Urban ....1:180,000...........Appleton
1:190,000...........Kaukauna
1:410,000...........New London
1:350,000...........Seymour

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 740,000 feet

Approximate southernmost coordinate (Y) = 555,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Ozaukee County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kenosha, Milwaukee, Ozaukee, and Racine Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°53’40.000000”
Origin Latitude:	42°13’00.000000”
False Easting:	185928.3728 meters (610000.003 U.S. Survey Feet)
False Northing:	0.0009 meters (0.003 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000260649

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:74,000..............Northwest corner (high point)
Urban ....1:250,000............Port Washington
1:99,000..............Cedarburg
1:300,000............Mequon, Thiensville
1:140,000............Grafton

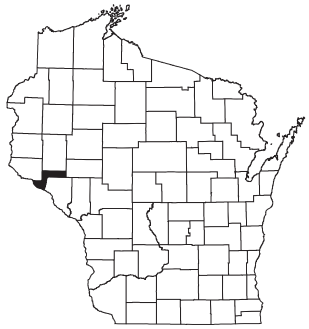
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 565,000 feet

Approximate southernmost coordinate (Y) = 355,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Pepin County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

Note: Pepin and Pierce Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	92°13’40.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°38’10.135939”
False Easting:	167640.3354 meters (550000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	86033.0876 meters (282260.222 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000362977

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:47,000.............T25N, R11W, Sec 27 (high point)
Urban ....1:125,000...........Durand
1:62,000.............Pepin

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 532,000 feet

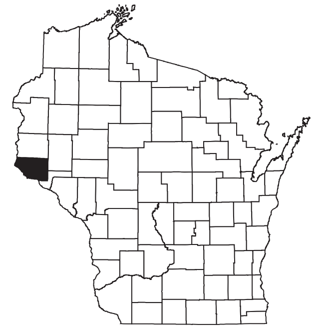
Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Pierce County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Lambert Conformal Conic

Note: Pepin and Pierce Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	92°13’40.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°38’10.135939”
False Easting:	167640.3354 meters (550000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	86033.0876 meters (282260.222 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000362977

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:58,000.............T26N, R16W, Sec 12 (high point)
Urban ....1:60,000.............Ellsworth
1:128,000...........River Falls
1:91,000.............Prescott
1:119,000...........Bay City
1:238,000...........Elmwood, Spring Valley

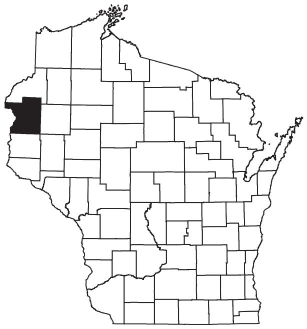
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 247,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Polk County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	92°38’00.000000”
Origin Latitude:	44°39’40.000000”
False Easting:	141732.2823 meters (464999.996 U.S. Survey Feet)
False Northing:	0.0059 meters (0.019 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000433849

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:58,000.............NE, SW, and NW corners (low points)
Urban ....1:156,000...........Osceola
1:95,000.............Frederick, Luck, Centuria
1:181,000...........Balsam Lake
1:83,000.............St. Croix Falls
1:400,000...........Clear Lake, Amery

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

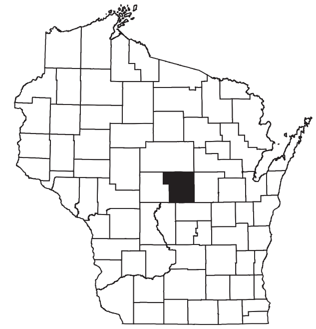
Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Portage County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°30’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°25’00.566311”
False Easting:	56388.1128 meters (185000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	50022.1874 meters (164114.460 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000399360

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:63,000.............T23N, R9E, Sec 22 (high point)
Urban ....1:200,000...........Stevens Point
1:160,000...........Plover

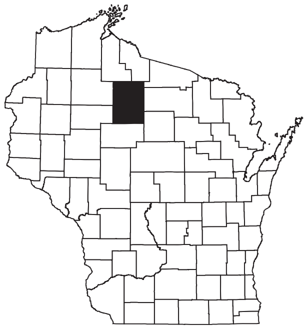
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 95,000 feet

Approximate southernmost coordinate (Y) = 101,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Price County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	90°29’20.000000”
Origin Latitude:	44°33’20.000000”
False Easting:	227990.8546 meters (747999.995 U.S. Survey Feet)
False Northing:	0.0109 meters (0.036 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000649554

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:55,000..............Timms Hill (highest point in WI)

Urban ....1:500,000............Park Falls, Fifield, Phillips, Prentice

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Racine County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kenosha, Milwaukee, Ozaukee, and Racine Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°53’40.000000”
Origin Latitude:	42°13’00.000000”
False Easting:	185928.3728 meters (610000.003 U.S. Survey Feet)
False Northing:	0.0009 meters (0.003 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000260649

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:151,000.............T3N, R20E, Sec 13 (high point)
Urban ....1:285,000.............Racine
1:178,000.............Wind Point
1:188,000.............Burlington
1:200,000.............Union Grove
1:250,000.............Waterford

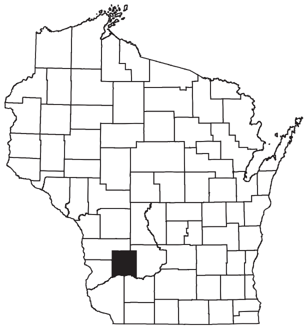
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 144,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Richland County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°25’50.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°19’20.326539”
False Easting:	202387.6048 meters (664000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	134255.4253 meters (440469.675 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000375653

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:67,000.............Wisconsin River (southwest corner)
Urban ....1:178,000...........Richland Center
1:84,000.............Lone Rock
1:100,000...........Viola

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 383,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Rock County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	89°04’20.000000”
Origin Latitude:	41°56’40.000000”
False Easting:	146304.2926 meters (480000.000 U.S. Survey Feet)
False Northing:	0.0068 meters (0.022 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000337311

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:100,000.............T3N, R12E, Sec 22 (high point)
Urban ....1:188,000.............Janesville
1:320,000............Beloit
1:300,000.............Evansville
1:300,000.............Edgerton

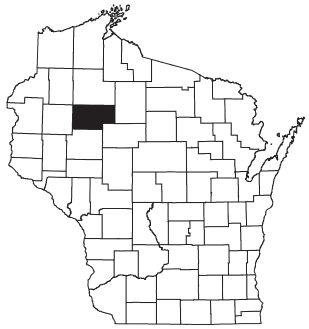
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 400,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Rusk County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°04’00.000000”
Origin Latitude:	43°55’10.000000”
False Easting:	250546.1013 meters (822000.001 U.S. Survey Feet)
False Northing:	0.0234 meters (0.077 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000495976

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:48,000.............Southwest corner

Urban ....1:500,000...........Ladysmith, Hawkings, Sheldon

1:200,000...........Bruce

1:160,000...........Weyerhauser

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 500,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Sauk County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	89°54'00.000000"
Origin Latitude:	42°49'10.000000"
False Easting:	185623.5716 meters (609000.001 U.S. Survey Feet)
False Northing:	0.0051 meters (0.017 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000373868

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:34,000.............Sauk Point (elev 1600 ft)
Urban ....1:500,000...........Baraboo
1:500,000...........Reedsburg, Wisconsin Dells, Lake Delton
1:200,000...........Plain
1:93,000.............Spring Green

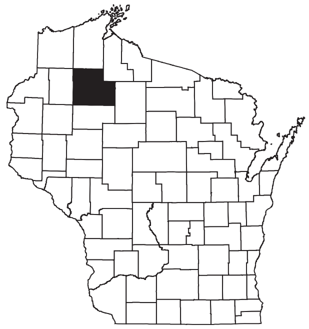
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 120,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Sawyer County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	91°07’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	45°54’00.356873”
False Easting:	216713.2336 meters (711000.001 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	120734.1631 meters (396108.667 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000573461

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:57,000.............Chippewa River (south edge)
Urban ....1:150,000...........Hayward
1:470,000...........Winter
1:180,000...........Radisson
1:78,000.............Exeland

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Shawano County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°36’20.000000”
Origin Latitude:	44°02’10.000000”
False Easting:	262433.3253 meters (861000.001 U.S. Survey Feet)
False Northing:	0.0096 meters (0.031 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000321440

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:78,000.............Southwest corner
Urban ....1:500,000...........Shawano
1:230,000...........Bonduel
1:120,000...........Mattoon
1:190,000...........Wittenberg, Tigerton

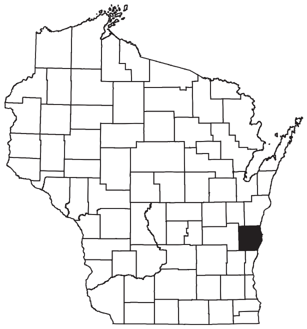
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 200,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Sheboygan County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Kewaunee, Manitowoc, and Sheboygan Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	87°33’00.000000”
Origin Latitude:	43°16’00.000000”
False Easting:	79857.7614 meters (262000.006 U.S. Survey Feet)
False Northing:	0.0012 meters (0.004 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000233704

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:66,000.............Northwest corner
Urban .... 1:230,000...........Sheboygan, Plymouth
1:290,000...........Sheboygan Falls
1:500,000...........Elkhart Lake, Oostburg, Random Lake

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 100,000 feet

Approximate southernmost coordinate (Y) = 101,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

St. Croix County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	92°38’00.000000”
Origin Latitude:	44°02’10.000000”
False Easting:	165506.7302 meters (542999.997 U.S. Survey Feet)
False Northing:	0.0103 meters (0.034 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000381803

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:67,000.............T30N, R15W, Sec 25 (low point)
Urban ....1:230,000...........Deer Park
1:82,000.............Hudson
1:300,000...........New Richmond
1:500,000...........River Falls, Somerset
1:144,000...........Baldwin
1:137,000...........Glenwood City

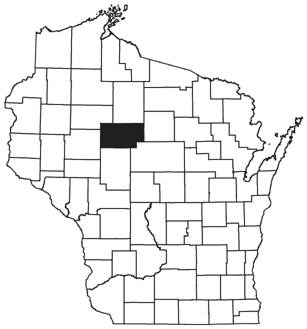
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Taylor County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°29'00.000000"
Latitude of the Central Parallel and Coordinate Origin:	45°10'40.159509"
False Easting:	187147.5744 meters (614000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	107746.7522 meters (353499.136 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000597566

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:62,000.............T33N, R1E, Sec 22 (high point)
Urban ....1:190,000...........Medford
1:370,000...........Stetsonville
1:120,000...........Rib Lake
1:280,000...........Westboro
1:150,000...........Gilman

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Trempealeau County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	91°22’00.000000”
Origin Latitude:	43°09’40.000000”
False Easting:	256946.9138 meters (843000.000 U.S. Survey Feet)
False Northing:	0.0041 meters (0.013 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000361538

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:40,000.............T20N, R8W, Sec 20 (high point)
Urban ....1:500,000...........Whitehall, Blair
1:119,000...........Trempealeau
1:300,000...........Osseo, Independence
1:220,000...........Arcadia, Strum
1:140,000...........Galesville, Ettrick

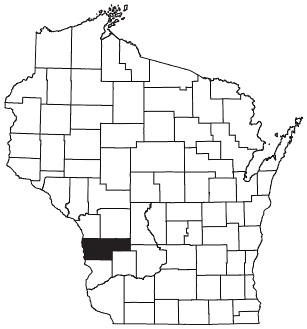
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 778,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Vernon County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°47’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	43°34’30.118583”
False Easting:	222504.4451 meters (730000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	47532.0602 meters (155944.768 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000408158

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:52,000.............Northwest corner
Urban ....1:120,000...........La Farge
1:66,000.............Viroqua, Stoddard
1:55,000.............Westby
1:70,000.............Coon Valley, Ontario, Readstown

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

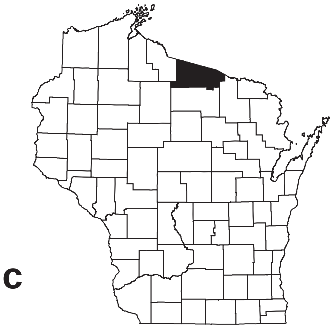
Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Vilas County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°29'20.000000"
Latitude of the Central Parallel and Coordinate Origin:	46°04'40.238726"
False Easting:	134417.0689 meters (441000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	50337.1092 meters (165147.666 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000730142

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:84,000.............T42N, R11E, Sec 36 (high point)

Urban ....1:270,000...........Eagle River

1:310,000...........St. Germain

1:500,000...........Sayner, Boulder Junction

1:150,000...........Woodruff

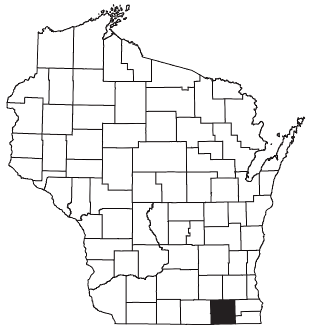
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

Approximate southernmost coordinate (Y) = 84,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Walworth County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	88°32’30.000000”
Latitude of the Central Parallel and Coordinate Origin:	42°40’10.063549”
False Easting:	232562.8651 meters (763000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	111088.2224 meters (364461.943 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000367192

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:87,000.............T2N, R17E, Sec 19 (high point)
Urban ....1:140,000...........Elkhorn
1:260,000...........Pell Lake
1:500,000...........Lake Geneva, Delavan
1:120,000...........Whitewater

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

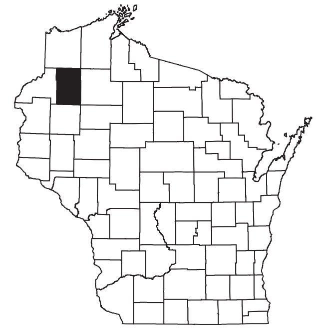
Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Washburn County

WISCRS (Wisconsin Coordinate Reference Systems)



Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	91°47’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	45°57’40.391400”
False Easting:	234086.8682 meters (768000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	188358.6058 meters (617973.193 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000475376

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:74,000..............T38N, R10W, Sec 6 (high point)
Urban ....1:500,000............Shell Lake
1:430,000............Spooner
1:230,000............Minong
1:160,000............Birchwood

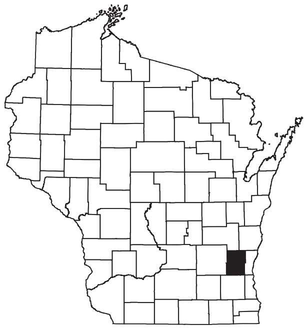
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 500,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Washington County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°03’50.000000”
Origin Latitude:	42°55’05.000000”
False Easting:	120091.4415 meters (394000.004 U.S. Survey Feet)
False Northing:	0.0030 meters (0.010 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000373800

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:65,000.............T9N, R18E, Sec 14 (Holy Hill)

Urban ....1:137,000...........Westbend

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Waukesha County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°13’30.000000”
Origin Latitude:	42°34’10.000000”
False Easting:	208788.4180 meters (685000.001 U.S. Survey Feet)
False Northing:	0.0034 meters (0.011 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000346179

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:63,000.............T7N, R18E, Sec 32 (high point)
Urban ....1:130,000...........Waukesha
1:185,000...........Brookfield, Menominee Falls
1:126,000...........Elm Grove
1:280,000...........Oconomowoc, Mukwonago
1:110,000.............Hartland

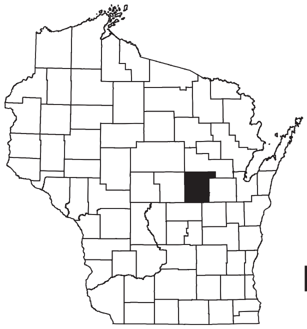
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Waupaca County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

The parameters for this projection are:

Origin Longitude:	88°49’00.000000”
Origin Latitude:	43°25’13.000000”
False Easting:	185013.9709 meters (607000.003 U.S. Survey Feet)
False Northing:	0.0070 meters (0.023 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000333645

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:80,000.............T25N, R13E, Sec 12 (high point)

Urban ....1:320,000...........Waupaca

1:500,000...........Clintonville, Weyauwega

1:310,000...........New London

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 500,000 feet

Approximate southernmost coordinate (Y) = 300,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Waushara County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	89°14'30.000000"
Latitude of the Central Parallel and Coordinate Origin:	44°06'50.198565"
False Easting:	120091.4402 meters (394000.000 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	45069.7587 meters (147866.367 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000392096

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:64,000.............T20, R10E, Sec 20 (high point)
Urban ....1:270,000...........Wautoma
1:135,000...........Redgranite
1:140,000...........Plainfield
1:250,000...........Coloma

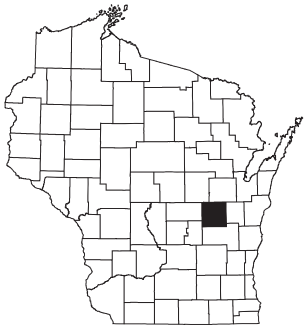
Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 300,000 feet

Approximate southernmost coordinate (Y) = 100,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).



Winnebago County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Transverse Mercator

Note: Calumet, Fond du Lac, Outagamie, and Winnebago Counties share the same projection.

The parameters for this projection are:

Origin Longitude:	88°30’00.000000”
Origin Latitude:	42°43’10.000000”
False Easting:	244754.8893 meters (802999.999 U.S. Survey Feet)
False Northing:	0.0049 meters (0.016 U.S. Survey Feet)
Scale Factor on Central Meridian:	1.0000286569

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:98,000.............Shore of Poygan Lake (west boundary)
Urban ....1:300,000...........Oshkosh, Neenah, Menasha
1:500,000...........Winneconne

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 700,000 feet

Approximate southernmost coordinate (Y) = 427,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Wood County

WISCRS (Wisconsin Coordinate Reference Systems)

Projection: Lambert Conformal Conic

The parameters for this projection are:

Origin Longitude:	90°00’00.000000”
Latitude of the Central Parallel and Coordinate Origin:	44°21’45.343690”
False Easting:	208483.6173 meters (684000.001 U.S. Survey Feet)
False Northing and Northing of the Central Parallel at the Central Meridian:	134589.7540 meters (441566.551 U.S. Survey Feet)
Scale Factor on Central Parallel:	1.0000421209

Note: Distance units in meters; angular units in degrees, minutes, seconds; and the scale factor are exact.

Approximate Ground to Grid Ratios:

Rural (worst) .... 1:58,000........... Powers Bluff

Urban ....1:500,000.......... Wisconsin Rapids

1:160,000.......... Marshfield

Minimum Coordinate Values:

Approximate westernmost coordinate (X) = 600,000 feet

Approximate southernmost coordinate (Y) = 400,000 feet

Notes:

1. WISCRS parameters, above, are for use with the GRS 80 ellipsoid.
2. The *de facto* horizontal geodetic datum and adjustment for WISCRS is NAD 83 (1991). However, ground-to-grid ratios, for most applications, are also negligible for other adjustments of NAD 83 (e.g., NAD 83 (1986), NAD 83 (1997)).

Regional Coordinate Systems

Coordinate systems may be designed for global, regional, or local use. This section provides an overview of Wisconsin coordinate reference systems used for regional or statewide applications.

Rectangular coordinate reference systems such as Universal Transverse Mercator and State Plane have a long-established use in surveying and mapping and are commonly used in computer-aided design (CAD), geographic information systems (GIS), and global positioning system (GPS) software. The overall scale accuracy of global and regional coordinate systems tends to be lower than those of local coordinate systems. Because of this, ground-to-grid differences are large enough to require special accommodation/adjustment for applications requiring high accuracy.

The State Plane Coordinate (SPC) System was introduced nationally in the 1930s by the U.S. Coast & Geodetic Survey to accommodate the needs of surveying, mapping, and engineering projects. Based on both the Lambert conformal conic and transverse Mercator projections, State Plane Coordinate Systems were developed for every state such that there would be no more than one foot of distortion in every 10,000 feet of distance on the ellipsoid.

Wisconsin is covered by three Lambert projections comprising South, Central, and North State Plane Coordinate zones *(see Figure 16).* Each zone has a false origin located south and west of the zone so that the entire area covered will have positive coordinate values. The approximate north-south width of each zone (158 miles) was selected so the maximum scale factor requirement of 1:10,000 would be met.

SPC zone boundaries follow county lines because the coordinate systems are designed to support local surveying and mapping needs. Similarly, the standard unit selected for SPC was the U.S. Survey Foot rather than the international foot in keeping with historic use and legal precedent. The original SPC was based on NAD 27. Therefore, this set of coordinate systems is identified as SPC 27.

When NAD 83 was developed the SPC parameters were redefined. At the federal level SPC 83 utilizes meters, rather than feet, as the unit of measure. However, in Wisconsin statutes, Chapter 236 specifies the U.S. Survey Foot as the unit of measure. SPC 83 was assigned a different false easting than SPC 27 so that coordinate values in the two systems could easily be distinguished. This difference is 31,500 feet in easting.

SPC 83 parameters are the same regardless of the NAD 83 adjustment, making documentation about the datum and adjustment particularly critical. SPC 83 should be denoted with its datum adjustment for clarity – for example, SPC 83 NAD 83 (1991).

It is important to understand that simply converting the units and adjusting the false easting value cannot relate the SPC 27 and SPC 83 systems. This is because there is no exact mathematical conversion between these two datums.

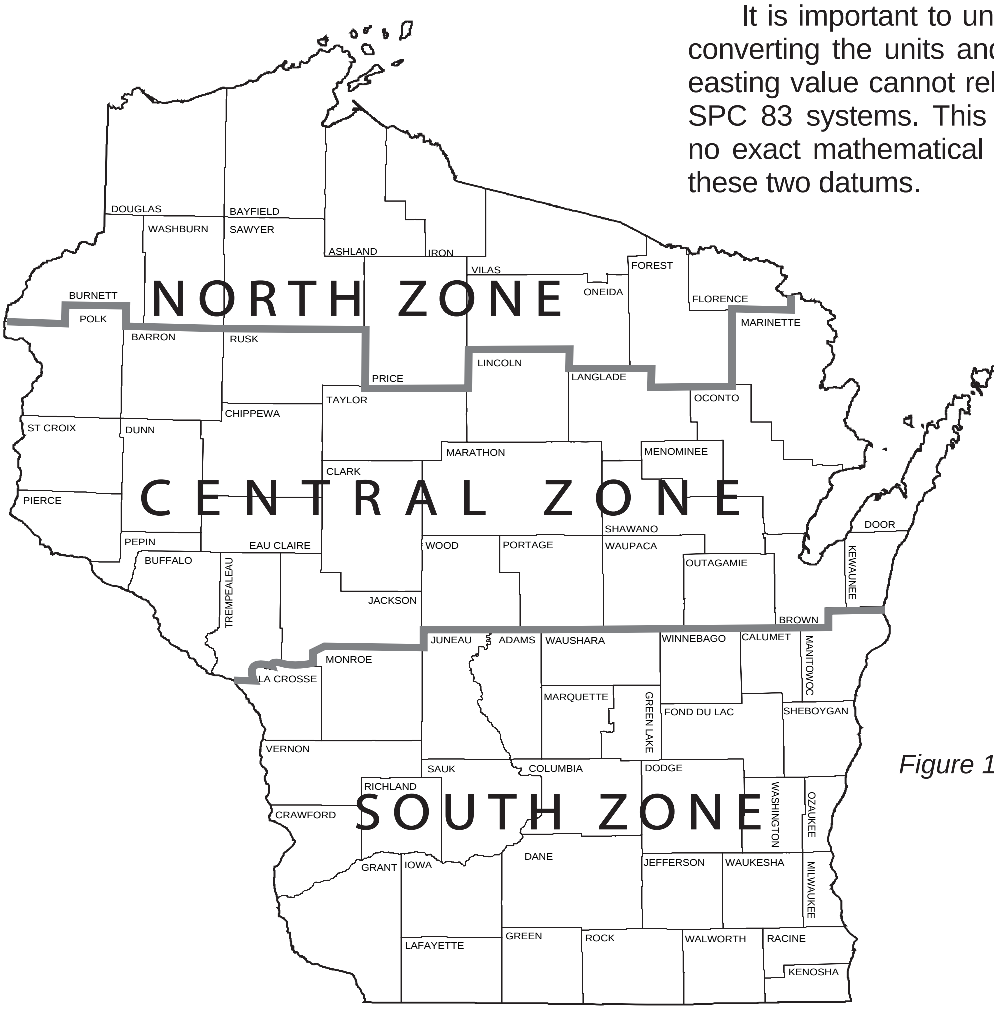


Figure 16: Wisconsin State Plane Coordinate (SPC) System

		SPC 27	SPC 83
North Zone	Projection:	Lambert conformal conic	Lambert conformal conic
	Scale Factor at Central Meridian:	1.0	1.0
	1st Standard Parallel:	45° 34’	45° 34’
	2nd Standard Parallel:	46° 46’	46° 46’
	Longitude of Central Meridian:	-90° 00’	-90° 00’
	Latitude of Origin:	45° 10’	45° 10’
	False Easting:	2,000,000 feet (US Survey Foot)	600,000 meters
	False Northing:	0	0
	Unit:	foot (US Survey Foot)	meter
Central Zone	Projection:	Lambert conformal conic	Lambert conformal conic
	Scale Factor at Central Meridian:	1.0	1.0
	1st Standard Parallel:	44° 15’	44° 15’
	2nd Standard Parallel:	45° 30’	45° 30’
	Longitude of Central Meridian:	-90° 00’	-90° 00’
	Latitude of Origin:	43° 50’	43° 50’
	False Easting:	2,000,000 feet (US Survey Foot)	600,000 meters
	False Northing:	0	0
	Unit:	foot (US Survey Foot)	meter
South Zone	Projection:	Lambert conformal conic	Lambert conformal conic
	Scale Factor at Central Meridian:	1.0	1.0
	1st Standard Parallel:	42° 44’	42° 44’
	2nd Standard Parallel:	44° 04’	44° 04’
	Longitude of Central Meridian:	-90° 00’	-90° 00’
	Latitude of Origin:	42° 00’	42° 00’
	False Easting:	2,000,000 feet (US Survey Foot)	600,000 meters
	False Northing:	0	0
	Unit:	foot (US Survey Foot)	meter

Universal Transverse Mercator

The Universal Transverse Mercator (UTM) coordinate system was developed by the Department of Defense for military purposes and is a global coordinate system. UTM has 60 north-south zones. The zone width of 6 degrees was chosen to maintain a scale difference of no more than 1 part in 2,500 (1 inch in 208 feet).

Zones in the UTM system are numbered from west to east starting at the 180th meridian. The origin for each zone is at the intersection of the zone's central meridian and the equator. A false easting of 500,000 meters is assigned to the central meridian to avoid negative coordinate values.

Wisconsin lies about equally in UTM zones 15 and 16 *(see Figure 17).* Federal and state agencies sometimes extend a zone so that project work remains in one system. In these cases, the zone may be referred to as Zone 15 Extended, or Zone 15E.

UTM parameters are the same for NAD 27 and NAD 83 making datum and adjustment information particularly critical. In Wisconsin, UTM coordinate differences on the two datums are approximately 200 meters in northing, and less than 10 meters in easting.

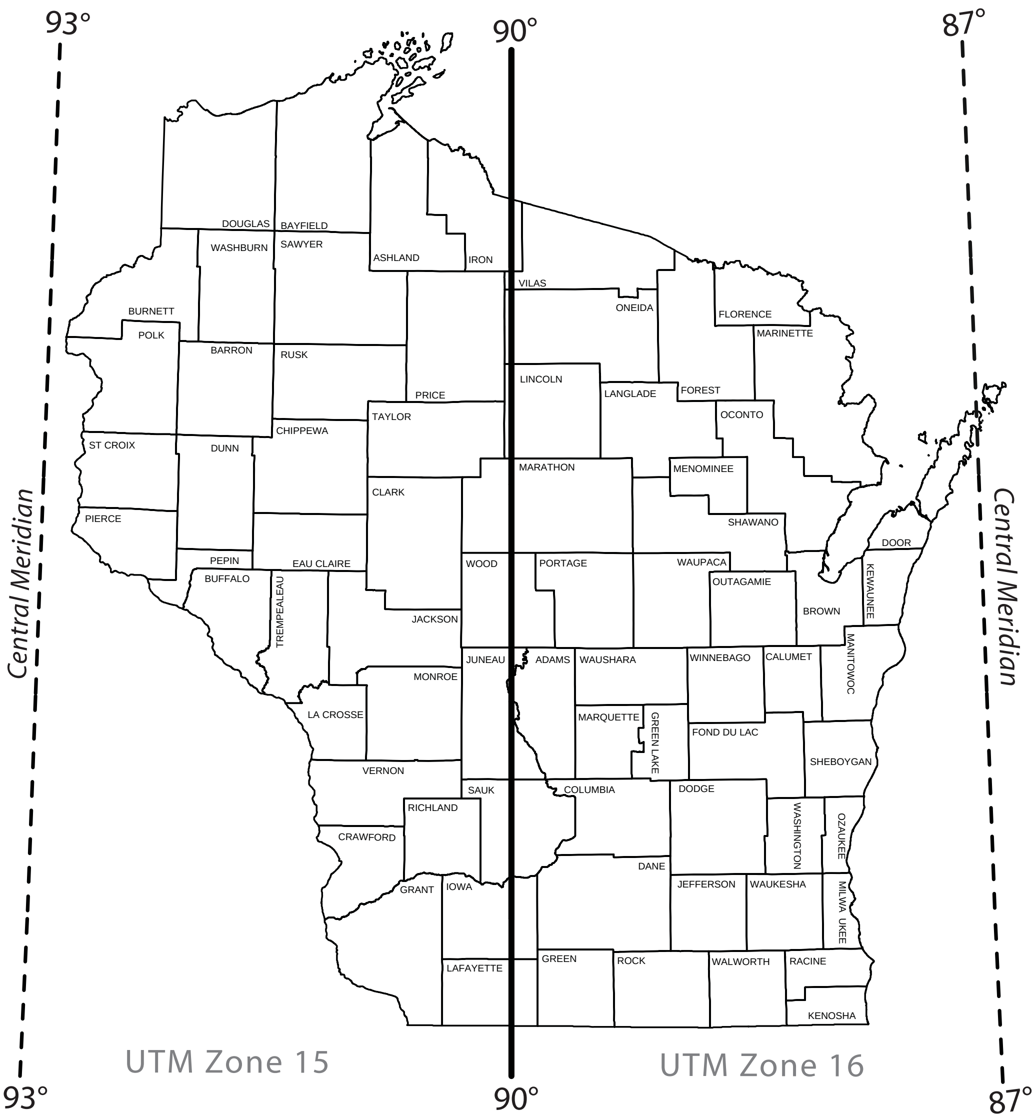


Figure 17: UTM Zones 15 and 16 showing the difference in orientation based on each central meridian

Zone 15

Projection:	Transverse Mercator
Scale Factor at Central Meridian:	0.9996
Longitude of Central Meridian:	93°W (-93°)
Latitude of Origin:	0°
False Easting:	500,000 meters
False Northing:	(0)*
Unit:	meter

Zone 16

Projection:	Transverse Mercator
Scale Factor at Central Meridian:	0.9996
Longitude of Central Meridian:	87°W (-87°)
Latitude of Origin:	0°
False Easting:	500,000 meters
False Northing:	(0)*
Unit:	meter

** The UTM Coordinate System does not define a false northing.*

Wisconsin Transverse Mercator

In the mid-1980s the Wisconsin Department of Natural Resources developed the Wisconsin Transverse Mercator (WTM) coordinate system to avoid having the state divided into two UTM zones.

This system centers a UTM-like zone on the 90th meridian (west) thereby covering the state with one zone, sometimes referred to as zone "15-1/2" *(see Figure 18).* The distortion in the projection increases from the center toward the eastern and western extremes of the state. A false easting of 500,000 meters and a false northing of -4,500,000 meters are used to produce more convenient coordinate values for Wisconsin. WTM is an example of a coordinate system designed and created to satisfy a particular regional need and to avoid problems caused by use of two UTM zones.

Unlike UTM, WTM was redefined for the NAD 83 datum. WTM 83 has a different false easting and northing than WTM 27. WTM 83 coordinates are based on a false easting of 520,000 meters and a false northing of -4,480,000 meters. Together with the 200 meter and 10 meter (shifts discussed previously (see UTM)), the total difference in coordinate values between WTM 27 and WTM 83 is slightly more than 20,000 meters, or roughly 13 miles, in both northing and easting.

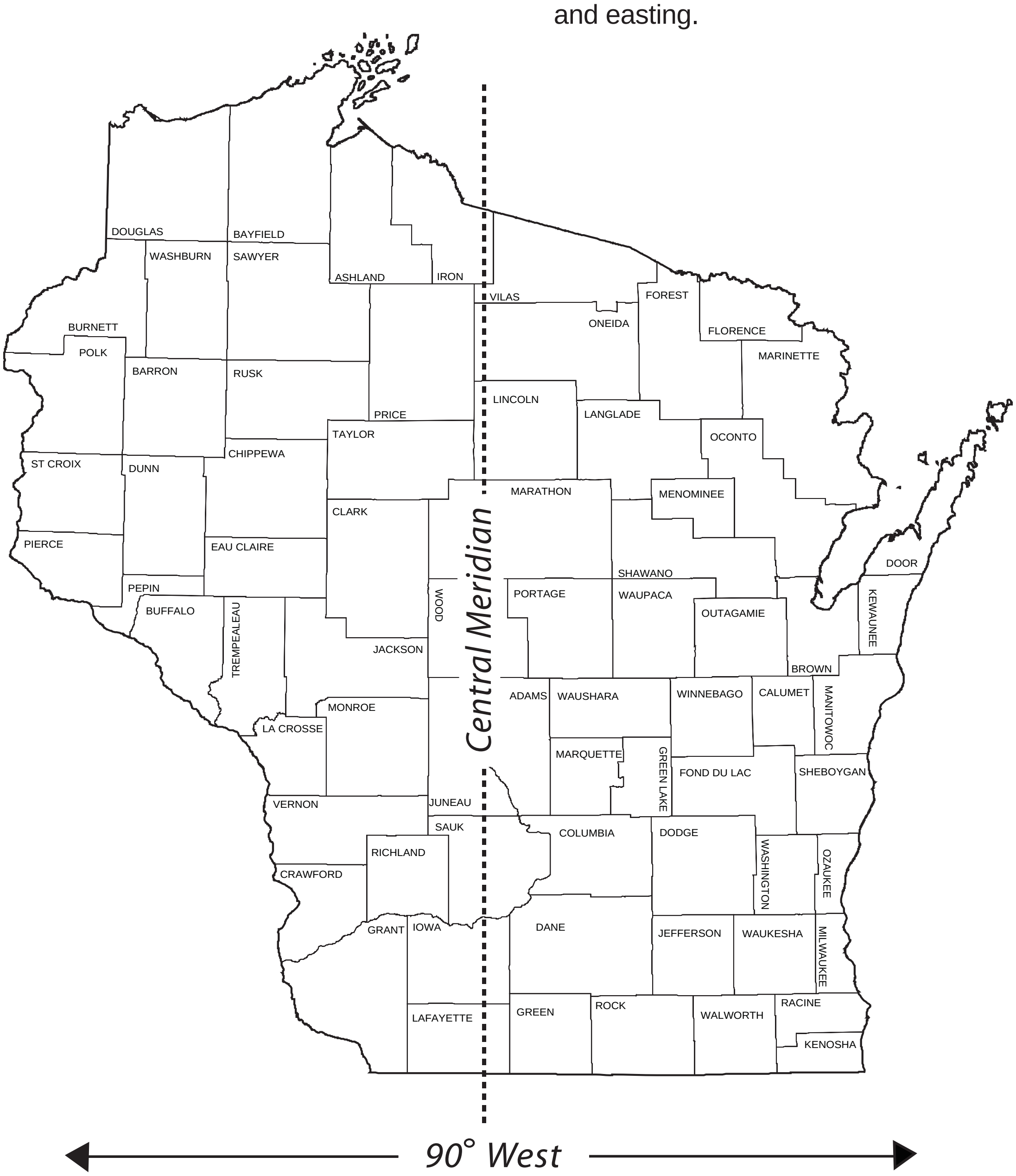


Figure 18: Wisconsin Transverse Mercator (WTM) coordinate system

WTM 27

Projection:	Transverse Mercator
Scale Factor at Central Meridian:	0.9996
Longitude of Central Meridian:	90°W (-90°)
Latitude of Origin:	0°
False Easting:	500,000 meters
False Northing:	-4,500,000 meters
Unit:	meter

WTM 83

Projection:	Transverse Mercator
Scale Factor at Central Meridian:	0.9996
Longitude of Central Meridian:	90°W (-90°)
Latitude of Origin:	0°
False Easting:	520,000 meters
False Northing:	-4,480,000 meters
Unit:	meter

The U.S. National Grid (USNG) is a spatial referencing system approved as a federal standard by the Federal Geographic Data Committee in 2001. Based on UTM and closely related to the Military Grid Reference System (MGRS), USNG is commonly described as a seamless, nationwide "geoaddressing" system. USNG geoaddresses are unique world-wide, and for this reason, the federal government has heavily promoted USNG as a common "language of location" for emergency response and recovery.

During emergency situations, there are many ways to communicate locations including street addresses, arbitrary Cartesian grid references (A-1, B-3, etc.), and map coordinates. A lack of standardized means to communicate locations has proven to be problematic during past large-scale disasters. With multiple agencies and organizations responding to these situations, multiple spatial referencing systems may be in use, thus leading to confusion and communication problems. USNG is intended to be the solution to this problem.

A USNG geoaddress is an alphanumeric string comprised of three components: a unique 6° x 8° grid zone designator, a 100,000-meter square identifier, and a 4-10 digit grid coordinate value in meters. *(see Figure 19).*

A unique aspect of the USNG system is the ability to truncate the number of coordinate digits depending upon the locational precision required. Pairs of numbers con-

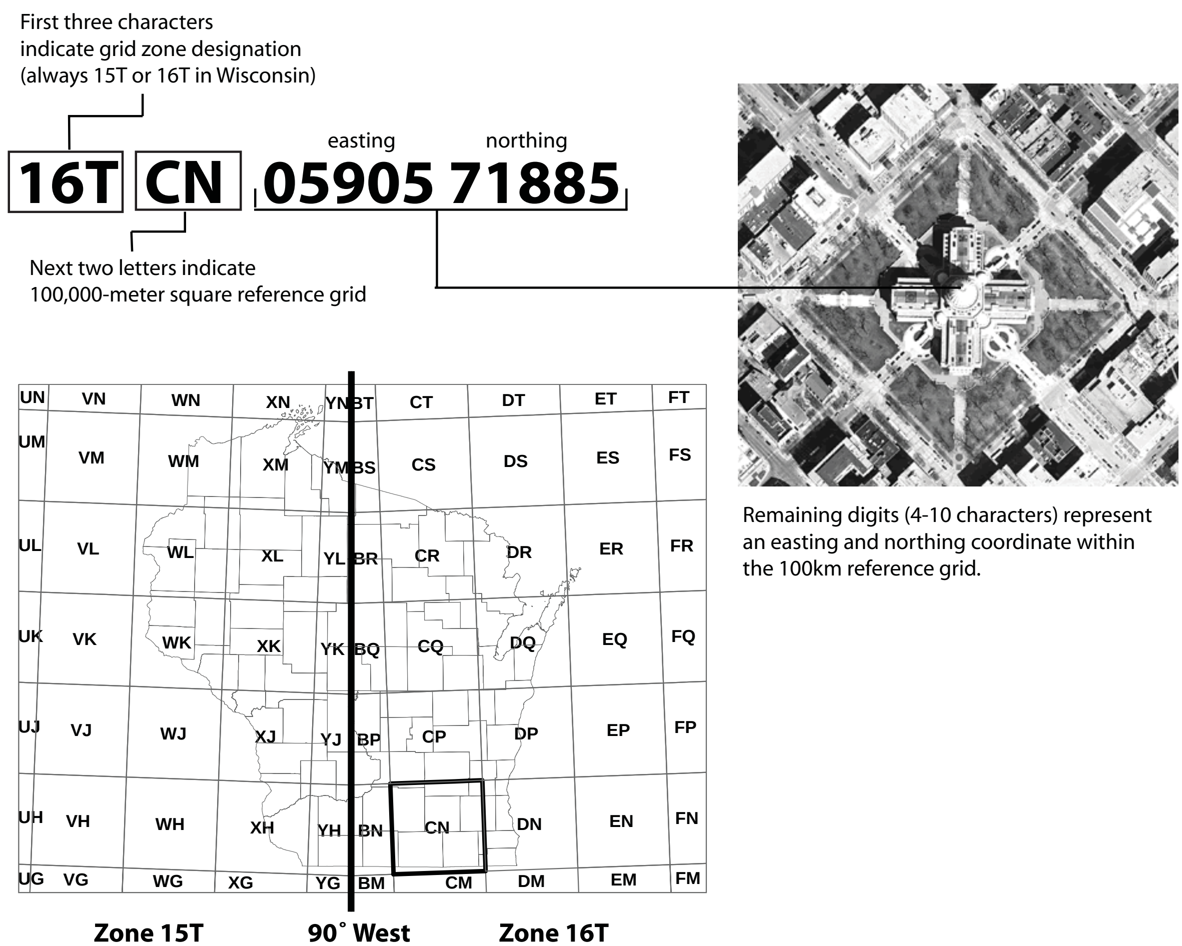


Figure 19: U.S. National Grid Coordinates of the Wisconsin State Capitol

sisting of 4, 6, 8 or 10 digits will designate grids having, respectively, 1km, 100m, 10m, or 1m extents.

USNG is intended to supplement, not replace, street addresses in common use throughout the U.S. for many years. Nor is USNG appropriate for surveying or mapping applications requiring a high degree of precision. Although the FGDC standard allows for greater precision in special cases, by convention USNG geoaddresses are typically precise to no more than one meter.

How to implement and utilize USNG is a common point of confusion. It is not necessary to convert existing geospatial data from a locally-favored coordinate reference system, such as WTM or WISCRS, in order to use USNG. Instead, USNG is best conceptualized as a grid reference system that can be overlaid on existing maps and geographic data, much in the same way multiple grid reference systems are found on U.S. Geological Survey topographic maps.

As of May 2009, the Federal Geographic Data Committee maintains the most comprehensive Web site related to USNG, including links to conversion software, tips and tricks, case studies, and educational resources. See www.fgdc.gov/standards/usng/ for more details.

Glossary

Central meridian
Central north-south line of origin though the area of interest, used in many rectangular coordinate systems to orient the coordinate grid.

Conic projection
A map projection of an ellipsoid onto a cone. Along a given line of latitude, the lines of longitude on a conical projection map are equally spaced radial lines, that converge at a pole. Lambert's conformal conic projection is the most well-known conic projection *(see Figure 1)*.

Conversion (see also: transformation)
The exact process of changing the coordinates of a point from one coordinate reference system to another coordinate reference system. *(see Figure 13).*

Coordinate
A set of numbers that describes a two- or three-dimensional location with respect to the origin of a given coordinate reference system.

Coordinate reference system
A rectangular reference framework, defined by a geodetic datum, a map projection referenced to the datum, and a unit of measurement, that is used to describe two- or three-dimensional locations on the surface of the Earth. A coordinate must be associated with a coordinate reference system for it to be related to any other coordinate. Common examples are the geographic coordinate system of latitude and longitude, and the Wisconsin Transverse Mercator coordinate system.

CORS (see also: Wisconsin CORS, page 12)
The National Geodetic Survey (NGS) coordinates two networks of continuously operating reference stations (CORS) throughout the United States: the National CORS network and the Cooperative CORS system that provides access to GPS data that are disseminated by organizations other than NGS. Each CORS site provides GPS measurements in support of 3-dimensional positioning activities. The CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

All national CORS data are available from NGS at their original sampling rate for 30 days. After that time, the data are resampled to a 30 second sampling rate. Cooperative CORS data are available from the participating organization that operates the respective site.

CORPSCON (see also: NADCON and VERTCON)
A computer program that allows the user to convert coordinates between geographic, State Plane, Universal Transverse Mercator (UTM) and U.S. National Grid systems on the North American Datum of 1927 (NAD 27), the North American Datum of 1983 (NAD 83) and High Accuracy Reference Networks (HARNs). CORPSCON uses the National Geodetic Survey (NGS) program NADCON to convert between NAD 27, NAD 83 and HARNs.

CORPSCON, Version 6.0, performs vertical conversions to and from the National Geodetic Vertical Datum of 1929 (NGVD 29) and the North American Vertical Datum of 1988 (NAVD 88). Vertical conversions are based on the NGS program VERTCON and can be performed for the continental U.S. only.

Cylindrical projection
A map projection of an ellipsoid onto a cylinder. In a cylindrical projection, lines of longitude are equally-spaced parallel lines, while lines of latitude are parallel but are spaced farther apart with increasing distance from the equator *(see Figure 2)*.

Datum
A mathematically-defined reference surface used to represent the size and shape of the Earth. A horizontal datum is defined by an ellipsoid, and its fixation with respect to the surface of the earth. The two most commonly used horizontal datums in Wisconsin are the North American Datum of 1927 (NAD 27) and the North American Datum of 1983 (NAD 83). A vertical datum is used for referencing elevations of points on the surface of the Earth. The most commonly used vertical datum in Wisconsin is the North American Vertical Datum of 1988 (NAVD 88).

Developable surface
(see also: Projection)
A three-dimensional surface that can be flattened without distortion, (e.g., a cylinder or a cone). Developable surfaces are traditionally

used for projecting an ellipsoid onto a plane and for sectioning the surface of the earth in order to create a profile of that surface.

Elevation
The vertical distance from a reference datum to a point or object, usually on the surface of the Earth.

Elevation factor
Used to convert a distance on the ground to its equivalent distance on an ellipsoid. Relates the ratio of the radius of the earth to the sum of the radius of the earth plus the ellipsoid-ground separation.

Ellipsoid
A mathematical surface (an ellipse rotated about its minor axis) that provides a convenient model of the size and shape of the earth. The ellipsoid is chosen to best meet the needs of a particular geodetic datum system design.

Ellipsoid height **(see also: geoid height, orthometric height)**
The perpendicular distance from a point on the surface of the earth to the reference ellipsoid. (Also known as geodetic height) *(see Figure 11*).

False easting/False northing
A numerical constant used to eliminate negative coordinates in a system, or to change the coordinates to more convenient values. The false easting and/or northing values are assigned to the true origin of a map projection. *(see Figure 3).*

False origin
The zero point for a coordinate system, as distinguished from a true origin. The true origin of a coordinate system might be assigned arbitrary coordinate values, to eliminate negative coordinates in the system. (This is done using false eastings and/or northings.) The false origin is an assumed point, typically west and south of the projection area, having a coordinate value of 0,0. *(see Figure 3).*

Geocentric
Measuring from the center of the Earth.

Geodetic coordinates
Also called geographic coordinates.

Geodetic distance
The arc distance on a reference ellipsoid *(see Figure 6).*

Geographic coordinates
The quantities of latitude and longitude which define the position of a point on the surface of the Earth with respect to the reference ellipsoid. Lines of longitude run north-south and indicate the number of degrees from the prime meridian (0 degrees longitude). Lines of latitude run east-west and indicate the number of degrees from the equator (0 degrees latitude). *(see Figure 7).*

Geoid
A surface that best fits the global equivalent of mean sea level extended continuously through the continents. It is a theoretically contiguous surface that is perpendicular at every point to the direction of gravity *(see Figure 11).*

Geoid height/Geoid separation
(see also: ellipsoid height, orthometric height.

The perpendicular distance between the geoid and the reference ellipsoid, at a point. A negative geoid separation indicates that the geoid is below the ellipsoid. In Wisconsin, the geoid separation is roughly minus 30 meters. *(see Figure 11)*.

Ground-to-grid ratio
Statistic that expresses the difference between distances calculated on the grid surface and distances measured on the ground. Small ratios (e.g., 1:500,000) indicate less difference, while larger ratios (e.g., 1:5,000) indicate more difference.

High Accuracy Reference Network (HARN)
A network of control points precisely measured using GPS instruments under standards set by the National Geodetic Survey. In 1988, the Wisconsin Department of Transportation and NGS began to jointly establish the HARN in Wisconsin with 80 stations. This was the basis for the NAD 83 (1991) adjustment.

International Terrestrial Reference System/Framework (ITRS/ITRF)

ITRS describes procedures for creating reference frames for use with measurements on the Earth's surface. The ITRF is the measurement data of the ITRS. ITRF solutions are produced every few years using the latest mathematical and surveying techniques from observations at stations around the globe.

Monumented Survey Points

Permanent objects placed to mark key survey points such as "control points" used for both geodetic surveying and land surveying. Vertical control points are also known as "bench marks." Well-monumented points might be used in subsequent surveys. They are durable, intended to be permanent, and most often consist of cast or stamped metal disks set in rock or concrete, or on rods driven into the ground.

NADCON

Created by the National Geodetic Survey, NADCON is a federal standard horizontal datum transformation computer program. NADCON transforms latitude and longitude coordinate values based on models of real data. The accuracy of transformations should be used with caution, NADCON cannot improve the accuracy of data. The accuracy of transformations between NAD 27 and NAD 83 (1986) is typically 12-18 cm, and 5-6 cm between NAD 83 (1986) and NAD 83 (1991).

National Geodetic Survey (NGS)

NOAA's National Geodetic Survey (NGS) defines and manages a national coordinate database. This network, the National Spatial Reference System (NSRS), provides the foundation for mapping and charting, and a multitude of scientific and engineering applications. NGS develops federal standards for geodetic surveys and helps to coordinate surveying methods. NGS State Geodetic Advisors are stationed in several states, including Wisconsin, to work with local communities to expand surveying capabilities.

National Spatial Reference System (NSRS) **(see also: spatial reference system)**

The National Spatial Reference System (NSRS) is the foundation of the National Spatial Data Infrastructure (NSDI) and acts as a consistent, accurate, and precise national coordinate system. The NSRS is managed by the National Geodetic Survey (NGS) and incorporates all NGS geodetic control.

Orthometric height **(see also: ellipsoid height, geoid height)**

The vertical distance from a point on the surface of the Earth to the geoid. The orthometric height is the sum of the geoid height and the ellipsoid height and is sometimes considered the "elevation above sea level" *(see Figure 11)*.

Projection

The method used to transform and portray the curved surface of the earth as a flat (map) surface. Although there are theoretically an infinite number of possible projections, a relatively small number are commonly used. Different projection systems have differing amounts and patterns of distortion and are suited for different purposes.

Rectangular coordinate system

A two- or three-dimensional coordinate system with mutually orthogonal (right angle) axes designated x, y, and z (if three-dimensional). In a rectangular coordinate system a distance along the X-axis is typically called an "easting," and a distance along the Y-axis is typically called a "northing". The Wisconsin State Plane Coordinate System is an example of a rectangular coordinate system. (Also known as a Cartesian coordinate system.)

Scale factor

The ratio of a projection (grid) distance to corresponding ellipsoid distance. Because projection of the ellipsoid onto a flat surface creates distortions, the scale factor varies from place to place. A value larger then one (e.g., 1.0001) means the scale grid distances are larger than ellipsoid distances. A smaller value (e.g., 0.9999) means grid distances are smaller than ellipsoid distances *(see Figure 5)*.

Spatial reference system **(see also: National Spatial Reference System (NSRS))**

A spatial reference system represents the location of objects or features with respect to a geographic area, large or small. Commonly used spatial referencing systems are related to geographical units such as the Public Land Survey System, the U.S. National Grid, and Census wards, blocks and tracts. More robust geographic (coordinate-based) spatial referencing systems incorporate latitude, longitude, height, and gravity values for a local, regional, or global coordinate system, and a network of permanent reference points for positioning other points.

Standard line/Standard parallel
A defined line in a map projection along which distances the ellipsoid and the map projection plane are equal. It is a line of no distortion (along which the scale factor is equal to 1.0). Many map projections have two standard lines. For example, for Lambert projections, if the cone intersects the ellipsoid, the first and second standard parallels are lines of latitude where the scale factor is equal to 1.0. These are the lines of intersection between the cone and ellipsoid. *(see Figures 1 and 2)*.

Transformation (see also: conversion)
In the strictest sense of the word, this refers to a "best fit," or modeled method of data conversion between two or more sets of geographic data. *(see Figure 14).*

Unit of measurement
Rectangular coordinate systems may use meters, International Foot, or the U.S. Survey Foot as the unit of measurement. Most surveying and mapping work at the local level is based on the U.S. Survey Foot. When a conversion from one of these units to the other is performed, it is important to ascertain which standard foot (U.S. Survey or International Foot) is involved.

The international foot, based upon a redefinition of the meter in 1959, is equivalent to 0.3048 meter. The U.S. Survey Foot, upon which many years of land tenure information and legislation are based, retained the 1893 definition of 1200/3937 meter*. In Wisconsin, Chapter 236 of State Statutes requires use of the U.S. Survey Foot with the State Plane Coordinate System, for certain purposes. The Wisconsin county coordinate systems also use the U.S. Survey Foot.

**For conversion of meters to U.S. Survey Feet, multiply the meters by 3.28083333333 (to 12 significant figures). For conversion of meters to international feet, multiply the meters by 3.28083989501 (to 12 significant figures).*

VERTCON
A computer program created by the National Geodetic Survey to compute the modeled difference in orthometric height between the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29) for a given location specified by latitude and longitude. As a datum transformation model, VERTCON, can not maintain the full vertical control accuracy of geodetic leveling. Ideally, one should process level data using the latest reduction software and adjust it to established NAVD 88 control. However, VERTCON accuracy is suitable for a variety of mapping and charting purposes.

WISCON
A computer program designed to transform coordinates from one Wisconsin datum/coordinate system to another. WISCON does not handle conversions for structured GIS or CAD data files. It works with user-entered individual point values, and with sets of point data in certain formats. WISCON is produced by SMP Software under contract with the Wisconsin Department of Transportation (WisDOT). WISCON v. 2.2 supports the following: Horizontal Coordinate Systems: Geographic (latitude/longitude), State Plane (WI and four adjoining states), Universal Transverse Mercator (WI and adjoining regions), Wisconsin County (developed by WisDOT), Wisconsin Transverse Mercator (developed by WisDNR), and Great Lake's Lambert Projection (developed by Army Corps of Engineers).

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NOS Education Discovery Kits — *oceanservice.noaa.gov/education/kits/geodesy/welcome.html*
The Geodetic Tool Kit — *www.ngs.noaa.gov/TOOLS/*
The Geoid Page — *www.ngs.noaa.gov/GEOID/*
National and Cooperative CORS — *www.ngs.noaa.gov/CORS/*
National Readjustment — *www.ngs.noaa.gov/NationalReadjustment/*
NGS FAQs — *www.ngs.noaa.gov/faq.shtml*

National Geospatial-Intelligence Agency:
WGS84 — *earth-info.nga.mil/GandG/wgs84/index.html*
Earth Gravity Model — *www1.nga.mil/ProductsServices/GeodesyandGeophysics/WorldGeodeticSystem/Pages/EarthGravityModel.aspx*
Coordinate Systems Analysis — *www1.nga.mil/ProductsServices/GeodesyandGeophysics/Coordinates/Pages/default.aspx*

US Army Corps of Engineers:
International Great Lakes Datum:
www.lre.usace.army.mil/greatlakes/hh/newsandinformation/iglddatum1985/

Wisconsin Department of Transportation:
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Wisconsin State Cartographer's Office:
County Coordinate Test Point Data - NAD 83 and NAD 27:
www.sco.wisc.edu/coordinate-reference-systems/coordinate-reference-systems.html
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www.sco.wisc.edu/land-surveying/hmp-passive-network.html

Revisions

May 2009

- Corrected spelling of Niagara. (page 61)

January 2012

- Added exact metric equivalent of the U.S. Survey Foot. (page 3) *
- Removed statement about the use of NAD27 on federal topographic quandrangles. Newer "U.S. Topo" products are now based on NAD 83. (page 6) *
- Corrected the stated difference between false eastings in NAD 27 and NAD 83 State Plane Coordinates. (page 98) *
- Updated addresses for State Cartographer's Office Web pages. (page 111)
- Corrected Web page address for NOAA Ocean Service. (page 111)
- Updated Web page address for WISCORS. (page 111)
- Updated addresses for NGA Web pages. (page 111)

** Thank you to Glen Schaefer, Wisconsin Department of Transportation, for providing these updates.*

June 2015

- Removed "Oconto, Sales" from the Approximate Ground to Grid Ratios/Urban 1:500,000 and replaced as "Oconto". (page 66)