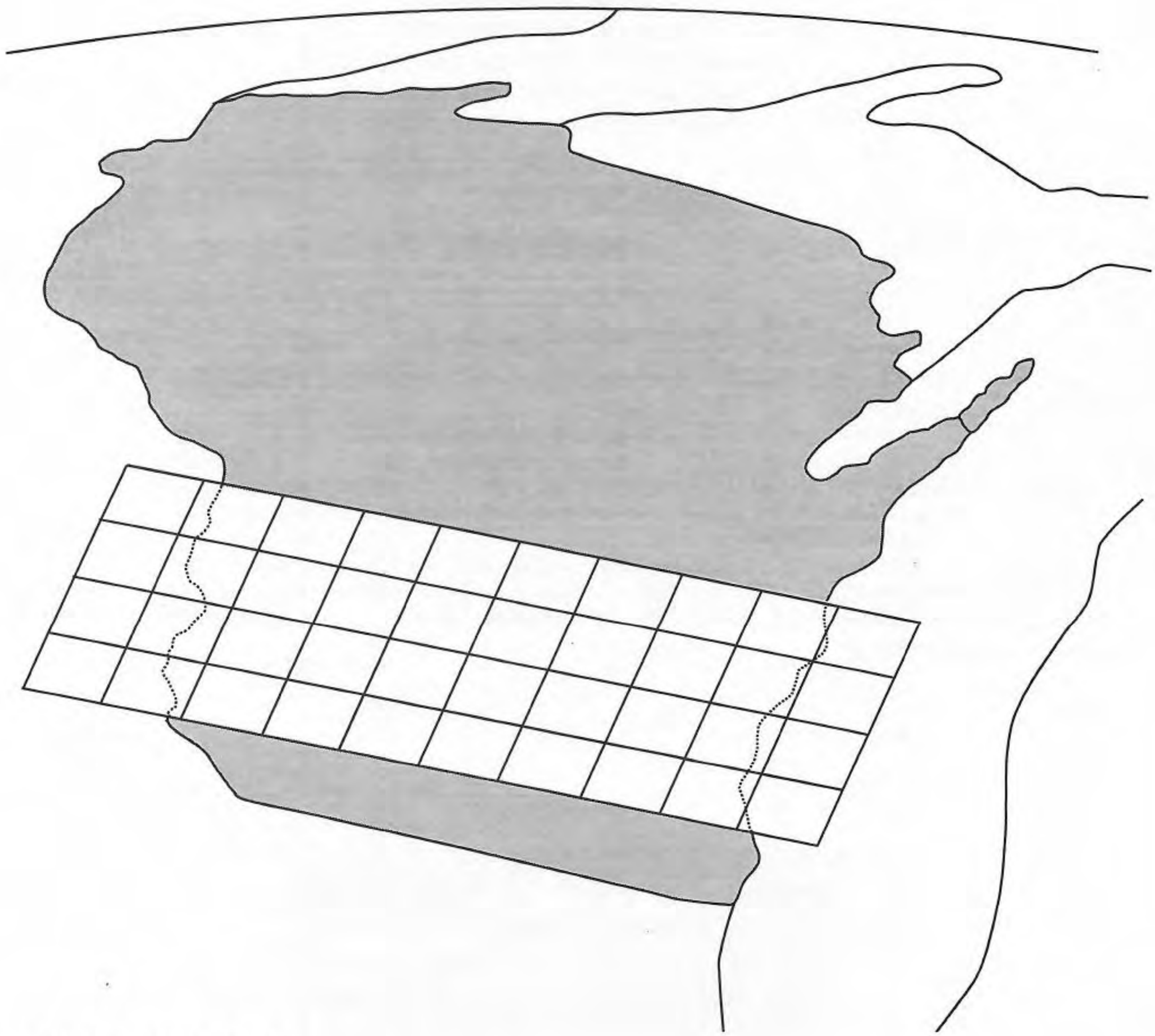
Wisconsin
Coordinate Systems



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About the SCO...

The State Cartographer's Office (SCO), established in 1973, is a unit of the University of Wisconsin-Madison. Its office is located on the 1st floor of Science Hall.

As an "outreach" office of the university and as a clearinghouse, the SCO functions in a wide variety of ways to develop and maintain effective mapping for the entire state. It maintains files on maps and data currently available from federal, state and local governments, and commercial mapping firms. A wide variety of information is available from the SCO about mapping, aerial imagery, and geodetic control. Information on the use, application and development of geographic and land information system (GIS/LIS) technology is also available. For some topics, additional descriptive information and index maps are available.

Order this handbook from the SCO:

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Foreword

Within recent years, Wisconsin has been host to several datum adjustments and numerous new coordinate systems or redefinitions. This handbook was developed to aid the land information community in transforming data between these various systems to meet data sharing and integration needs. For the first time, all of Wisconsin's coordinate systems, and their defining parameters, are compiled in one document.

Since this handbook is intended to be a coordinate system user's manual, we have assumed some knowledge of basic underlying concepts such as geodetic datums, projections, and coordinate systems. Only a brief treatment is given to these topics here. The section on references and suggested readings points to more detailed information.

We recognize that the geographic coordinate system of latitude and longitude is the ideal system for exchanging data. In fact, many organizations—such as the U.S. Bureau of Land Management and the Wisconsin Land Information Association—recommend this. However, most geographic data collection, management, and analysis occurs in the context of a plane coordinate system. As a result, this handbook focuses on the rectangular coordinate systems commonly used in our day-to-day computerized surveying and mapping environments.

The regional coordinate systems described in this handbook are well established and described in great detail in many other sources. The Wisconsin County Coordinate System is part of the more recent phenomenon of local coordinate systems. For this reason, we have given more attention to these systems in developing this handbook.

We hope that this handbook provides the necessary information for users of Wisconsin's coordinate systems.

Disclaimer

The Wisconsin State Cartographer's Office (SCO) claims no responsibility for the accuracy or correctness of the coordinate system parameters in this handbook. The Wisconsin County Coordinate System parameters have been copied by the SCO, without intentional alteration, directly from digital files provided by the Wisconsin Department of Transportation. The SCO is under no liability whatsoever resulting from the use of this data.

Anyone aware of discrepancies involving these coordinate system parameters is encouraged to submit such information to the SCO.

Importance of Coordinate Systems

Coordinate systems serve as the framework by which geographic data are referenced to the earth's surface. As such, coordinate systems are vital to mapping, surveying, and engineering. Coordinate systems are especially important in geographic and land information systems because they provide a common reference for all information.

This handbook describes coordinate systems used in the state of Wisconsin. The remainder of this section introduces the basics of map projections, along with a discussion of geographic and rectangular coordinate systems. The section on Regional Coordinate Systems describes and lists the parameters for the State Plane (SPC), Universal Transverse Mercator (UTM), and Wisconsin Transverse Mercator (WTM) coordinate systems. The last portion of this handbook discusses local coordinate systems and the Wisconsin County Coordinate System, and provides an alphabetical listing of Wisconsin County Coordinate System parameters.

Map Projections and Coordinate Systems

The most common and perhaps best known earth coordinate system, which is not rectangular, is the *geographic*. This system divides the earth into east-west parallel lines of latitude and north-south lines of longitude that converge toward the poles. The global coordinate system of latitude and longitude is spherical, and uses angular units of degrees, minutes, and seconds.

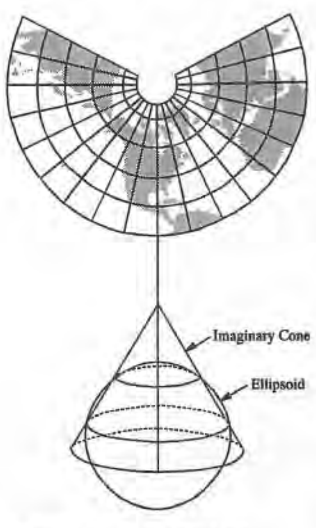

Figure 1: The Lambert conformal conic projection.

Unfortunately, measurements, computations, and the computer storage of geographic data are difficult to manage and manipulate using angular units. In contrast, rectangular coordinate systems allow easier storage and less intensive computations of position, area, and distance.

Rectangular coordinate systems are mathematically based on the principles of map projections. A *map projection* transforms points from the ellipsoid of a *datum* (a mathematically defined model of the size and shape of the earth) to a plane. The projection process transforms the spherical surface of the earth to a flat (map) surface onto which a rectangular coordinate grid can be overlaid.

The three-dimensional earth's surface cannot be transformed and portrayed on a flat map without introducing some distortion. Distortion caused by stretching or compressing the surface can affect shape, area, scale (distance), or direction, depending upon the projection used. Many map projections have been devised to minimize particular distortions, but no single projection gives an exact representation of the surface of the earth.

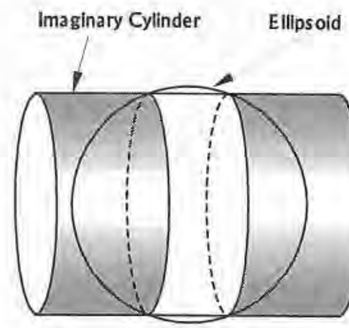

Figure 2: The transverse Mercator projection.

The two most common projections used as reference surfaces for rectangular coordinate systems are the Lambert conformal conic *(Figure 1)* and the transverse Mercator *(Figure 2)*. Both of these projections have varying scale but retain the correct shape of the mapped surface. Scale variation is greatest in north-south directions for Lambert projections and in east-west directions for transverse Mercator projections *(Figure 3)*.

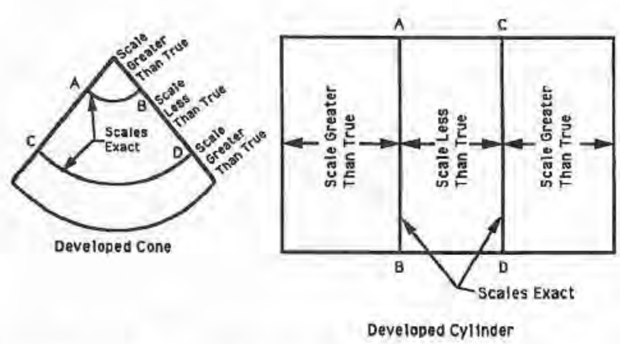

Figure 3: Plane (flat) mapping surfaces, developed from a Lambert cone (left) and a transverse Mercator cylinder (right). Lines AB and CD on both projection surfaces are standard lines. Note pattern of scale variation [after Wolf and Brinker (1989)].

It is important to note the difference between a map projection and a rectangular coordinate system. A map projection simply defines how the surface of the earth is transformed to a flat surface. A horizontal rectangular coordinate system is then superimposed on this projected surface and referenced to a horizontal datum.

A rectangular coordinate system is defined by four things: a map projection (referenced to a datum), an orientation, a point of origin, and a unit of measurement. Note that a map projection makes up *only part* of the definition of a rectangular coordinate system. For example, the State Plane Coordinate System (SPC) is a rectangular coordinate system that, by its definition, uses a specific set of transverse Mercator and Lambert conformal conic map projections. SPC is a coordinate system, not a projection.

Coordinate systems are designed to meet the needs of a particular application or user. Thus, Wisconsin has several coordinate systems in common use. This handbook is a compilation of those coordinate systems in one reference publication.

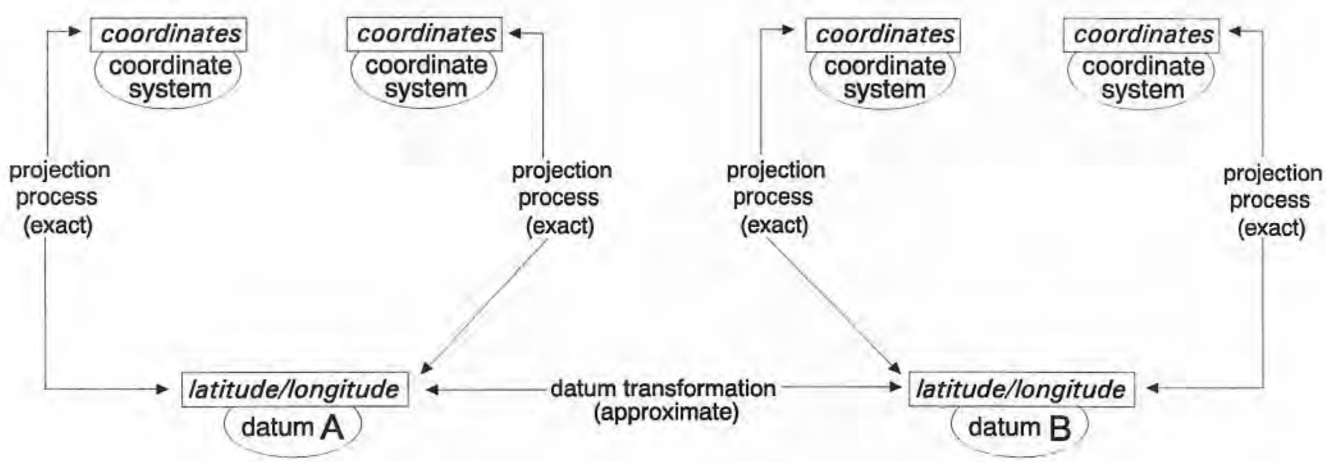

Figure 4: Data transformation between datums and coordinate systems.

Coordinate and Datum Transformation

The ability to connect projects and data through a common coordinate system is increasingly necessary with the automation, exchange, and merging of geographic information. However, converting data has become more complicated than in the past due to an increasing number of datums, adjustments, and coordinate systems.

A *coordinate conversion or transformation*[1] is the process of bringing a coordinate from one defined coordinate system (or zone) into another through a series of algorithms based on the latitude/longitude position of the point *(Figure 4)*. Coordinate systems based on the same datum retain a perfect mathematical relationship, allowing coordinate values to be precisely transformed between them.

A *datum transformation* is the process of bringing-coordinate values referenced to one defined datum into another datum system *(Figure 4)*. The recent geodetic datum adjustments in the United States are not perfectly related to the older datums because they 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 measurement observations that produced the latitude/longitude position.

Transformation Considerations

When transforming between datums or coordinate systems, it is worthwhile to consider the quality of a point's original value. A transformation cannot improve the quality or better the accuracy of the data. *It is up to the user to be aware of, and work within, the limitations of the original data.*

Selection of the most appropriate transformation method depends upon the data and its potential uses or applications. Considerations include:

- *The reference datum of the original coordinate values.*
- *The reference datum of the new coordinate values.*
- *The accuracy of the original coordinate values.*
- *The accuracy of the new coordinate values.*

Two other important considerations in data conversion are units of measurement and significant figures. The GRS 80 ellipsoid and several recent coordinate system definitions use the meter as their base unit. Yet most surveying and mapping information collected and produced at the local level is based upon 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, see p. 6) is involved.*

[1]In the strictest sense of the word, a transformation refers to an approximated method of data conversion. However, common usage today also embraces "exact" conversions.

With the appropriate unit conversion factor and other coordinate system parameters, the number of *significant figures* carried through the computation is also important. Using too few digits will result in an incorrect conversion of data.

Transformation Methods

Coordinate and datum transformations are performed by various methods. Some of these methods support highly accurate geodetic and surveying work, and others are approximate but adequate for mapping and other purposes.

The only ***exact*** method of datum transformation requires the original survey measurement information. This information is used to geodetically recompute positions in the new datum system. (Coordinate data can be exactly converted through a series of mathematical formulas, providing the coordinate systems are referenced to the same datum.) Another method of data transformation uses a least squares approach to ***"best fit"*** 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. These two methods require geodetic expertise to effectively use and analyze results.

A third transformation method uses a set of gridded data models to interpolate ***approximate*** corrections, which are then applied to produce the transformed coordinate values. Federally produced software programs such as NADCON, CORPSCON, and VERTCON are based on this commonly used method of addressing datum-to-datum transformations.

Software & Tools

NADCON and VERTCON are now standards within the federal government for datum transformations. The U.S. Army Corps of Engineers has developed a coordinate transformation program called CORPSCON which incorporates NADCON and VERTCON and handles a variety of coordinate systems.

WISCON, a product recently developed specifically for Wisconsin's data transformation needs, can be an effective replacement for the federal programs. WISCON is a comprehensive software program that incorporates the NADCON, CORPSCON, and VERTCON packages, as well as the algorithms necessary to perform Wisconsin County Coordinate System conversions. Use of WISCON is limited to Wisconsin and its four bordering states. Contact the SCO for more information on WISCON.

Many private software vendors in the GIS, CAD, and mapping arenas have incorporated the federal, or other, transformation packages into their products. *It is important to review the software documentation to ascertain which transformation packages, and which versions, are being used.*

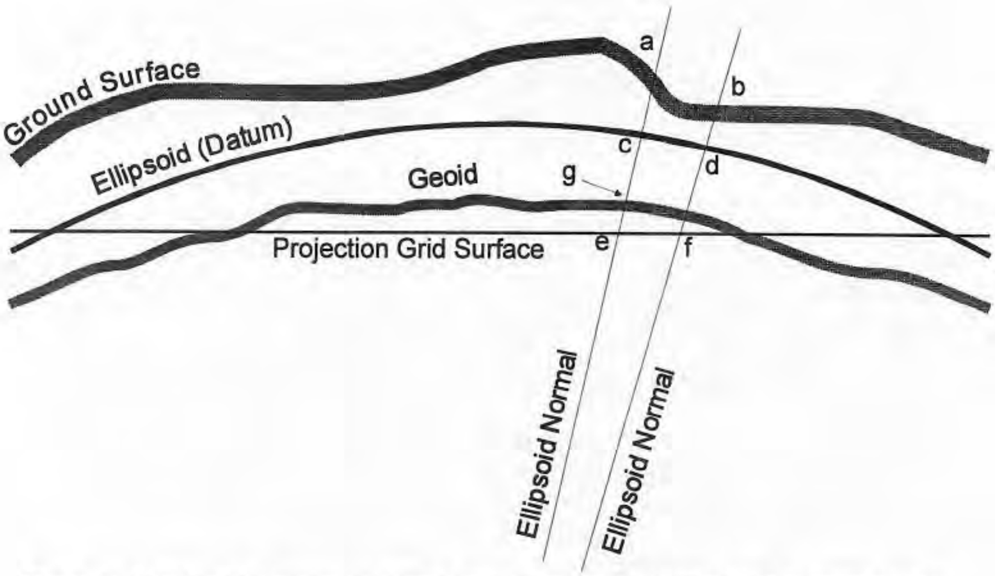

Figure 5: Relationships among earth and mapping surfaces. (Surfaces and separations are exaggerated for clarity.)

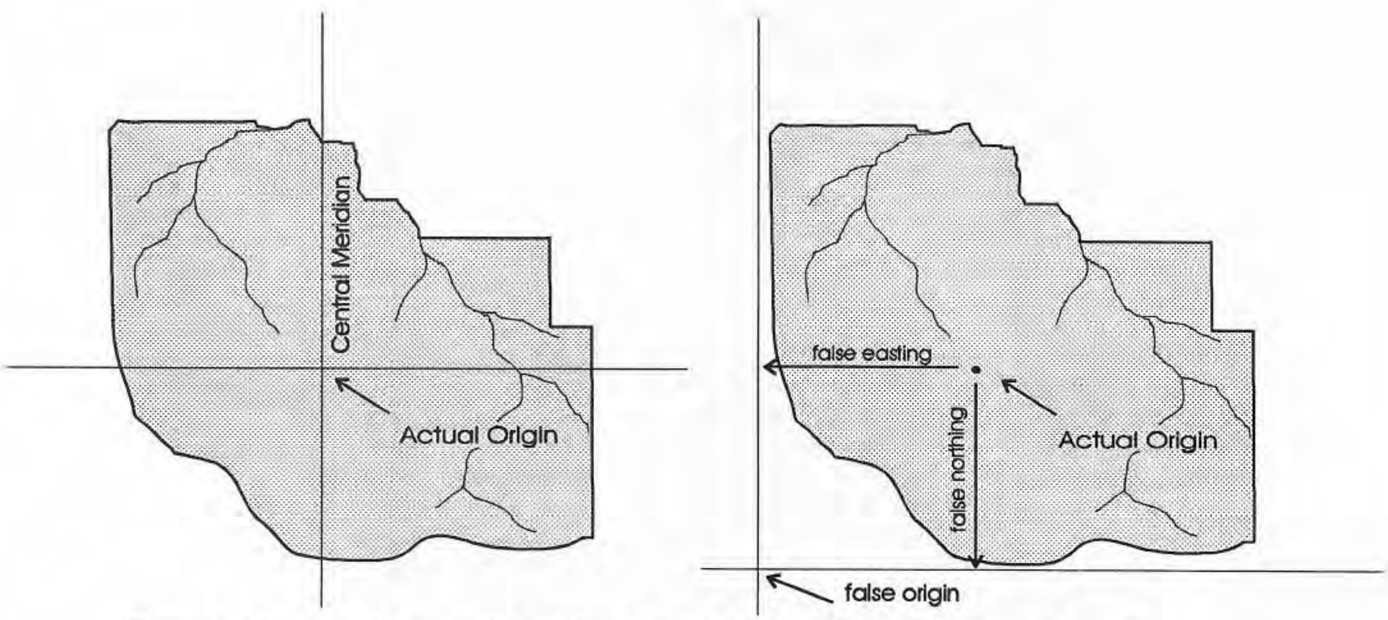

Figure 6: Adjustment of a rectangular coordinate system's origin, by false easting and false northing, to produce a false origin.

Summary of Terms

Ellipsoid

A mathematical surface (an ellipse rotated around the earth's polar axis) which 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. *(Figure 5).*

Datum

A mathematically defined reference surface used to represent the size and shape of the earth. A horizontal datum is defined by its ellipsoid, latitude and longitude orientation, and a physical origin. 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).

Geoid

An undulating surface represented by extending the earth's mean sea level through the land areas. The geoid is a theoretical surface perpendicular at every point to the direction of gravity *(Figure 5).*

Geoidal separation

The perpendicular distance between the geoid and the reference ellipsoid, at a point *(c to g on Figure 5).* A negative geoidal separation indicates that the geoid is *below* the ellipsoid. In Wisconsin, the geoid separation is roughly 30 meters and is a negative value.

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.

Coordinate systems—

geographic system:

The network of curved lines (latitude and longitude) representing the earth's spherical surface. These coordinates are measured in angular values of degrees, minutes, and seconds, and are based on the equator and an arbitrary location of a prime meridian as the origin location.

rectangular system:

A network of two sets of straight parallel lines intersecting at right angles and superimposed on a map projection. The origin (zero point) is located based upon the area covered on the earth. Coordinate values are usually expressed in feet or meters.

Standard line (Standard parallel)

A defined line in a map projection along which the scale of 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, in Lambert projections, the north latitude and the south latitude (sometimes called the first and second standard parallels, respectively) are lines of latitude where the scale factor is equal to 1.0 on the ellipsoid.

Central meridian

Central line of origin through the area of interest, used in many rectangular coordinate systems to orient the coordinate grid.

Actual origin, false origin

The *actual* point of origin (zero point) for the coordinate system, as distinguished from a *false* origin *(Figure 6).* The *actual* origin is the true geodetic origin of the system, but it may be assigned arbitrary coordinate values, to eliminate negative coordinates in the system. (This is done using false eastings and/or northings—see below). The *false* origin is an assumed point, typically to the west and south of the projection area, which has a coordinate value of 0,0.

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 the projection system *(Figure 6).*

Design elevation

The elevation of the map projection surface. Regional coordinate systems are usually designed at mean sea level, however the design elevation of a local coordinate system typically represents the median elevation in the area *(Figure 10, p. 14).*

Scale factor

A ratio, at a given point, of projection (grid) distance *(e to f on Figure 5)* to ellipsoid distance *(c to d on Figure 5).* Because the transformation of the ellipsoid to a flat surface creates distortions, the scale factor on a map varies from place to place. A value larger than one (e.g., 1.0001) means the scale at a given point is larger than actual (or "scale greater than true.") A smaller value (e.g., 0.9999) means the scale is less than true *(Figure 3, p. 1).*

continued on next page...

Ground to grid ratio

This statistic expresses the difference between distances calculated on the grid surface *(e to f on Figure 5)* and distances measured on the ground *(a to b on Figure 5)*. Small ratios (e.g., 1:500,000) indicate less difference, while larger ratios (e.g., 1:5,000) indicate more difference. Converting a ground distance to a grid distance requires the combination of two factors: the *scale factor* (see above) and the *elevation factor*, which relates ground distances to ellipsoid distances.

Units of Measure (Linear)

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) is involved.*

The international (S.I.) 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[1]. 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 System also uses the U.S. Survey Foot.

[1]For conversion of meters to U.S. Survey Foot, 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 signficant figures).

Regional Coordinate Systems

This section briefly discusses and lists the design parameters for three common rectangular coordinate systems that are most useful for mapping large areas or regions, such as multiple counties or an entire state.

Due to their long established use in mapping and surveying applications, these systems are commonly used as the means to store geographic data in a variety of computer-aided design (CAD) and geographic information system (GIS) software. The overall scale accuracy of these systems tends to be lower than those of local coordinate systems, and the ground-to-grid differences are large enough to be cumbersome in applications requiring high accuracy.

State Plane Coordinates

The State Plane Coordinate (SPC) system was introduced nationally in the 1930's 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). The scale of the Lambert projection varies from north to south *(Figure 3, p. 1)*; therefore, it is used mostly for areas that extend in an east-west direction. The transverse Mercator projection varies in scale in an east-west direction *(Figure 3, p. 1)*, making it most suitable for areas primarily extending north and south.

Wisconsin is covered by three Lambert projections—one for each of its State Plane Coordinate zones: South, Central, and North. Each zone has a false origin located at the southwest corner 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 that the maximum scale difference between the ellipsoid and projection distances would not exceed one part in 10,000.

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 (S.I.) in keeping with local use and legal precedent. The original SPC was based on a horizontal geodetic datum called the North American Datum of 1927 (NAD 27). This set of coordinate systems is now called SPC 27.

A more recent horizontal datum, the North American Datum of 1983 (NAD 83), was developed by the National Geodetic Survey in the 1980's. As a result, the SPC was redefined based upon the new NAD 83 datum. SPC 83 utilizes meters, rather than feet, as the unit of measure (in Wisconsin, Chapter 236 of State Statutes continues the U.S. Survey Foot definition for SPC 83.) In addition, SPC 83 was assigned a different false easting than SPC 27 so that coordinate values in the two systems could easily be distinguished.

It is important to understand that the SPC 27 and SPC 83 systems cannot be related simply by converting the units and adjusting the false easting value. This is because the datum conversion is not exact. (The NAD 83 datum represents both a redefinition and readjustment, as well as the removal of geodetic network errors built up over the years). For more information on this topic, refer to the SCO's publication, *Wisconsin Geodetic Control*.

Universal Transverse Mercator

The Universal Transverse Mercator (UTM) projection and coordinate system was developed by the Department of Defense for military purposes and is a *global* coordinate system. The UTM projection has 60 north-south zones arranged edge-to-edge around the equator. The zone width (6 degrees wide) was choosen to maintain a scale difference of no more than 1 part in 2,500. Zones in the UTM system are numbered from west to east starting at the 180th meridian. Wisconsin lies about equally in zones 15 and 16. The origin for each zone is at the intersection of the zone central meridian and the equator. A false coordinate easting value of 500,000 meters is assigned to the central meridian to avoid negative coordinate values.

With the introduction of NAD 83, the specific parameters of the UTM system were not redefined. However, the user should be aware that this datum difference causes a "shift" in coordinate values. The differences in Wisconsin amount to roughly 200 meters in northing, and 10 meters in easting, and are traceable to use of a different ellipsoid and datum definition plus the removal of geodetic network errors.

Wisconsin Transverse Mercator

The Wisconsin Department of Natural Resources developed the Wisconsin Transverse Mercator (WTM) projection and coordinate system to avoid splitting the state 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." The distortion in the projection increases from the center toward both the east and west edges of the state. A false easting of 500,000 and a false northing of -4,500,000 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 need and to avoid problems caused by the use of two zones.

Unlike UTM, WTM 27 *has been* 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 and a false northing of -4,480,000. Together with the 200 meter and 10 meter "shifts" discussed above (see UTM), the total difference in coordinate values between WTM 27 and WTM 83 is slightly more than 20,000 meters (in both northing and easting).

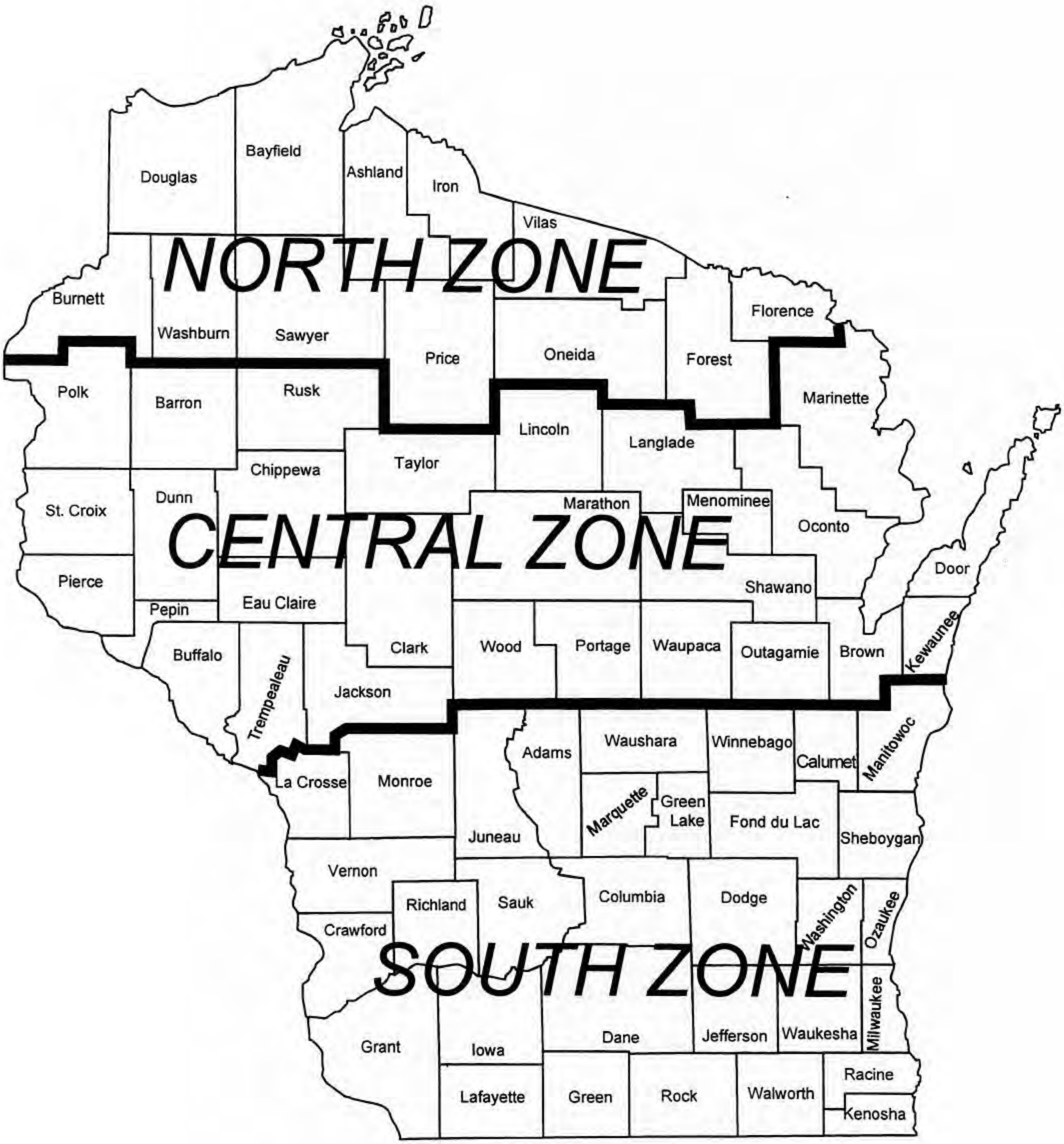

Figure 7: Wisconsin State Plane Coordinate (SPC) System.

State Plane Coordinate

North, Central, and South Zones

North Zone

	SPC 27	SPC 83
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

	SPC 27	SPC 83
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

	SPC 27	SPC 83
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

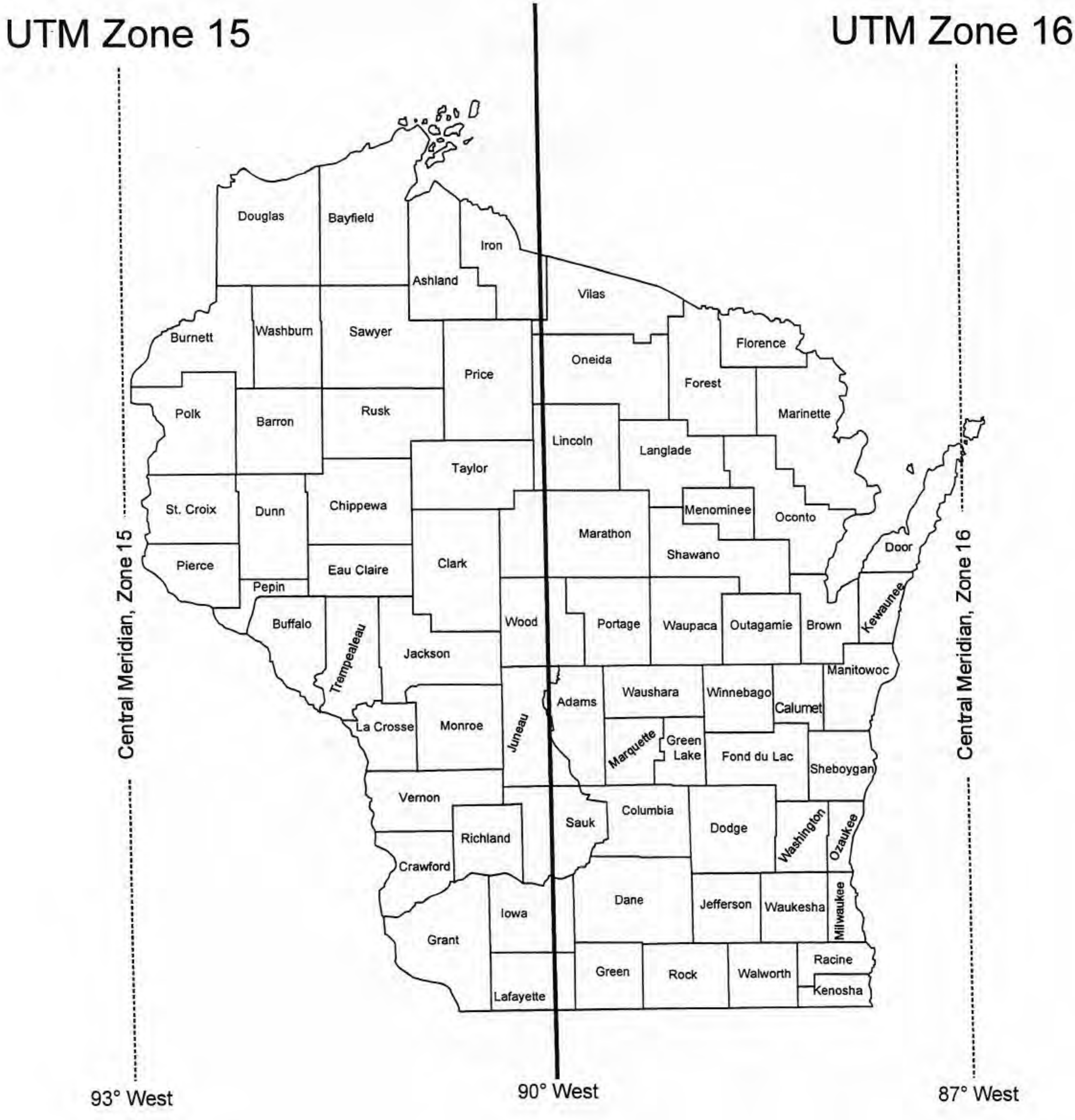

Figure 8: Universal Transverse Mercator (UTM) Coordinate System.

Universal Transverse Mercator

Zones 15 & 16

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.

Figure 9: Wisconsin Transverse Mercator (WTM) Coordinate System.

Wisconsin Transverse Mercator

	WTM 27	WTM 83
Projection:	Transverse Mercator	Transverse Mercator
Scale Factor at Central Meridian:	0.9996	0.9996
Longitude of Central Meridian:	90° W (-90°)	90° W (-90°)
Latitude of Origin:	0°	0°
False Easting:	500,000	520,000
False Northing:	-4,500,000	-4,480,000
Unit:	meter	meter

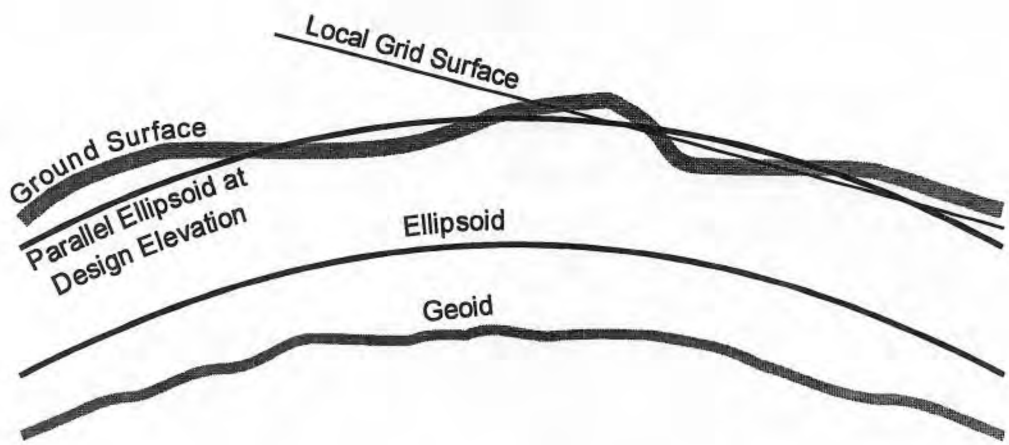

Figure 10: Relationships among earth and mapping surfaces in a local plane coordinate system. (Surfaces and separations are exaggerated for clarity.)

Local Coordinate Systems

As discussed in the previous section, regional coordinate systems, such as the State Plane (SPC), Universal Transverse Mercator (UTM), and Wisconsin Transverse Mercator (WTM) provide effective reference systems for large areas. This standardized referencing supports registration and integration between different data sets covering common areas.

However, other systems may be more appropriate where a closer correspondence between ground values and grid values is needed. One approach that meets this need is a mathematically derived *local* coordinate system.

Mathematically derived coordinate systems, including the regional systems discussed earlier, are based on the principles of map projections—i.e., the systematic plane (flat) representation of all or part of the surface of the earth. Local projections are developed over smaller areas than regional projections to minimize projection distortions. When a local coordinate system is properly designed, its coordinates can be converted to any other mathematically-based coordinate system. In this way, precise data sharing is preserved between local and regional systems.

One limitation of regional coordinate systems is that distances computed on the grid surface are not eqivalent to actual ground distances. To relate the two distances, scale and elevation factors must be applied. Proper use of these factors can be confusing and cumbersome in local surveying, mapping, and GIS/LIS projects.

A common method used to minimize the ground-to-grid differences has been to develop localized "project" elevation and scale factors, applying these universally to ground distances in the area. Another method has been to compute an average elevation and scale factor for a project area. However, since these practices are based on averages over an area, *they do not maintain a mathematically precise relationship* between the ground and the coordinate systems related to it.

A mathematically derived local projection and coordinate system is a plane coordinate system developed from a known ellipsoid and designed to minimize grid/ground differences in a local region. The origin for a local coordinate system is selected to optimize the projection and is generally near the geographic center. It is also common to assign a false easting and/or false northing to the origin to assure that coordinates have positive values throughout the local area *(Figure 6, p. 4)*. In addition to the origin, the local coordinate system must have a defined axis, a unit of measure, and a projection.

Axes are lines of either constant x or constant y values, and are typically the north and east lines running through the origin. The unit of measure is the increment of the coordinate system. Rectangular systems typically use the U.S. Survey Foot, the international foot, or the meter. The State Plane Coordinate System based on the NAD 27 datum was defined using the U.S. Survey Foot. For applications based upon deeds, land conveyances, or other cadastral information, the U.S. Survey Foot is the preferred unit of measure.

A projection is defined in terms of a horizontal datum, a vertical reference surface, and a map projection surface. The horizontal datum definition includes the ellipsoid and its parameters and constants describing measurement origins. Conversions between coordinate systems on the same datum are accomplished easily. However, datum-to-datum conversions, such as between NAD 27 SPC and NAD 83 SPC coordinates, must be approximated because of datum development and definition issues. *Local projection and coordinate systems cannot resolve datum-to-datum conversion issues (Figure 4, p. 2).*

Projections can be based on a vertical reference surface other than mean sea level. By basing the projection on an average or median elevation, coordinate system grid distances can more closely match ground distances. This aspect of a local coordinate system's design minimizes the grid-to-ground distance differences.

Three common projection surfaces used for local systems are the Lambert conformal conic, the transverse Mercator, and the tangent plane. The specific projection chosen for a local coordinate system is selected to minimize distortion and optimize the projection.

Local projection and coordinate systems are most often developed on a county basis. In 1993, the Wisconsin Department of Transportation developed a statewide set of local coordinate systems based upon counties, called the Wisconsin County Coordinate System. (Minnesota preceded Wisconsin in developing county coordinate systems, and has successfully used them for several years.) The Wisconsin County Coordinate System is described in the next section of this handbook.

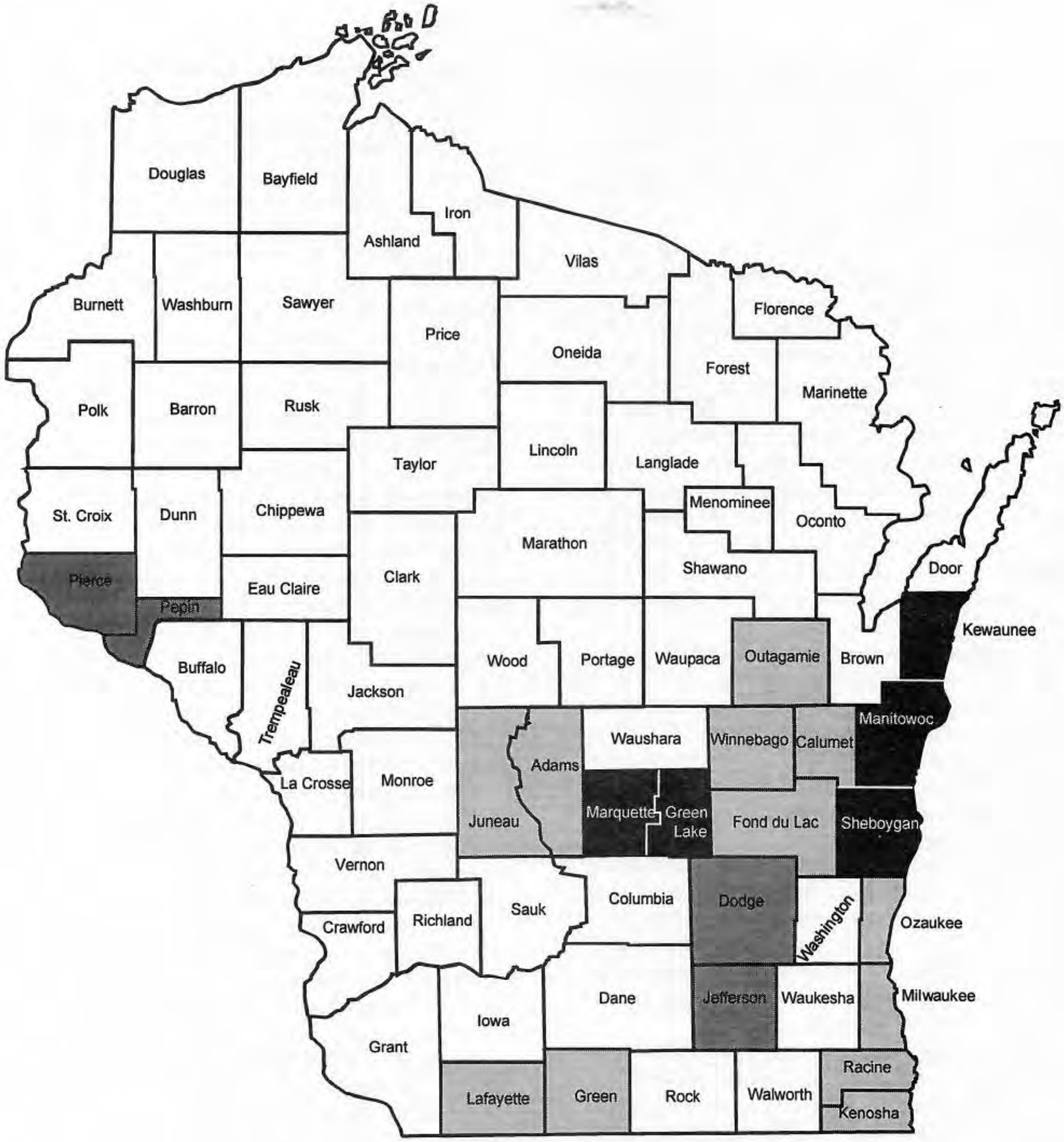

Figure 11: Wisconsin County Coordinate System (WCCS), developed by the Wisconsin Department of Transportation. Adjoining counties shown with a common tint share a single coordinate system. Untinted counties each have by a separate coordinate system.

Wisconsin County Coordinate System

Individual Wisconsin counties began to develop and use their own coordinate systems in the 1980's. The Wisconsin Department of Transportation (WiDOT) saw the need for a statewide set of standardized and mathematically based local coordinate systems for use in large scale mapping and roadway design. In 1993, WiDOT contracted with Fairview Industries for the development of a unified set of county coordinate systems *(Figure 11)*.

While the resulting county systems are still under review by WiDOT, and their use within WiDOT is not official agency policy, WiDOT has made them available for wider public use. Several local governments have begun to use these coordinate systems. Since the county coordinate systems are mathematically relatable to NAD 83 (1991), their use is allowed under Chapter 236 of Wisconsin Statutes (Chapter 236 covers subdivision platting and is the statute where the use of coordinate systems and datums is mentioned).

It is important to note that these county coordinate systems are not legislatively defined or mandated for adoption. Their use at the local level is voluntary. Unless officially adopted by local ordinance or regulation, there is no mechanism for making these coordinate systems "official" or of public record.

The full summary report, prepared by Fairview Industries for WiDOT, describing the design and methodology for developing the Wisconsin County Coordinate System is available by contacting the WiDOT Office of Technical Services. The following is a brief overview of their design.

Design Considerations

The Wisconsin County Coordinate System (WCCS) is designed so that each county has its own coordinate system, although two or more adjoining counties may share the same coordinate systems (i.e., they use identical design parameters).

The coordinate systems are mathematically based and related to the National Geodetic Reference System (NGRS). This maintains the benefits of the NGRS network while providing the opportunity for developing rectangular coordinate systems with minimal differences between ground and projected grid distances. The ground and grid difference is minimized by elevating a parallel local ellipsoid (the reference surface) to the median, or most commonly occuring, ground level in the county. *(Figure 10, p. 14)*.

The design considerations for the Wisconsin County Coordinate System include: reference to the NAD 83 (1991) datum adjustment, 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 urban areas and transportation corridors, as well as in rural areas.

Design Process

The purpose of the Wisconsin County Coordinate System is to provide a mathematically rigorous and more convenient method for relating ground measurements to geodetic control and other coordinate values.

As mentioned earlier, each county coordinate system was developed by introducing a local parallel ellipsoid that passes through the median elevation of the area. To develop each local ellipsoid, U.S. Geological Survey 1:100,000-scale topographic maps were analyzed to determine average highs, lows, and elevation profiles for each county. A minimum of fifteen points were selected from each county, including the county seat and populated areas.

Using the county maximum and minimum latitude and longitude values, a rectangular geographic area was determined. Geoidal separation values for NGRS (National Geodetic Reference System) First and Second Order geodetic control points in this geographic area were then averaged to determine each county's geoidal separation parameter value.

The county profile, the computed median elevation, and the county shape were then used to select the optimal projection type and the exact placement of the central meridians or standard parallels for each county.

After the individual county projections were determined, the points in the county profile were run through test programs to verify the design. This step identified any computation or coordinate value interpretation errors and verified the quality of the projection against the design constraints.

Opportunities for combining counties were then examined regionally. For example, in the Fox River Valley area, the heavily urbanized areas around Appleton that cross county boundaries were candidates for combined coordinate systems. Also, counties that were known to be working on joint land records projects were combined if possible.

Design Results

- All coordinate systems were developed for individual counties. In some cases more than one county is adequately served by a single coordinate system design. In no case does a county have more than one coordinate system. *Figure 11* illustrates the counties that share combined coordinate systems. (There are 59 separate coordinate systems to cover the 72 counties).

continued on next page...

- The maximum allowable scale error was set at one part in 50,000 for urban areas and one part in 30,000 for rural areas. All urban areas, including villages as small as 1,000 population, met the one part in 50,000 requirement, except the city of Ashland in Ashland County which is 1 part in 30,000. Three areas of the state fell below the rural 1 part in 30,000: the tops of both Rib Mountain and Mt. Whittlesey, and a low area in northwestern Iron County. The design constraint of keeping each county on one projection system made it necessary to exceed the design criteria in these areas.
- Compared to regional coordinate systems, these local coordinate systems improve ground-to-grid discrepancies by a factor of ten. This is more than a three-fold improvement over the average scale factor approach and is very comparable to the improvements that were obtained in the Minnesota county coordinate system.

Using the Wisconsin County Coordinate System

Using a local coordinate system requires additional considerations due to the elevated reference surface. Since the Wisconsin systems were designed using the parallel ellipsoid method, a new reference ellipsoid needs to be defined for each local system by adding the design elevation and geoid separation (a negative value in Wisconsin) to the semi-major and semi-minor axes of the GRS 80 ellipsoid used to define the NAD 83 datum. The local coordinate system can then be defined based upon this new reference ellipsoid.

For example, the Marathon County coordinate system's design elevation is 396.24 meters and the geoidal separation is -32.64 meters. Added to the GRS 80 ellipsoid parameters, this results in a semi-major axis a of 6,378,500.60 meters (6,378,137.0 + 396.24 - 32.64) and a semi-minor axis b of 6,357,115.9141403 meters (6,356,752.3141403 + 396.24 - 32.64).

When modifying the GRS 80 ellipsoid parameters to account for the design elevation of a Wisconsin County Coordinate System, using the proper unit conversion, an appropriate number of significant figures, and double precision numeric expression are all critical to the quality of the resulting data transformation. These and other important considerations for coordinate transformations are discussed in the Coordinate and Datum Transformation section *(page 3)* of this handbook.

Adams County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1280 high, 820 low]*
Geoidal Separation:	- 35.05 meters
Origin Longitude:	90° 00' 00"
Origin Latitude:	43° 22' 00"
False Easting:	147,218.6945 meters *(483,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999999

Approximate Ground to Grid Ratios

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

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

Approximate western most coordinate (X) = 400,000 feet

Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Adams and Juneau County have the same projection system. The Wisconsin River flows between the counties and the transverse Mercator projection fits the elevation pattern created by the River.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Ashland County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	365.76 meters *(1200 feet) [1840 high, 600 low]*
Geoidal Separation:	- 30.84 meters
Origin Longitude:	90° 37' 20"
Origin Latitude:	45° 42' 22"
False Easting:	172,821.9456 meters *(567,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Elevations above 1800 feet on Mt. Whittlesey fall below the 1:30,000 criteria. The southern 26 miles of Ashland County is a 1500 foot plateau while the communities on the shore average 600 feet in elevation. This difference in elevation can not be reconciled by any projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Barron County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	365.761 meters *(1200 feet) [1600 high, 1000 low]*
Geoidal Separation:	- 29.83 meters
Origin Longitude:	91° 51' 00"
Origin Latitude:	45° 08' 00"
False Easting:	93,150.0000 meters *(305,609.625 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

Approximate Ground to Grid Ratios

Rural (worst)	1:57,000	Blue Hills, 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

Approximate western most coordinate (X) = 226,000 feet
Approximate southern most coordinate (Y) = 27,000 feet

Design Comments:

In an effort to comply with existing data systems as much as possible, the already designed country coordinate system for Barron County was used. This system was designed by North Country Surveying in January, 1993. A complete design report is available from the Barron County Land Information Office.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Bayfield County

Wisconsin County Coordinate Sytem

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1680 high, 600 low]*
Geoidal Separation:	- 30.45 meters
Origin Longitude:	91° 09' 10"
Origin Latitude:	45° 20' 00"
False Easting:	228,600.4572 meters *(750,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	46° 55' 30"
South Latitude:	46° 24' 50"

Approximate Ground to Grid Ratios

Rural (worst)	1:31,000	North end of Sand Island
Urban	1:99,000	Washburn
	1:75,000	Bayfield, Iron River, Cornucopia
	1:114,000	Drummond, Port Wing
	1:500,000	Grandview
	1:238,000	Cable

Approximate western most coordinate (X) = 650,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The Lambert projection fits the southern two tiers of townships and lands north of those tiers that are below 1000 feet in elevation better than a transverse Mercator. The shoreline and all communities except Iron River also have less distortion with the Lambert than with a transverse Mercator.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Brown County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	35.80 meters *(117.454 feet) [1080 high, 580 low]*
Geoidal Separation:	- 35.80 meters
Origin Longitude:	88° 00' 00"
Origin Latitude:	43° 00' 00"
False Easting:	31,600.0000 meters *(103,674.3333 feet)*
False Northing:	4,600.00 meters *(15,091.8333 feet)*
Scale Factor:	1.000020

Approximate Ground to Grid Ratios

Rural (worst)	1:45,000 .... T12N, R20E, Sec 24, high point
Urban	1:97,000 .... Green Bay
	1:120,000 .... Pulaski
	1:66,000 .... Denmark

Approximate western most coordinate (X) = 38,000 feet
Approximate southern most coordinate (Y) = 467,000 feet

Design Comments:

The Brown County coordinate system was designed in the 1991. The parameters were selected to fit the lake shore, the Fox Valley, and the city of Green Bay.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Buffalo County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1360 high, 640 low]*
Geoidal Separation:	- 30.33 meters
Origin Longitude:	91° 47' 50"
Origin Latitude:	43° 28' 53"
False Easting:	175,260.3505 meters *(575,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	1.0000000

Approximate Ground to Grid Ratios

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

Urban .... 1:90,000 .... Alma
1:161,000 .... Mondovi
1:81,000 .... Buffalo

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

Most of the communities in Buffalo County are at lower elevations. There is a significant amount of rural land along ridges. The design elevation was selected to optimize the lower lands.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Burnett County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.80 meters *(1000 feet) [1440 high, 800 low]*
Geoidal Separation:	- 26.84 meters
Origin Longitude:	92° 27' 28"
Origin Latitude:	45° 21' 50"
False Easting:	64,008.12802 meters *(210,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	46° 05' 00"
South Latitude:	45° 42' 50"

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 100,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Lambert projection models the high and low elevation differences better than a transverse Mercator in Burnett County. Burnett County has little variation in elevation. Nearly all of the county lies between 900 and 1,100 feet in elevation. The lows lie along the St. Croix River and highs are located in the southeastern township.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Calumet County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	243.840 meters *(800 feet) [1120 high, 700 low]*
Geoidal Separation:	- 35.75 meters
Origin Longitude:	88° 30' 00"
Origin Latitude:	42° 43' 10"
False Easting:	244,754.8895 meters *(803,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 828,000 feet
Approximate southern most coordinate (Y) = 427,000 feet

Design Comments:

Winnebago, Calumet, Fond du Lac, and Outagamie Counties have the same projection system. This was done because of the many urban areas on the county boundaries, the common boundaries with Lake Winnebago, and the advantages of a common projection over the moderate gains if each projection was done separately.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Chippewa County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.80 meters *(1000 feet) [1530 high, 800 low]*
Geoidal Separation:	- 29.258 meters
Origin Longitude:	91° 17' 40"
Origin Latitude:	44° 34' 52"
False Easting:	60,045.72009 meters *(197,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 08' 30"
South Latitude:	44° 48' 50"

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

Approximate western most coordinate (X) = 101,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Lambert projection models the high and low elevation differences better than a transverse Mercator in Chippewa County. The "central parallel" is shifted southward to compensate for the general rise in elevation from south to north. This projection was completed in January 1993.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Clark County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	365.761 meters *(1200 feet) [1480 high, 880 low]*
Geoidal Separation:	- 32.36 meters
Origin Longitude:	90° 42' 30"
Origin Latitude:	43° 36' 00"
False Easting:	199,949.1998 meters *(656,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999994

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

Clark County is longer in the north-south than the east-west direction. The central meridian was moved west of center to better fit the higher ground on the eastern side of the County.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Columbia County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1480 high, 770 low]*
Geoidal Separation:	- 34.99 meters
Origin Longitude:	89° 23' 40"
Origin Latitude:	42° 27' 30"
False Easting:	169,164.3383 meters *(555,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 35' 30"
South Latitude:	43° 20' 00"

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

Approximate western most coordinate (X) = 451,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The high and low elevations of the county are within 4 miles of each other. Except for these extreme elevations the county has relatively modest changes in elevations. Lambert parameters were selected to optimize urban areas.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Crawford County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1300 high, 610 low]*
Geoidal Separation:	- 32.29 meters
Origin Longitude:	90° 56' 20"
Origin Latitude:	42° 43' 00"
False Easting:	113,690.6274 meters *(373,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 20' 30"
South Latitude:	43° 03' 30"

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Lambert projection reduces high and low elevation distortions slightly better than a transverse Mercator in Crawford County. It also fits the major urban area of Prairie du Chien with less distortion than the Mercator.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Dane County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1480 high, 760 low]*
Geoidal Separation:	- 34.18 meters
Origin Longitude:	89° 25' 20"
Origin Latitude:	41° 45' 00"
False Easting:	247,193.2944 meters *(811,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 13' 50"
South Latitude:	42° 54' 30"

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,Marshall
	1:180,000	Stoughton
	1:86,000	West Side Catholic Seminary Hill

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 400,000 feet

Design Comments:

The transverse Mercator projection fits the extreme elevation differences better than the Lambert, however the Lambert projection fit the overall terrain and the urban areas with less distortion than the Mercator.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Dodge County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1200 high, 780 low]*
Geoidal Separation:	- 34.51 meters
Origin Longitude:	88° 46' 30"
Origin Latitude:	41° 28' 20"
False Easting:	263,347.7267 meters *(864,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

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

Approximate western most coordinate (X) = 800,000 feet

Approximate southern most coordinate (Y) = 630,000 feet

Design Comments:

Dodge and Jefferson County have the same projection system. In Dodge County the urban areas are close to the Mercator north-south line. In Jefferson County the Rock River runs approximately north to south with most of the urban areas lying near the river. Dodge and Jefferson counties were combined because their separately developed transverse Mercator projections were within six miles of each other.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Door County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	213.360 meters *(700 feet) [860 high, 580 low]*
Geoidal Separation:	- 36.44 meters
Origin Longitude:	87° 16' 20"
Origin Latitude:	44° 24' 00"
False Easting:	158,801.1176 meters *(521,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999991

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Door County transverse Mercator projection fits the lake shore well at 1:250,000 and minimizes the inland distortion. A skewed projection was tried, but this did not significantly improve the rural or urban distortions.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Douglas County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.80 meters *(1000 feet) [1340 high, 600 low]*
Geoidal Separation:	- 26.87 meters
Origin Longitude:	91° 55' 00"
Origin Latitude:	45° 53' 00"
False Easting:	59,131.31826 meters *(194,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999994968

Approximate Ground to Grid Ratios

Rural (worst)	1:41,000	Northeast corner of County 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

Approximate western most coordinate (X) = 98,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Douglas County has a high elevation ridge through the center of the county and falls off in elevation to the north and south. The primary urban area is in the low elevation area to the north on Lake Superior. This projection was completed in June 1992.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Dunn County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1280 high, 720 low]*
Geoidal Separation:	- 28.78 meters
Origin Longitude:	91° 53' 40"
Origin Latitude:	44° 24' 30"
False Easting:	51,816.104 meters *(170,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.99999773

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 102,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Dunn County coordinate system was designed in 1991. The transverse Mercator projection centered on the county fits the terrain best.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Eau Claire County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1320 high, 740 low]*
Geoidal Separation:	- 30.94 meters
Origin Longitude:	91° 17' 20"
Origin Latitude:	44° 02' 50"
False Easting:	120,091.4402 meters *(394,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 00' 50"
South Latitude:	44° 43' 50"

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

The Lambert projection models the variations in high and low elevations for Eau Claire County better than a transverse Mercator. The city of Eau Claire was also optimized, while maintaining the design criteria for the rural areas, particularly the southern half of the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Florence County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	426.721 meters *(1400 feet) [1720 high, 1020 low]*
Geoidal Separation:	- 32.87 meters
Origin Longitude:	88° 08' 30"
Origin Latitude:	45° 26' 20"
False Easting:	133,502.6670 meters *(438,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.9999935

Approximate Ground to Grid Ratios

Rural (worst)	1:81,000	low point on Menominee River
Urban	1:500,000	Florence
	1:150,000	Long Lake

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

There is a general rise in elevation from the east to the west. The central meridian was placed 4 miles west of the eastern boundary of the county to accommodate this rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Fond du Lac County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	243.840 meters *(800 feet) [1240 high, 750 low]*
Geoidal Separation:	- 35.75 meters
Origin Longitude:	88° 30' 00"
Origin Latitude:	42° 43' 10"
False Easting:	244,754.8895 meters *(803,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

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

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

Winnebago, Calumet, Fond du Lac, and Outagamie counties have the same projection system. This was done because of the many urban areas on the county boundaries, the common boundaries with Lake Winnebago, and the advantages of a common projection over the moderate gains in the projections if each was done separately.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Forest County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	487.681 meters *(1600 feet) [1920 high, 1260 low]*
Geoidal Separation:	- 33.16 meters
Origin Longitude:	88° 38' 00"
Origin Latitude:	44° 00' 20"
False Easting:	275,844.5516 meters *(905,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

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

Approximate western most coordinate (X) = 800,000 feet
Approximate southern most coordinate (Y) = 500,000 feet

Design Comments:

The central meridian was moved east five miles to compensate for a general rise in the elevation from east to west in the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Grant County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1260 high, 600 low]*
Geoidal Separation:	- 32.44 meters
Origin Longitude:	90° 48' 00"
Origin Latitude:	41° 24' 40"
False Easting:	242,316.4847 meters *(795,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

Approximate Ground to Grid Ratios

Rural (worst)	1:46,000	low points on far western boundary
Urban	1:74,000	Lancaster, Blue River, Cassville
	1:51,000	Fennimore, Muscoda
	1:142,000	Platteville, Montfort
	1:300,000	Cuba City, Bloomington
	1:103,000	Boscobel

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 400,000 feet

Design Comments:

The high land in Grant County runs along Military Ridge, falling off in elevation to the Wisconsin and Mississippi Rivers. Fennimore and Muscoda are communities at the near extreme elevations of the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Green County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1160 high, 760 low]*
Geoidal Separation:	- 33.32 meters
Origin Longitude:	89° 50' 20"
Origin Latitude:	42° 13' 30"
False Easting:	170,078.7402 meters *(558,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	42° 47' 20"
South Latitude:	42° 29' 10"

Appproximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 558,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Green and Lafayette County have the same projection system. Both the Lambert and transverse Mercator projections balanced the elevation differences in the counties well. The Lambert provided a better fit for the urban areas. The low points in Green County are in the southeastern and southwestern corners.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Green Lake County

Wisconsin County Coordinate System

Projection: Lambert Conformal Conic
Design Elevation: 274.321 meters *(900 feet) [1080 high, 760 low]*
Geoidal Separation: - 35.72 meters
Origin Longitude: 89° 14' 30"
Origin Latitude: 43° 05' 40"
False Easting: 150,876.3018 meters *(495,000 feet)*
False Northing: 0.00 meters *(0.00 feet)*
North Latitude: 43° 56' 50"
South Latitude: 43° 40' 00"

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

Approximate western most coordinate (X) = 494,000 feet
Approximate southern most coordinate (Y) = 196,000 feet

Design Comments:

Green Lake and Marquette Counties have the same coordinate system. The combined coordinate system introduces slightly more distortion at high elevations in both counties. The one system provides minimal distortion in community areas in both counties.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Iowa County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1680 high, 640 low]*
Geoidal Separation:	- 33.76 meters
Origin Longitude:	90° 09' 40"
Origin Latitude:	42° 32' 20"
False Easting:	113,081.0262 meters *(371,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The highest elevations in Iowa County run generally on an east west line through the county. The lowest point is on the northern boundary along the Wisconsin River. A Lambert conformal conic projection would exaggerate these extremes.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Iron County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	487.681 meters *(1600 feet) [1840 high, 600 low]*
Geoidal Separation:	- 30.39 meters
Origin Longitude:	90° 15' 20"
Origin Latitude:	45° 26' 00"
False Easting:	220,980.4420 meters *(725,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

Approximate Ground to Grid Ratios

Rural (worst).........1:20,000 ....Along Shoreline of Lake Superior

Urban..................1:500,000.............Hurley, Mercer
1:83,000 ....Montreal
1:380,000.............Upson

Approximate western most coordinate (X) = 650,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

The areas in the northeast corner of Iron County, below 1000 feet in elevation, fall below the 1:30,000 criteria. This area is approximately 30 square miles. Most of the county is nearer 1600 feet elevation and is fit within the criteria.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Jackson County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1360 high, 700 low]*
Geoidal Separation:	- 32.65 meters
Origin Longitude:	90° 44' 20"
Origin Latitude:	43° 47' 40"
False Easting:	125,882.6518 meters *(413,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 25' 10"
South Latitude:	44° 09' 50"

Approximate Ground to Grid Ratios

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

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Lambert projection models the elevation extremes in Jackson County a little better than a transverse Mercator. The eastern "handle" of the county is modeled well with the Lambert.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Jefferson County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1040 high, 780 low]*
Geoidal Separation:	- 34.51 meters
Origin Longitude:	88° 46' 30"
Origin Latitude:	41° 28' 20"
False Easting:	263,347.7267 meters *(864,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

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

Approximate western most coordinate (X) = 800,000 feet

Approximate southern most coordinate (Y) = 500,000 feet

Design Comments:

Jefferson and Dodge County have the same projection system. In Dodge County the urban areas are close to the Mercator north-south line. In Jefferson County the Rock River runs approximately north to south with most of the urban areas lying near the river. Dodge and Jefferson counties were combined because their separately developed transverse Mercator projections were within six miles of each other.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Juneau County

Wisconsin County Coordinate Systerm

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1360 high, 820 low]*
Geoidal Separation:	- 35.05 meters
Origin Longitude:	90° 00' 00"
Origin Latitude:	43° 22' 00"
False Easting:	147,218.6945 meters *(483,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999999

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

Approximate western most coordinate (X) = 478,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Adams and Juneau County have the same projection system. The Wisconsin River flows between the counties and the transverse Mercator projection fits the elevation pattern created by the River.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Kenosha County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	213.360 meters *(700 feet) [950 high, 580 low]*
Geoidal Separation:	- 34.66 meters
Origin Longitude:	87° 53' 40"
Origin Latitude:	42° 13' 00"
False Easting:	185,928.3719 meters *(610,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Kenosha, Racine, Milwaukee, and Ozaukee Counties share a coordinate system. These counties share a general rise in elevation from Lake Michigan westward. The central meridian of their common projection was moved to the east to accomodate the elevation rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Kewaunee County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	182.880 meters *(600 feet) [1000 high, 580 low]*
Geoidal Separation:	- 34.02 meters
Origin Longitude:	87° 33' 00"
Origin Latitude:	43° 16' 00"
False Easting:	79,857.760 meters *(262,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	1.0000000

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

Approximate western most coordinate (X) = 205,000 feet
Approximate southern most coordinate (Y) = 386,000 feet

Design Comments:

Kewaunee, Manitowoc, and Sheboygan counties have the same projection system. The Sheboygan County projection was completed in December 1992 and was designed to fit the lake shore area and the general rise in elevation from east to west within Sheboygan County. This trend is true for Manitowoc and Kewaunee counties as well.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

LaCrosse County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1360 high, 640 low]*
Geoidal Separation:	- 32.02 meters
Origin Longitude:	91° 19' 00"
Origin Latitude:	43° 27' 04"
False Easting:	130,454.6609 meters *(428,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999994

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

There is a general rise in the County from the Mississippi River eastward. The Mercator parameters were selected to optimize the city of LaCrosse and lower elevation urban areas.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Lafayette County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1400 high, 680 low]*
Geoidal Separation:	- 33.32 meters
Origin Longitude:	89° 50' 20"
Origin Latitude:	42° 13' 30"
False Easting:	170,078.7402 meters *(558,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	42° 47' 20"
South Latitude:	42° 29' 10"

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Lafayette and Green County have the same projection system. Both the Lambert and the transverse Mercator balanced the elevation differences in the counties well, but a Lambert provided a better fit to the urban areas.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Langlade County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	457.201 meters *(1500 feet) [1840 high, 1040 low]*
Geoidal Separation:	- 34.08 meters
Origin Longitude:	89° 02' 00"
Origin Latitude:	44° 12'25"
False Easting:	198,425.1968 meters *(651,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 18' 30"
South Latitude:	45° 00' 00"

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

Approximate western most coordinate (X) = 550,000 feet

Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

There is a general rise in elevation from south to north in Langlade County. The county is approximately eight miles longer on the east-west direction. The Lambert projection was selected to minimize distortion in the major urban area of Antigo.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Lincoln County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	426.721 meters *(1400 feet) [1920 high, 1220 low]*
Geoidal Separation:	- 31.90 meters
Origin Longitude:	89° 44' 00"
Origin Latitude:	44° 50' 40"
False Easting:	116,129.0323 meters *(381,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The Wisconsin River flows from north to south through the center of the county. There is also a general rise in elevation east and west from the river. The transverse Mercator projection was selected over a Lambert conformal conic because the worst rural ratios were better using the Mercator.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Manitowoc County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	182.880 meters *(600 feet) [1040 high, 580 low]*
Geoidal Separation:	- 34.02 meters
Origin Longitude:	87° 33' 00"
Origin Latitude:	43° 16' 00"
False Easting:	79,857.7600 meters *(262,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	1.0000000

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

Approximate western most coordinate (X) = 132,000 feet
Approximate southern most coordinate (Y) = 228,000 feet

Design Comments:

Manitowoc, Kewaunee, and Sheboygan counties have the same projection system. The Sheboygan County projection was completed in December 1992 and was designed to fit the lake shore area and the general rise in elevation from east to west within Sheboygan County. This trend is true for Kewaunee and Manitowoc counties as well.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Marathon County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	396.24 meters *(1300 feet) [1920 high, 1115 low]*
Geoidal Separation:	- 32.64 meters
Origin Longitude:	89° 46' 12"
Origin Latitude:	44° 24' 20"
False Easting:	74,676.14935 meters *(245,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 03' 23"
South Latitude:	44° 44' 43"

Approximate Ground to Grid Ratios

Rural (worst)........ 1:30,000.............. Rib Mountain Summit (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

Approximate western most coordinate (X) = 102,000 feet
Approximate southern most coordinate (Y) = 101,000 feet

Design Comments:

The Lambert projection models the high and low elevation differences better than a transverse Mercator in Marathon County. There is some exception to average fit in the County around Rib Mountain. This projection was completed in January 1992.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Marinette County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1660 high, 580 low]*
Geoidal Separation:	- 35.28 meters
Origin Longitude:	87° 42' 40"
Origin Latitude:	44° 41' 30"
False Easting:	238,658.8774 meters *(783,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999986

Approximate Ground to Grid Ratios

Rural (worst) .... 1:53,000.............. T37N, R20E, Sec 5, high point

Urban .... 1:380,000 .... Marinette

.... 1:500,000 .... Pestigo, Wausaukee
.... 1:250,000 .... Crivitz, Coleman
.... 1:140,000 .... Goodman, Amberg
.... 1:54,000.............. Niagra

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

An overall fit of the county that was no worse than 1:70,000 could have been achieved, but the fit south of an east-west line through Wausaukee would have been worse than the selected projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Marquette County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1280 high, 780 low]*
Geoidal Separation:	- 35.72 meters
Origin Longitude:	89° 14' 30"
Origin Latitude:	43° 05' 40"
False Easting:	150,876.3018 meters *(495,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 56' 50"
South Latitude:	43° 40' 00"

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

Marquette and Green Lake Counties have the same coordinate system. The combined coordinate system introduces slightly more distortion at high elevations in both counties. The one system provides minimal distortion in community areas in both counties.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Menominee County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1420 high, 820 low]*
Geoidal Separation:	- 35.20 meters
Origin Longitude:	88° 25' 00"
Origin Latitude:	44° 43' 00"
False Easting:	105,461.0109 meters *(346,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999994

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

Approximate western most coordinate (X) = 200,000 feet

Approximate southern most coordinate (Y) = 50,000 feet

Design Comments:

There is a general rise in elevation from the east to the west. The central meridian is located about 3.5 miles east of the eastern boundary of the county to accommodate the general elevation rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Milwaukee County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	213.360 meters *(700 feet) [860 high, 580 low]*
Geoidal Separation:	- 34.66 meters
Origin Longitude:	87° 53' 40"
Origin Latitude:	42° 13' 00"
False Easting:	185,928.3719 meters *(610,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 563,000 feet
Approximate southern most coordinate (Y) = 228,000 feet

Design Comments:

Kenosha, Racine, Milwaukee, and Ozaukee Counties share a coordinate system. The counties all share a general rise in elevation from Lake Michigan westward. The central meridian was moved to the east to accomodate the elevation rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Monroe County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	335.281 meters *(1100 feet) [1440 high, 720 low]*
Geoidal Separation:	- 33.29 meters
Origin Longitude:	90° 38' 30"
Origin Latitude:	42° 54' 10"
False Easting:	204,521.2091 meters *(671,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 09' 40"
South Latitude:	43° 50' 20"

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

Approximate western most coordinate (X) = 584,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The highest areas in Monroe County run north-south through the County and fall off to the east and west of the ridge line. The Lambert projection was selected and shifted to the north.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Oconto County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	243.840 meters *(800 feet) [1760 high, 580 low]*
Geoidal Separation:	- 35.42 meters
Origin Longitude:	87° 54' 30"
Origin Latitude:	44° 23' 50"
False Easting:	182,880.3658 meters *(600,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999991

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The high and low elevations are evenly modeled with the Mercator projection and the cities and communities are fit well.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Oneida County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	487.7 meters *(1600 feet) [1800 high, 1460 low]*
Geoidal Separation:	- 30.84
Origin Longitude:	89° 32' 40"
Origin Latitude:	45° 11' 10"
False Easting:	70,104.14021 meters *(230,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 50' 30"
South Latitude:	45° 34' 00"

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 102,000 feet
Approximate southern most coordinate (Y) = 101,000 feet

Design Comments:

The Oneida County coordinate system was designed in March 1991. The county has a small range of elevations and the county is longer in the east west than the north south directions.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Outagamie County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	243.840 meters *(800 feet) [1000 high, 600 low]*
Geoidal Separation:	- 35.75 meters
Origin Longitude:	88° 30' 00"
Origin Latitude:	42°43' 10"
False Easting:	244,754.8895 meters *(803,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

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

Approximate western most coordinate (X) = 740,000 feet
Approximate southern most coordinate (Y) = 555,000 feet

Design Comments:

Winnebago, Calumet, Fond du Lac, and Outagamie counties have the same projection system. This was done because of the many urban areas on the county boundaries, the common boundaries with Lake Winnebago, and the advantages of a common projection over the moderate gains in the projections if each was done separately.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Ozaukee County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	213.360 meters *(700 feet) [960 high, 580 low]*
Geoidal Separation:	- 34.66 meters
Origin Longitude:	87° 53' 40"
Origin Latitude:	42° 13' 00"
False Easting:	185,928.3719 meters *(610,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 565,000 feet
Approximate southern most coordinate (Y) = 355,000 feet

Design Comments:

Kenosha, Racine, Milwaukee, and Ozaukee Counties share a coordinate system. The counties all share a general rise in elevation from Lake Michigan westward. The central meridian was moved to the east to accomodate the elevation rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Pepin County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1280 high, 660 low]*
Geoidal Separation:	- 30.05 meters
Origin Longitude:	92° 13' 40"
Origin Latitude:	43° 51' 43"
False Easting:	167,640.3353 meters *(550,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 45' 00"
South Latitude:	44° 31' 20"

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

Approximate western most coordinate (X) = 532,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

Pepin County has the same coordinate system as Pierce County. These counties were able to be combined with very little degradation of either county's system.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Pierce County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1280 high, 680 low]*
Geoidal Separation:	- 30.05 meters
Origin Longitude:	92° 13' 40"
Origin Latitude:	43° 51' 43"
False Easting:	167,640.3353 meters *(550,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 45' 00"
South Latitude:	44° 31' 20"

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

Approximate western most coordinate (X) = 400,000 feet

Approximate southern most coordinate (Y) = 247,000 feet

Design Comments:

Pierce County has the same coordinate system as Pepin County. These counties were able to be combined with very little degradation of either county's system.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Polk County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1400 high, 680 low]*
Geoidal Separation:	- 28.13 meters
Origin Longitude:	92° 38' 00"
Origin Latitude:	44° 39' 40"
False Easting:	141,732.2834 meters *(465,000 feet)*
False Northing:	0.00 meters (0.00 feet)
Scale Factor:	1.00000000

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

Polk County rises in elevation from west to east. The Mercator central meridian was shifted to the west to provide the best fit for the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Portage County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	341.37668 meters *(1120 feet) [1300 high, 940 low]*
Geoidal Separation:	- 34.0 meters
Origin Longitude:	89° 30' 00"
Origin Latitude:	43° 58' 00"
False Easting:	56,388.1128 meters *(185,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 39' 00"
South Latitude:	44° 11' 00"

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

Approximate western most coordinate (X) = 95,000 feet
Approximate southern most coordinate (Y) = 101,000 feet

Design Comments:

This coordinate system was designed in 1992 and was designed to optimize the city of Stevens Point.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Price County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	457.201 meters *(1500 feet) [1951 high, 1220 low]*
Geoidal Separation:	- 30.31 meters
Origin Longitude:	90° 29' 20"
Origin Latitude:	44° 33' 20"
False Easting:	227,990.8560 meters *(748,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

Approximate Ground to Grid Ratios

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

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

Approximate western most coordinate (X) = 700,000 feet

Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The lowest points in the County are along the west boundary and the highest are along the eastern boundary. The county is longer in the north to south direction which influenced the selection of the Mercator projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Racine County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	213.360 meters *(700 feet) [920 high, 580 low]*
Geoidal Separation:	- 34.66 meters
Origin Longitude:	87° 53' 40"
Origin Latitude:	42° 13' 00"
False Easting:	185,928.3719 meters *(610,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 144,000 feet

Design Comments:

Kenosha, Racine, Milwaukee, and Ozaukee Counties share a coordinate system. The counties all share a general rise in elevation from Lake Michigan westward. The central meridian was moved to the east to accomodate the elevation rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Richland County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1300 high, 660 low]*
Geoidal Separation:	- 33.71 meters
Origin Longitude:	90° 25' 50"
Origin Latitude:	42° 06' 50"
False Easting:	202,387.6048 meters *(664,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 30' 10"
South Latitude:	43° 08' 30"

Approximate Ground to Grid Ratios

Rural (worst)	1:67,000	Southwest Corner on River
Urban	1:178,000	Richland Center
	1:84,000	Lone Rock
	1:100,000	Viola

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 383,000 feet

Design Comments:

The general rise in elevation from the Wisconsin River northward overcomes the slight elongation in the north-south direction. The Lambert projection shifted slightly south was selected to match the elevation rise. The major urban area, Richland Center, falls very close to the center of the projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Rock County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1080 high, 740 low]*
Geoidal Separation:	- 33.65 meters
Origin Longitude:	89° 04' 20"
Origin Latitude:	41° 56' 40"
False Easting:	146,304.2926 meters *(480,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

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

Approximate western most coordinate (X) = 400,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

The Rock River runs approximately north to south with most of the urban areas on the river. The Sugar River in the southwest creates another low area.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Rusk County

Wisconsin County Coordinate system

Projection:	Transverse Mercator
Design Elevation:	365.761 meters *(1200 feet) [1720 high, 1060 low]*
Geoidal Separation:	- 30.01 meters
Origin Longitude:	91° 04' 00"
Origin Latitude:	43° 55' 10"
False Easting:	250,546.1011 meters *(822,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

Approximate Ground to Grid Ratios

Rural (worst)	1:48,000	Southwest corner of the county
Urban	1:500,000	Ladysmith, Hawkins, Sheldon
	1:200,000	Bruce
	1:160,000	Weyerhauser

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 500,000 feet

Design Comments:

A transverse Mercator projection minimizes the distortions in the city of Ladysmith, the transportation routes, and rural areas. The extreme high and low elevations occur in the western ten miles of the county. The design balances them and fits the remainder of the county well.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

St. Croix County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1280 high, 680 low]*
Geoidal Separation:	- 29.29 meters
Origin Longitude:	92° 38' 00"
Origin Latitude:	44° 02' 10"
False Easting:	165,506.731 meters *(543,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999995

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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The elevations in St. Croix County generally rise eastward from the St. Croix river. The central meridian was shifted to the west of center for a best fit.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook).

Sauk County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1600 high, 700 low]*
Geoidal Separation:	- 34.52 meters
Origin Longitude:	89° 54' 00"
Origin Latitude:	42° 49' 10"
False Easting:	185,623.5713 meters *(609,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999995

Approximate Ground to Grid Ratios

Rural (worst)	1:34,000	Sauk Point, elev 1600 ft.
Urban	1:500,000	Baraboo
	1:500,000	Reedsburg, Wis Dells, Lake Delton
	1:100,000	Prairie du Sac, Sauk City
	1:200,000	Plain
	1:93,000	Spring Green

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 120,000 feet

Design Comments:

The communities fit the Mercator projection better than a Lambert conformal conic projection because the cities are at lower elevations and lie closer to the center of the Mercator projection. The cities are on the central meridian. The median elevation was about 960 feet.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Sawyer County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	426.721 meters *(1400 feet) [1800 high, 1150 low]*
Geoidal Separation:	- 29.27 meters
Origin Longitude:	91°07' 00"
Origin Latitude:	44° 48' 50"
False Easting:	216,713.2334 meters *(711,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	46° 04' 50"
South Latitude:	45° 43' 10"

Approximate Ground to Grid Ratios

Rural (worst)	1:57,000	South edge of county at Chippewa River
Urban	1:150,000	Hayward
	1:470,000	Winter
	1:180,000	Radisson
	1:78,000	Exeland

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

Sawyer County is six miles longer in the east-west direction and a Lambert projection fits the county slightly better than a transverse Mercator projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Shawano County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1440 high, 780 low]*
Geoidal Separation:	- 35.75 meters
Origin Longitude:	88° 36' 20"
Origin Latitude:	44° 02' 10"
False Easting:	262,433.3249 meters *(861,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999990

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 200,000 feet

Design Comments:

Both a Lambert conformal conic and the transverse Mercator fit the overall terrain in the county. The Mercator was used because the city of Shawano and the extreme highs and lows were a better fit with this projection.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Sheboygan County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	182.880 meters *(600 feet) [1280 high, 580 low]*
Geoidal Separation:	- 34.02 meters
Origin Longitude:	87° 33' 00"
Origin Latitude:	43° 16' 00"
False Easting:	79,857.760 meters *(262,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	1.0000000

Approximate Ground to Grid Ratios

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

Approximate western most coordinate (X) = 100,000 feet
Approximate southern most coordinate (Y) = 101,000 feet

Design Comments:

Sheboygan, Manitowoc, and Kewaunee counties have the same projection system. The Sheboygan County projection was completed in December 1992 and was designed to fit the lake shore area and the general rise in elevation from east to west within Sheboygan County. This trend is true for Manitowoc and Kewaunee Counties as well.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Taylor County

Wisconsin County Coordinate system

Projection:	Lambert Conformal Conic
Design Elevation:	426.721 meters *(1400 feet) [1760 high, 1100 low]*
Geoidal Separation:	- 30.80 meters
Origin Longitude:	90° 29' 00"
Origin Latitude:	44° 12' 30"
False Easting:	187,147.5743 meters *(614,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	45° 18' 00"
South Latitude:	45° 03' 20"

Approximate Ground to Grid Ratios

Rural (worst)	1:62,000	T 33N, R 1 E, 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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

Taylor County has general rise in elevation from west to east and from south to north. The Lambert projection was shifted south to accommodate the general south to north rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Trempealeau County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1360 high, 660 low]*
Geoidal Separation:	- 31.23 meters
Origin Longitude:	91° 22' 00"
Origin Latitude:	43° 09' 40"
False Easting:	256,946.9138 meters *(843,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999998

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

Approximate western most coordinate (X) = 778,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The design elevation for Trempealeau County was picked below the median elevation because most communities and transportation corridors are at lower elevations.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Vernon County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1360 high, 640 low]*
Geoidal Separation:	- 32.86 meters
Origin Longitude:	90° 47' 00"
Origin Latitude:	43° 08'50"
False Easting:	222,504.4450 meters *(730,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	43° 41' 00"
South Latitude:	43° 28' 00"

Approximate Ground to Grid Ratios

Rural (worst).........1:52,000 ....Northwest corner of County

Urban..................1:120,000.............La Farge
1:66,000 ....Viroqua, Stoddard
1:55,000 ....Westby
1:70,000 ....Coon Valley, Ontario, Readstown
1:500,000.............Hillsboro

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The high and low elevations are scattered throughout the county. Because the county is longer in the east-west direction than the north-south direction, the Lambert was selected.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Vilas County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	518.161 meters *(1700 feet) [1880 high, 1540 low]*
Geoidal Separation:	- 30.99 meters
Origin Longitude:	89° 29' 20"
Origin Latitude:	45° 37' 30"
False Easting:	134,417.0688 meters *(441,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	46° 13' 30"
South Latitude:	45° 55' 50"

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

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 84,000 feet

Design Comments:

Vilas County has a modest range of elevations with no general rise or fall across the county in any direction. The Lambert projection was optimized on the elevations of the communities.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of Summary of Terms section of this handbook.)

Walworth County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	274.321 meters *(900 feet) [1140 high, 780 low]*
Geoidal Separation:	- 33.91 meters
Origin Longitude:	88° 32' 30"
Origin Latitude:	41° 40' 10"
False Easting:	232,562.8651 meters *(763,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	42° 45' 00"
South Latitude:	42° 35' 20"

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

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

The lowest point in Walworth County is near the center of the east boundary. The highest elevations extend from the center of the county southward. The Lambert minimizes these extremes. A transverse Mercator exaggerated these same extremes.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Washburn County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	365.761 meters *(1200 feet) [1520 high, 940 low]*
Geoidal Separation:	- 28.17 meters
Origin Longitude:	91° 47' 00"
Origin Latitude:	44° 16' 00"
False Easting:	234,086.8681 meters *(768,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	46° 09' 00"
South Latitude:	45° 46' 20"

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

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 500,000 feet

Design Comments:

The Namekagon River runs east to west through the north central area of the county. Elevations generally rise north and south from the river making the Lambert projection the best choice for the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Washington County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	304.801 meters *(1000 feet) [1320 high, 760 low]*
Geoidal Separation:	- 34.66 meters
Origin Longitude:	88° 03' 50"
Origin Latitude:	42° 55' 05"
False Easting:	120,091.4402 meters *(394,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999995

Approximate Ground to Grid Ratios

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

Urban..................1:137,000.............Westbend
1:500,000.............Hartford

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Washington County has a general elevation rise from the east to the west. The central meridian passes through the southeast corner of the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Waukesha County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1200 high, 720 low]*
Geoidal Separation:	- 34.45 meters
Origin Longitude:	88° 13' 30"
Origin Latitude:	42° 34' 10"
False Easting:	208,788.4176 meters *(685,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999997

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

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

Waukesha County has a general rise in elevation from east to west. The highest point in the county is west of center. The central meridian was shifted east of center to compensate for the general elevation rise. The projection optimizes urban areas and transportation corridors rather than optimizing all elevations.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Waupaca County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	274.321 meters *(900 feet) [1200 high, 750 low]*
Geoidal Separation:	- 36.07 meters
Origin Longitude:	88° 49' 00"
Origin Latitude:	43° 25'13"
False Easting:	185,013.9701 meters *(607,000 f*eet)
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

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

Approximate western most coordinate (X) = 500,000 feet
Approximate southern most coordinate (Y) = 300,000 feet

Design Comments:

There is a general rise in elevation from east to west across Waupaca County. The central meridian was moved to the east to accommodate this rise.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Waushara County

Wisconsin County Coordinate system

Projection:	Lambert Conformal Conic
Design Elevation:	304.801 meters *(1000 feet) [1280 high, 750 low]*
Geoidal Separation:	- 35.83 meters
Origin Longitude:	89° 14' 30"
Origin Latitude:	43° 42' 30"
False Easting:	120,091.4402 meters *(394,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 15' 10"
South Latitude:	43° 58' 30"

Approximate Ground to Grid Ratios

Rural (worst)	1:64,000	T20N, R10E, Sec 20 - high point
Urban	1:270,000	Wautoma
	1:135,000	Redgranite
	1:140,000	Plainfield
	1:250,000	Coloma

Approximate western most coordinate (X) = 300,000 feet
Approximate southern most coordinate (Y) = 100,000 feet

Design Comments:

The elevations of the county rise from east to west and then falls off at the west boundary. The Lambert projection is centered on the county.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Winnebago County

Wisconsin County Coordinate System

Projection:	Transverse Mercator
Design Elevation:	243.840 meters *(800 feet) [980 high, 740 low]*
Geoidal Separation:	- 35.75 meters
Origin Longitude:	88° 30' 00"
Origin Latitude:	42° 43' 10"
False Easting:	244,754.8895 meters *(803,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
Scale Factor:	0.999996

Approximate Ground to Grid Ratios

Rural (worst)	1:98,000	West boundary on shore of Poygan Lake
Urban	1:300,000	Oshkosh, Neenah, Menasha
	1:500,000	Winneconne

Approximate western most coordinate (X) = 700,000 feet
Approximate southern most coordinate (Y) = 427,000 feet

Design Comments:

Winnebago, Calumet, Fond du Lac, and Outagamie counties have the same projection system. This was done because of the many urban areas on the county boundaries, the common boundaries with Lake Winnebago, and the advantages of a common projection over the moderate gains in the projections if each was done separately.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

Wood County

Wisconsin County Coordinate System

Projection:	Lambert Conformal Conic
Design Elevation:	335.281 meters *(1100 feet) [1440 high, 930 low]*
Geoidal Separation:	- 34.63 meters
Origin Longitude:	90° 00' 00"
Origin Latitude:	43° 09' 05"
False Easting:	208,483.6170 meters *(684,000 feet)*
False Northing:	0.00 meters *(0.00 feet)*
North Latitude:	44° 32' 40"
South Latitude:	44° 10' 50"

Approximate Ground to Grid Ratios

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

Urban ....1:500,000.............Wisconsin Rapids
1:160,000.............Marshfield

Approximate western most coordinate (X) = 600,000 feet
Approximate southern most coordinate (Y) = 400,000 feet

Design Comments:

There is a general rise from south to north in Wood County. The Lambert projection was centered on Wisconsin Rapids.

(Note: All feet units for the Wisconsin County Coordinate System are U.S. Survey Foot. Please see further discussion of this issue on page 6 of the Summary of Terms section of this handbook.)

References and Suggested Readings

ASCE/ACSM/ASPRS, 1994. *Glossary of the Mapping Sciences*, Bethesda, MD, 581 pp.

Contains definitions for nearly 10,000 terms covering the broad professional areas of surveying, mapping, and remote sensing.

Burkholder, E. F., 1993. Design of a Local Coordinate System for Surveying, Engineering, and LIS/GIS. *Surveying and Land Information Systems*, Vol. 53, No. 1, pp 29-40.

Introduces local coordinate systems, how they can be derived, and their advantages over regional coordinate systems.

Johnson, G. W., 1985. A Minnesota County Coordinate System. Paper presented at the 33rd Annual Meeting of the Minnesota Land Surveyors Association, February 8, 16 pp.

Covers the development of a County Coordinate System in Minnesota. Explains the drawbacks of State Plane Coordinates, and the limitations of project coordinate systems.

Mitchell, H.C., 1945. *The State Plane Coordinate Systems (A Manual for Surveyors)*, US Coast and Geodetic Survey Special Publication 235, National Geodetic Survey, Silver Spring, MD, 62 pp.

Defining manual for the State Plane Coordinate System of 1927, including an overview of the development of the system. Discusses in detail control surveys and computations, and includes defining parameters, formulas, tables, and a summary of legislation for the coordinate system.

Robinson, et al, 1995. *Elements of Cartography (6th ed.)*, New York: John Wiley & Sons, 664 pp.

Introductory text in cartography; Chapter Four introduces concepts of geodesy, coordinate systems, and map scale. Chapter Five provides an overview of map projections.

Snyder, J., 1987. *Map Projections - A Working Manual*, US Geological Survey Professional Paper 1395, US Government Printing Office, Washington, DC, 20402, 377 pp.

Compilation and discussion of map projection systems used by the USGS, including the appearance, usage, history, and equations for each projection. Contains a detailed discussion of map projection concepts such as latitude and longitude, datums, and scale.

Stem, J., 1989. *State Plane Coordinate System of 1983*, NOAA Manual NOS NGS 5, National Geodetic Survey, Silver Spring, MD, January, 119 pp.

Defining manual for the State Plane Coordinate System of 1983, including the parameters and equations necessary to perform computations. Provides background information on map projections, the state plane coordinate system, and related legislation.

U.S. Geological Survey, 1989. Map Projections Poster, Reston, VA.

Describes properties, characteristics, and uses of many historic and current map projections.

Vonderohe, A. P., et al., 1991. *Introduction to Local Land Information Systems for Wisconsin's Future*, Wisconsin State Cartographer's Office, Madison, WI, 59 pp.

Chapter Two covers a variety of topics related to spatial reference frameworks, such as the Public Land Survey System, the National Geodetic Reference System, GPS, and the Wisconsin High Precision Geodetic Network.

von Meyer, N., 1990. County Coordinate Systems, *ACSM Bulletin*, June, pp. 51-52.

Provides an overview of coordinate systems and their development, with a specific focus on county coordinate systems, and their advantages for certain applications.

von Meyer, N., 1993, Wisconsin County Coordinate Systems, report to the Wisconsin Department of Transportation, Technical Services, August 31, 89 pp.

Describes the development of a ground based statewide coordinate system for Wisconsin, including a summary of the projection design process and the coordinate system parameters.

Wisconsin State Cartographer's Office, 1992. *Wisconsin Geodetic Control*. Madison, WI: Wisconsin State Cartographer's Office, 16 pp.

Provides a broad discussion of geodetic control, why it is important, what it is used for, and its current condition within the state. Recent developments, including readjusted federal datums and the global positioning system, are highlighted.

Wolf, P. R., and R. C. Brinker, 1994. *Elementary Surveying (9th ed.)*, New York: HarperCollins College Publishers, 760 pp.

General guide to surveying; includes topics on control surveys, satellite surveying systems, and the State Plane and Universal Transverse Mercator coordinate systems.