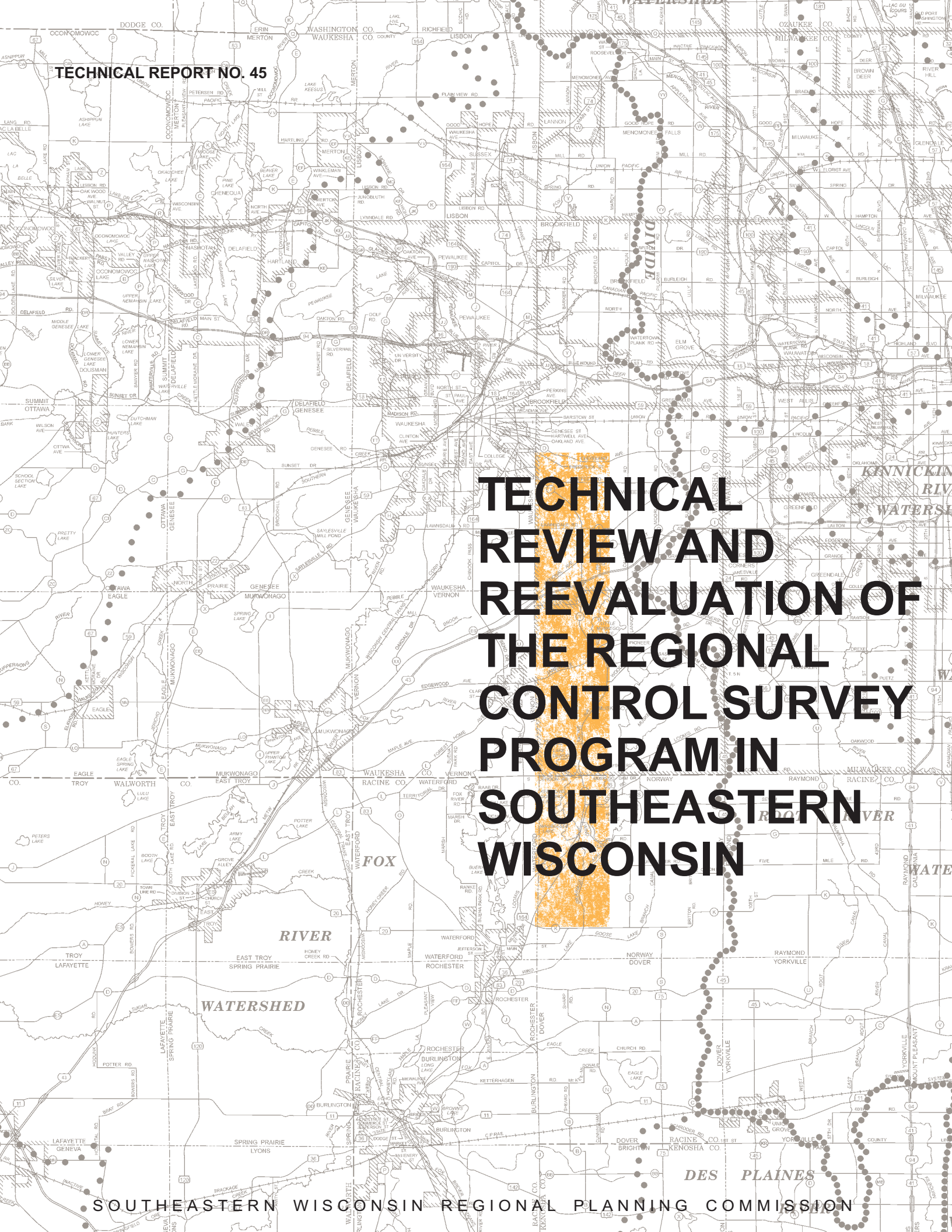
TECHNICAL REPORT NO. 45

TECHNICAL REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM IN SOUTHEASTERN WISCONSIN



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TECHNICAL REVIEW AND REEVALUATION OF REGIONAL CONTROL SURVEY PROGRAM IN SOUTHEASTERN WISCONSIN

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for the

Southeastern Wisconsin Regional Planning Commission

March 2008

Inside Region: $10.00
Outside Region: $20.00

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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STATEMENT OF THE EXECUTIVE DIRECTOR

Since early 1964, the Regional Planning Commission has recommended to the governmental agencies operating within the Southeastern Wisconsin Region the use of a unique system of survey control as a basis for the compilation of large-scale topographic and cadastral maps; as a basis for the conduct of land and engineering surveys; and, since 1985, as a basis for the development of automated, parcel-based, land information and public works management systems within the Region. The recommended survey control system involves the remonumentation of the U.S. Public Land survey corners within the Region and the establishment of State Plane Coordinates for those corners in order to provide a reliable horizontal survey control network. The system also includes the establishment of elevations for the remonumented corners and for related auxiliary benchmarks to provide a reliable vertical survey control network fully integrated with the horizontal survey control network.

Through the cooperative efforts of the Commission and its constituent counties and municipalities, the recommended horizontal and vertical survey control system has been extended over the entire seven-county Region. All of the 11,753 U.S. Public Land Survey corners within the Region have been monumented, and the locations, coordinate positions, and elevations of the corners have been determined to a high level of accuracy. The resulting survey control network has been widely used in the preparation of large-scale topographic and cadastral maps, in the conduct of land and engineering surveys, and in the creation of parcel-based land information and public works management systems within the Region.

All of the horizontal control survey work within the Region has been referenced to the North American Datum of 1927 (NAD 27), a datum based upon the Clarke Spheroid of 1866, a spheroid which fits the North American Continent and the Southeastern Wisconsin Region well. All of the vertical survey control work within the Region has been referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29), a datum formerly known as the Sea Level Datum of 1929.

The Federal government in 1973 determined to undertake a readjustment of the national horizontal control survey network, and to adopt a new horizontal datum known as the North American Datum of 1983 (NAD 83), utilizing a new reference spheroid known as Geographic Reference System of 1980. In 1977 the Federal government further determined to undertake a readjustment of the national vertical control survey network and to adopt a new vertical datum, known as the North American Vertical Datum of 1988 (NAVD 88). The use of these new datums within the Region does not provide any significant advantages over the continued use of the old datums. Since no benefits can be shown to accrue from the use of the new datums, and since a change in datums would incur very high costs, the Commission has determined to continue to utilize the older datums as a basis for its surveying and mapping activities within Southeastern Wisconsin.

In order to facilitate the use of the new datums within the Region by such agencies as may determine to do so, the Commission in July 1993 and October 1994 entered into agreements with Earl F. Burkholder, Consulting Geodetic Engineer, for the development of operational computation systems that would permit the ready and reliable bidirectional transformation of coordinates between the two horizontal and two vertical datums concerned. The computation systems were documented in SEWRPC Technical Report No. 34, *A Mathematical Relationship Between NAD27 and NAD83(91) State Plane Coordinates in Southeastern Wisconsin,* December 1994, and SEWRPC Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin,* December 1995. Time has proven the computational systems documented in these reports to be sound and useful for their intended purposes.

Further changes in surveying and mapping technology in the fifteen years since 1993 caused the Commission to institute a further review and evaluation of the regional control survey and mapping program and the Commission's role in that program. These changes have included, among others, the adjustment of the once "new" datums to create NAD 83 (2007) and NGVD 88 (2007); the increasingly widespread use of Global Positioning System (GPS) technology for both horizontal and vertical positioning; and the proposed provision of Continuously Operating Reference Station (CORS) facilities within the Region by the Wisconsin Department of Transportation to facilitate the use of GPS technology. These changes, and particularly the ability of GPS technology to accurately locate coordinate positions, have led some practitioners to question the continued need for monumentation of the control survey network. Therefore, following its long-standing practice, the Commission created a Technical Advisory Committee of knowledgeable users of the regional control survey system and asked that Committee to: 1) critically review and evaluate the status and continued utility of the Commission survey network; 2) recommend any needed changes in the network and the means for its perpetuation, maintenance, and use; and 3) recommend the Commission's role, if any, in such perpetuation, maintenance, and use.

The findings and recommendations of the Technical Advisory Committee are set forth in this report. These findings and recommendations may be summarized as:

1. The Commission should continue to utilize NAD 27 and NGVD 29 as the basis for its horizontal and vertical survey control network within the Region;
2. The Commission, in cooperation with its constituent counties, should continue to maintain the network of monuments that perpetuate the U.S. Public Land Survey System within the Region;
3. The Commission and its constituent counties should continue to maintain the network of benchmarks within the Region that make available to users accurate elevations referenced to NGVD 29; and
4. The Commission should undertake the development of a new methodology for the bidirectional transformation of State Plane Coordinates between NAD 27 and NAD 83 (2007) and elevations between NGVD 29 and NAVD 88 (2007).

Respectfully submitted,

Philip C. Evenson

Philip C. Evenson,
Executive Director

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April 3, 2008

Mr. Phillip C. Evenson, Executive Director
Southeastern Wisconsin Regional Planning Commission
P.O. Box 1607
Waukesha, Wisconsin 53187

Dear Mr. Evenson,

Transmitted herewith is a report entitled, "Review and Reevaluation of Regional Control Survey Program" as developed through a series of meetings with the Technical Advisory Committee established by the Commission to provide guidance in the review and reevaluation. The Committee consisted of competent users who testified to the utility of the existing horizontal and vertical control survey networks and applauded the foresight of the Commission in establishing, maintaining, and using those networks over the past 40 years. That investment continues to support many applications of surveying and mapping data in various disciplines.

With development of computerized databases, proliferation of satellite positioning capability, and an ever-increasing number of spatial data users, the Commission has come under pressure to reevaluate the Regional Control Survey Program with regard to continued maintenance and use of the existing monumented networks, choice of datums, and operational procedures. The challenge is to reconcile applications of new technology with existing maps and records.

I met with the Technical Advisory Committee on three occasions to listen, offer comments, and engage in discussion. Individual contributions and interactions within the Committee were excellent and my intent has been to capture the collective wisdom of the Committee in the report.

First and foremost, the report recommends continued maintenance and use of the existing horizontal and vertical survey control networks. With regards to datums, the report goes on to recommend policies and procedures intended to capture and preserve the value of the existing survey control networks. Finally, the report contains a recommendation to develop bidirectional transformations whereby existing database values and spatial data obtained using modern positioning technologies may be made to be compatible.

Thank you for the opportunity to be of service to the Commission.

Yours truly,

Earl F. Burkholder

Earl F. Burkholder, PS, PE
Consulting Geodetic Engineer

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List of Acronyms and Abbreviations

1.	CBN	Cooperative Base Network.
2.	CORPSCON	Program written by U.S. Corps of Engineers for coordinate and datum transformations.
3.	CORS	Continuously Operating Reference Stations - permanent GPS receiver installations.
4.	DOD	U.S. Department of Defense.
5.	ECEF	Earth-centered Earth-fixed - rectangular geocentric coordinates used by DOD for GPS.
6.	FBN	Federal Base Network.
7.	FGCS	Federal Geodetic Control Subcommittee represents various federal agencies.
8.	FGDC	Federal Geographic Data Committee - interagency organization responsible for the NSDI.
9.	Galileo	Satellite positioning system being built by the European community.
10.	GEOIDxx	Geoid height interpolation programs published by NGS in 19XX and 20XX.
11.	GLONASS	Russian satellite navigation system similar to the U.S. GPS system.
12.	GNSS	Global Navigation Satellite System - includes GPS, Glonass, and Galileo systems.
13.	GPS	Global Positioning System - satellite system built by U.S. DOD and used worldwide.
14.	GRS 80	Geodetic Reference System of 1980 - ellipsoid used for the NAD 83 datum and with the ITRF.
15.	HARN	High Accuracy Reference Network as established by NGS. The former name was the High Precision Geodetic Network (HPGN) and may still be used in some documents.
16.	HTDP	Horizontal Time Dependent Program used by NGS to move data epoch to epoch.
17.	IGLD 55	International Great Lakes Datum developed by U.S. and Canada and published in 1955.
18.	IGLD 85	International Great Lakes Datum developed by U.S. and Canada and published in 1985.
19.	ITRF	International Terrestrial Reference Frame - international scientific global datum.
20.	NAD 27	North American Datum of 1927 - horizontal datum established by NGS.
21.	NAD 83	North American Datum of 1983 - Horizontal datum established by NGS.
22.	NAD 83 (1986)	Original NAD 83 values as computed and published in 1986.
23.	NAD 83 (1991)	NAD 83 values published by NGS in 1991 for points in Wisconsin.
24.	NAD 83 (1997)	NAD 83 values published by NGS in 1997 for points in Wisconsin.
25.	NAD 83 (2007)	NAD 83 values resulting from a national readjustment and published by NGS in 2007.
26.	NAD 83 (xxxx)	NAD 83 values as published in a yet unknown future year.
27.	NADCON	NGS program written to perform datum conversions between NAD 27 and NAD 83.
28.	NAVD 88	North American Vertical Datum of 1988 - published and maintained by NGS.
29.	NAVD 88 (1991)	Original adjustment of the new national vertical datum for Wisconsin.
30.	NAVD 88 (2007)	2007 adjustment of the WI-HMP data on NAVD 88.
31.	NGS	National Geodetic Survey - responsible for national survey control network.
32.	NGVD 29	National Geodetic Vertical Datum of 1929 - vertical datum published by NGS.
33.	NOAA	National Oceanic and Atmospheric Administration - parent agency to NGS.
34.	NSDI	National Spatial Data Infrastructure - the underlying framework of spatial data policies.
35.	NSRS	National Spatial Reference System - combined horizontal/vertical survey control network.
36.	P.O.B.	Point of Beginning.
37.	Region	Seven-county area served by the SEWRPC.
38.	RTK	Real-Time Kinematic, a mode of using GPS to establish survey positions in real time.
39.	RTN	Real-Time Network of GPS CORS stations providing support for real-time positioning.
40.	SEWRPC	Southeastern Wisconsin Regional Planning Commission.
41.	USC&GS	U.S. Coast & Geodetic Survey - predecessor to NGS.
42.	USGS	U.S. Geological Survey - responsible for national mapping program in the U.S.
43.	USPLSS	U.S. Public Land Survey System.
44.	VERTCON	NGS program written to perform datum conversions between NGVD 29 and NAVD 88.
45.	WAAS	Wide Area Augmentation System corrections provided by Federal Aviation Administration.
46.	WGS 84	World Geodetic System of 1984 - DOD datum and ellipsoid used for GPS.
47.	WI-HMP	Wisconsin Height Modernization program.
48.	WisDOT	Wisconsin Department of Transportation.

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TECHNICAL REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM IN SOUTHEASTERN WISCONSIN

INTRODUCTION

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) has, for over 40 years, promulgated establishment of horizontal and vertical survey control networks within the seven-county Region. Those networks serve as a framework for the conduct of land and engineering surveys; for the preparation of large-scale topographic and cadastral maps; and as a foundation for the creation of parcel-based land and public works information systems within the Region. Dividends on that investment have been significant in terms of orderly infrastructure development, efficient land administration policies, and avoided costs. However, technological developments need to be assessed in terms of compatibility with established policies and operational procedures. Those developments include issues such as the creation of computerized databases, transition from analog to digital mapping, creation of multiple control survey datums, digital data storage, spatial information management, global positioning system (GPS) measurements, and other tools for generating, analyzing, and using spatial data.

Given that SEWRPC established networks of horizontal and vertical survey control are in place and provide a reliable foundation for many spatial data activities throughout the seven-county Region, it is important for the Commission, cognizant public officials, and users to recognize the value of these networks, and act to preserve the investment which these networks represent. It is also important for the Commission to review recent technological developments in terms of compatibility with the existing databases and current policies and procedures. To that end, the Commission established a Technical Advisory Committee on the Review and Reevaluation of the Regional Control Survey Program with a charge to:

1. Critically review and reevaluate the status and continued utility of the Commission control survey network;

2. Recommend any needed changes in the network and in the means for its perpetuation, maintenance and use; and

3. Recommend the Commission's role, if any, in the perpetuation, maintenance, and use of the network and identify any attendant funding requirements and sources.

The membership of the Technical Advisory Committee is listed in Appendix A. The committee met three times and discussed issues, raised questions, offered suggestions, and provided insight into the issues, concerns, and priorities addressed in this report. The Committee was convinced of the continuing need to maintain the Commission control survey network to support land and engineering surveys within the Region and agreed that the Commission survey control network should continue to serve as the foundational framework for automated parcel based land and public works information systems within the Region. The minutes of the three all-day committee meetings held are included in Appendix B.

MONUMENTATION

A survey monument is an object, either natural or constructed, that has been surveyed and precisely located. In years gone by a natural monument could be called for as, for example, the course of a stream, a lake shoreline, or an identifiable rock outcrop. As survey methods and measurements improved, natural monuments have given way to constructed monuments such as a cross chiseled into a concrete pad to mark a survey point; iron pipes,

rods, or axles driven into the ground to mark a property corner; or chiseled crosses set on hydrant flanges to serve as bench marks. Even better, appropriately inscribed brass tablets have been embedded into concrete monuments or grouted into bedrock outcrops; stainless steel rods have been driven deep into the ground; or a huge pedestal erected to mark a particular location. Several criteria for survey monuments are:

1. The monument must be stable. If the survey mark is located in unconsolidated fill material, on the side of a hill subject to lateral movement, on a stream bank that erodes away, or in such a manner that it is subject to frost heave, then the value of any surveyed position for the mark is easily compromised and the usefulness of the mark is destroyed.

2. The monument must be permanent. Cases exist in which a cedar post has been retrieved from a swamp and positively identified as the mark set over 100 years ago by a surveyor who carefully described its location. Although impressive, such an example is not an argument for wood survey monuments. More typically, a permanent monument is constructed of stone, concrete, or nonferrous metal and built such that a very specific point on the object is identified as being the survey mark.

3. A good survey monument is also readily accessible. In years gone by, geodetic survey markers were located on hill or mountain tops from which other distant points could be viewed. However, the value of a survey monument is enhanced if the monument is also located in proximity to where it is to be used. In recent years, high-order traverse and GPS surveying has been used to transfer remote and/or hilltop positions to more convenient locations (often on public property or rights-of-way) where they are easily usable.

4. The value of a survey monument is also enhanced to the extent the site is free of obstacles, such as trees or buildings, which prevent line of sight to other objects.

Stated differently, the ideal survey monument is one that is located close to where it is needed, is accessible, is permanent, is stable, and has reliable survey control associated with it. In the big picture, survey monuments provide end users reliable convenient access to the horizontal and vertical datums adopted for use in a given area. Nationally, the adopted datums are part of the National Spatial Reference System (NSRS). Within the seven-county Region, the datums include NAD 27, NGVD 29, and the newer datums of the NSRS.

At this point, a distinction should be made between geodetic control monuments and survey monuments intended to mark property corners. Their purposes, although quite similar, are somewhat different. A geodetic marker is intended to provide the end user ready access to geodetic datums while the property corner is intended to delineate property boundaries. Prior to GPS surveying, geodetic survey points were marked with substantial permanent monuments. Each monument location was also carefully chosen for stability to protect the investment required to establish it. On the other hand, property corner markers are usually set on the property corner, whether convenient or not, and offsets are only used when it is impossible to set a marker on the actual property corner. Property corners are often marked with iron pipes or rods driven into the earth and are admittedly not as permanent as the USPLSS monuments or a typical geodetic survey marker.

Surveyed property corner markers are also called for in legal descriptions of real property and a fundamental tenet of land ownership is that an original undisturbed monument controls the location of associated property lines even if current measurements are inconsistent with the stated location of the monument. Two points of which to be aware include:

1. The role of the surveyor is to collect, evaluate, and present evidence. That evidence may include records of prior surveys, knowledge of local history and practice, measurements and retracements, and any other information having an impact on the correct determination of the intent of the parties.

2. When the surveyed location of USPLSS corners and property corners have been defined by state plane coordinates (as is generally the case throughout the seven-county Region) then the ambiguity of any

subsequently resurveyed location can be enormously reduced. Working with the horizontal and vertical survey control networks as established by the Commission, spatial data users throughout the Region find anticipated agreement between current measurements and record values. Consequently, evaluation of evidence is greatly facilitated and expensive litigation of boundary disputes is avoided.

It is now possible using currently available GPS equipment and measurements to replicate, in the field, the location of any point for which State Plane Coordinate values have been previously determined and to do so within a tolerance of one centimeter. The State Plane Coordinate positions, and to a lesser degree elevations, can be determined from measurements made to orbiting satellites. Because of this positioning ability, issues of the continued importance of survey monuments and multiple datums must be addressed in any reevaluation of the Commission's Regional control survey program.

It may be argued that coordinates derived from measurements to orbiting satellites have effectively replaced monumented positions as a way for the end-user to gain access to the NSRS. It is routinely possible for a competent surveyor using GPS to establish and/or reestablish the known position of a corner within practical tolerances – say within 0.05 to 0.10 foot. Nonetheless, it is often much easier for a lay person (a neighbor or the courts) to understand the location of a property corner related to a visible nearby survey control monument or other physical feature (such as roads, fences, or streams) than to believe the numbers generated from an electronic receiver collecting signals from orbiting satellites.

There is a long-standing legal history involving priority of coordinates and monuments with regard to definition of property lines. Although GPS technology can be used to show remarkable agreement between record and surveyed positions, it is viewed as premature to question the role or the legal stature of called-for monuments. The GPS surveyed location of a geodetic control monument or a property corner can be accomplished with similar ease and efficiency. However, just because a property corner can be competently located with GPS - independent of a nearby geodetic control monument - does not mean that is the way everyone should do it. Prudent policy should continue to honor the well-established principle that the undisturbed monument is prima-facie evidence. As practice continues to evolve, the agreement between a monument-based location and the satellite-derived location should fall within the combined positional tolerance of both sources. It is therefore indicated in the Concluding Recommendations of this report that the monumented USPLSS should continue to be used indefinitely as the basis of cadastral and other surveys and land records within the Region.

MULTIPLE DATUMS

A datum is a reference to which survey measurements are related and against which they may be checked. Horizontal datums are referenced to parallels of latitude and meridians of longitude on a mathematical ellipsoid model of the Earth and vertical datums are referenced to sea level or to some other more precisely defined surface. Traditional horizontal and vertical datums have different origins. A clear understanding of datums is also complicated by the number of datums, differences in the way each datum is defined, who defined it, and when it was defined. Briefly, the horizontal and vertical datums of interest in the seven-county Region include:

- Horizontal - Each datum is associated with an ellipsoid, an epoch, an origin, and an azimuth.

    1. NAD 27 is based upon the Clarke Spheroid of 1866 with an origin at station "MEADES RANCH," in Kansas.
    2. NAD 83 is based upon the Geodetic Reference System of 1980 (GRS 80) with an origin at the Earth's center of mass as best determined in 1980. The origin is defined by the published coordinates of the network.
    3. WGS 84 is both a datum and an ellipsoid with the origin located at the Earth's center of mass. The U.S. Department of Defense (DOD) updates the WGS 84 as required to match observed satellite orbits. While update changes are small, WGS 84 is always "current."

4. ITRF is defined by the global scientific community independent of the U.S. DOD and the WGS 84. The ITRF uses the GRS 80 ellipsoid instead of the WGS 84 ellipsoid. Otherwise, as datums, the ITRF and WGS 84 are nearly identical.

- Vertical - Each vertical datum is associated with an epoch and a reference surface.

1. NGVD 29 is based upon sea level as defined by historical observations of water levels at 26 tide gages along the coasts of North America.
2. NAVD 88 is based upon one primary bench mark elevation and very precise differential level circuits covering the United States from coast to coast and border to border. This datum has been designated by WisDOT as NAVD 88 (1991).
3. NAVD 88 (2007) within Wisconsin is a more recent adjustment of the national vertical survey control network based upon observations made in Wisconsin by the WI-HMP. The entire SEWRPC planning Region has been included in that program.
4. IGLD 85 is a dynamic datum used by scientists in U.S. and Canada to compute accurate hydraulic gradients in the Great Lakes system.

Although each datum was established for a particular reason, the number of datums makes it difficult for spatial data users in various endeavors to maintain interoperability and compatibility. For local spatial data users, the obvious preference is to pick one horizontal datum and one vertical datum and to use them exclusively. That is what the Commission has done by continuing to use the NAD 27 and the NGVD 29 datums. That goal is laudable and possible within limits. However, external pressures aside, it is also advantageous for SEWRPC spatial data users to employ modern positioning technology in the normal conduct of business. The problem is that the introduction of GPS technology, which is earth centered, makes the continued use of the NAD 27 and NGVD 29 datums – which are not earth centered – difficult.

The National Geodetic Survey (NGS), formerly known as the U.S. Coast and Geodetic Survey (USC&GS), is a component of the National Oceanic and Atmospheric Administration (NOAA) and is the agency responsible for establishing and maintaining survey datums in the United States. NGS is a small agency but, since the early 1800s, has enjoyed a proud tradition of conducting high-caliber surveys to establish precise geodetic positions on both horizontal and vertical control monuments throughout the United States. A brief summary of horizontal datums, www.ngs.noaa.gov/PUBS_LIB/geodetic_survey_1807.html, was written by Joe Dracup, former Chief Geodesist for the USC&GS, as:

> *In 1879 the first national datum was established and identified as the New England Datum. Station PRINCIPIO in Maryland, about midway between Maine and Georgia, the extent of the contiguous triangulation was selected as the initial point with its position and azimuth to TURKEY POINT determined from all available astronomical data, i.e. 56 determinations of latitude, 7 of longitude, and 72 for azimuth.*
>
> *Later its position was transferred to station MEADES RANCH in Kansas and the azimuth to WALDO by computation through the triangulation. The Clarke Spheroid of 1866 was selected as the computational surface for the datum in 1880, replacing the Bessel spheroid of 1841 used after 1843. Prior to 1843, there is some evidence that the Walbeck 1819 spheroid was employed.*
>
> *The datum was renamed the U.S. Standard Datum in 1901 and in 1913 the North American Datum (NAD) as Canada and Mexico adopted the system. In 1927 an adjustment of the first-order triangulation of the U.S., Canada and Mexico was begun and completed about 1931. The end result was the North American Datum of 1927 (NAD 27).*

A similar history of the vertical datums was written by Ralph Moore Berry (1976), former Assistant to the Director of NGS, who notes that the National Geodetic Vertical Datum of 1929 is identical to the Sea Level

Datum of 1929 except for the name change to avoid the implication that a "zero" elevation provides a reliable distinction between what is land and what is ocean. No bench mark elevations or names of stations were changed – only the name of the datum was changed.

The horizontal control survey network currently used by the Commission in the seven-county Region is based upon the North American Datum of 1927 (NAD 27) and the vertical control survey network is based upon the National Geodetic Vertical Datum of 1929 (NGVD 29).

In the normal conduct of its operations, NGS has readjusted data and updated both the horizontal and vertical datums in the United States – including in the State of Wisconsin. The absolute shifts from NAD 27 to NAD 83 (1986) ranged in values from about 6 feet to 11 feet in the north/south direction and about 36 feet to 39 feet in the east/west direction. The shift from NAD 83 (1991) to the latest NAD 83 (2007) is typically less than 0.25 feet in both north/south and east/west directions. Differences in vertical datums NGVD 29 to NAVD 88 range from about 0.08 feet to 0.32 feet. Changes in bench mark elevations due to the latest vertical readjustment, NAVD 88 to NAVD 88 (2007), are still being evaluated but the differences are acknowledged to be quite small. A random check of six points within the Region produced a mean difference of 0.036 foot. Although not identified, movement of a disturbed monument could account for some of that difference.

Several realizations of the datum updates include:

1. A horizontal datum update from NAD 27 to the North American Datum of 1983. The final results were published in 1986 so the datum is known as the NAD 83 (1986).

2. A horizontal datum update in 1991 based upon improved horizontal positions as a result of using GPS technology. The update is state specific and known as NAD 83 (1991) for Wisconsin.

3. A horizontal datum update in 1997 based upon a rigorous 3-D GPS survey to improve the vertical component. That update is also state specific and known within Wisconsin as NAD 83 (1997).

4. Updates to the International Great Lakes Datum. Scientific agencies within Canada and the United States have long collaborated on elevation issues in Canada and the upper Midwest. The International Great Lakes Datum (IGLD) was established in 1955 in recognition of the continuing rebound of the Earth's crust in the greater Hudson Bay region in response to removal of the crustal loading since the most recent ice age. A separate issue is that conventional orthometric heights do not accurately reflect hydraulic gradients for the Great Lakes System. The IGLD was designed to use dynamic heights in place of orthometric heights and the IGLD was intended to be readjusted every 30 years or so to reflect the on-going crustal rebound. A map on page 14 of the December 1989 issue of the Commission's "Technical Record" shows that, if the predicted rate has been constant for the past 30 years, the ground surface in the vicinity of Milwaukee has subsided about 0.15 feet. That means that the water level on a bench mark near Milwaukee has risen about 0.15 feet in 30 years. Those issues and changes, although small, do affect elevations as used in the Region.

5. A vertical datum update in 1988. Following readjustment of the horizontal datum published in 1986, NGS turned their attention to updating the vertical datum in the United States. The new vertical datum adjustment is known as the North American Vertical Datum of 1988 (Zilkoski, et.al., 1992). From a scientific perspective, the NAVD 88 is superior to the NGVD 29 because elevation differences between bench marks (both locally and coast to coast) are more consistent than those of the NGVD 29. An added advantage is the consistency established between the new NAVD 88 and the IGLD 85 due to the underlying geopotential numbers being the same on both datums. The difference is that NAVD 88 uses orthometric heights while the IGLD uses dynamic heights.

6. A rigorous 3-D adjustment. In 2007, NGS readjusted the entire National Spatial Reference System and combined the various state-specific HARN adjustments into a single adjustment constrained to the

national network of Continuously Operating Reference Stations (CORS) whose positions are precisely known and continuously monitored. The adjustment provides 3-D consistency throughout the United States and supersedes the state-specific localized adjustments conducted between 1986 and 2007. The latest readjustment, known as the NAD 83 (2007), was completed in February 2007 and the adjusted information is available from NGS. The readjustment used GPS observations available through June 2006.

With publication of the NAD 83 (2007), the NSRS is effectively a single 3-D datum with separate horizontal and vertical components. The horizontal components (latitude and longitude) of the NAD 83 (2007) are very similar to previous horizontal datums but the vertical component of the NAD 83 (2007) is an ellipsoid height (h) derived from the GPS surveyed 3-D positions. Orthometric height (elevation H as given on the NAVD 88) remains referenced to the geoid and the difference between the two heights (ellipsoid minus orthometric) is known as the geoid height (N). If the geoid height at a point is known, the elevation at the point is obtained as ellipsoid height – geoid height ($H = h - N$). These relationships are shown on the figure included on page 9 of the attached minutes of the third meeting of the Advisory Committee. NGS has developed geoid modeling software for use by the spatial data user community. The programs are called GEOID93, GEOID96, GEOID99, and GEOID03. Geoid modeling is an ongoing area of geodetic research at NGS and improving the geoid model in Wisconsin is one objective of the WI-HMP.

WisDOT has also conducted geodetic surveys – both horizontal and vertical – within the Region and has conducted localized readjustments in conjunction with NGS. Those results are available as part of the NGS database and eligible to contribute to the realization of the NSRS in the Region.

Separately, GPS was developed by the DOD and has become the standard positioning system used worldwide. The datum used by the DOD for GPS is the World Geodetic System of 1984 (WGS 84) and includes both an ellipsoid and a formal datum definition. The GPS satellites physically orbit the Earth's center of mass and the intent of the DOD is for the datum to match the orbits as closely as practicable. That means the WGS 84 datum origin is modified from time to time to reflect better knowledge of that center of mass. The various epochs of WGS 84 are numbered in GPS weeks starting 6 January 1980 and include WGS 84 (G730), WGS 84 (G873), and WGS 84 (G1150) which was implemented on 20 January 2002. Orbits of the GPS satellites are monitored continuously by the DOD and ephemerides are computed for the orbits – both predicted and historical. (The predicted orbits are known as the "broadcast" ephemeris and the historical orbits are known as the "precise" ephemeris). Those orbit parameters (from either ephemeris) are the basis of positions computed from GPS observations. The point is that WGS 84 is governed by knowledge of the Earth's center of mass, that GPS signals are native to WGS 84, and that the DOD maintains GPS for its declared purposes. It could be said that civilian communities worldwide are at the mercy of the DOD with regard to continued use of GPS.

The international scientific community also monitors GPS satellite orbits and has defined the International Terrestrial Reference Frame (ITRF), which very closely matches the WGS 84. However, determination and use of the ITRF is separate from and not controlled by the DOD. The ITRF is designed for a global best fit and continental drift is reflected in the positions determined with respect to the ITRF. On the other hand, the NAD 83 is fixed to the North American continent and, for practical purposes, the NAD 83 moves with the North American plate. The NAD 83 as a datum is very stable for most areas within the United States, including the seven-county SEWRPC Region. NGS incorporates both ITRF and NAD 83 in the positions published for the CORS network.

This paragraph is included for information purposes and judged to have little or no impact on the issues currently being discussed with regard to datums being used within the SEWRPC Region. The Russian GLONASS and the European Galileo systems use neither the WGS 84 nor the NAD 83 datums. To the extent that becomes an issue in the United States, the vendors deal with those issues and satellite positioning equipment marketed in the United States is designed to be used on the NAD 83, the ITRF, or the WGS 84 datums.

All of this background is offered for the purpose of understanding better the questions related to continued use of the NAD 27 and NGVD 29 datums within the SEWRPC Region. Ideally, there would be a civilian datum, which

does not change, and a military/scientific datum to serve other purposes. However, the problem is that the "civilian" datum is subject to periodic upgrades and that modern measurements obtained from GPS are inextricably linked to the WGS 84 "military" datum. Due to separate origins for horizontal and vertical datums, there is no "fixed" or mathematically defined relationship between the WGS 84, the NAD 83 (2007), and the NGVD 29/NAVD 88 datums. That means spatial data users, both internal and external to SEWRPC, find themselves in a position of needing to deal with elements of the various datums if they wish to take advantage of modern GNSS positioning.

Scenario: It is already possible for those willing to purchase the newest equipment to enjoy the luxury of carrying an instrument into the field that is capable of providing real-time positioning within 0.10 feet (3 centimeters) or better. Given on-going development, the same portable field equipment will also have storage capacity and processing capability to access the spatial database – eventually in real time. Without using a proven reliable transformation, it is not reasonable to expect values from the SEWRPC databases to be compatible with data collected with modern GPS units.

The problem to be avoided is for the end user to contend with datum issues instead of proceeding with productive work. Implemented appropriately, the datum issues will have been addressed behind the scenes and the spatial data user, both internal and external, will be able to engage in productive spatial data activities without needing to worry about datum differences.

If bidirectional transformations are developed, it will be possible to transform data bidirectionally between NAD 27/NGVD 29 (older datums) and the NAD 83 (2007)/NAVD 88 (newer datums) at an acceptable level. No transformation will be perfect but each of the two following options is anticipated:

1. In the first case, the existing database values will be converted to NAD 83 (2007) values and used in the field unit so that "record" values are compatible with those being obtained from satellites orbiting the Earth's physical center of mass.

2. In the second case, the observed GPS values will be converted to NAD 27 and NGVD 29 values so that the modern "GPS" values will be compatible with those currently residing in the SEWRPC database.

In either case, the "relative" differences between common points in both systems should be very similar. Due to known distortion existing within the NAD 27 datum, the transformed values will not be "perfect." For Second- and Third-Order comparisons and for use in local civil infrastructure development and cadastral parcel definition, those relative comparisons should be very acceptable. However, there will be some limit beyond which such procedures are not sufficiently precise for geodetic control surveys. That level of transformational integrity will need to be determined in blind testing against known values during development and testing of the bidirectional transformation algorithms.

Similar criteria also need to be applied to other field and office operations. Consistent policies need to be developed and applied so that all users know specifically what datum they are working on and what procedures must be followed to achieve consistent results. For example, it is desirable for NAD 27 coordinate values to be expressed in U.S. survey feet and for NAD 83 (2007) coordinate values to be expressed in meters. Nevertheless, some practioners and agencies, including WisDOT, express NAD 83 (2007) state plane coordinate values in feet, giving rise to potential confusion and mistakes.

CORS, RTK, and RTN

GPS is one of several satellite positioning systems. The Russian system is called GLONASS and the Europeans are building a system called Galileo. The all-inclusive designation and abbreviation is Global Navigation Satellite Systems (GNSS). Those abbreviations (GPS and GNSS) are often used interchangeably.

GNSS positioning technology has matured to the point that it is possible to determine horizontal and vertical positions within 0.5 feet or better in real-time. And, depending upon the level of sophistication applied, the geodetic position of a point can be determined economically in 3 dimensions within 2 to 5 centimeters (about 0.1 to 0.2 feet). Even more precise geodetic positions are routinely possible using carrier-phase GPS baselines to build a network tied to the NGS CORS.

Peer reviewed journals are revered as the best source of technical information and there is an enormous amount of material published in reputable journals. However, trade magazines also contain a wealth of information on equipment and procedures such as that summarized below. With an ever expanding array of spatial data applications and attendant technologies such as continuously operating reference stations (CORS), real-time kinematic (RTK) GPS operations, and real-time GPS networks (RTN), the following general accuracies, (Stone 2008), are intended to be used as comparative rather than exact.

With respect to the following tabulation, two other points are: 1) GPS data are not reported on the NAD 27 or the NGVD 29 datums; and 2) one needs to be careful about specifying whether accuracies in the listing apply to absolute or relative positions. Code-phase positions are considered absolute while carrier-phase data provide relative accuracies.

Typical operations and accuracies attainable with GPS include:

	Within about
1. Hand-held code-phase receivers operating in autonomous mode	5 m or 15 ft
2. WAAS enabled code-phase receivers that differentially correct the autonomous position in real-time.	2 to 3 m or 10 ft
3. A differentially corrected position from a pair of code-phase receivers - one remote and one (maybe permanent) base station.	1 to 2 m or 8 ft
4. Code-phase observations that can have differential corrections applied in various combinations in a post-processing effort.	0.5 to 2 m or 6 ft
5. RTK carrier-phase observations for single baselines over nominal distances (up to 4 km) using two or more receivers simultaneously. Communication between receivers, either radio or cell phone, is required. One of the two receivers is a base (possibly a permanent installation) and the second is a remote (rover). There is no redundancy on a single baseline.	0.05 to 0.5 m or 1.5 ft
6. RTK carrier-phase observations to multiple bases. With multiple vectors from several base stations, there is a check on the observed position and the quality of the solution is enhanced accordingly.	0.01 to 0.2 m or 0.5 ft
7. RTK carrier-phase network solutions. Real time network (RTN) solutions are based upon multiple permanent base stations configured in a local network that is capable of broadcasting corrections to local remote units. High quality positions are available in real time.	

Transportation departments in the states of Ohio (2004) and Michigan (2005) were pioneers in the United States for investing in statewide RTNs. Private networks have also been installed and supported on a user subscription basis in various states, e.g., Texas and Virginia (2007). In other cities and metropolitan areas

(Albuquerque and Atlanta), a smaller permanent GPS network serves the needs of local users. Getting a RTN set up and operational is no trivial undertaking. But, once established, a RTN can work quite well for the mutual benefit of subscribing users. WisDOT is in the process of installing a RTN that will cover the seven-county Region (and more) by April 2008. The WisDOT RTN is based upon the NAD 83 (2007).

Although the capability of a RTN can be quite impressive, not all RTNs are created equal (equipment brand compatibility is still an issue). NGS is working to develop guidelines for the establishment of reliable RTNs. Such networks, whether public or private, provide subscribing users the ability to position points precisely anywhere within the RTN coverage. 0.001 to 0.1 m or 0.3 ft

8. On-line Positioning User Service (OPUS) dual-frequency receiver data. Dual-frequency carrier-phase data are collected for a minimum of 2 hours and sent via e-mail to NGS for processing. The results are typically sent back within minutes and provide an absolute position within about 0.05 to 0.10 meters. The solution is developed automatically without human intervention and is based upon using data from the NGS CORS network. Within limits, the quality of a position can be improved by extending observation time or using additional data sets. 0.02 to 0.05 m or 0.2 ft

9. OPUS-Rapid Static (OPUS-RS) which requires at least 15 minutes of dual-frequency carrier-phase data. Data sets can be submitted via e-mail to NGS for processing using a newer algorithm. Results are still being tested but indications are that the resulting positions are as good as regular OPUS solutions. However, the CORS for an OPUS-RS solution must typically be closer (within tens of miles rather than hundreds of miles) to the new point being established. A general comment is that the strength of an OPUS solution is more time dependent (on changing geometry with respect to the satellites) while the OPUS-RS solution is more distance dependent (from the CORS used in the solution). 0.02 to 0.05 m or 0.2 ft

10. Static carrier-phase data, single baseline or network. The time-proven methods of static GPS data collection, either at permanent installations or on a tripod set up for the purpose, provide GPS users the opportunity to establish a single baseline or a network of baselines enjoying internal consistencies of 1 ppm or better on a routine basis. Longer observing times (sometimes in excess of 2 hours) aid in achieving small tolerances and geodetic accuracies. Sites with good sky visibility are required and data processing must be monitored carefully to assure high-quality results. 0.005 to 0.020 m or 0.02 ft

The GNSS manufacturers are building and selling equipment that uses signals from the various satellite systems and the user often need not be concerned about which system contributes to the result – especially when the position is generated and used in real time. That represents an enormous benefit to the spatial data user community – especially given that the datum issues (as described herein) are addressed appropriately.

OPTIONS FOR COMMISSION

Several alternatives are listed for Commission consideration:

1. "Status quo" is probably best described as continuing to do what is being done now. That means the values in the existing databases are based upon NAD 27 and NGVD 29 and ongoing development of the civil infrastructure, topographic mapping, cadastral overlays, flood plain studies, and other spatial data uses are based upon those datums. It also means that use of modern GPS positioning methods is hampered because the GNSS systems generate answers and solutions based upon the WGS 84 and/or the NAD 83. The multiple datum challenge derives from the fact that GNSS satellites physically orbit the Earth's center of mass and GNSS data and results are native to those datums.

2. An alternative would be to move the existing horizontal and vertical databases to the NAD 83 (2007) horizontal datum and the NAVD 88 (2007) vertical datum. The advantage would be enhanced interoperability with more persons and organizations working on the same horizontal and vertical datums. While technically possible, this alternative would also be a very expensive undertaking. It would be a formidable task to transform the large number of geographic positions comprising the survey control networks within the seven-county Region as well as the huge volume of information in the form of digital maps and hard-copy topographic and cadastral maps; land subdivision plats and certified survey maps; plats of surveys; flood plain delineations and associated hydraulic grade lines along hundreds of miles of streams and water courses, and the entire land information and public works management systems used throughout the Region. The benefits of making that transition would need to justify both the dollar cost and the inconvenience of doing so.

3. A more reasonable approach is to develop bidirectional transformations that can be used to convert between NAD 27 and NAD 83 (2007) values and between NGVD 29 and NAVD 88 (2007) values. Due to the distortions known to exist in the older datums, it is impossible to develop closed form mathematical equations to be used for all points. If this alternative is selected, the following issues need to be considered and addressed:

    a. Transformations can be used to convert NAD 27 and NGVD 29 values to NAD 83 and NAVD 88 values so that users are working with values that are compatible with GPS operations – including real-time positioning.

    b. Transformations can be used to convert NAD 83 GPS derived values and NAVD 88 values to NAD 27 and NGVD 29 values so that data to be added to the existing database will be compatible with what is already there.

    c. Users will be able to choose and use either approach as dictated by the circumstance. This option provides the most flexibility and convenience. However, this option also has the potential of being misused by those who are even mildly careless in specifying which datum they are using.

    d. It may be the position of the Commission to continue using NAD 27 and NGVD 29 for all internal uses and to provide the transformation procedures to external users. That makes external users responsible for performing and using the transformations. While cleaner for internal Commission operations, that policy will certainly increase the cost to the Commission to secure services of those using the modern positioning technologies. It would also adversely impact the Commission's ability to use modern positioning technologies efficiently – e.g., the WisDOT planned implementation of a RTN.

    e. Current transformations as described in SEWRPC Technical Reports No. 34 and No. 35 were developed separately for horizontal and vertical datums. Given the NAD 83 (2007) is a 3-D datum, the transformation modeling for the current effort should be done with the 7-parameter Helmert transformation. The tools used in Technical Report 34 were valid for 2-D transformations but the Helmert transformations are specifically applicable for combining both the horizontal and vertical

transformations into a single modeling operation. The Helmert transformation would be developed and tested before being implemented. Once the transformation process is proven, implementation will consist of using simple algorithms similar to those used in Technical Report 34. While the tested and adopted Helmert algorithms would be published and available to anyone, the end user will be able to perform simple bidirectional transformations using separate parameters for horizontal and vertical data.

4. Another alternative – conversion of the existing database into an integrated three-dimensional database – would be a huge step and, whether done all at once or incrementally, would be quite costly. But the potential benefits (e.g., interoperability between applications and disciplines for spatial data users all over the world) will likely make this alternative attractive at some point in the future. Although not recommended at this time, this alternative is described in order to provide context and comparison for the other alternatives. If the existing horizontal and vertical databases are converted to a single database, the datum issues largely disappear because:

   a. All subsequent spatial data operations are based upon values stored in the integrated 3-D database.
   b. Each point is stored as absolute X/Y/Z coordinates along with covariance information that provides reliable statistical information on spatial data accuracy.
   c. Any database point selected will have its positional accuracy immediately available in each of three dimensions. The user will be able to impose a filter of any (selectable) magnitude to decide what points are usable.
   d. The relative position between any point-pair is immediately available at the ground level of either endpoint (user's choice) and the direction between points is referenced to the true meridian through the standpoint. Geodetic forward and back azimuths are both available.
   e. The user can select any convenient point-of-beginning (P.O.B.) and all relative distances/directions drawn from the database are reported based on a tangent plane through the selected P.O.B. This feature obviates the need for a low distortion projection.
   f. Plotting topographic maps is facilitated by computing the relative local easting and northing from any selected P.O.B. For small-scale maps, multiple P.O.B.s can be selected to constrain plotting distortions within any desired limit.
   g. When working with relative values, datum issues are largely moot because datum issues are applicable to absolute coordinates.
   h. The standard deviation of any computed distance, azimuth, or elevation is immediately available if the covariance information has been stored in the 3-D database. Such data are (or can be) standard products of modern positioning technology and processing software.

   Technical details for developing and using the integrated 3-D global spatial data model (GSDM) are included in a book, “The 3-D Global Spatial Data Model” written by Earl F. Burkholder and published by CRC Press.

USING GPS TO DETERMINE ORTHOMETRIC HEIGHTS

Another issue deserving careful consideration is using GPS as the primary means by which to establish orthometric heights. WisDOT has been engaged in the WI-HMP for several years and has conducted leveling operations within the Region as well as throughout the state. Reliable NAVD 88 (2007) elevations established by the WisDOT and published in the NGS database will provide valuable data for developing the vertical part of the transformation process.

NGS has studied the use of GPS to establish orthometric height and has published draft specifications for those operations. WisDOT has also developed operational procedures, which would be evaluated and incorporated as

appropriate in developing the bidirectional transformations. The following issues need to be considered in evaluating the use of GPS for establishing orthometric heights.

1. Geoid modeling is a critical part of using GPS to establish orthometric heights. There is a simple relationship between ellipsoid height, geoid height, and orthometric height given as:

$$h = H + N \quad (1)$$

where h = ellipsoid height (from GPS)
H = orthometric height (elevation)
N = geoid height (from geoid modeling)

Orthometric height is found by re-writing equation (1) as:

$$H = h - N \quad (2)$$

Another form of equation (1) that uses differences between two points is:

$$\Delta h = \Delta H + \Delta N \quad (3)$$

where Δh = change in ellipsoid height (from GPS)
ΔH = change in orthometric height
ΔN = change in geoid height (from geoid modeling)

The change in orthometric height between two points is then found using:

$$\Delta H = \Delta h - \Delta N \quad (4)$$

Equation (4) represents an approximation but is widely used with excellent results. From a theoretical perspective, the ellipsoid height is measured along the ellipsoid normal while the orthometric height is measured along the plumb line. Because the ellipsoid and geoid heights are not parallel with the orthometric height, the measurements involved must theoretically be added as vectors, not as scalars. The various geometrical elements are illustrated in Figure 1 of the minutes of the February 15, 2008, meeting of the Technical Advisory Committee – see Appendix B.

The nonparallelism of the ellipsoid normal and the plumb line through a point is called the deflection-of-the-vertical and rarely, if ever, exceeds 5 seconds of arc within the seven-county Region. The impact of that small deflection-of-the-vertical on computed orthometric heights anywhere within the seven-county Region, even for elevations up to 1,200 feet, is less than 0.001 foot and is deemed insignificant whether using equation (2) or equation (4).

The importance of using equation (4) instead of equation (2) is that a change in geoid height (a relative quantity between points) is modeled more reliably than the absolute value of N, the geoid height at a point. The change in geoid height is related to the slope of the geoid and is typically more severe in areas of significant terrain variations – mountainous areas. As stated in the previous paragraph, the slope of the geoid in the seven-county Region is quite small. A consequence is that GPS derived ellipsoid height differences used in conjunction with geoid height differences can be used to determine orthometric height differences within First-Order leveling specifications. As an example, the GPS derived elevation differences described on page 58 of the SEWRPC report, "Definition of a Three-Dimensional Model for Southeastern Wisconsin" (Burkholder, 1997) very nearly meet the FGCS specifications for conventional First-Order leveling. The worst component in the example is 0.013 feet times the square root of the distance in miles and the First-Order class I specification is 0.012 feet times the square root of the distance in miles. The First-Order Class II specification is 0.017 feet times the square root of the distance in miles.

2. Critical grades, such as those encountered when laying sanitary sewers, are closely connected to relative elevations along the sewer line. Local differential spirit leveling may be expected to continue to be the most cost effective method for determining relative elevation differences in those circumstances. Other circumstances in which relative elevation difference is critical include hydraulic grade lines and flood plain determinations.

3. Geoid models are better now than in the past and geoid models in the future will be better than those currently available. A valuable product of the current Wisconsin Height Modernization Program will be an improved geoid model for the seven-county Region (and other parts of Wisconsin). When comparing specifications for GPS orthometric height determination with those for conventional leveling, it appears that GPS technology can be used to determine precise elevation differences for points approximately 4.5 miles or more apart. Although GPS technology may be used to establish orthometric heights over shorter distances, spirit leveling remains the preferred method for determining reliable relative elevation differences over shorter distances.

Once the bidirectional transformations have been developed, the data and procedures will be available for testing and evaluating the performance of using GPS to establish orthometric heights. That testing and evaluation should be an identifiable part of the scope of Phase II.

DESCRIPTION AND COST TO DEVELOP BIDIRECTIONAL TRANSFORMATIONS

The scope for developing the proposed bidirectional transformations is listed in two phases. Phase I should include developing, testing, and proving the conceptual framework described herein. Representative high-quality geodetic data within the Region obtained from the SEWRPC databases and from other federal, state, and private sources should be used and integrated into Phase I activities. Upon satisfactory completion of development and testing the algorithm for a representative area within the Region, Phase II should consist of applying the process to the remainder of areas included within the seven-county Region and of publishing the bidirectional transformation equations. A concise User's Guide should also be a part of the Phase II report.

The estimated cost for Phase I lasting from 6 to 12 months is $25,000.

The preliminary estimated cost for Phase II lasting for another 9 months is $25,000.

Givens:

1. Published First- and Second-Order NAD 27 control points within and adjacent to the Region.
2. Published First- and Second-Order NGVD 29 elevations within and adjacent to the Region.
3. Published 3-D X/Y/Z NAD 83 (2007) control values on CORS and other control points in the Region – including WisDOT Height Modernization Program control stations.
4. Published NAVD 88 (2007) First- and Second-Order elevations on existing bench marks within and adjacent to the Region.

Additional vectors observations/computations:

1. Static dual-frequency GPS observations on selected NAD 27 and NGVD 29 points.
2. Network of vectors from established CORS to selected control points – NAD 27, NGVD 29 and existing NAD 83 (2007).

Tools:

1. Applicable software tools routinely available from NGS include:

    a. GEOID03 and other geoid models

b. NADCON
c. VERTCON
d. Other

2. Existing transformations procedures identified for NAD 27 to NAD 83 (1991) and NGVD 29 to NAVD 88 (1991) in the following publications:

   a. SEWRPC Technical Report No. 34, *A Mathematical Relationship Between NAD 27 and NAD 83 (91) State Plane Coordinates in Southeastern Wisconsin*, 1994.
   b. SEWRPC Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin*, 1995.

3. Other matrix, data manipulation, and network adjustment software may include:

   a. Star-net
   b. Ez-Adjust
   c. Vendor specific
   d. Generic

Procedures

Procedures envisioned for developing the bidirectional transformations include:

1. Inventory of published First-Order (or better) horizontal control points within the Region.

2. Inventory of published First- and Second-Order bench marks within the Region.

3. Identify subset of points holding both horizontal and vertical control.

4. Identify additional points to be tied in with additional GPS observations.

5. Use VERTCON to convert NGVD 29 elevations to NAVD 88 (1991) elevations, then use GEOID03 to compute corresponding ellipsoid heights.

6. Use NADCON to convert NAD 27 latitudes and longitudes to NAD 83 (1991) latitudes and longitudes. Then compute geocentric X/Y/Z NAD 83 (1991) values for the chosen common stations. Estimate the standard deviation for each component of each station – easting, northing, and up.

7. Determine (high order) NAD 83 (2007) X/Y/Z coordinates for common points either from existing records or new GPS survey. The number of new GPS observations needed is as identified in step 4 above. The standard deviations of NAD 83 (2007) points will be determined and used.

8. Hold common points and standard deviations in both datums. Use a Helmert 7-parameter transformation to solve for Tx, Ty, Tz, Rω, Rφ, Rκ, and scale. This solution will also provide standard deviations of the solved parameters. An alternative will be to solve for separate scale in three directions rather than one scale for all three directions.

9. Evaluate the scope (area coverage) for which those parameters provide acceptable results. "Blind tests" will be conducted to verify the level of accuracy achieved by the transformation. Note, it is known that distortions exist between the older NAD 27 datum and the newer NAD 83 (2007) datum. This is analogous to the procedures used for the previous transformations in the 1990s. Acceptable horizontal transformations for the seven-county Region were obtained using 14 different sets of parameters.

10. The transformations in the mid 1990s determined parameters for horizontal and vertical transformation separately. Modern GPS data on the NAD 83 (2007) are 3-D so the 3-D Helmert transformation will be used to model horizontal and vertical distortions simultaneously.

11. Once the Helmert transformation parameters are determined, it will be possible to model separate horizontal and vertical procedures for local provable use. X/Y/Z values will be converted to latitude/longitude/ellipsoid height. Those latitude/longitude values will be converted to NAD 83 (2007) state plane coordinates and ellipsoid heights will be converted to NAVD 88 (2007) orthometric heights using GEOID03. From there, local bidirectional transformations can be computed as noted in (a) and (b) below. An estimate of the accuracy will be available from the statistics of the transformation process.

    a. For horizontal, using the new local transformations will be very similar to using the transformation parameters developed in 1994 to convert between NAD 27 and NAD 83 (1991). These new transformations, as were the 1994 transformations, will be developed using an empirical approach and will model the inherent uncertainties within the confines of existing control in both the NAD 27 and the NAD 83 (2007) datums. The transformations will be tested to ensure performance at a level that will support land surveying and public works engineering applications.
    b. For vertical, the local transformation will be very close to that obtained by using VERTCON. The difference will be that geoid modeling will be used twice – once in converting NGVD 29 orthometric heights to (NAD 27) ellipsoid heights and again when converting NAD 83 (2007) ellipsoid heights to NAVD 88 (2007) orthometric heights. This empirical procedure will need careful testing to document the level of acceptability.

Although not referenced previously, the recommendations in this report are intended to be compatible with the fundamental principles and concepts described in the series of four articles by Meyer, et. al., (2004, 2005, and 2006).

CONCLUDING RECOMMENDATIONS

The Commission is to be commended for identifying the need and taking steps to protect the investment in the basic horizontal and vertical survey control networks in the seven-county Region. These recommendations are made in recognition of the value of the existing networks, wide-spread reliance on Commission established survey control by spatial data users in various disciplines, the capability of newer positioning technologies, and requests from external users for the Commission to establish compatibility between existing survey control and the recently updated horizontal and vertical datums as published by the National Geodetic Survey (NGS).

Specific recommendations include:

1. **Continued use of NAD 27 and NGVD 29.** The Commission, in cooperation with its constituent counties, should continue the established policy of basing the horizontal survey control network on the North American Datum of 1927 (NAD 27) and the vertical network on the National Geodetic Vertical Datum of 1929 (NGVD 29). Given the investment in existing horizontal and vertical control databases, the proven quality of those control values, and continued reliance on those datums by spatial data users within the seven-county Region, the benefits of migrating from the NAD 27 and the NGVD 29 to the newer North American Datum of 1983 (2007), and to the North American Vertical Datum of 1988 (2007) do not justify the costs of transforming the huge volume of spatial data records – both hardcopy and digital. As a separate issue, it is acknowledged that migrating from one datum to another (the focus of this report) is distinctly different from refinements associated with a readjustment of the high-quality geodetic observations underlying the NAD 83 (2007).

2. **Maintenance of the USPLSS monumentation.** The Commission should continue to rely on the surveyed positions of the USPLSS survey monuments as established on the NAD 27 throughout the

Region. The relative position of each undisturbed monument is fundamental to definition of cadastral boundaries, to stability of land ownership records, and to geometrical consistency within the topographic maps covering the entire seven-county Region. The Commission and its constituent counties should continue to replace USPLSS monuments that are disturbed or destroyed and to survey the positions of those new monuments.

3. **Maintenance of the NGVD 29 bench marks.** The Commission should continue to rely on the surveyed positions of the network of NGVD 29 bench marks established by the Commission. The importance of reliable bench mark elevations is emphasized and spatial data users throughout the Region have a reasonable expectation that the existing vertical network will be maintained. While it is acknowledged that precise geodetic leveling operations can be quite expensive, the Commission should continue to maintain the network of vertical bench marks and replace those monuments whose elevations become compromised. More economical methods for establishing elevations over long distances (greater than about 5 miles) using GPS technology and geoid modeling are being developed and proven. But, for the foreseeable future, it appears that differential spirit leveling will continue to be a cost effective method for determining control bench mark elevations for public works and land surveying applications.

4. **Development of bidirectional transformations.** Recognizing advances in positioning technology and the subsequent impact of those advances on many uses of spatial data (both digital data files and hard-copy maps), the Commission should pursue development and publication of transformation procedures by which bidirectional conversions between the NAD 27 and NAD 83 (2007) horizontal datums and the NGVD 29 and NAVD 88 (2007) vertical datums can be accomplished. The procedures should be well defined, technically defensible, published, and easy to use. Developing bidirectional transformations is a major recommendation of this report and cost estimates for developing those transformations have been set forth earlier herein.

5. **Provide technical assistance in using the bidirectional transformations.** With regard to continued use of existing datums by the spatial data user community, the Commission is an excellent resource and should endorse, promote, and support appropriate training sessions whereby procedures involving use of the bidirectional transformations are presented to the user community. While use of the bidirectional transformations is intended to be straightforward, it will be critical to emphasize the importance of being very specific about (and keeping careful track of) whether data are being moved **from** NAD 27 and NGVD 29 or **to** NAD 27 and NGVD 29.

   A separate, but related issue involves methodologies by which transformed data are used in conjunction with newer technologies, specifically GPS, CORS, and RTN. It is presumed that spatial data users will work with both the existing databases related to the old datums and modern survey techniques related to the new datums. It is further presumed that spatial data users are responsible for their own professional development and competent acquisition and use of spatial data. Nonetheless, a posture of helpful assistance on the part of the Commission in offering seminars, technical support, and even actual incidental transformations would greatly aid both the Commission and the user community in preserving the value of the existing NAD 27 and NGVD 29 databases.

6. **Active participation in the professional community.** The Commission should continue to participate in the broader professional community by developing and publishing technical papers related to the value and benefits of using a well-controlled digital spatial database. In particular, it will be beneficial for the Commission to establish a formal liaison with the WI-HMP to assure, to the extent possible, that the value of policies, records, procedures, and information held by each is made available to the other.

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Part 3 - November 2006	"Communications – Making that First Rover Connection"
Part 4 - December 2006	"On-Grid – An Initiative in Support of TRN Development"
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Appendix A

TECHNICAL ADVISORY COMMITTEE FOR THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

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Appendix A

TECHNICAL ADVISORY COMMITTEE FOR THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

Kurt W. Bauer, PE, RLS, AICP ..... Chairman, Executive Director Emeritus, SEWRPC, County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
John M. Bennett, PE ..... City Engineer-Director of Public Works, City of Franklin
John P. Casucci, RLS ..... Survey Land Development Manager, R. A. Smith National, Inc.
Harold S. Charlier, RLS ..... Executive Director, Wisconsin Society of Land Surveyors
Michael R. Duckett, PE, RLS ..... President, Duckett Group; Executive Director, Southeast Wisconsin Professional Baseball District
John T. Ellingson, PE, RLS ..... Wisconsin State Geodetic Advisor, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geodetic Survey
Thomas M. Grisa, PE ..... Director of Public Works, City of Brookfield
Gregory G. High, PE ..... Director; Architectural, Engineering and Environmental Services; Milwaukee County Department of Transportation and Public Works
Marcia G. Lindholm, PE ..... Civil Engineer Senior, City of Milwaukee Department of Public Works
Cecil F. Mehring, PE ..... Former Manager of Planning and Engineering Services, Racine County, Department of Public Works
George E. Melcher ..... Director of Planning and Development, Kenosha County
Robert W. Merry, RLS ..... Chief Technical Officer, Aero-Metric, Inc.
Kent B. Pena ..... State GIS Coordinator, USDA Natural Resources Conservation Service
Glen R. Schaefer, PE, RLS ..... Geodetic Engineer, Wisconsin Department of Transportation
Daniel R. Talarczyk, RLS ..... Survey Services Supervisor, Milwaukee Metropolitan Sewerage District
Thomas J. Tym ..... Head, Technology Services Department, Ruekert-Mielke, Inc.
William T. Wambach, PE, RLS ..... Former District Director, District 1, Wisconsin Department of Transportation

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Appendix B

MINUTES OF THE MEETINGS OF THE SEWRPC COMMITTEE ON TECHNICAL REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM FOR SOUTHEASTERN WISCONSIN

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INTRODUCTORY COMMENTS TO MINUTES

The deliberations of the Commission's Technical Advisory Committee on the Review and Reevaluation of the Regional Control Survey Program constituted an important basis for the conclusions and recommendations contained in the Consultant's report to the Commission. It was, therefore, deemed important to append a copy of the minutes of the Advisory Committee meetings to the Consultant's report. Such use of the Advisory Committee minutes had no precedent in long standing Commission practice concerning the preparation and use of the minutes of its advisory committees.

Therefore, the following procedure was used in preparing the minutes of the Advisory Committee meetings for presentation in this Appendix. The Committee members were, as usual, provided with a draft of the minutes of the first two meetings of the Committee for consideration and approval at the next succeeding meetings. The draft minutes were then revised in their entirety to reflect all of the changes directed to be made by the Committee in this initial review and approval of the draft minutes. The revised minutes were then submitted for further review and approval at another subsequent Committee meeting. Thus, a draft of the minutes of the first Committee meeting held on July 25, 2007 was provided to the Committee members for consideration and review at their meeting held on November 16, 2007. Those minutes were then revised in their entirety to reflect all of the changes directed to be made in the draft minutes by the Committee at the meeting held on November 16, 2007. A copy of the revised minutes was then provided to the Committee for further consideration and approval at the Committee meeting held on February 15, 2008. A similar procedure was followed with respect to the minutes of the meeting held on November 16, 2007. This procedure was necessarily modified with respect to the minutes of the last meeting held on February 15, 2008, since the minutes of that meeting were approved on the basis of a postcard ballot. Because of this unorthodox procedure, minute page numbers cited in the revised minutes refer to page numbers of the initial draft, and may therefore appear to be incorrect as cited in the revised draft.

The procedure was designed to provide an accurate record of the deliberations, conclusions, and recommendations of the Committee, and the minutes as herein presented were carefully considered and approved by the Committee for use by the Consultant in drafting his report, and by the Commission in considering that report. Careful review of these minutes is important to a good understanding of the conclusions and recommendations set forth in the Consultant's report.

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Southeastern Wisconsin Regional Planning Commission

Notice of First Meeting and Agenda

TECHNICAL ADVISORY COMMITTEE ON THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

DATE: July 25, 2007

TIME: 9:00 A.M.

PLACE: Regional Planning Commission Offices
Commissioners' Conference Room
W239 N1812 Rockwood Drive
Waukesha, WI

AGENDA:

1. Roll Call
2. Introduction of Committee members and staff
3. Commission Charge to Committee (copy enclosed)
4. Proposed procedure
5. Description and status of Commission control survey and mapping program
(copy enclosed)
6. Presentation of issues requiring consideration (copy enclosed)
7. Other business
8. Consideration of Date and Time of Next Meeting
9. Adjournment

Kurt W. Bauer
Chairman

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REVISED MINUTES OF THE FIRST MEETING

TECHNICAL ADVISORY COMMITTEE
FOR THE REVIEW AND REEVALUATION OF THE
REGIONAL CONTROL SURVEY PROGRAM

DATE: July 25, 2007

TIME: 9:00 a.m.

PLACE: Commissioners' Conference Room
Regional Planning Commission Offices
W239 N1812 Rockwood Drive
Waukesha, Wisconsin

Members Present

Kurt W. Bauer Chairman	Executive Director Emeritus, SEWRPC, County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
John M. Bennett	City Engineer-Director of Public Works, City of Franklin
John P. Casucci	Survey Land Development Manager, R.A. Smith National, Inc.
Harold S. Charlier	Executive Director, Wisconsin Society of Land Surveyors
John T. Ellingson	Wisconsin State Geodetic Advisor, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geodetic Survey
Thomas M. Grisa	Director of Public Works, City of Brookfield
Gregory G. High	Director; Architectural, Engineering and Environmental Services; Milwaukee County Department of Transportation and Public Works
Marcia G. Lindholm	Civil Engineer Senior, City of Milwaukee Department of Public Works
Cecil F. Mehring	Former Manager of Planning and Engineering Services, Racine County Department of Public Works
George E. Melcher	Director of Planning and Development, Kenosha County
Robert W. Merry	Chief Technical Officer, Aero-Metric, Inc.
Kent B. Pena	State GIS Coordinator, U.S. Department of Agriculture Natural Resources Conservation Service
Glen R. Schaefer	Geodetic Engineer, Wisconsin Department of Transportation
Daniel R. Talarczyk	Survey Services Supervisor, Milwaukee Metropolitan Sewerage District
Thomas J. Tym	Head, Technology Services Department, Ruekert-Mielke, Inc.

Members Absent

Michael R. Duckett	President, Duckett Group; Executive Director, Southeastern Wisconsin Professional Baseball District
William T. Wambach	Former District Director, District 1, Wisconsin Department of Transportation

Guest Present

David Ulatowski	Engineering Technician VI, City of Milwaukee Department of Public Works

Staff Present

Earl F. Burkholder	Consulting Geodetic Engineer
Donald P. Simon	Chief Planning Illustrator, SEWRPC; Deputy County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
Lynn G. Heis	Staff Secretary, SEWRPC

CALL TO ORDER AND ROLL CALL

Chairman Bauer called the meeting to order at 9:00 a.m. Roll call was taken by circulating an attendance signature sheet, and a quorum was declared present.

INTRODUCTION

Chairman Bauer welcomed the Committee members to the Commission offices; and, on behalf of the Commission, thanked the members for their willingness to serve on the Committee, and to make their experience and knowledge available to the Commission as a public service. He then asked each of the members present to introduce themselves and to provide a short description of their professional interests.

CHARGE TO COMMITTEE

Chairman Bauer presented the Regional Planning Commission's charge to Committee (copy attached.) He noted the charge in essence requests a critical review by the Committee of the Commission promulgated and implemented control survey and mapping program, and the formulation of recommendations for any needed changes in the program. There were no questions raised or comments made with respect to that charge.

PROPOSED PROCEDURE

Chairman Bauer outlined the procedure proposed to be followed in the conduct of the Committee's work. He noted that the Committee is to be staffed by Mr. Earl F. Burkholder, PLS, PE, Consulting Geodetic Engineer and faculty member of New Mexico State University. He indicated further, it was hoped the Committee could complete its work in three meetings.

In this, the first meeting, he said, the Committee would review a paper describing the control survey and mapping program promulgated and implemented by the Commission; and would review, discuss, and comment upon, a presentation by Mr. Burkholder setting forth the issues which needed to be considered by the Committee in order to respond to the Commission's charge to the Committee. Mr. Burkholder would then prepare a staff memorandum setting forth the technical and user concern issues involved, together with potential alternative and recommended Commission responses to those issues, giving due consideration to the Committee's deliberations and directions provided at the first meeting.

At the second meeting, he said, the Committee would review a preliminary draft of the memorandum prepared by Mr. Burkholder; and would direct revisions to be made in the memorandum, which the Committee may find necessary or desirable, with particular attention to the recommendations proposed to be made to the Commission.

At the third, and hopefully last meeting, he said, the Committee would review a revised draft of the staff memorandum, again with particular attention to the recommendations contained therein; direct any further changes in those recommendations found necessary, and consider approval of the Committee's recommendations as set forth in the final draft of the memorandum prepared by Mr. Burkholder. Upon approval of those recommendations, the Committee's findings and recommendations, as expressed in the memorandum, would be transmitted to the Commission for consideration and action.

There were no comments or questions concerning the proposed procedure.

DESCRIPTION AND STATUS OF COMMISSION CONTROL SURVEY AND MAPPING PROGRAM

Chairman Bauer indicated a copy of a paper describing the Commission promulgated and implemented control survey and mapping programs within the Region had been provided to all members of the Committee for review prior to the meeting (copy attached). He then undertook a review of the paper with the Committee. The following questions were raised and comments made during the course of the review.

Mr. Charlier called attention to the statement on page 78 of the paper on which the specifications covering the preparation of the cadastral maps were given, and asked about the origin of the specified 2.5-foot or more gaps or overlaps in adjoining property boundary lines that were to be shown on maps. Chairman Bauer indicated this specification was, intended to specify the gaps or overlaps, which as a practical matter, can be graphically shown on the maps. He noted further that the property boundary line dimensions shown on the cadastral maps were ground level dimensions, and noted the practice reflected was not theoretically correct in that those dimensions should be reduced to the map projection used.

In the discussion that followed, it was noted by Mr. Schaefer that the Wisconsin Department of Transportation (WisDOT) had originally introduced the Wisconsin County Coordinate System (WCCS) to avoid the need to apply the combination factor (scale and sea-level reduction factors) used with the State Plane Coordinate system in moving measured or recorded distances between the map projection and ground level – the so called grid to ground conversion. He also noted that the word "System" was singular in the Wisconsin County Coordinate System and the word "Systems" was plural in the Wisconsin Coordinate Reference Systems.

Mr. Grisa noted he was under the impression that the use of the State Plane Coordinate system in its classic form was widely, if not universally, accepted and expressed surprise at the use of the County Coordinate System. He noted the City of Brookfield required all land subdivision plats and certified survey maps be related to that system and that the City's cadastral maps and related land and public works information systems were based upon the State Plane Coordinate system. He expressed concern about the implications of any departure from this historic, and in his opinion, sound practice.

Chairman Bauer noted that, in his opinion, the creation and promulgation of the use of WCCS was a mistake, and reflected poor surveying and mapping practice. He noted that as originally developed by the WisDOT in 1995, the WCCS was in error, and that this error was corrected in 2006, when the new Wisconsin Coordinate Reference Systems (WISCRS) were developed. Mr. Ellingson indicated the WCCS developed in 1995 was, in fact, not in error, but utilized a nonconventional method to produce the grid coordinates, a method that was problematic to some of the user communities and to some software vendors.

Mr. Schaefer noted that a nonconventional method was indeed used in the development of the original County Coordinate systems, and that that method involved, in effect, raising the reference ellipsoid to near ground level, then developing the map projection; as opposed to the conventional approach of simply raising the map projection to near ground level. As a consequence, some users and some software vendors experienced difficulties in using the County Coordinate systems as originally developed He noted further that the reference ellipsoid used in the development of both the WCCS and the WISCRS was the Geodetic Reference System of 1980 (GRS 80); and not the Clark Spheroid of 1866, which was used nationwide in the original development of the State Plane Coordinate systems. This, he said, leads to the use of two geodetic datums – the North American Datum of 1927 (NAD 27) – used for the original State Plane Coordinate system and adopted by the Regional Planning Commission for use within the Region – and the North American Datum of 1983 (NAD 83) – used by the National Geodetic Survey (NGS) in developing a revised State Plane Coordinate system.

Mr. Ellingson indicated that in spite of the original nonconventional definition of WCCS, and the subsequent revision of the county coordinate system, the system was widely used within the State by the WisDOT and by counties and municipalities in the creation of automated geographic information systems including by Waukesha County. Chairman Bauer indicated, and Mr. Tym confirmed, that the county coordinate system was not used by any of the seven counties or 147 municipalities within the seven-County Southeastern Wisconsin Region as a basis for the creation of geographic information systems, parcel based land information systems, or public works management systems, all such systems within the seven-county Southeastern Wisconsin Region were based upon the State Plane Coordinate System—NAD 27.

Chairman Bauer noted, as Mr. Schaefer had indicated, that both the WCCS and the WISCRS were based upon the NAD 83. He noted further that the NGS had, since abandoning NAD 27 for NAD 83, adjusted data on the NAD 83 datum at least four times producing successively the NAD 83 (1986), NAD 83 (1991), NAD 83 (1997), and NAD 83 (2007) adjustments. Mr. Schaefer indicated that common usage refers to the four adjustments on the NAD 83 datum as different "datums," which is technically incorrect; e.g., the most recent adjustment – NAD 83 (2007) – should be referred to as the "2007 adjustment on the NAD 83 datum," but is often commonly called the "NAD 83 (2007) datum."

Mr. Merry noted that in all areas of Wisconsin outside of the seven-county Southeastern Wisconsin Region, most of his firm's mapping efforts were based upon the county coordinate system. He noted that the use of the two county coordinate systems, combined with and the use of different datums, had resulted in much confusion and difficulties in the conduct and use of control surveys and in the preparation and use of maps.

In answer to a question by Mr. Casucci, Chairman Bauer indicated the Commission was not at this time, proposing any changes to the use of the State Plane Coordinate system or NAD 27 nor in the use of the National Geodetic Vertical Datum of 1929 (NGVD 29) within the Region. Mr. Burkholder's report, he said, would have to address this, among other issues. In this respect he noted that the NGS had also adjusted the vertical datum in use within the United States, abandoning the NGVD 29 -- used as a basis for all of the Commission's work in this area -- for a new datum, the North American Vertical Datum of 1988 (NAVD 88). He noted that the differences in these two datums within the Region were just enough to cause confusion and errors, the differences ranging up to a maximum difference of about two-tenths of a foot within the Region. He indicated that, in his opinion, the United States would have been better served had the NGS followed the practice which he understood was adopted in Great Britain, namely to keep the older datums in use for land surveying and public works engineering purposes, and to use the newer datums for military and scientific purposes.

Mr. Talarczyk noted that the Milwaukee Metropolitan Sewerage District requires all District engineering design work to be conducted utilizing the State Plane Coordinate System – NAD 27. He noted that this appeared to present a problem for some vendors who are not experienced in geodetic surveying, and who attempt to utilize Global Positioning System (GPS) technology in field surveys by calibrating GPS measured coordinate values to NAD 27 coordinate values by calibration rather than making proper conversions. Rob Merry agreed with Mr. Talarczyk indicating that when attempts are made to calibrate GPS readings to existing control survey data, and particularly so when different datums are involved, errors may be introduced in a number of ways, some simply through the occupation of control survey station monuments that have been disturbed. Chairman Bauer observed, with respect to the example cited, that anyone following good surveying practice would know if a Commission monument had been disturbed since the Commission's control survey station recovery forms – the so called dossier sheets – contain tie distances to reference marks, which distances should be checked before a monument is used.

PRESENTATION OF ISSUES REQUIRING CONSIDERATION

Chairman Bauer then asked the Committee to, in effect, continue its discussion under Item 6 of the agenda – the presentation by Mr. Burkholder of the issues requiring consideration in the effort to address the Commission's charge to the Committee. He noted Mr. Burkholder had set forth a preliminary list and attendant descriptions of such issues, and that a copy of this list and descriptions had been provided to all members of the Committee for review prior to the meeting (copy attached.) He then asked Mr. Burkholder to undertake a review of the issues and description document with the Committee.

Mr. Burkholder indicated he had prepared the preliminary list and description of issues that needed to be addressed to elicit discussion of the issues and thereby assist in completing a critical review of the Commission's control survey and mapping efforts. Mr. Burkholder stressed that he was present to listen to the comments of the Committee members, which comments he would then consider in preparing a preliminary draft of the desired report to the Commission. He then proceeded with a presentation of the list. The following questions were raised and comments made during the course of the presentation.

Mr. Burkholder noted that the issue of datum definitions had, at this point in the meeting, already been discussed. He noted that this was a major issue with respect to the Commission program, and noted that the Commission had in the past attempted to address this issue by commissioning the preparation of SEWRPC Technical Report No. 34 "A Mathematical Relationship Between NAD 27 and NAD 83 (1991) State Plane Coordinates in Southeastern Wisconsin," December, 1994 and a companion SEWRPC Technical Report No. 35 "Vertical Datum Differences in Southeastern Wisconsin," December, 1995. Copies of these reports, he noted, were available for examination at this meeting.

In answer to a question by Chairman Bauer, Mr. Merry indicated he had used the State Plane Coordinate conversion methodology presented in SEWRPC Technical Report No. 34, and had found it to provide better conversion results than did NADCON, the method promulgated by the NGS for such conversions.

Mr. Schaefer indicated that the Commission, practicing land surveyors, and public works engineers were in reality faced with the existence of multiple horizontal and vertical datums, and that this "fact of life" should not be expected to change. He indicated further that with the introduction and increasing use of Global Positioning System (GPS) technology, the issue of

these multiple datums was a source of potential confusion and error, and it was therefore essential that practitioners gain a good working knowledge of the problems concerned and the means for their resolution. He indicated further that, in his opinion, those means lay in the development of conversion methodologies that provide the levels of accuracies required for land surveying and public works engineering purposes. For certain applications, he said, the desired conversions may require additional field surveys. He also noted that the use of GPS technology required a working knowledge on the part of land surveyors and civil engineers of geodetic surveying principles and practices, whereas historically knowledge of plane surveying principles and practices was adequate.

Mr. Burkholder observed the need to distinguish between absolute and relative values, absolute values being expressed in terms of coordinate values – albeit those values being based upon differing datums; relative values being expressed in terms of direct measurements. When one moves from one datum to another, he said, the shift is in the absolute values, the relative values remain unchanged. The relative value of the data expressed in terms of NAD 27 and NGVD 29 remain valid; when these values are expressed in the context of different datums a problem may be created for some users.

With respect to the issue of the maintenance of, and continued reliance on, monuments as a basis for the control of land and public works engineering surveys, Chairman Bauer distributed a letter and attachments from Mr. Wambach, a Committee member who was unable to attend today's meeting, noting that Mr. Wambach felt very strongly about the need to continue to maintain the monuments marking the U.S. Public Land Survey System. In the discussion which followed, a strong consensus was expressed in the Committee that the monuments marking the U.S. Public Land Survey System within the Region needed to be maintained for both technical and legal reasons as a basis for the conduct of land and public works engineering surveys within the Region.

Mr. Burkholder called attention to the Height Modernization Program funded by the NGS and carried out within Wisconsin by the WisDOT. Chairman Bauer noted that the Commission made a substantial effort to maintain a network of bench marks within the Region that provide orthometric heights at an accuracy level adequate for land and public works engineering surveys. He noted that the introduction of GPS technology raised a question as to whether or not this network should continue to be maintained if it becomes possible to obtain orthometric heights within the Region with sufficient accuracy by GPS technology. He noted further that some consulting firms within the Region were using GPS technology in conjunction with the Commission bench marks to obtain, in effect, geoid heights, and then to use those heights to obtain orthometric elevations in the conduct of sanitary and storm sewer system maintenance.

Chairman Bauer indicated the Commission had received little information about the extent to which the bench marks are used by land surveyors and public works engineers. Messrs. Bennett, Casucci, Grisa, and Talarczyk all indicated their agencies extensively use the Commission bench marks in the conduct of their surveying activities.

Mr. Burkholder noted that the issues of height modernization could also be extended to include the use of ellipsoid heights in place of orthometric elevations. Chairman Bauer observed that this may be another case of geodesists needlessly complicating the work of land surveyors and civil engineers for no good practical reason.

In answer to a further question by Chairman Bauer, Messrs. Bennett, Grisa, and Talarczyk indicated that the Commission bench marks provide an adequate level of accuracy for public

works engineering purposes. Messrs. Merry and Schaefer indicated GPS technology was being used to develop orthometric heights in areas where there is a minimal amount of vertical control to bring such control to a site and then perform spirit level surveys within the site.

Mr. Bennett indicated that, in his opinion, the control survey and attendant mapping system promulgated by the Commission over the last forty years works very well, and that its use has not presented any significant problems within the City of Franklin, nor apparently within all of Milwaukee County and all of the Milwaukee Metropolitan Sewerage District service area. He indicated the decision by the WisDOT to shift to new datums is a cause for concern and the potential impacts of this shift need to be addressed along with the means for resolution. Mr. Bennett further observed that the City of Franklin no longer uses hard copy analogue maps keeping both topographic and attendant cadastral maps in solely digital format. It may be feasible, he said, to convert such digital maps to a new datum by computer manipulation. Chairman Bauer cautioned against total reliance upon digital formats for maps, indicating such reliance places the agency concerned at the mercy of vendor changes in software and hardware systems. He noted that digital maps prepared for Waukesha County approximately two decades ago could no longer be "read," and the costly data would have been lost if hard copies of the maps concerned had not been kept. Mr. Casucci agreed, indicating that vendors were changing Autocad software on a virtually six-month basis at substantial costs to the users.

Mr. Schaefer observed that the reason cited for maintaining hard copies of maps are analogous to the reasons why monuments should continue to be used to perpetuate the location of control survey stations.

Mr. Ellingson said that in his opinion, continued reliance and use of the old State Plane Coordinate System based on NAD 27 was a mistake and consideration should be given to a data conversion, which would modernize the Commission's control survey system. Mr. Merry indicated that, given the constant revision of the horizontal adjustments by NGS, remaining with the Commission's State Plane Coordinate system based on NAD 27 was not such a bad thing. Mr. Casucci agreed with Mr. Merry noting not only that stability in the coordinate values was highly desirable, but that a shift within the seven-County Region would entail massive and costly adjustments to the automated land information systems which have been created within the Region.

Mr. Melcher also agreed with Mr. Merry, indicating Kenosha County had relied on the Commission's mapping system to create the County automated parcel based land information system, which system performed well, and he did not wish to see money wasted in needless changes.

Mr. Grisa indicated if a shift in the Commission's datum and coordinate values was to be considered, it would be essential that those proposing the shift demonstrated the benefits of the shift would exceed the massive costs entailed.

Mr. Tym indicated that certainly any benefits from such a shift were highly problematic. He noted that the relative positions of the control survey monument and the attendant distances and bearings would not change; therefore, he asked, what benefit would accrue to moving the coordinate positions of property boundaries, street rights-of-way, storm and sanitary sewer system, manholes, water system hydrants and valves, public utility poles, and the myriad of details contained in the new, well developed, land information systems within the Region. Mr. Grisa agreed with Mr. Tym indicating that the shifts Mr. Ellingson was proposing had no practical implication for land surveyors or public works engineers, and the confusion that would

be created in the administration of comprehensive zoning ordinances, and in flood plain and wetland regulation, would become a major problem as seen by elected officials.

Chairman Bauer indicated the matter of multiple datums and the need for conversion of coordinate values based upon differing datums was one of the important issues Mr. Burkholder would have to address in his report to the Commission. He noted that changing technology, such as the use of GPS technology, and the introduction of real time kinematic (RTK) surveying techniques based upon continuous operating reference stations (CORS) within the Region made addressing this issue critical.

Mr. Schaefer noted that the WisDOT was in the process of establishing a network of CORS stations within the State for use by the WisDOT in its surveying work. When the network of such stations is in place and found to be operating properly, it is likely the WisDOT will facilitate their use for the conduct of RTK surveys by other public and by private agencies. Mr. Ellingson noted the system would be based upon NAD 83 (2007).

Mr. Bennett said that, in his opinion, Southeastern Wisconsin had one of the best control survey and mapping systems in the world, or at least in the United States, and he has found, through his professional associations, that the system is in fact, the envy of other public works professionals. He indicated further, that the City of Franklin had established its own CORS station and had experienced no trouble of any kind in the use of the Commission coordinate values in the conduct of RTK and other engineering surveys within the City. If the Federal and State governments are determined upon the use of coordinate systems based on other datums, then the matter of conversion between systems will have to be addressed. The Commission system should not however, in any case, be abandoned.

Mr. Schaefer indicated perhaps some additional background information on WisDOT's work would be helpful to the Committee in its deliberations. He noted WisDOT was establishing a virtual reference system utilizing initially 25 CORS stations based upon NAD 83 (2007). The NGS has promised they would provide the parameters identifying the differences between, and the means for converting between, the NAD 83 (2007) adjustment and previously used NAD 83 datum adjustments. The NGS has not as yet provided those parameters, he said. In addition to the use of RTK technology in horizontal survey work, WisDOT desired to utilize this technology to obtain orthometric elevations on points, and to transfer orthometric elevations between points, but realized in the mid-1990s that the ellipsoid heights required to accomplish this were not available at the accuracy required. Therefore, WisDOT conducted observations in 1997 at 78 of the original 80 HARN stations established in 1991. However, the parameters needed to convert between NAD 83 (1991) and NAD 83 (1997) have to date not been provided by NGS. As a result, a number of WisDOT projects are currently using the NAD 83 (1991) adjustment coordinates and some projects are using the NAD 83 (1997), or NAD 83 (2007) adjustment coordinates. He indicated WisDOT addresses this issue by reoccupying common stations and creating its own conversion parameters. Mr. Schaefer noted further that parameters would have to be provided to move between the newer datums and NAD 27 at desired accuracy levels. Depending upon the accuracy levels desired, this may require, he said, reobservation at some points in the older system so coordinate values are available at the selected points in both the old and new systems.

Mr. Casucci indicated issues involving the horizontal and vertical datums should be separated and indicated he would be concerned about any efforts to convert horizontal locations. Chairman Bauer indicated since multiple datums already exist, it would appear that a means will have to be devised by which conversions can be made between coordinates expressed on the

NAD 83 (2007) datum used by the CORS stations being installed by WisDOT, and the NAD 27 datum with sufficient accuracy for land surveying and public works engineering purposes. Mr. Merry indicated it should be possible to accomplish this without additional field surveys, since GPS positioning essentially provides latitude, longitude, and ellipsoid heights.

Mr. Casucci indicated that perhaps the solution would be to utilize latitude and longitude on the dossier sheets and control survey diagrams. Chairman Bauer observed this would not resolve the issue of multiple datums since the values for latitude and longitude derived from different datums would still be different.

Mr. Ellingson suggested a practice be initiated of simply recording positions in NAD 83 (2007) as they are obtained by surveyors when utilizing existing U.S. Public Land Survey monuments. If this were done, he said, over time it should become possible to do a system readjustment and move, thereby, from NAD 27 to the NAD 83 (2007) coordinate values. Mr. Merry disagreed indicating the accuracy of the derived new coordinate values would be a major issue, since it would be unknown if the field operations associated by different land surveyors and public works surveyors were done in a manner which would meet the desired accuracy values. Chairman Bauer agreed, noting that great care had been taken to meet the Commission specified accuracy levels of Third-Order, Class I for the horizontal control survey network, and Second-Order, Class II for the vertical control survey network. This care required rigidly following NGS practices with respect to instrumentation and procedures.

The meeting was adjourned at 12:00 noon for lunch and reconvened at 12:30 p.m.

Chairman Bauer opened the reconvened meeting by noting that the discussion engendered by Mr. Ellingson just before lunch raised the issue of the need for metadata with respect to the Commission control survey and mapping system. He noted that a careful review of the land surveyor certificate on the Commission Record of U.S. Public Land Survey Control Station, the so called dossier sheets, will show that that certificate provides all of the needed metadata with respect to the U.S. Public Land Survey corner perpetuation involved. The certificate sets forth the "pedigree" of corner monumentation extending as far back in time as possible, often to the original work of the U. S. Government surveyors in 1836. With respect to the coordinate values, the metadata exist in the reference on the sheets to the accuracy levels of the horizontal and vertical control surveys concerned, namely, Third-Order, Class I and Second-Order, Class II, respectively. The field and computational practices involved in the conduct of the surveys follow NGS specifications with respect to both instrumentation and use of that instrumentation. The metadata for the topographic maps consist of the notation on each map sheet that the map meets National Map Accuracy Standards; compliance with those standards having been field checked by the Commission staff. Metadata for the cadastral maps consist of the notation on each map sheet that the map meets published Commission specifications governing the preparation of the map. The issue of the provision of metadata for the attribute data used in the compilation of the parcel based land information and public works management systems is the responsibility of the counties and municipalities involved in the creating of those systems. He noted that the provision of metadata for control survey data developed by the conversion of the existing Commission State Plane Coordinates would be another issue Mr. Burkholder would have to address in his recommendations to the Committee and the Commission.

In answer to a question from Chairman Bauer, Mr. Schaefer indicated with respect to vertical control, WisDOT was utilizing the NAVD 88 datum. Mr. Schaefer noted that the Height Modernization Program was conducted by WisDOT in five phases, to date, covering different geographic areas of the State. Upon completion of those first five phases, it was determined to

adjust all differential level data acquired and the adjustment to be constrained by only two points in southwestern Wisconsin. As a result, the elevations as determined by the adjustment made in 2007 are different from the elevations for bench marks in southeastern Wisconsin which were previously published in 2004. No means for developing and presenting the metadata in a readily useable form has as yet been developed by the NGS. Consequently, WisDOT is using the syntax of NAVD 88 (1991) for the first adjustment and NAVD 88 (2007) for the most recent adjustment. Data adjusted in 2004 are based on the NAVD 88 (1991) adjustment.

Mr. Charlier indicated that there had been no discussion of the potential costs involved in any recommended changes to the Commission system, and asked whether the provision of such costs was a responsibility of the Committee. Chairman Bauer responded that Mr. Burkholder would, in his report, have to include estimates of the costs of the implementation of any of his recommendations, together with potential sources of funding.

In answer to a question by Mr. Tym, Mr. Burkholder indicated his report would have to identify alternative approaches to the resolution of the issues identified, together with a preferred alternative. Chairman Bauer noted in this respect, that doing nothing was always an option, and that even the maintenance of the U.S. Public Land Survey corner monuments could be abandoned and the use of vertical monuments substituted. The actual monuments, he said, were being disturbed or destroyed at the rate of approximately 4 percent a year.

Mr. Grisa indicated he was uneasy about Chairman Bauer's comments concerning a do-nothing option, the implication being that such an option would have zero costs. In reality, he said, that option would carry with it major costs, not only in land and public work engineering survey operations which would be carried out in the absence of a monumented control survey network, but in related potential errors in the administration of land use control ordinances and in the construction of facilities.

Mr. Grisa asked if Mr. Burkholder's report would document what other metropolitan areas in the U.S. may be doing in this respect, and what institutional structures were being used for the programs concerned. Chairman Bauer indicated the scope of work and funding for Mr. Burkholder's efforts did not extend to include a survey of practices elsewhere. He noted that automated geographic information, parcel based land information, and public works management systems were being created in a large number of places and that articles describing those efforts occasionally appear in trade publications such as *Public Works Magazine* and *POB,* but rarely in peer reviewed journals. He noted that it was his experience that the creation of these systems was generally the purview of data management personnel who have very little in-depth understanding of geodesy, survey control, or mapping.

Mr. Merry observed that the Commission has compiled a massive, invaluable database which supports the efficient conduct of land and public works engineering surveys within the Region, and the preparation of the foundational elements of automated land and public works information systems. He also stated that the area stands well ahead of the rest of the nation in this respect, having done for decades what other areas are only now beginning to do.

Mr. Grisa noted that if the Commission discontinued its operations in the control and survey mapping areas, then the question would have to be answered as to how that work would be performed – at the individual county or municipal level, or by the creation of another area-wide entity.

Chairman Bauer asked for comments on the adequacies of the record of U.S. Public Land Survey Control Station sheets – the so called dossier sheets – and the control summary diagrams. He noted that while there are reference bench marks set for every remonumented U.S. Public Land Survey corner, other bench marks exist in the area, including NGS, U.S. Geological Survey, WisDOT, Milwaukee Metropolitan Sewerage Commission, Racine County, City of New Berlin, City of Milwaukee, and Commission bench marks, ranging in order from first through third order, and that the Commission maintains a file of these bench marks that is available to potential users. The dossier sheets, he noted, contained to the extent practicable, an azimuth mark. In addition to these marks – which usually consist of another U.S. Public Land Survey corner visible from the corner concerned, the Commission maintains a file on Commission traverse stations, which are sometimes useful in the conduct of local surveys, and the data for such stations are available from the Commission.

Ms. Lindholm indicated that the control summary diagrams are sometimes reissued with changes in the distances and bearings concerned without accompanying revised dossier sheets, so that the reason for the changes are not readily apparent – being potentially attributable to either resurveys or to changes in monumented corner positions or both. A means for correcting this deficiency would be helpful, she said.

Mr. Ellingson indicated that if the Commission could solicit and obtain data on the coordinate positions of the monumented corners as determined on an ad hoc basis by the field reoccupation and use of the corners from the users, and if the quality of the coordinate data submitted was controlled, this would over time provide a valuable database correlating NAD 27 with the new NAD 83 (2007) positions. A compilation of such data over time would make a future translation possible at minimum cost. Mr. Casucci agreed with Mr. Ellingson indicating that the collection and cataloguing of such GPS observations would be desirable.

Mr. Schaefer cautioned that if a means of converting from NAD 27 to NAD 83 (2007) is developed which provides sufficient accuracies for the uses intended and if new field observations are made through the ad hoc reoccupation of a station using GPS technology, and if such resurvey indicates a discrepancy between the coordinate values concerned, care will have to be taken to determine the reason for the discrepancy; which could lie in, among other sources, the field procedures used, or in some cases, in disturbance of the monument concerned.

There being no further questions or comments, Chairman Bauer attempted to summarize the Committee deliberation in order to assist Mr. Burkholder in the preparation of the preliminary draft of his report. Chairman Bauer indicated he perceived a Committee consensus exists with respect to the following points:

1. Land surveyors and public works engineers practicing within the Region have found the control survey system and attendant large-scale mapping program promulgated by the Commission to be adequate for the conduct of land and engineering surveys within the Region, and as the foundational elements for the creation of good automated parcel based land information and public works management systems; the horizontal datum utilized being NAD 27 and the vertical datum utilized being the NGVD 29.

2. Land surveyors and public works engineers were, in reality, faced with the existence and use of multiple horizontal and vertical geodetic datums within the Region, and that this situation should not be expected to change.

In this respect, four horizontal adjustments on the NAD 83 datum have been made all of which are in use within the seven county Region since the abandonment of the NAD 27 datum by NGS: NAD 83 (1986), NAD 83 (1991), NAD 83 (1997), and NAD 83 (2007). To date, two vertical adjustments on the NAVD 88 datum have been made by NGS upon its abandonment of the NGVD 29 datum; namely NAVD 88 (1991) and NAVD 88 (2007). All of these adjustments result in shifts in the absolute position of the points involved, but do not significantly change the relative positions of the points to other points within the Region; an exception being when a new value is assigned to a monument, which has been subjected to local movement.

The abandonment of the NAD 27 datum and adoption by the NGS of the NAD 83 datum gives rise to the existence of two State Plane Coordinate Systems within the Region. Moreover, the decision by the WisDOT to create and utilize County Coordinate systems in order to eliminate the need to make grid to ground corrections creates a third coordinate system within the Region. All land surveys recording the creation of land subdivision plats and certified survey maps within the Region, and all automated, parcel based land information and public works management systems created within the Region by the seven counties, the Milwaukee Metropolitan Sewerage District, the individual municipalities and the Commission staff are based on the State Plane Coordinate System, NAD 27.

3. The Commission promulgated control survey system based upon the NAD 27 and NGVD 29 datums have been used within the Region for over forty years in the conduct of land and engineering surveys; the preparation of land subdivision plats and certified survey maps; the compilation of large-scale topographic and cadastral maps; and in the creation of extensive parcel based land information and public works management systems.

   The most recent application of the Commission survey control network has been in the operation of the Diggers Hotline Program within the Region which utilizes maps prepared to Commission standards, and are based on NAD 27. The Wisconsin Electric Power Company has indicated it is able to save over $1 million per year through the ability to accurately place, in a timely way, new subdivision plats on Diggers Hotline maps compiled to Commission standards and on the Commission promulgated datums.

4. The introduction of GPS technology makes it imperative the Commission address the issue of the existence of multiple datums and multiple adjustments in order to preserve the utility of its horizontal and vertical control survey network. GPS survey techniques provide highly-accurate horizontal positions in the form of earth centered latitude, longitude, and ellipsoid heights. The ellipsoid heights could be converted to orthometric elevations if geoid heights concerned are known with sufficient accuracy for the purposes intended.

   The use of GPS technology will be further facilitated within the Region by the establishment by WisDOT of continuously operating reference stations (CORS) within the Region that will facilitate the efficient conduct of real time kinematic survey operations within the Region. The CORS stations are to be related to the NAD 83 (2007) datum.

5. Given the changes in geodetic datums and survey techniques, it will be important, if not essential, for the Commission to develop a means for converting between horizontal

positions expressed in NAD 27 coordinates and such positions expressed in NAD 83 (2007), and between NGVD 29 and NAVD 88 (2007). The Commission has already developed a means for such conversion between NAD 27 and NAD 83 (1991) and between NGVD 29 and NAVD 88 (1991). These methods are set forth respectively in SEWRPC Technical Report No. 34, *A Mathematical Relationship Between NAD 27 and NAD 83 (1991), December, 1994* and SEWRPC Technical Report No. 35 *Vertical Datum Differences in Southeastern Wisconsin, December, 1995*. These conversion methods are sufficiently accurate for most land survey and public works engineering purposes, although not for control survey purposes.

6. The continued use of the Commission's control survey network based upon the NAD 27 and NGVD 29 datums will require understanding by land surveyors and public works engineers of the relationship between these datums and the NAD 83 (2007) and NAVD 88 (2007) datums; of the means for converting between these datums; and of accuracies, both absolute and relative, involved in the conversions.

7. The costs and benefits entailed in any proposed conversion of Commission data from NAD 27 and NGVD 29 to NAD 83 (2007) and NAVD 88 (2007), would have to be assessed when consideration of such conversion.

OTHER BUSINESS AND CONSIDERATION OF DATE AND TIME OF NEXT MEETING

Chairman Bauer noted that he had already reported the only correspondence received and addressed to the Committee, namely Mr. Wambach's letter of July 28, 2007, concerning the importance of monuments in the preservation and use of the U. S. Public Land Survey System, (copy attached.)

Chairman Bauer then asked the members of the Committee if there were any further business to consider. There being none, Chairman Bauer then asked the Committee to consider a date and time for the next Committee meeting.

After a brief discussion, it was agreed the next meeting of the Committee would be held on Friday, October 26, 2007, at the Commission offices beginning at 9:00 a.m.

ADJOURNMENT

There being no further business to come before the Committee, on a motion by Mr. Melcher, seconded by Mr. Bennett, and carried unanimously, the meeting was adjourned at 3:45 p.m.

Respectfully Submitted,

Lynn G. Heis
Committee Secretary

KWB/lgh
01/02/08
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ATTACHMENT I

COMMISSION CHARGE TO COMMITTEE

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COMMISSION CHARGE TO COMMITTEE

The Regional Planning Commission has, for over 40 years, promulgated and been engaged in the establishment of a control survey network within the Region intended to serve as a framework for the conduct of land and engineering surveys; for the preparation of large scale topographic and cadastral maps; and as a sound foundation for the creation of parcel based land and public works information systems within the seven county Southeastern Wisconsin Region. Given that the Commission recommended control survey network has now been in place and in use for some time, and given the major changes that have occurred in surveying and mapping technology over the last approximately twenty years, the Commission believes that a critical review and reevaluation of the status, and continued utility, of the network, and of the Commission's role in the perpetuation of that network to be in order.

Accordingly, pursuant to Section 66.0309(7) of the Wisconsin Statutes, the Commission has established a Technical Advisory Committee to assist it in the desired review and reevaluation of the regional control survey and mapping program. The Commission desires the Committee to:

1. Critically review and reevaluate the status and continued utility of the Commission control survey network;

2. Recommend any needed changes in the network and in the means for its perpetuation, maintenance and use; and

3. Recommend the Commission's role, if any, in the perpetuation, maintenance and use of the network and identify any attendant funding requirements and sources.

In conducting the desired critical review and reevaluation, the Committee should give due consideration to the continued need for the control survey network to provide a framework for the conduct of land and engineering surveys within the Region; and to serve as one of the foundational elements for automated parcel based land and public works information systems within the Region.

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ATTACHMENT II

DESCRIPTION OF REGIONAL CONTROL SURVEY AND MAPPING PROGRAM

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A Control Survey and Mapping Project for an Urbanizing Region (A Study in Persistence)

K.W. Bauer, PE, RLS, AICP

ABSTRACT: In 1964, the Southeastern Wisconsin Regional Planning Commission proposed a large-scale topographic and cadastral mapping program for its 2,689 square-mile seven-county planning area. The integrated maps were to be based upon a then unique system of survey control which combined the U.S. Public Land Survey System with the State Plane Coordinate System, and which could provide a sound basis for the conduct of land and engineering surveys throughout the planning area. The Commission has pursued implementation of the recommended control survey and mapping program for 40 years. Under the program, all 11,753 U.S. Public Land Survey corners within the planning area have been remonumented and placed upon the State Plane Coordinate System by high-order traverse and global positioning system surveys. Elevations of bench marks accessory to the remonumented corners have been obtained by high-order differential level circuits, thus placing a monumented control survey station of known position on both the U.S. Public Land Survey and State Plane Coordinate Systems, and of known elevation, at one-half mile intervals throughout the planning area. Large-scale topographic maps have been completed for about 89 percent of the planning area and companion cadastral maps for about 76 percent of the planning area. The mapping and control survey system has served the area well over time, facilitating area-wide and local planning, engineering, and surveying operations. Importantly, the mapping and control survey system has provided a sound basis for the creation of computerized, parcel-based land and public works information systems within the planning area.

Introduction

Southeastern Wisconsin is one of the large urbanizing regions of the United States. The seven constituent counties comprising the region—Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha—have a combined area of 2,689 square miles, representing about five percent of the total area of the State. The region, however, contains about 36 percent of the resident population of Wisconsin, provides about 37 percent of the total employment in the State, and contains about 40 percent of all the tangible wealth of the State, as measured by equalized assessed valuation. There are 147 cities, villages, and towns within the seven-county region, which increasingly function as a single socio-economic unit.

The extensive land-use development and redevelopment occurring within the region generates a high demand for land and for supporting public works facilities of all types; and, in turn, for the services of the professionals involved in surveying and mapping; transfer of title to land and improvements; assessment and appraisal of real property; and construction and reconstruction of public works facilities. The proper planning and design of land-development projects and of supporting public works facilities within the region require constant attention to two factors: the land itself with its topography and other physical characteristics, and the boundaries of real property ownership. Definitive information about these two factors is essential if land is to be properly developed, and if supporting public works are to be soundly conceived and effectively executed. The need to provide this information, in turn, generates a need for a control survey network, both as a basis for the production of adequate topographic and cadastral maps, and as a basis for the cost-effective execution of land use and engineering surveys which can be properly integrated on an area-wide basis.

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Conceptualization of the Proposed Control Survey and Mapping Program

The Southeastern Wisconsin Regional Planning Commission was created pursuant to State law in 1960 as the official planning agency

for the seven-county southeastern Wisconsin region. From its inception, the Commission recognized the need for accurate large-scale topographic and cadastral maps as a basis for a sound regional planning program; and the concomitant need for the establishment of a control survey network as a basis for the preparation of the needed maps.

In February 1964, the Commission published a report setting forth a recommended large-scale topographic and cadastral mapping program and an attendant—at the time—unique control survey system, both as a basis for the preparation of the needed maps and the conduct of land and engineering surveys within the seven-county region (SEWRPC 1964).

In the report, the Commission held that it was essential that the control survey system meet two basic design criteria if the maps based upon it were to be effective planning and engineering tools. First, the control survey system was to permit the accurate correlation of real property boundary line maps with topographic maps. Second, the control survey network was to be monumented on the ground so that lines on the maps could be accurately reproduced in the field, when planned land-use development and supporting public works projects reach the construction stage. That is, for planning and engineering purposes, the control survey system was to provide not only the foundation for the preparation of maps which accurately reflect both topographic and cadastral conditions, but also maps with lines which could be readily and accurately reproduced upon the ground as well. The topographic and cadastral maps were to be prepared at scales large enough not only for comprehensive planning, but also for detailed site-development planning and preliminary engineering. Importantly, the topographic and cadastral maps were to be based upon a common control survey network so that the two types of maps could be accurately correlated.

Adopted Control Survey and Mapping Program

Based upon the requirements set forth in the conceptualization stage, the Commission adopted a then unique control survey system which combined the U.S. Public Land Survey and the National Geodetic Control Survey Systems. The system required the relocation and monumentation of all U.S. Public Land Survey section and quarter-section corners, including the centers of sections, and the utilization of these corners as stations in Third Order Class I traverse surveys and Second Order Class II differential level surveys; the high-order traverse and level surveys being tied, respectively, to the national horizontal control survey system and the national vertical control survey system.

It was determined that these orders of control survey accuracy would be adequate as a basis, not only for the needed mapping, but also for the conduct of land and engineering surveys throughout the region. The traverse network was to establish reliable grid lengths and grid bearings for all quarter-section lines, as well as the geographic positions, in the form of state plane coordinates, of the U.S. Public Land Survey corners; while the level network was to establish reliable elevations for the monuments marking the U.S. Public Survey corners and of certain accessories thereto. The State Plane Coordinate values were to be based upon the North America Datum of 1927 (NAD 27), while the elevations were to be based upon the National Geodetic Vertical Datum of 1929 (NGVD 29)—the datums at that time promulgated by the federal government.

The adopted control survey system provides a common system of control for real property boundary lines as well as for topographic mapping, and for the conduct of both land and engineering surveys. Since all new land subdivision plats must, by State law, be tied to corners established in the U.S. Public Land Survey, and since the accuracy of these plats can be controlled by local land subdivision regulations, the property boundary line maps can be readily and accurately updated and extended into newly developing areas. By locating and monumenting the U.S. Public Land Survey corners and accurately placing these corners on the State Plane Coordinate System, it becomes at once possible to prevent the future loss of these corners and to make the use of the State Plane Coordinate System practical for land and engineering surveys.

The ability to accurately correlate topographic and real property boundary line data by simple overlay techniques (analogue or digital) provides great savings in research time during the planning and design phases of municipal public works projects. Such correlated information makes possible the consideration and analysis of many alternative configurations for such proposed public work facilities as drainage and flood control works, trunk sewers, water

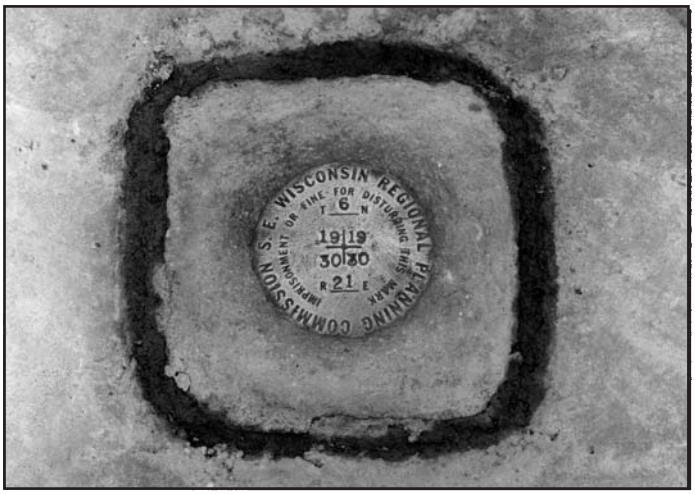


Figure 1. A survey monument installed to mark a U.S. Public Land Survey corner in the traveled way of a road. The monument is set slightly below the surface of the road. In open areas, monuments are set flush with the surrounding surface.

transmission lines, and major traffic ways, and thereby consideration and evaluation of many alternative solutions to drainage, sewerage, water supply, and transportation problems.

The adopted control survey system places a monumented, recoverable control survey station of known position on the U.S. Public Land Survey System and the State Plane Coordinate System, and provides bench marks of known elevation, at approximately one-half-mile intervals throughout the planning area. This monumented control survey network not only expedites the conduct of surveys that are made almost daily, year in and year out, by public work agencies for planning, design, and construction layout purposes, but also correlates and coordinates all survey work throughout the planning area. In this regard, the adopted control survey system is particularly valuable in providing for the preparation of accurate as-built records for the mapping of underground utilities.

The adopted control survey system also makes the State Plane Coordinate System available, as a practical matter, for property boundary survey control, without violating long established principles of boundary law and land survey practice. Importantly, the system provides the foundation for the creation of modern, automated, parcel-based, land information systems and public works management systems.

Specifications for Control Survey and Mapping

The specifications governing the control survey work require that the monuments placed to mark the located public land survey corners consist of pre-cast, reinforced, concrete monuments having engraved brass caps embedded in the tops (Figure 1). The monuments are usually set flush with, or set slightly below, the surface. The set monuments are referenced by measured ties to at least four witness marks. A U.S. Public Land Survey monument record—or dossier sheet—is prepared for each corner monumented so as to facilitate its ready recovery and use. These dossier sheets are prepared in an 8.5 by 11 inch format and identify the corner, the state plane coordinates of the corner, and the elevation of the monumented corner. The sheets contain a sketch showing the monument erected in relation to the salient features of the immediate vicinity—i.e., all witness monuments set together with the attendant ties to the corner, the elevation of supplementary bench-marks, and a bearing to an azimuth mark visible from the station. The dossier sheets also contain a surveyor's affidavit indicating how the corner was located and identifying any discrepancies between the corner as located and any previous locations (Figure 2).

The specifications require that the horizontal control surveys used to determine the State Plane Coordinate positions of the monumented corners meet Third Order Class I accuracy, as defined by the Federal Geodetic Control Committee. Furthermore, they require that the vertical control surveys used to determine beach wash elevations meet Second Order Class II accuracy, as defined by the Federal Geodetic Control Committee.

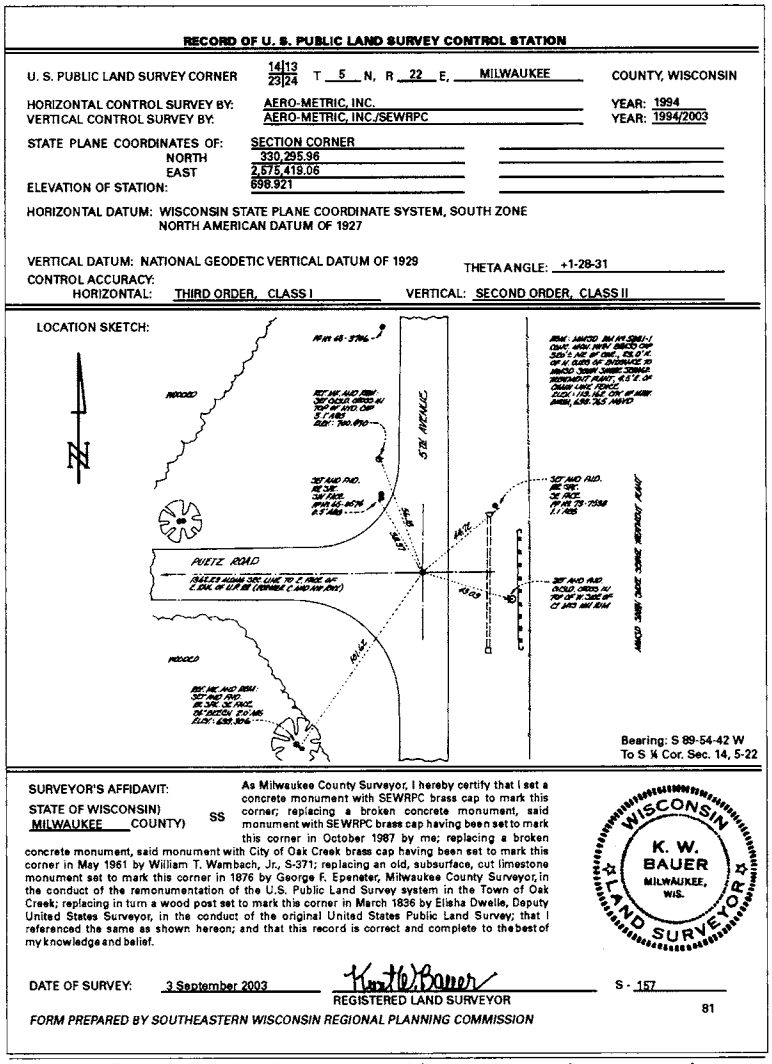
The control survey information is presented in a series of control survey summary diagrams, each diagram covering six U.S. Public Land Survey sections. The diagrams show:

- All monuments erected;
- The ground-level lengths, the sea level-grid lengths, and the grid bearings of the exterior boundaries of each quarter-section surveyed;
- The number of degrees, minutes, and seconds in the interior angles of each quarter-section surveyed;
- The state plane coordinates of all quarter-section corners set, together with their U.S. Public Land Survey System identification;
- The elevations of all monuments set; and
- The basic survey control stations established by the U.S. Coast and Geodetic Survey and

used to tie the public land survey corners to the geodetic control datum, together with the coordinates of those stations.

The angle between the geodetic and grid bearing is given, as is the combination scale and sea-level reduction factor used to convert grid to horizontal ground-level distances. In addition, the diagrams define the area (in acres) of the U.S. Public Land Survey quarter-sections surveyed, as computed using ground-level distances and grid bearings (Figure 3).

Separate specifications are provided to govern the preparation of topographic and cadastral maps. With respect to the topographic maps, these specifications require that the maps be photogrammetrically compiled to National Map Accuracy Standards at a scale of one inch equals 100 feet, with a vertical contour interval of two feet in urban areas or areas proposed to be converted to urban use; and at a scale of one inch equals 200 feet, with a vertical contour interval of two feet in rural areas. The maps are to be constructed upon the Commission-adopted control survey system. The topographic maps, in addition to showing the usual contours, spot elevations, planimetric and hypsometric detail, and coordinate grid ticks, show, in their correct position and orientation, all U.S. Public Land Survey system, corners, and lines established by the control surveys; and the equation between any specified local datum and the National Geodetic Vertical Datum of 1929 NGVD (see Figure 3). The finished topographic maps are field checked to assure compliance with National Map Accuracy Standards (see Figure 4).



RECORD OF U. S. PUBLIC LAND SURVEY CONTROL STATION

U. S. PUBLIC LAND SURVEY CORNER 14|13 / 23|24 T 5 N, R 22 E, MILWAUKEE COUNTY, WISCONSIN

HORIZONTAL CONTROL SURVEY BY: AERO-METRIC, INC. YEAR: 1994
VERTICAL CONTROL SURVEY BY: AERO-METRIC, INC./SEWRPC YEAR: 1994/2003

STATE PLANE COORDINATES OF: SECTION CORNER
NORTH 330,295.96
EAST 2,575,419.06
ELEVATION OF STATION: 698.921

HORIZONTAL DATUM: WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE NORTH AMERICAN DATUM OF 1927

VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM OF 1929 THETA ANGLE: +1-28-31

CONTROL ACCURACY:
HORIZONTAL: THIRD ORDER, CLASS I VERTICAL: SECOND ORDER, CLASS II

LOCATION SKETCH:

SURVEYOR'S AFFIDAVIT:

STATE OF WISCONSIN) SS
MILWAUKEE COUNTY)

As Milwaukee County Surveyor, I hereby certify that I set a concrete monument with SEWRPC brass cap to mark this corner; replacing a broken concrete monument, said monument with SEWRPC brass cap having been set to mark this corner in October 1987 by me; replacing a broken concrete monument, said monument with City of Oak Creek brass cap having been set to mark this corner in May 1961 by William T. Wambach, Jr., S-371; replacing an old, subsurface, cut limestone monument set to mark this corner in 1876 by George F. Epenater, Milwaukee County Surveyor,in the conduct of the remonumentation of the U.S. Public Land Survey system in the Town of Oak Creek; replacing in turn a wood post set to mark this corner in March 1836 by Elisha Dwelle, Deputy United States Surveyor, in the conduct of the original United States Public Land Survey; that I referenced the same as shown hereon; and that this record is correct and complete to the best of my knowledge and belief.

WISCONSIN K. W. BAUER MILWAUKEE, WIS. LAND SURVEYOR

DATE OF SURVEY: 3 September 2003 Kurt W. Bauer S - 157
REGISTERED LAND SURVEYOR

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Figure 2. Typical dossier sheet prepared for each control survey station, setting forth information necessary for the recovery and use of a station such as the state plane coordinates of the corner, the elevation of the monument, location sketch, detailed description, and a Surveyor's affidavit.The affidavit provides, in effect, a "pedigree" for the corner extending, wherever possible, back to the original location of the corner by the Government Surveyor.

The specifications require that the matching cadastral maps be compiled on the same coordinate grid as the topographic maps, and also show in their correct location and orientation, the U.S. Public Land Survey System quarter-section lines and corners established by the control surveys. The specifications require that the grid ticks and each section and quarter-section corner be plotted to within 1/100 of an inch of the true position as expressed by the coordinate values for the corners. Each real property boundary corner is to be plotted within 1/40 of an inch of the record position. Any gaps or overlaps between adjoining property boundary lines of 2.5 feet or more are to be shown as mapped lines. Overlaps or gaps of less than 2.5 feet are evident only from an examination of the recorded property boundary line dimensions shown on the maps. The constructed location of the property boundary lines must be checked against ground truth provided by the matching topographic maps in the form of building

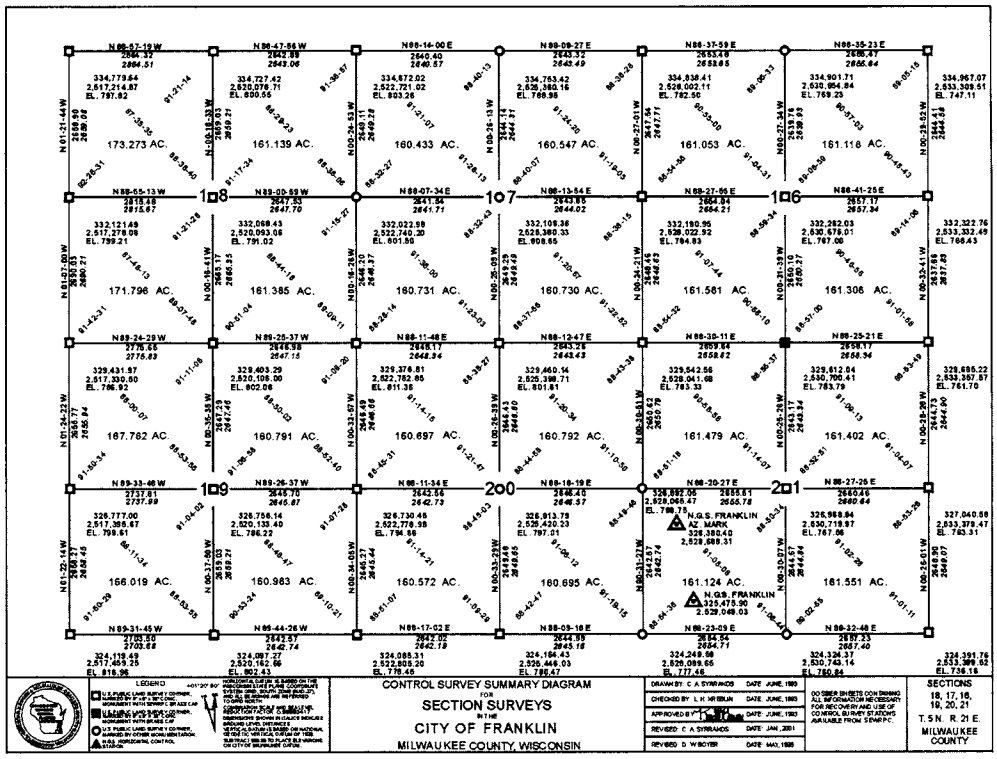

Figure 3. An example of a control survey summary diagram for a six-square mile area showing the grid, ground lengths, and grid bearings of the exterior boundaries of each one-quarter section; the area of each one-quarter section; all monuments erected; the interior angles of each one-quarter section; the state plane coordinates of all section corners, one-quarter section corners, and the center of a section monuments set; National Geodetic control stations utilized to tie the U.S. Public Land Survey corners to the horizontal geodetic control datum, together with the coordinates of these stations; the average angle between the geodetic and grid bearings for the six-square-mile area; and the average combination scale and sea level reduction factor for the area.

outlines, pavement edges, railway tracks, fences, and stream and water course locations. Figure 5 shows the matching cadastral map for the topographic map shown in Figure 4.

Program Status

The Commission has, since 1964, been engaged in the completion of the control survey, topographic mapping and cadastral mapping program as that program was originally envisioned. The work has involved cooperative efforts of, and funding by, the seven counties concerned, a number of cities, villages and towns, private utilities operating in the region, and state and federal agencies. The work of locating and monumenting the U.S. Public Land Survey corners was generally allocated to the cognizant county surveyors, and in some cases by contract to registered land surveyors in private practice. The control survey and topographic mapping work was contracted out to photogrammetric engineering firms. The cadastral mapping was done by Commission staff or contracted to private firms.

As of the end of 2004, all 11,753 U. S. Public Land Survey corners within the southeastern Wisconsin planning region were located, monumented, and placed on the State Plane Coordinate System. Large-scale topographic maps were completed for a total of 2,181 square miles, or 81 percent of the total area of the region; topographic mapping for an additional 204 square miles, or about eight percent of the total area of the region is currently underway. Large-scale cadastral maps have been completed for a total of 2,041 square miles, or 76 percent of the total area of the region. The topographic mapping work is expected to be completed in 2005, with the completion of the cadastral mapping work to follow.

In addition to pursuing completion of the remaining mapping, the Commission has initiated essential maintenance efforts. In the urban and urbanizing counties of the region,

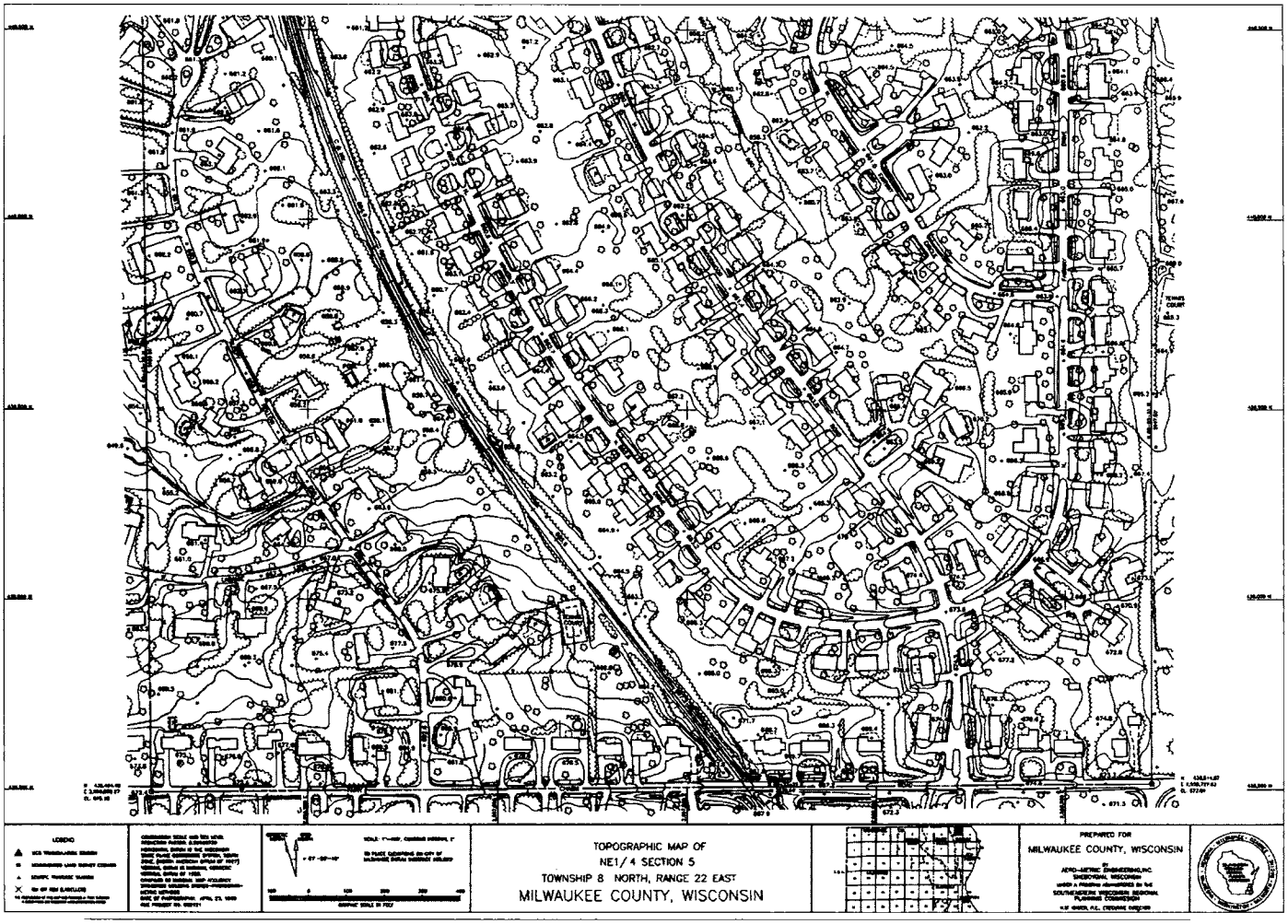

Figure 4. A typical, photogrammetrically compiled, large-scale topographic base map meeting National Map Accuracy Standards at a scale of 1:1,200 (one inch equals 100 feet) with a vertical contour interval of two feet. Topographic maps show U.S. Public Land Survey corners, the monuments erected at these corners, and the grid lengths and bearings of the section and quarter section lines, as well as the usual topographic and cultural features of the landscape.

approximately four percent of the monumented corners are disturbed or destroyed annually through various construction activities and must be replaced. This work also entails the maintenance of the ancillary bench marks. Urban development and redevelopment activities also require the remapping of some of the areas for which topographic mapping was completed. About 730 square miles, or about 27 percent of the initially mapped areas, have been or are in the process of being remapped to date.

The cadastral maps are maintained annually. Because Wisconsin law requires land subdivision and certified survey maps to be tied to corners set in the U.S. Public Land Survey, these maps can be readily updated. With the control survey system in place, all new plats are tied not only to the U.S. Public Land Survey System, but also to the State Plane Coordinate System, and surveys have common points of beginning and a common bearing base. This permits annual updating of the cadastral maps by computerized techniques.

Although the present status of computer technology could not be envisioned in 1964, the control survey and mapping system has provided a sound foundation for the modernization of land records and the creation of automated parcel-based land information and public works management systems within the southeastern Wisconsin region. To facilitate computer application, Commission specifications have, since 1987, required the delivery of finished topographic and cadastral maps in digital, as well as hardcopy, format. Moreover, the Commission has converted previously com-

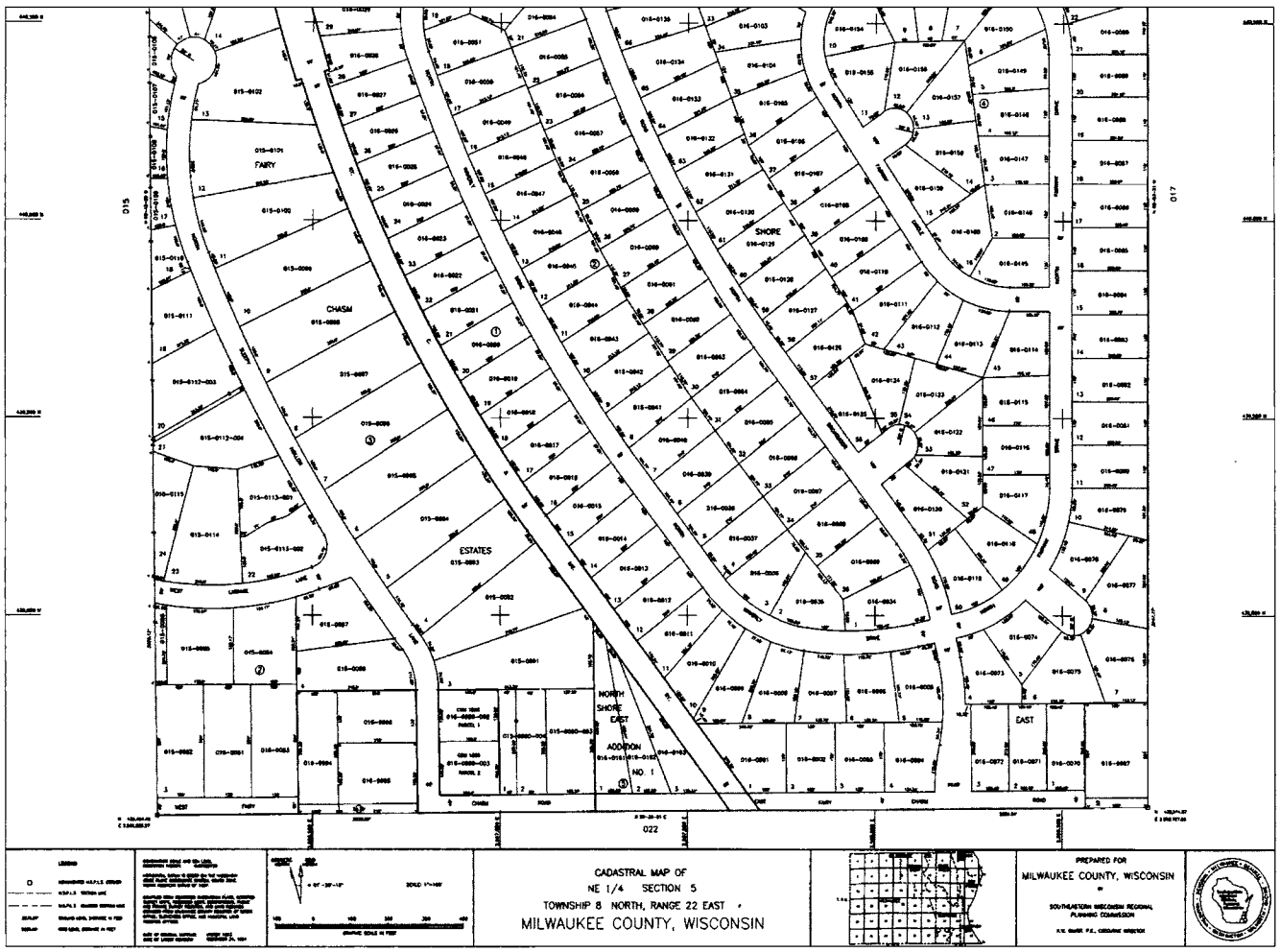

Figure 5. A typical, large-scale cadastral map constructed as an overlay to its companion large-scale topographic map. Cadastral maps show U.S. Public Land Survey corners, the monuments erected at these corners, and the grid lengths and bearings of the section and quarter section lines; well defined planimetric features, including major streams and watercourses, real property boundary lines, street, alley, and public and utility easement lines, widths and rights-of-way, subdivision names or certified survey map numbers; block numbers; lot numbers and dimensions; street names; and parcel identification numbers. The later provide the link between geographic locations and attribute files in parcel-based land information and public works management systems.

pleted topographic and cadastral maps to digital format.

Issues

The Commission control survey and mapping system has performed well: horizontal and vertical control survey networks have been widely and successfully used in the conduct of both land and public works engineering surveys over the forty-year period of the project. Time has proved the adopted system to be sound. Very few discrepancies and disputes have been encountered with respect to the control survey network or the topographic and cadastral maps.

The Commission is aware of only nine disputes concerning the location of the remonumented Public Land Survey corners, which resulted in the relocation of monumented corners—a credit to the county and private surveyors commissioned to locate the corners. In each case, the disputes were resolved collegially between the land surveyors concerned. Only one known discrepancy is known to have occurred with respect to the State Plane Coordinate positions of remonumented U.S. Public Land Survey System corners. This discrepancy was due to the failure to recover a first-order triangulation station during the supplementary horizontal control surveys. The triangulation station, which

had been paved over during land development work, was later recovered, and this necessitated the readjustment of the coordinate positions of some nearby U.S. Public Land Survey corners. Challenges to the accuracy of the hypsometric and planimetric data shown on the topographic maps have been generally resolved in favor of the completed maps. Some cadastral map sheets have had to be recompiled due to errors found in the initial compilation of property boundary lines.

With the adoption by the federal government of the North American Datum of 1983 (NAD-83) and, in Wisconsin, subsequently, NAD-83(91), and following the adoption of the North American Vertical Datum of 1988 (NGVD-88), the Commission was faced with an important issue. Shifts in the positions of stations on NAD-83(91) versus the positions on the North American Datum of 1927 (NAD-27) have a maximum value in latitude within the region of approximately 11 feet, and in longitude of approximated 39 feet.

Within southeastern Wisconsin, replacement of NAD-27 by NAD-83(91) would adversely affect literally tens of thousands of existing maps and associated public records in hard-copy and digital format. Such replacement would require that new horizontal coordinates be computed, utilizing original control survey measurements, for the 11,753 monuments now marking U.S. Public Land Survey corners within the region. The dossier sheets for each of these corners would require revisions, as would the control survey summary diagrams that tie these monuments together into an integrated network. These changes would, in turn, have to be carried over to the approximately 8,500 individual large-scale topographic maps and approximately 7,700 individual large-scale cadastral maps that have been prepared on NAD-27 over the past approximately 40 years.

In addition, the utility of thousands of subdivision plats, certified survey maps, plats of surveys, and survey records referenced to NAD-27 would be affected. Thousands of sets of integrated aerial photographs containing land use, soil, wild life habitat, wetland, floodland, and environmental corridor delineations, again referenced to NAD-27, would also be adversely affected by a conversion to NAD-83(91), as would the parcel-based, digital land information and public works management systems developed by governmental agencies and private utilities within the region. The cost of converting from NAD-27 to NAD-83(91) has been estimated to approximate two million dollars in each of the seven counties of the region. Proponents of the conversion to NAD-83(91) have yet to document any benefits that would offset these conversion costs. For these and other reasons, the Commission determined to continue to utilize NAD-27 in its work.

The differences between elevations referred to NGVD-29 and NGVD 88 within the region range from about 0.1 to about 0.4 foot. For some applications, these differences are small enough to have no significant impact, but for such applications as establishing grades for trunk sewer construction, or for the regulation of development in flood hazard areas—where the State Administrative Code requires flood easements to be acquired if the proposed modification of a bridge or culvert, or of a stream channel, results in upstream or downstream increasing in flood elevation of 0.01 foot or more—the confusion of elevations referenced to these two datums could have costly consequences. The Commission has calculated peak flood flows and stages associated with the 10, 50, and 100 year recurrence interval floods for 831 lineal miles of stream channel within the region and delineated, on large-scale topographic and cadastral maps, flood hazard lines for 676 lineal miles of stream channel, These data are referenced to NGVD-29 and, they have been incorporated into county and municipal floodland zoning ordinances. For these and other reasons, the Commission determined to continue to utilize NGVD-29 in its work.

Nevertheless, in order to facilitate the use of NAD-83(91) and the NGVD-88 datums within the region by such users as may determine to do so in spite of good reasons to the contrary, the Commission, in 1993 and 1994, commissioned Mr. Earl F. Burkholder, Consulting Geodetic Engineer, to develop methodologies that could be used for the ready and reliable bi-directional transformation of coordinates and elevations between the two horizontal and two vertical datums concerned. Since there are no precise mathematical relationships between the datums, the methodologies were developed through mathematical model studies and permit transformations within Third Order Class I horizontal and Second Order Class II vertical control survey accuracies, which are adequate for land survey and public works engineering purposes (SEWRPC 1994; SEWRPC 1995).

Conclusions

In 1964 the Southeastern Wisconsin Regional Planning Commission proposed the creation of an integrated topographic and cadastral mapping program within its approximately 2,700 square mile planning jurisdiction. The mapping was to be based upon a then unique system of survey control which accurately combined the U.S. Public Land Survey and State Plane Coordinate systems. Through persistent commitment over a period of 40 years, this mapping and control survey system, as originally conceived, has been put into place.

The control survey system places a monumented station of known position on both the U.S. Public Land Survey and State Plane Coordinate systems at one-half mile intervals throughout the planning region. Accessory bench marks provide attendant elevation data. The control survey system and the attendant large scale topographic and cadastral maps provide the foundational elements for the creation at the county and local municipal levels of computerized parcel based land information and public works management systems, as well as the basis for the conduct of coordinated land and engineering surveys within the entire planning area.

The Commission control survey and mapping system has performed well over time. The horizontal and vertical control survey networks have been widely and successfully used in the conduct of both land and public works surveys over a forty year period. The control survey network has been used in the preparation of thousands of subdivision plats, certified survey maps, plats of surveys, and survey records. The control survey networks have been extensively used in the planning, design, and construction of public works of all types within the Region, including such major works as the construction of a seventeen mile deep tunnel sewage conveyance and storage facility serving the greater Milwaukee metropolitan area. The control survey and mapping system has also been used to accurately map land use, soils, wild life habitat, wetlands, floodlands, and environmental corridors throughout the region, and in such special applications as the accurate mapping of major airport approach zones and the location and height of obstructions that constitute hazards to air navigation in the glide paths of such zones.

The completed control survey and mapping system now comprises an integral and invaluable part of the public infrastructure of the seven-county planning region. The system requires, and receives, annual maintenance in the form of replacement of broken, disturbed, buried, or destroyed U.S. Public Land Survey corner monuments and attendant bench marks; the continuous up-dating of the cadastral maps on a generally monthly basis; and the periodic preparation of new topographic maps for subareas of the region exhibiting need.

REFERENCES

SEWRPC (Southeastern Wisconsin Regional Planning Commission). 1964. *Planning Guide No. 2: Official Mapping Guide*. SEWRPC, Waukesha, Wisconsin.

SEWRPC (Southeastern Wisconsin Regional Planning Commission). 1994. *Technical Report No. 34: A mathematical relationship between NAD-27 and NAD-83(91) state plane coordinates in southeastern Wisconsin*. SEWRPC, Waukesha, Wisconsin.

SEWRPC (Southeastern Wisconsin Regional Planning Commission). 1995. *Technical Report No. 3: Vertical Datum Differences in Southeastern Wisconsin*. SEWRPC, Waukesha, Wisconsin.

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ATTACHMENT III

PRELIMINARY LIST AND ATTENDANT DESCRIPTIONS OF ISSUES REQUIRING CONSIDERATION

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White Paper – 2007

Review and Re-evaluation of SEWRPC Survey Control System

Givens:

1. Since the 1960's, the SEWRPC (the Commission) has made a large investment in horizontal and vertical survey control networks in the 7 county region.

2. Those networks have paid excellent dividends over the decades in terms of orderly development of civil infrastructure and administrative stability of cadastral parcels.

3. The value of that investment is threatened by:

    A. Users not being aware of the control systems or knowing how to use them.
    B. Underlying changes in the definition of datums by the federal government.
    C. The technological ability of modern systems to position a point on the ground efficiently – obviating the need to start from a reference monument.
    D. Absence of a legislative mandate to use the existing survey control networks.

4. The Commission has established a Technical Advisory Committee to review both administrative and technical aspects of the existing control systems with the idea of:

    A. Capturing and preserving the value of previous efforts/investment.
    B. Identifying concepts and issues that serve to detract from using the systems.
    C. Recognizing contributions of new technology to the manner in which spatial data are generated, manipulated, and used.
    D. Recommending policies and procedures for enhancing the value of the survey control networks from both:
        1. An administrative perspective and,
        2. The technical perspective.

5. Other:

Goals: Any and all recommendations should conform to and support the following:

1. The value of the existing survey control network should be preserved and enhanced to the extent possible and practicable.
2. The impact of new technology will be evaluated and accommodated as appropriate.
3. The impact of working with digital data will be considered.
4. Any new procedures must be technically rigorous and readily defensible.
5. Policies should be formulated with the idea of keeping it simple.
6. Any changes must be accomplished within the framework of the legal system.
7. New policies and procedures that are adopted will need to be embraced by the user community. An educational effort may be needed.
8. Other

Issues:

1. Datum definitions by NGS:
    a. Horizontal.
    b. Vertical.
2. No datum conversion is exact – what geometrical integrity is required?
    a. Acceptable procedures need to be discussed and identified.
    b. "Standardized" software is most desirable.
3. State plane coordinates – are long-standing and "standard."
4. Low distortion projections – who needs, who benefits, and at what cost?
5. "Big" question – To what extent must the record data be consistent with GPS results?
    a. GPS satellites orbit earth's physical center of mass (WGS84).
    b. GPS results can be displayed in "standard" format.
6. Are GPS results "absolute" or "relative" and with respect to what?
7. At what point, if ever, will satellite orbits replace physical ground monuments?
8. Status of "spatial data" education – surveying/photogrammetry/geography/geomatics.

Concepts:

1. Who needs/uses SEWRPC control?
2. What GPS technology is being used -
    a. For GIS/mapping purposes?
    b. For surveying/engineering applications?
3. Difference between absolute and relative:
    a. Absolute coordinates used for "inventory/location."
    b. Relative measurements used for design/construction.
4. Positioning by GPS:
    a. Autonomous: stand-alone and differentially corrected.
    b. Static relative positioning (potentially very precise).
    c. Kinematic and real-time kinematic – operation and quality of results.
    d. CORS: including private, community, NGS, and/or OPUS and OPUS-RS.
    e. GPS real-time networks – one receiver/person – within 2 cm.
5. In what way does Height Modernization contribute to or impact this review?
6. With the digital revolution, spatial data are now characterized as digital and 3-D – see articles posted at www.globalcogo.com/refbyefb.html (e.g. #47).

Resources (available to and used by consultant):

1. A Control Survey and Mapping Project for an Urbanizing Region (A Study in Persistence) – Kurt Bauer, PE, RLS, AICP
2. SEWRPC Technical Report #34 NAD27 to NAD83(91)
3. SEWRPC Technical Report #35 NGVD29 to NAVD88
4. Definition of a Three-Dimensional Spatial Data Model for SE Wisconsin
5. Recent American Surveyor series of 7 articles on Real-time Networks
6. NGS 10-year plan – see www.ngs.noaa.gov/INFO/tenyearnews.shtml
7. Wisconsin Coordinate Reference System (WISCRC).

ATTACHMENT IV

CORRESPONDENCE FROM COMMITTEE MEMBER
WILLIAM T. WAMBACH

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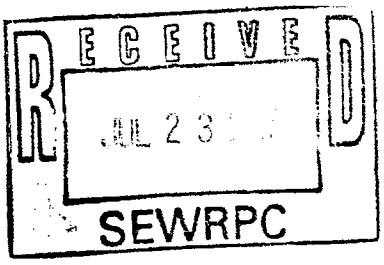
Wm. T. (Bill) Wambach, RLS, PE
900 Prairie Run, #35
SUN PRAIRIE WI 53590-4167
E-mail: oldgoat25@spwl.net
Phone: (608)837-2054



July 18, 2007

K.W. Bauer, Chairman
Technical Advisory Committee on
The Review and Reevaluation of the
Regional Control Survey Program
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Dr
WAUKESHA WI 53186

Dear Kurt,

Since I can't attend the July 25th meeting, I very much appreciate getting the Notice, agenda & attached information.

Regarding Issue #7: "At what point, if ever, will satellite orbits replace physical ground monuments?" I would like the rest of the committee to discuss my reaction to this question: Why would we want to replace physical ground monuments?

My thought proceeds to: Consider a densely populated urban setting, which usually results in very high land values. Buildings are built concurrent with the property lines, identified by physical ground monuments. In the future, using satellite orbits and more refined measurement & calculation techniques, someone determines that the building is encroaching on a calculated property line. Did the building move? No! The property corners should remain precisely where the physical ground monuments were originally placed, and their positions preserved by physical ground monuments. No improvements in accuracy of computation should ever be permitted to supersede the evidence of the physical ground monument.

I trust the group will take my octogenarian professional opinions into consideration.

Sincerely,

Bill Wambach

Encl.

Coordinates Versus Confusion

COORDINATES VERSUS CONFUSION[a]

Discussions by Gerard H. Pesman, John G. McEntyre, and William T. Wambach, Jr.

GERARD H. PESMAN,[3] M. ASCE.—It is indeed unfortunate that the ASCE committee on interaction between Education and Practicioners is not more active so that the author could leave his ivory tower and get into the field. The author's apparent philosophy, as shown by this paper, is a typical example of educational inbreeding that is slowly strangling the country with "educated" hangers on.

These are harsh statements; but after 15 yr of searching for the truth, which includes monuments, and beginning to be able to dent the legal profession slightly in changing "legal" descriptions, the writer takes a very dim view of the proposed ideas, and actually considers them dangerous.

In the writer's opinion, the best title is a strong fence (physical monument), and a shotgun. In the mining states of the West, anyone can start title by planting four posts (physical monuments), claiming a mineral discovery, and filing a recorded notice in the Courthouse. These old timers and new timers, as of the last uranium boom, could not care less about coordinates, and often did not even care what section they were in; but they did know where their claim corners were, and if they had a good claim, they did pertetuate these corners.

Land sales based on paper record only were tried early in the history of the United States and failed miserably. Paper subdivisions have caused unbelievable problems to those of us that are asked to reproduce a physical line on the ground. Now, when we are on the threshold of a physical survey agreement with electronic distance measuring and advanced instrumentation, it is suggested that we go back to the paper system through the use of coordinates. In the writer's opinion, too much paper and not enough monuments have caused much grief and the loss of professional stature.

All of us in the surveying profession use coordinates, but there is still much confusion on the use of the State Grid, even within our own ranks. When a local system is used, values are set on a physical monument that is considered the strongest. The client can see the monument, and is often as thrilled as we are when an old one is found. Clients cannot see coordinates except as numbers on a map. Intended parcels of land have been, and are still a surveyor's nightmare, and intent by coordinates in the hands of land owners, realtors, and attorneys will really make an impossible situation. At the present time, if a land description was qualified as to survey, legal, land owner, realtor, or abstracter's description, it would give us a clue as to the complexity of actually defining the boundaries. Since the aforementioned people are involved in land sales, it behooves us to educate them, and hopefully to the point that

[a] September, 1970, by Robert T. Howe (Proc. Paper 7528).

[3] Surveyor, Survey Engineers Inc., Grand Jct., Colo.

any land description will be prepared by a surveyor, and be fully monumented when sold. When there is a clear cut responsibility, the public can be satisfied, and can see their property lines. Title insurance can delete the exception "what an accurate survey will show." Surveyor's will communicate with each other, instead of talking through lawyers, because they can be explicit, and they have the responsibility of land lines. There is nothing like a monument in the ground, with a surveyor's name or number on it, to accentuate his ability to describe the same, and make sure it is correct.

In construction layout, the same problem often exists. Architectural renderings that are not based on an accurate topographic survey with control monuments on the site are often impossible. It has been the writer's experience that planned condominiums have landed in the middle of a river. For the sake of economy—false economy—an accurate topographic survey was not made. Coordinates which are not field established will lead to the same difficulties. Lack of surveys, self esteem, and not knowing whether we are surveyors, engineers, lawyers, or professors, has seriously curtailed our performance.

Because there is a concept within the legal profession, (without educational background), that they should examine the survey chain of title as well as the people chain of title, firm giant steps must be taken to set up Land Courts that are oriented towards surveys. We also need to assume the responsibility, in every court house in the United States, of having County Surveyor offices that are in charge of land records, and check physical monuments in new subdivisions. A State Coordinate system in conjunction with computers can be an enormous boon, but until paper records are field checked with identifiable, worthwhile monuments (which are also described on record) we are going to have the same chaos. Photogrammetry has been bandied around as a magic panacea for our present confusion. It can be a tremendous aid, and should be used as much as possible, but again, in dense woods, it fits the role of paper records, and hinders rather than helps.

In conclusion, the writer believes that CULDATA and the author are sincerly endeavoring to come up with ideas to help solve the nationwide scramble of land records. With good reason, i.e., lack of qualified field surveyors, they are groping for an answer that can be made in an office. The contract surveyors of the 1890's who worked for $600 for 36-sq mile township surveys in our mountain country were not sincere, and started many of our paper records. Sometimes they were caught, by a field inspector who noted fraudulent calls for monuments that weren't there, but more often their surveys were accepted. At the present time, if we are honest, it is impossible to tell the intent, or to follow the footsteps. If footsteps had been followed of the hatchet claims and land descriptions left in the hands of surveyors, instead of quick buck artists and land companies, there wouldn't have been double patents in Kentucky. It is the writer's opinion that double patents produce overlaps or hiatuses, and are the result of parties outside the surveying profession, or one of our members who is not strong enough in the belief in his own ability to field survey and then describe the land. We need to take the responsibility entirely, live up to it, and therefore sell our increased prestige to the general public.

JOHN G. McENTYRE,[4] F. ASCE.—The presentation of a comprehensive and efficient land data system as proposed in two major reports published by the

[4] Prof. of Land Surveying, Purdue Univ., West Lafayette, Ind.

University of Cincinnati (3,5) is to be commended. The paper presents a good discussion of the aspects of legal descriptions of parcels and the indexing of deeds and other documents relating to land titles as proposed under CULDATA.

The CULDATA system as proposed originally and as presented in the paper involves the same basic principles as proposed in the paper "Land Surveying and Land Registration" (14) which was published in February, 1963. The 1963 paper presents a much more detailed and specific structure for a state organization to administer such a plan and goes into much more detail concerning possible insurance of title. CULDATA does add the feature of using electronic computers which was not as feasible when the proposal published in 1963 was under study (1953-1954). Also the proponents of CULDATA added an excellent idea when they proposed the use of approximate coordinates for quick-use purposes.

The primary purpose for this discussion, however, is to draw the attention of the proponents of the CULDATA system, the author, and the readers to Ref. 14.

Appendix.—Reference.

14. McEntyre, John G., and McNair, Arthur J., "Land Surveying and Land Registration," *Journal of the Surveying and Mapping Division*, ASCE, Vol. 89, No. SU1, Proc. Paper 3437, Feb., 1963, pp. 59-75.

WILLIAM T. WAMBACH, JR.,[5] F. ASCE.—The title of this paper implies that there will be no confusion in the identification on the earth surface of a survey corner if that corner is defined by coordinates. If new corners were selected by choosing a coordinate position, referenced to specified existing control monuments, this could be true. However, that is not the usual way people select the position for a new corner. A buyer and a seller usually agree to a location on the ground, and then write up a contract which describes in words the corner they have agreed to. In some cases, one or the other of the parties hires a registered surveyor to measure the selected corner location in reference to existing control monuments and prepare a map and description defining the selected corner. Unfortunately, in far too many cases, some person relatively unskilled in measurement techniques, property law and description writing prepares the description of the corner for their contract.

The author refers to "the surveyor's age-old devotion to monuments." The writer believes it would be more correct to state "the court's decisions that monuments control over distances and directions given in words." The courts have, in the writer's opinion, very wisely determined that the intent of the buyer and the seller, when specified as being a monument on the ground, is clearly the monument and not the measurements which were determined subsequently to the selection of the corner.

The author also states that he is now convinced that the devotion to monuments is the source of most of the disputes about land ownership. The writer's opinion, based on over 20 yr of land surveying experience, is that descriptions written for corners at which no monument was ever placed are the prime

[5] Chmn., Committee on Land Surveying, Surveying and Mapping Div., ASCE, Sun Prairie, Wis.

source of disputes, followed by lost, obliterated, disturbed, poorly placed, or dishonestly placed monuments.

The author makes reference several times in his paper to early surveys having been "poorly" made. It is the writer's experience that there is no more evidence of poor surveying practice by the early surveyors than there is today, or will be in the future. Accuracy of position is a function of the degree of refinement of measurement techniques and knowledge of statistical probability of the accuracy of a measurement. Related to that time in man's history, the early American surveyors did remarkably accurate work. Since man will undoubtedly continue to progress, future generations will find the measurement work done by us to be far less exact than they will need for their purposes. Does that mean that today we are surveying "poorly"? The writer thinks not.

The author gives the example of a new facility constructed from a set of scaled drawings. He rightly stated that the results will not be the exact image of the precise drawing, and yet useful results are obtained. He asks "Why then, can there not be exact coordinate descriptions of land parcels with marks set on the ground to represent, as accurately as may be necessary, the correct points?" The writer's opinion is that there can.

The author states that land surveyors have been saying "The State Plane Coordinate Systems may be fine in theory, but they will never be able to help us solve the problems in our work." That implies that many surveyors have been saying that. The writer must agree that some few surveyors hold that viewpoint. It is the writer's opinion, however, that most knowledgeable surveyors have been promoting the use of the State Plane Coordinate System for more than 15 yr. The parting of the ways between surveyors and the author comes with the proposal for an instant changeover to absolute control of position by coordinates. Ninety-nine percent of the property corners in this country do not now have precise coordinate descriptions. The determination of precise coordinates for these corners is, if the pun will be pardoned, a monumental task.

In proposing steps toward adoption of a coordinate based system, the author suggests that surveyors must join attorneys and land title insurance companies to devise appropriate systems and promote legislative changes required. One of the constructive critics (not "a leading opponent") of the system proposed by the author is Gurdon H. Wattles, who is a title engineer. Men in Wattles' profession, as well as others who are land surveyors, merely caution the cost of this needed change is so great that it must come about by evolution rather than revolution.

The writer agrees with the author that the first step must be legislative change. Many states have taken the first logical step of adopting legislation permiting the use of state plane coordinates as supplementary identification of corners. To have attempted to pass legislation making state plane coordinates mandatory would have been foolhardy, since the scarcity of high order precision control monuments make compliance prohibitively costly in large areas of the country. The next necessary step after adoption of legislation permitting the use of the State Plane Coordinate System in property descriptions is densification of the network of high order precision monumentation. Then, and only then, will it be possible to adopt legislation to require the use of state plane coordinates on every property description.

With regard to the author's conclusion, this writer must express his opinion that accepting a theoretical coordinate description of a point as correct

will not end all confusion and dispute. The basis of the coordinate system is a point on the earth's surface and a direction from that point. The system is then extended by establishing monuments at many other points on the ground and measuring their relationship to the point of origin of the system. Since measurement is a statistical approximation of the exact theoretical distance between points, improvement of measurement techniques in the future will show a better approximation of the distance than is determined today. The numbers (coordinates) that are used today to identify a point will then no longer be valid.

The point will not change—the coordinates will. Therefore, the writer concludes that the "age-old devotion" of property owners, surveyors, title companies and the courts to monuments is well-founded and wise.

Southeastern Wisconsin Regional Planning Commission

Notice of Second Meeting and Agenda

TECHNICAL ADVISORY COMMITTEE ON THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

DATE: November 16, 2007

TIME: 9:00 A.M.

PLACE: Regional Planning Commission Offices
Commissioners' Conference Room
W239 N1812 Rockwood Drive
Waukesha, WI

AGENDA:

1. Roll Call

2. Consideration of Minutes of the Meeting of July 25, 2007 (copy enclosed).

2. Report and presentation by Mr. Earl F. Burkholder (copy enclosed).

3. Other business

4. Consideration of Date and Time of Next Meeting

5. Adjournment

Kurt W. Bauer
Chairman

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REVISED MINUTES OF THE SECOND MEETING

TECHNICAL ADVISORY COMMITTEE
FOR THE REVIEW AND REEVALUATION OF THE
REGIONAL CONTROL SURVEY PROGRAM

DATE: November 16, 2007

TIME: 9:00 a.m.

PLACE: Commissioners' Conference Room
Regional Planning Commission Offices
W239 N1812 Rockwood Drive
Waukesha, Wisconsin

Members Present

Kurt W. Bauer Chairman	Executive Director Emeritus, SEWRPC, County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
John M. Bennett	City Engineer-Director of Public Works, City of Franklin
John P. Casucci	Survey Land Development Manager, R.A. Smith National, Inc.
Harold S. Charlier	Executive Director, Wisconsin Society of Land Surveyors
Michael R. Duckett	President, Duckett Group; Executive Director, Southeastern Wisconsin Professional Baseball District
John T. Ellingson	Wisconsin State Geodetic Advisor, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geodetic Survey
Thomas M. Grisa	Director of Public Works, City of Brookfield
Gregory G. High	Director; Architectural, Engineering and Environmental Services; Milwaukee County Department of Transportation and Public Works
Marcia G. Lindholm	Civil Engineer Senior, City of Milwaukee Department of Public Works
Cecil F. Mehring	Former Manager of Planning and Engineering Services, Racine County Department of Public Works
George E. Melcher	Director of Planning and Development, Kenosha County
Robert W. Merry	Chief Technical Officer, Aero-Metric, Inc.
Glen R. Schaefer	Geodetic Engineer, Wisconsin Department of Transportation
Thomas J. Tym	Head, Technology Services Department, Ruekert-Mielke, Inc.
William T. Wambach	Former District Director, District 1, Wisconsin Department of Transportation

Members Absent

Kent B. Pena	State GIS Coordinator, U.S. Department of Agriculture Natural Resources Conservation Service
Daniel R. Talarczyk	Survey Services Supervisor, Milwaukee Metropolitan Sewerage District

Guest Present

Donald G. Dittmar	Manager, Land Information Systems Division, Waukesha County Department of Parks and Land Use
Staff Present	
Earl F. Burkholder	Consulting Geodetic Engineer
Donald P. Simon	Chief Planning Illustrator, SEWRPC; Deputy County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
Lynn G. Heis	Staff Secretary, SEWRPC

CALL TO ORDER AND ROLL CALL

Chairman Bauer called the meeting to order at 9:00 a.m. Roll call was taken by circulating an attendance signature sheet, and a quorum was declared present.

CONSIDERATION OF MINUTES OF THE MEETING OF JULY 25, 2007.

Chairman Bauer noted that copies of the minutes of the first meeting of the Technical Advisory Committee for the Review and Reevaluation of the Regional Control Survey Program had been distributed to all members of the Committee for review prior to the meeting. He asked the Committee to consider approval.

In the discussion that followed, it was noted by Mr. Schaefer that the Wisconsin Department of Transportation (WisDOT) had originally introduced The Wisconsin County Coordinate System (WCCS) to avoid the need to apply the combination factor (scale and sea-level reduction factors) used with the State Plane Coordinate system in moving measured or recorded distances between the map projection and ground level – the so called grid to ground conversion. He also noted that the word "System" was singular in the Wisconsin County Coordinate System and the word "Systems" was plural in the Wisconsin Coordinate Reference Systems.

Messrs. Schaefer and Grisa called attention to the second full paragraph on page 5, indicating that the last sentence contained the word "had" twice. Mr. Schaefer suggested that the phrase "data on" be inserted after the word readjusted in the penultimate line of that paragraph. Mr. Schaefer further suggested, and the Committee agreed, that the Commission adopt the National Geodetic Survey standard for datum acronyms so that, for example, in the last line of the paragraph concerned, the acronyms would be noted as NAD 83, NAD 83 (1991), NAD 83 (1997), and NAD 83 (2007). Mr. Schaefer noted that the last line of the paragraph concerned also contained a superfluous conjunction "and." With respect to proper usage, Mr. Schaefer also noted that when referring to a survey monument, the term "bench mark" should be two words, not one. The term "benchmark" would be used when referring to a reference condition in an analysis or study. The Committee agreed that this convention should also be adopted throughout the Commission's work.

Mr. Schaefer called attention to the seventh line of the first paragraph on page 6, noting that the correct acronym for the North American Vertical Datum of 1988 should be NAVD 88 and suggested that same error was made throughout the minutes and should be corrected.

Chairman Bauer noted that Mr. Wambach, based upon his review of the minutes, had indicated by telephone that the word "illicit" in the third line of the first partial paragraph on page 7, should be "elicit." He also indicated his general agreement with and support of the conclusions reached during the Committee's deliberations at the July 25, 2007 meeting.

Mr. Burkholder called attention the fourth line of the last paragraph on page 7, noting that the technology referred to should be correctly identified as "Global Positioning System" not "Geographic Positioning System."

Mr. Schaefer called attention to the last full paragraph on page 11 carrying over to page 12, and suggested that the paragraph be revised to read as follows: Mr. Schaefer indicated perhaps some additional background information on WisDOT's work would be helpful to the Committee in its deliberations. He noted WisDOT was establishing a virtual reference system utilizing initially 25 CORS stations based upon NAD 83 (2007). The NGS has promised they would provide the parameters identifying the differences between, and the means for converting between, the NAD 83 (2007) adjustment and previously used NAD 83 datum adjustments. The NGS has not as yet provided those parameters, he said. In addition to the use of RTK technology in horizontal survey work, the WisDOT desired to utilize this technology to obtain orthometric elevations on points, and to transfer orthometric elevations between points, but realized in the mid-1990s that the ellipsoid heights required to accomplish this were not available at the accuracy required. Therefore, WisDOT conducted observations in 1997 at 78 of the original 80 HARN stations established in 1991. However, the parameters needed to convert between NAD 83 (1991) and NAD 83 (1997) have to date not been provided by NGS. As a result, a number of WisDOT projects are currently using the NAD 83 (1991) adjustment coordinates and some projects are using the NAD 83 (1997), or NAD 83 (2007) adjustment coordinates. He indicated WisDOT addresses this issue by reoccupying common stations and creating its own conversion parameters. Mr. Schaefer noted further that parameters would have to be provided to move between the newer datums and NAD 27 at desired accuracy levels. Depending upon the accuracy levels desired, this may require, he said, reobservation at some points in the older system, so coordinate values are available at the selected points in both the old and new systems.

Mr. Schaefer cautioned that it may be misleading to identify NAD 83 as a horizontal adjustment because technically it is a three-dimensional adjustment, however, the vertical component in that adjustment deals with ellipsoid heights whereas NAVD 88 deals with orthometric heights.

Mr. Schaefer called attention to the last paragraph on page 13 and suggested that this paragraph be revised to read as follows: In answer to a question from Chairman Bauer, Mr. Schaefer indicated with respect to vertical control, WisDOT was utilizing the NAVD 88 datum. Mr. Schaefer noted that the Height Modernization Program was conducted by WisDOT in five phases, to date, covering different geographic areas of the State. Upon completion of the first five phases, it was determined to adjust all differential level data acquired and the adjustment to be constrained by only two points in Southwestern Wisconsin. As a result, the elevations as determined by the adjustment made in 2007 are different from the elevations for bench marks in southeastern Wisconsin which were previously published in 2004. No means for developing and presenting the metadata in a readily useable form has as yet been developed by the NGS. Consequently, WisDOT is using the syntax of NAVD 88 (1991) for the first adjustment and NAVD 88 (2007) for the most recent adjustment. Data adjusted in 2004 are based on the NAVD 88 (1991) adjustment.

Mr. Schaefer called attention to the last full paragraph on page 16 and suggested that that paragraph be revised to read as follows: In this respect, four horizontal adjustments on the NAD 83 datum have been made all of which are in use within the seven county Region since the abandonment of the NAD 27 datum by NGS: NAD 83 (1986), NAD 83 (1991), NAD 83 (1997), and NAD 83 (2007). To date, two vertical adjustments on the NAVD 88 datum have been made by NGS upon its abandonment of the NGVD 29 datum; namely NAVD 88 (1991) and NAVD 88

(2007). All of these adjustments result in shifts in the absolute position of the points involved, but do not significantly change the relative positions of the points to other points within the Region; an exception being when a new value is assigned to a monument, which has been subjected to local movement.

There being no further corrections or additions, the minutes of the meeting of July 25, 2007, were approved as amended on a motion by Mr. Melcher, seconded by Mr. Bennett, and carried unanimously.

[Secretary's Note: Because the minutes of the meetings of the Committee are proposed to be appended to Mr. Burkholder's final report to the Commission, contrary to long established Commission policy, the minutes of the July 25, 2007, meeting have been revised in their entirety to reflect all of the changes directed to be made by the Committee at the meeting held on November 16, 2007. A copy of the revised minutes will be provided to the Committee for reconsideration and re-approval at the meeting scheduled to be held on February 15, 2008.]

REVIEW OF DRAFT REPORT

Chairman Bauer noted that copies of the preliminary draft of Mr. Burkholder's report dated October 2007, had been distributed to all members of the Committee for review prior to the meeting (copy attached.) He then asked Mr. Burkholder to undertake a page by page review of the report. The following comments were made, questions raised, and actions taken in the course of the review.

Mr. Mehring noted that the list of acronyms and abbreviations included two for SEWRPC-Nos. 2 and 34 in the list. It was agreed that No. 2 should be deleted and No. 34 retained. Mr. Grisa called attention to No. 23 on the list and suggested that the acronym be changed to NAD 83 (xxxx) and that the last term in the definition be changed to "the year xxxx." The Committee concurred. Mr. Schaefer suggested that the term NSRS be deleted from acronym No. 22. The Committee concurred.

Mr. Tym called attention to the third line of the second full paragraph on page 4 and suggested that the term "cognizant public officials and users" be inserted after the word Commission. The Committee concurred.
Mr. Grisa suggested that the term "proposed composition" be struck from the second title included in Appendix A, said Appendix being referred to on page 4. The Committee concurred.

Mr. High suggested that the first sentence in the second paragraph on page 4 be divided into two sentences which would read as follows: "Given that Commission established networks of horizontal and vertical survey control are in place and provide a reliable foundation for many spatial data activities throughout the seven-county Region, it is important for the Commission, cognizant public officials and users to recognize the value of these networks, and act to preserve the investment which these networks represent. It is also important for the Commission to review recent technological developments in terms of compatibility with the existing databases and current policies and procedures. The Committee concurred.

Chairman Bauer noted that in accordance with Mr. Schaefer's suggestion, the phrase "the NSRS (2007)" should be struck from the last sentence of the first paragraph on page 5.

Chairman Bauer suggested, and the Committee concurred, that the first numbered paragraph on page 5 be revised in the next draft of Mr. Burkholder's report so as to address only monumentation of the U.S. Public Land Survey corners, and not the issue of maintenance of bench marks. These, he said, were separate issues. He indicated that the Committee's strong consensus on the need to continue to perpetuate the U.S. Public Land Survey System within the Region through maintenance of the survey monuments concerned should be clearly stated, and that the issue of the maintenance of the bench marks within the Region should be separately addressed in the report after Mr. Burkholder has further investigated WisDOT's height modernization work, as well as the potential for utilizing the GPS system technology, rather than spirit leveling, for obtaining orthometric heights. Mr. Burkholder's conclusions with respect to the issue of bench mark maintenance should be expressed in a separate numbered paragraph he said. The Committee concurred.

Mr. Tym noted that the word "disturbed" was misspelled in the first numbered paragraph on page 5, and indeed throughout much of the remainder of the report and should be corrected.

Chairman Bauer reported that Mr. Casucci had, based upon his review of the draft report, requested in an e-mail message to the Committee Secretary dated November 14, 2007, that the word "inadvertently" be struck from the last sentence of the first numbered paragraph on page 5. He indicated that, in his opinion, the Commission should continue to replace monuments marking the U.S. Public Land Survey corners regardless of how monuments are disturbed or destroyed.

Mr. Tym called attention to the statement made in the second numbered paragraph on page 5 that the costs of migrating to the newer datums far outweighs the benefits associated with such migration, and indicated that the statement should be supported by quantative data.

A lengthy discussion ensued in which Mr. Grisa questioned the feasibility of quantifying the benefits of such migration.

Chairman Bauer indicated that in his opinion there was a practically unquantifiable, but huge cost entailed in not only transforming the very large number of geographic positions comprising the control survey networks within the Region, but also in transforming the huge volume of information in the form of digital and hard copy topographic and cadastral maps; land subdivision plats and certified survey maps; plats of surveys; flood plain delineations and associated hydraulic grade lines along hundreds of miles of streams and water courses, and entire land information and public works management systems that have been created within the Region at great expense. He indicated further, that in his opinion there were no offsetting benefits. Mr. Bennett indicated that there would be a least one offsetting benefit, namely that all of the agencies and interests concerned would be using the same datums. Chairman Bauer responded that that benefit could be more readily obtained by the means to transform values between datums and in any case, would disappear with the next adjustment of, or change in, datums.

Mr. Dittmar indicated that, in his experience, individuals who hold the opinion that migration to a new geodetic datum is not a major issue are usually individuals employed by agencies that do not have to manage and maintain large databases, or are agencies that have ample budgets. Mr. Dittmar indicated that, every year during budget preparation administrative officials and county board supervisors raise two issues with him concerning costs; one, the need to continue to maintain the monuments marking the U.S. Public Land Survey corners within the County and the attendant bench marks; and two, the desirability of moving from the existing to newer geodetic datums. He indicated that the recommendations of Mr. Burkholder and the Committee with respect to these issues were very important and the text of the report should support those

recommendations. Chairman Bauer noted that Mr. Dittmar has raised an important associated issue, namely how would the clearly huge costs of changing geodetic datums be funded.

Upon the conclusion of the discussion, Mr. Tym suggested, and the Committee concurred, that the text concerned be revised to, in effect, indicate that there were minimal benefits associated with the cost of migrating to newer geodetic datums that did not justify the costs involved.

Mr. Schaefer suggested that in his redraft of paragraph No. 2 on page 5, Mr. Burkholder should carefully distinguish between migrations between datums and between adjustments to datums.

Mr. Tym indicated that the phrase "and publication" be inserted after the word development in the third line of paragraph No. 3 on page 5. A brief discussion ensued in which it was indicated that the Commission's policy had been to make the transformation methodologies developed in the past for the Commission by Mr. Burkholder, available to anyone on request as well as to actually perform specific transformations upon request.

Chairman Bauer indicated that the recommendations set forth in paragraph No. 4 on page 5 and 6 and in paragraph No. 5 on page 6 were problematic. He indicated that the Commission had not in the past carried on professional training programs – a function that, in his opinion, should rest with the professions concerned working as may be required with professional societies and educational institutions such as the University of Wisconsin-Extension Service. A lengthy discussion ensued in which Mr. Mehring observed that at a minimum the Commission should make its staff resources available for participation in the needed professional training programs as presenters and instructors. Mr. Grisa agreed that the Commission should continued to be a resource in this respect. Mr. Mehring indicated further that the Commission had at least a more narrow responsibility in educating user communities about the reasons why the Commission is determined to remain on NAD 27 and NGVD 29, and to provide transformation procedures to newer datums. Mr. High suggested substituting the phrase "endorse, promote and support" in place of the word "develop" in the first sentence of the paragraph numbered 4.

Mr. Mehring observed that the Commission had, in the past, published technical reports concerning various issues, and indicated that perhaps a technical report concerning the use of geodetic datums and datum transformations would be in order. Chairman Bauer noted that the Commission had in the past published such reports – known as Technical Records – which did indeed sometimes set forth recommended technical procedures such as for storm sewer design. These reports were funded under the Commission's transportation and water quality management planning program; that the last such report had been prepared in December, 1993; and that funding of the costs entailed in preparing such a report would have to be found.

Mr. Schaefer noted that there were important benefits to be derived from the cooperative efforts of all of the interested and concerned parties including particularly WisDOT and SEWRPC. He indicated further, that within the State the greatest need to develop bidirectional transformation procedures exists within southeastern Wisconsin, and that parties utilizing the extant SEWRPC control survey data, WisDOT control survey data and the new technologies centered in GPS instrumentation would benefit from a bidirectional transformation method with related software programs. Therefore, he suggested there may be some financial support available from State sources to assist in developing those procedures and making them widely available.

Upon the conclusion of the discussion, it was agreed that Mr. Burkholder would reconsider the recommendations in paragraphs No. 4 and 5 on pages 5 and 6 and include in his revised draft of the report a new single paragraph, or paragraphs, setting forth his recommendations with respect

to this issue. In his revised draft Mr. Burkholder should distinguish the need to educate professionals in, for example the use of new technologies such as GPS, CORS and RTN; and the need to correlate the work of SEWRPC and WisDOT in this area.

In answer to a question by Mr. Bennett, Mr. Burkholder indicated that in his opinion it would certainly be possible to develop bidirectional transformation methods that would produce results adequate for public works engineering and land surveying applications, but not necessarily for geodetic surveying applications. In any case, he said, the procedures would have to be accompanied by information about the probable range of accuracy and precision involved.

Mr. Charlier called attention to the section of the draft report on monumentation, indicating that although the section constituted a very nice dissertation on the subject, its purpose within the context of the document was not clear to him. Another lengthy discussion ensued in which Mr. Melcher indicated that while the information presented may be elementary to practicing engineers and surveyors, its educational value with respect to public officials would be significant.

Messrs. Merry and Burkholder commented on the fact that the newer technologies are making it possible to locate specific points on the surface of the earth very quickly and very accurately. A lengthy discussion then ensued concerning the potential to, in the future, dispense with the use of monuments, substituting coordinate positions determined by satellite observations for the monuments. Chairman Bauer observed that this would require, with respect to the U.S. Public Land Survey corners, the prior determination of the coordinates of those corners. Because this has been done within the Region, he said, is precisely why some officials, including at least one County Director of Public Works, have questioned the need to continue to maintain the monuments marking the corners of the U.S. Public Land Survey System.

Mr. High observed that total reliance on coordinate positions may, in the long term, place society at risk since -- for various reasons -- the satellite based system may fail. Chairman Bauer agreed with Mr. High, noting that, although the possibility was remote, the navigation satellites may become targets during a war, or if an economic collapse occurs, society may not be able, or willing, to bear the very high costs of maintaining the satellites. He observed that viewed in this context, monuments were actually a very cheap and cost effective means of maintaining a survey control system. More importantly, however, he said, the need for monuments marking not only the corners of the U.S. Public Land Survey System, but all real property line boundaries was required by the American legal system which had its roots in the English legal system dating back almost one thousand years. Based upon a number of long standing decisions, courts of law may be expected to assign a priority of importance with respect to the location of real property boundaries, corners, and lines in the following order: natural monuments -- consisting of features in the landscape, artificial monuments of record, metes and bounds -- including within the latter in order of precedence measured distances and measured bearings. The courts, he said, may eventually include coordinates on this list, probably assigning them the lowest order of precedence; but even that is highly unlikely given the esoteric nature of coordinate values to laymen; that they are derived by measurements and computations; and the perceived ephemeral nature of coordinates given their relationship to different datums and datum adjustments in coordinate values given the measurements entailed in determining them and their relationship to different datums and datum adjustments. In his experience, real property owners place great reliance, and often great confidence, in visible survey monuments marking the boundaries of their holdings.

In answer to a question by Mr. Grisa, Chairman Bauer observed that there were locations – areas with high rise building, heavily wooded areas and areas in tunnels and under bridges where the GPS systems do not operate and where resort must be made to conventional survey techniques.

Mr. Burkholder observed that GPS technology provides absolute positions, and can be used to derive relative positions from those absolute provisions. There were times, however, he said, when relative measurements will take precedence over absolute measurements in survey work. Nevertheless, he said that technology is moving to the time when perhaps the satellite orbits may provide the best evidence of where a survey point was located.

Mr. Bennett disagreed with Mr. Burkholder indicating that coordinate values were simply, by themselves, an inadequate and uncertain basis for land and engineering surveys. The control system must be stable and usable by everyone concerned, he said, and not all agencies or practitioners can justify the costs involved in the use of the most advanced technologies.

Mr. Grisa observed that the report should be reorganized in that it was not clear to him where in the text the "Executive Summary" concluded and the body of the text began; and suggested that the paragraph entitled "Introduction" on page 4 be moved to wherever the "Executive Summary" concludes, thus making it clear as to where the body of the text begins.

Mr. Schaefer suggested that the last sentence of the first paragraph on page 9 be broken into two sentences and revised to read as follows: "Scientific definitions are more exacting, and indicate that the Earth's center of mass defines recent – although not historic – ellipsoids, and that horizontal datums are defined on the ellipsoids. Vertical datums are referenced to a equipotential surface known as the geoid, approximated by mean sea level.

Mr. Grisa indicated that it would be helpful in obtaining funding for the development of the necessary datum transformation methods to be able to indicate in the report some sense of the order of magnitude of the differences between positions on NAD 27 and NAD 83 (2007). He indicated that if the magnitude of the differences was in the order of one hundredth of a foot then it may not be necessary to be concerned about differences between the two datums. Chairman Bauer indicated that it may be difficult to respond to this suggestion given the complexities involved. He noted that between NAD 27 to NAD 83 (1991) the shifts in latitude ranged from about 6 to 11 feet within the Region, and that the shifts in longitude ranged from about 36 to 39 feet; these shifts being in absolute positions, and should not significantly affect the relative positions of survey points within the Region. He noted further that it would appear that distances derived from inverse computations utilizing control survey stations with coordinates referred to NAD 83 (1991) are generally closer to comparable distances derived from GPS observations, than comparable distances derived by inverse computations using coordinates referred to on NAD 27. The differences, however, are not significant, he said, and are all within the one part in 10,000 standard to be met by the Commission horizontal control survey system.

[Secretary's Note: The comparisons referenced by Chairman Bauer are provided in the following table taken from SEWRPC Technical Report No. 7, *Horizontal and Vertical Survey Control in Southeastern Wisconsin, 3rd Edition, August 1996.*]

DATA COMPARING DISTANCES DERIVED FROM GLOBAL POSITIONING TECHNOLOGY, NORTH AMERICAN DATUM OF 1927 STATION POSITIONS, AND NORTH AMERICAN DATUM OF 1983 STATION POSITIONS WITHIN THE SOUTHEASTERN WISCONSIN REGION

Station to Station (NGS)	Distance (feet)			Discrepancy Ratio	
	GPS	NAD-27	NAD-83(91)	GPS/NAD-27	GPS/NAD-83
New Lisbon-New Berlin	60,652.78	60,654.62	60,653.20	1:33,000	1:144,400
New Lisbon-Richfield	40,063.97	40,064.95	40,064.28	1:40,900	1:129,200
New Lisbon-Virmond	84,598.96	84,600.46	84,599.19	1:56,400	1:367,800
New Lisbon-Carrolville North Base	107,261.75	107,263.17	107,262.05	1:75,500	1:357,500
Richfield-Virmond	79,397.16	79,399.16	79,397.60	1:39,700	1:180,400
New Berlin-Carrolville North Base	72,800.76	72,800.81	72,800.96	1:1,500,000	1:364,000
Virmond-Carrolville North Base	102,953.42	102,955.43	102,953.42	1:51,200	1:51,476,700
New Lisbon-Oak	111,833.38	111,834.95	111,833.84	1:71,200	1:243,100
New Lisbon-Wauke	35,903.62	35,904.35	35,903.77	1:49,200	1:239,400
New Lisbon-Racine	184,255.59	184,257.59	184,256.85	1:92,100	1:146,200
New Lisbon-Somers	207,906.23	207,907.93	207,907.17	1:122,300	1:221,200
Carrolville North Base-Oak	16,439.12	16,439.60	16,439.51	1:34,200	1:42,200
Oak-Racine	72,692.16	72,692.55	72,692.95	1:186,400	1:92,000
Racine-Somers	39,591.04	39,590.79	39,591.06	1:158,400	1:1,978,600

Source: Wisconsin Department of Transportation and SEWRPC

Chairman Bauer noted further that with respect to vertical position, the Clarke Spheroid of 1866 - used as a basis for NAD 27 - fits the geoid within the Region better than does the Geodetic Reference System of 1980 ellipsoid used as the basis for NAD 83. Mr. Burkholder's work has indicated, he said, that the differences between orthometric elevations referred to NGVD 29 and such elevations referred to NAVD 88 range from approximately 0.08 to 0.32 foot within the Region.

Mr. Schaefer noted that NGVD 29 elevations are based on the geoid which approximates mean sea level. Geodetic distances used in NAD 27 are at the NGVD 29 elevation of zero. The surface of the Clarke Spheroid of 1866 and the geoid elevation of zero are not the same surface although they may match at random places. NAVD 88 elevations tend to approximate mean sea level but are not defined as such. Geodetic distances used in NAD 83 are on the surface of the GRS 80 ellipsoid which in Wisconsin differs by approximately 110 feet vertically from the geoid.

Mr. Burkholder observed that although it would be desirable to develop a single bidirectional transformation procedure for the entire Region, there were distortions in the datums concerned that become apparent in comparing data expressed on the two datums concerned. These differences may make it necessary to develop the transformation procedures for subareas of the Region.

Mr. Schaefer observed that in comparing newer survey work with older work, the older work may exhibit anomalies for a number of reasons, one of which may be that the monuments concerned may have moved; therefore, using the original positions of the old monuments will not fit the positions of the existing monuments as determined by the new work. He indicated that WisDOT had elected not to attempt to determine if all of the control survey monuments concerned are still in their original position, but instead to simply determine a new position.

Mr. Grisa referred to the 4th bulleted item on page 10 and indicated it would be desirable to include an estimate of a rate at which the rebound of the earth's crust is occurring within the Region. Chairman Bauer indicated that there were data available in the Commission files on this rate and that he would provide that information with the minutes of this meeting.

[Secretary's Note: The issue of crustal movement, and the need for the use of a dynamic – or equipotential – datum in dealing with the hydraulics of the Great Lakes was addressed in a December 1989 issue of the Commission's "Technical Record." The map on page 15 has been taken from that publication. It should be noted that the map indicates that in the vicinity of Milwaukee the apparent vertical movement rate was as determined by the U.S. Army Corps of Engineers in 1977 to be -0.5 feet per century, indicating that the earth's crust was actually subsiding in this area of the Great Lakes. In the approximately thirty years since the publication of the map that subsidence should have approximated 0.15 foot. The publication also included descriptions of the differences between spirit level elevations, orthometric heights, and dynamic heights.]

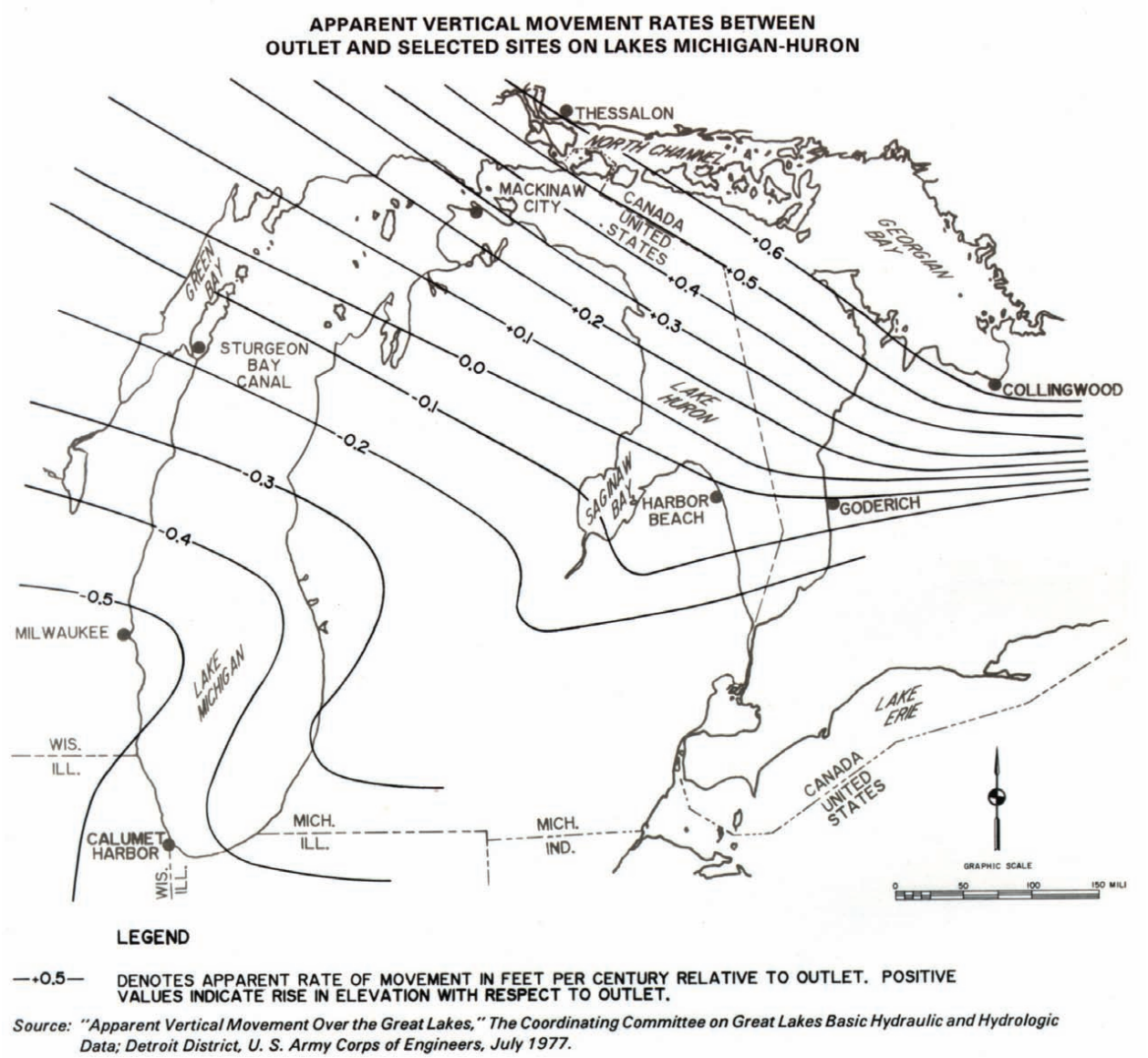
Mr. Schaefer noted that the sixth bulleted item beginning on the bottom of page 10 addressed both horizontal and vertical components of the control networks. He suggested that this item be divided into two bulleted items, one dealing with the horizontal component of the networks and the other the vertical. In the revision it would be helpful, he said, to explain that the NAD 83 (2007) adjustment was a three-dimensional adjustment, but that often only the horizontal component is utilized. He noted that there were really four components that defined the position of a point: latitude and longitude; ellipsoid height; and orthometric height.

Mr. Schaefer called attention to the second full paragraph on page 11 indicating that he felt there were some misleading statements in the paragraph and rather than take the time to describe these in the meeting, he suggested, and it was agreed, that he would provide a revised paragraph to the Committee Secretary for inclusion in the minutes of the report. Mr. Schaefer provided the following paragraph:

> Recommend deleting the last sentence of the paragraph which reads "The NGS incorporates both ITRF and NAD 83 in the positions published for the CORS stations and provides horizontal time dependent positioning (HTDP) software that can be used to translate positions from one epoch to another and between positions on the ITRF and NAD 83." The reason for this recommendation is that since Wisconsin is east of longitude W 111 degrees and the HTDP software only works between longitude W 111 and W 125 degrees, the software does not work in Wisconsin.

Mr. Grisa called attention to the description of the proposed bidirectional transformations and indicated it would indeed be important to be able to convert between NAD 27 and the selected newer datum – apparently NAD 83 (2007) – and that to be able to do so for use in both the field and office. Mr. Burkholder observed achieving this would be a challenge since there would be a need to keep distinct and separate not only the datum issues, but also the direction issues. Chairman Bauer indicated that he did not see a problem as long as a stated specified level of accuracy accompanied the bidirectional transformation method; indicated that if a surveyor or engineer desires to use the Commission's control survey data, but work in NAD 83 (2007), it will be possible using the bidirectional transformation procedure to provide the control survey coordinates in NAD 83 (2007) to the specified level of accuracy; or if a surveyor or engineer has completed field work and provides the municipality, County, or Commission with NAD 83 (2007) coordinates, and the data concerned are to be placed in the municipal, County or Commission database, the NAD 83 (2007) coordinates can be converted to NAD 27 values using the transformation procedure.

Map



Source: "Apparent Vertical Movement Over the Great Lakes," The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data; Detroit District, U. S. Army Corps of Engineers, July 1977.

Mr. Merry suggested that there could be problems with users confusing the two sets of coordinate values and this could lead to costly errors. Chairman Bauer agreed, and indicated precisely such an error had occurred during the design and construction of the MMSD deep tunnel conveyance system in which a design engineer had apparently used NAD 83 (1991) coordinate values for the location of a drop shaft when he should have used NAD 27 values. However, the Chairman said, no system can be made foolproof, and the selection of the correct coordinate values to use in a given application is a responsibility of the professional practitioner involved. He noted that confusing State Plane Coordinate values based upon NAD 83 (1991) with distances based upon NAD 27 should not in any case occur if the values based upon NAD 83 (1991) are expressed in meters – as they should be – and the values on NAD 27 are expressed in U.S. survey feet, as they should be.

Mr. Schaefer asked that the minutes show that the coordinate values of the NAD 83 (1991) were intended to be given in meters, the coordinates are nevertheless, sometimes given in U.S. Survey feet. He noted that this was the case within WisDOT and that the State Plane Coordinate values given for projects can't be used as an indication of the datum concerned.

Mr. High referred to the statement in the last full paragraph on page 12 that bidirectional transformations are proposed to be developed. He indicated that in his opinion, this appeared to be a recommendation which should not be made in the report until after all of the alternatives have been presented and evaluated. Chairman Bauer agreed, and indicated that the introductory sentence of the paragraph should be revised to read "If bidirectional transformations are to be developed …". Chairman Bauer noted that the recommendations made will be, not only Mr. Burkholder's, but the Committee's and will be addressed to the Regional Planning Commission.

Mr. Tym indicated that it would be important for the report to clearly identify the use to which the bidirectional transformation methods can be put. Mr. Burkholder agreed, indicating that it was not intended for the proposed transformation to be used in precise geodetic control applications, but in public works engineering and land surveying applications. Chairman Bauer indicated that it would appear to him that the accuracy level required should then be equivalent to one part in 10,000 or better, identical to the standard which the Commission horizontal control survey network is intended to meet.

In answer to a question by Mr. Merry, Chairman Bauer indicated that the bidirectional transformation method should provide coordinate values that could indeed be used to locate, at stated levels of accuracy, field positions. Mr. Burkholder agreed.

Chairman Bauer called attention to the levels of accuracy listed on page 13 for various survey techniques, indicating that -- as Mr. Burkholder had pointed out -- the values were taken from trade magazines and not peer reviewed journals. He suggested, and the Committee agreed, that some text be added to point this out and to briefly describe the reasons therefore. Mr. Burkholder noted that in the final report, it may be possible to combine in one table, the levels of accuracy for the various techniques set forth on page 13 and the observation scenarios set forth on page 14.

Chairman Bauer called attention to the last sentence in paragraph "E" on page 14, indicating that the statement made should be clarified to indicate the datum or datums involved. Mr. Schaefer agreed, indicating that if the statement intended to apply to the CORS network that WisDOT is in the process of developing, all coordinate positions will be on NAD 83 (2007) and NAVD 88 (2007).

Chairman Bauer called attention to the third sentence in paragraph "G" on page 14 which includes the phrase: "… CORS stations must typically be closer to the new point being established," and asked that the meaning of the term "closer" be defined in this case, that is, closer than what. Mr. Schaefer also indicated that the word "stations" should be removed from the sentence concerned.

The meeting was adjourned at twelve o'clock noon for lunch and reconvened at 12:30PM.

Chairman Bauer called attention to the heading on the top of page 15 suggesting that the title be changed to "Alternative Commission Actions." He noted that this section would have to address, among other issues, the recommended Commission action with respect to the continued

maintenance of the bench mark system within the Region and the potential of utilizing GPS technology to obtain accurate orthometric elevations within the Region.

Mr. Grisa objected to the phrase "do nothing" in the first numbered paragraph on page 15, noting that the Commission was indeed doing a great deal to maintain the control survey networks within the Region. Chairman Bauer suggested substituting the phrase "status quo."

Chairman Bauer called attention to the third numbered paragraph on page 15 concerning the datum transformations, and indicated that in formulating his recommendations as to how to address the problem of multiple datums within the Region, Mr. Burkholder should clearly identify the datums to be addressed by the transformation method to be developed – presumably NAD 27 and NAD 83 (2007). He noted that Mr. Burkholder had already prepared a bidirectional transformation for NAD 27 and NAD 83 (1991). He also observed that within the Region WisDOT apparently plans to continue to use NAD 83 (2007); the MMSD and many of the local municipalities use and apparently expect to continue to use NAD 27; and the seven counties use and apparently expect to continue to use NAD 27; some municipalities, including the City of Milwaukee ignore the use of coordinates and the related datum issues, relying on plane surveying techniques. He noted further that with respect to vertical datums, many municipalities within the Region use and apparently expect to continue to use NGVD 29 as do the seven counties; while some municipalities such as the City of Milwaukee still utilize local vertical datums. The Commission has, however, he said provided equations between such local datums and NGVD 29.

In answer to a question by Mr. Tym, Chairman Bauer indicated that he was not aware of the practices of the Wisconsin Department of Natural Resources (WDNR) in this respect, but noted that the U.S. Fish and Wild Life Service is currently considering adopting a rule with respect to wetland mapping that if adopted would require that wetland maps be based upon NAD 83 and NAVD 88; and that both the WDNR and the Commission had written letters to the U.S. Fish and Wild Life Service asking that the rule permit the utilization of other datums when cognizant Service officials find such use to be desirable. This request, he indicated, was driven by the fact that all of the historic and current wetland mapping within Southeastern Wisconsin is based upon the NAD 27 and NGVD 29 datums.

Mr. Bennett noted that within the City of Franklin, GPS technology is not utilized for determining elevations; the results being, in his opinion, inadequate accuracy. He indicated that the minimum allowable grade of an 8-inch-diameter sanitary sewer was 0.0040 foot per foot, or 0.4 foot per hundred feet, and that the City requires newly constructed sewers to be relaid if that minimum grade is not met. He indicated further that with respect to surface drainage, the City requires a minimum grade of 0.0050 foot per foot on concrete curbs and gutters and that, in his opinion, GPS technology is currently not accurate enough to be used for vertical control in connection with meeting these standards. Therefore, he said, the City continued to use spirit leveling for vertical control and for this reason believed that the Commission bench mark network should continue to be maintained. Chairman Bauer noted that the minimum permissible grade for larger diameter sanitary sewers were even flatter.

Mr. Grisa indicated that a similar situation existed with respect to the establishment of floodplain elevations and the delineation of floodplains; and that the continued maintenance of the Commission bench mark network was, in his opinion, needed for the efficient and effective administration of floodplain zoning ordinances where floodplain elevations often had to be established on a lot-by-lot basis. Chairman Bauer noted that in this respect WDNR regulations specify that the hydraulic grade of the 100-year recurrence interval flood flow not be increased by

more than 0.01 foot by proposed changes in channel cross sections or bridge and culvert waterway openings; a problematic requirement, he said, given the attainable accuracy of vertical control surveys as well as of the hydrologic and hydraulic modeling involved. Mr. Dittmar reiterated that the issue of the need to continue to maintain the network of Commission bench marks within the Region was invariably raised when County budgets were considered annually and that some County officials suggested that if maintenance of the bench mark network was indeed desirable, the cost be borne at the municipal rather than the County level.

Mr. Grisa observed that the need for accurate elevations was an area-wide need which transcended the boundaries of individual municipalities given that arterial streets and highways, sanitary sewerage facilities, and storm water drainage and flood control facilities all had to be developed on an area-wide basis, and that sound engineering practice would include an area-wide network of bench marks. Chairman Bauer observed that in the Milwaukee area, the kinds of facilities referred to by Mr. Grisa transcended county as well as municipal boundary lines and require uniform area-wide horizontal and vertical datums for planning and engineering purposes as well as attendant monument horizontal and vertical survey control stations. Mr. Melcher agreed, noting that the municipalities are an integral part of the counties and the Region and that the counties, therefore, had a responsibility to continue to maintain the bench marks within the Region.

Chairman Bauer observed that accurate area-wide horizontal and vertical datums and related control survey data were not only essential for the determination of line and grade for facility construction, but also for the preparation of accurate facility "as-built" data for use in the development of parcel based land information and public works management systems.

Chairman Bauer noted that it will be important for Mr. Burkholder's report to recommend whether or not GPS technology can be used to provide needed vertical control for public works engineering and land surveying purposes, or whether reliance will have to continue to be placed upon differential spirit leveling and bench marks.

Mr. Merry observed that utilizing static GPS measurement differences in height of between three to five hundredths of a foot per mile were achievable. Chairman Bauer objected indicating that to convert the ellipsoid heights provided by GPS measurements to the orthometric heights required knowledge of the geoid heights, which within this Region were not known with sufficient accuracy to provide the differences indicated. Mr. Merry agreed.

Chairman Bauer observed that a number of years ago the Commission had proposed a research project which would have utilized GPS measurements in conjunction with the Commission's bench mark network to obtain more accurate geoid heights within the Region so that GPS technology could be used in place of differential spirit level surveys. He said that this project had at that time been discussed with Mr. David B. Zilkoski, then in charge of height measurements within the NGS, who had enthusiastically supported the concept of the proposal and agreed to serve on an advisory committee if such a committee were formed. The project, Chairman Bauer said, was never funded.

Mr. Schaefer observed that if the specifications for GPS height and spirit leveling surveys are compared, it may be concluded that the differences in elevations between two points that are less than four and a half miles apart can be more accurately determined by spirit leveling, but if the distance between the two points is more than four and one half miles, GPS technology may be more accurate. He indicated that, in his opinion, differential spirit level surveys will continue to

be a cost effective means for determining elevations for public works and land surveying applications.

In answer to a question by Mr. Grisa, Chairman Bauer indicated that local municipalities should specify in their land subdivision control ordinances, as well as within the practices of their engineering departments, the horizontal and vertical datums/adjustments to be used within their municipality.

In answer to a question from Mr. Bennett, Mr. Charlier indicated that, with respect to elevation, practicing land surveyors within the Region, use whatever datum is specified by the local municipality concerned. Chairman Bauer observed that there were still a substantial number of local surveyors and local consultant municipal engineers that will use assumed elevations in marking out land and public works surveys. Mr. Charlier agreed that that may be a practice in municipalities where there is no established datum.

Mr. Grisa observed that many communities may not realize that WisDOT is now using different horizontal and vertical datums than those to which the Commission control survey networks are related. Chairman Bauer agreed and indicated that the problem was compounded by the use by WisDOT of the County Coordinate Systems which created cross boundary problems in what is actually a single metropolitan Region. Cecil Mehring observed that the problems inherent in the changing datums were further complicated by the fact that the majority of the WisDOT data are not referred to the current datums.

Mr. Mehring called attention the third numbered paragraph on page 15, noting that the wording implied a one-way conversion from NAD 27 to NAD 83 (2007). Mr. Schaefer agreed and indicated that the wording of paragraph 3c on page 15 should indicate that the proposed transformation procedure can be used to convert between NAD 27 and NAD 83 (2007). This same change is necessary, he said, in paragraph 3a.

Mr. Schaefer reiterated that geodetic distances expressed in the NAD 27 system are at sea-level as opposed to being on the ellipsoid; while geodetic distances in the NAD 83 system are on the ellipsoid; so it would appear that as proposed one “end” of a translation will be expressed in latitude and longitude and ellipsoid heights, while at the other “end” it may be expressed in latitude and longitude and elevation on the geoid. This, he said, would require conversion between the geoid and the ellipsoid, and that the geoid height required may not be known with sufficient accuracy within the Region.

Mr. Burkholder indicated that in the modeling process, the equations are not in closed form and the inexactnesses include both differentiations that existed within NAD 27, residual imperfections in the new datum and in small errors attributable to moving from the ellipsoid in one system to the geoid in the other.

Mr. Schaefer observed that the method used to adjust NGVD 29 data was totally different from that used to adjust the NAVD 88 (2007) data, and that, consequently, it would seem that a large number of common points will have to be selected to develop as proposed the needed transformation model. Mr. Burkholder observed that when he developed the vertical transformation procedure for the Commission approximately a decade ago, he abstracted all leveling data done by the Commission and then adjusted the data sequence by level line and simultaneously by area and found that the two approaches yielded the same transformation parameters. He indicated this issue would have to be revisited in the development of a new transformation method.

Mr. Merry suggested that Mr. Burkholder consider recommending the use of nine, instead of seven, parameter Helmert transformation in developing the needed procedure. Mr. Burkholder indicated he would consider the suggestion.

Chairman Bauer noted that Mr. Burkholder had long proposed the adoption of all earth centered x-y-z three-dimensional coordinate system as a basis for the location of points on the surface of the earth, and that he had written a book scheduled to be published soon describing his recommended system. He asked whether the proposed bidirectional transformation methodology might in any way preclude the future adoption and use of a true three-dimensional coordinate system within the Region.

A lengthy discussion ensued concerning the proposed three-dimensional coordinate system which would eliminate the problems associated with the use of multiple datums. In the discussion Mr. Burkholder noted that all of the advantages of the proposed system listed in paragraph number 4 on page 16 and 17 would be attained. Mr. Merry questioned the practicality of the system since it was intended to be earth centered and the realities of physical geodesy would create problems with the application of the system such as uncertainty surrounding the accurate location of the center of mass of the earth, possible instability in that location, and precession of the earth's axis.

In answer to a question by Mr. Schaefer, Mr. Burkholder indicated that in the proposed system, the zero point of the axes involved would be located at the earth's center of mass. The x and y axes would lie in the plane of the equator, while the z axis would lie along the earth's axis of rotation. He indicated that the location of a point in space relative to this system would follow the rules of solid geometry, and height would be a derived quantity; ellipsoids could be superimposed upon the axes which would then introduce the concepts of latitude, longitude, and ellipsoid and orthometric heights; geometrical integrity could be preserved without distortion.

Chairman Bauer called attention to page 17 and noted that estimated costs for carrying out Phase I and Phase II of the proposed bidirectional transformation work would have to be provided in the final draft of the report.

With respect to the "givens" listed on the bottom of page 17, Mr. Merry observed that attempting to combine newer data provided by the application of GPS technology, with older data provided by conventional historic survey techniques might reveal distortions in the systems concerned, and require the modeling involved to be conducted on a relatively small area basis. Mr. Burkholder agreed and indicated that this problem had been successfully addressed in the original effort of a decade ago. He indicated further that his intent would be to begin the analysis with record data and to then identify any additional observations that might be needed.

Mr. Schaefer observed that the heights considered in WisDOT's Height Modernization Program were not determined at the same points used in the 2007 adjustment of NAD 83; and that many bench marks do not have accurate horizontal positions; and that some GPS stations will have GPS derived orthometric heights which are not as good as such heights derived by differential leveling. Consequently, he said, it may be preferable to fall back on the method used by Mr. Burkholder in his original work for the Commission, that considered the horizontal control separately from the vertical, rather than in combination as is apparently being proposed for the new work. Another lengthy discussion ensued concerning this issue, in which Mr. Burkholder indicated that it was intended to accommodate to the extent practical, in the modeling, the HARN, CORS, NAD 83 (2007) and NAVD 88 (2007) data. Mr. Schaefer noted that the NAD 83 (2007) adjustment included CORS, HARN, and some other stations with sufficiently accurate horizontal

positions, and that some of those stations were not included in the vertical adjustment nor vice versa; but that the CORS and HARNS stations would be common stations unless those stations with two dimensions are treated different from those that have three dimensions attached. Mr. Burkholder responded that this was a valid criticism of the proposed approach, and indicated that he would wish to pursue this matter further with Mr. Schaefer before preparing the final draft of his report.

With respect to the first paragraph numbered 2 on the top of page 18, Mr. Schaefer noted that the paragraph should be revised to clarify and support the procedures for horizontal and vertical transformations. The discussion then focused on the detailed procedures proposed to be used in developing the bidirectional transformation method as listed on page 18 and 19, particularly involving issues raised by Mr. Merry concerning the use and treatment of ellipsoid heights derived from GPS measurements, the NGS geoid modeling, and the need for geoid height data at both ends of the transformation. Mr. Burkholder indicated that he was not yet satisfied that the same geoid model should be used at both ends of a transformation, and whether or not the use of a different model at each end of a transformation could be accommodated within the desired accuracy levels of the transformation method.

Mr. Schaefer observed that introducing an intermediate "three dimensional" step in the procedure would require the use of geoid heights to convert between ellipsoid and orthometric heights, a process that involved a number of steps incorporating the use of values that are not very well defined, in particular, geoid height values within the Region, and suggested that a more direct approach would be to use the NGVD 29 and the NAVD 88 (2007) heights, comparing these for known common horizontal positions so that in the modeling the complex intermediate steps could be avoided. Mr. Burkholder indicated that this suggestion had a great deal of merit and should be considered and included in the testing of the methods to be used if the work proceeds.

Chairman Bauer observed that if the recommendation that the Commission develop bidirectional transformation models is accepted by the Commission, and if the recommended work is funded, the creation of a small technical advisory committee to oversee the work would be desirable and could be recommended in the final report.

By consensus, the Committee directed Mr. Burkholder to proceed with the preparation of a revised draft of his report to the Commission, considering in his report the suggestions and directions made and given at this meeting. Chairman Bauer indicated that consideration of the revised draft of Mr. Burkholder's report would be the principal item of business at the third meeting of the Committee.

OTHER BUSINESS AND CONSIDERATION OF DATE AND TIME OF NEXT MEETING

Chairman Bauer then asked the members of the Committee if there were any further business to consider. There being none, Chairman Bauer then asked the Committee to consider a date and time for the next Committee meeting.

After a brief discussion, it was agreed the next meeting of the Committee would be held on February 15, 2008, at the Commission offices beginning at 9:00 a.m.

ADJOURNMENT

There being no further business to come before the Committee, on a motion by Mr. Melcher, seconded by Mr. Charlier, and carried unanimously, the meeting was adjourned at 3:00PM.

Respectfully Submitted,

Lynn G. Heis
Committee Secretary

KWB/lgh
02/20/08
#132710 v2 - C/S - Minutes 2nd Meeting

ATTACHMENT I

PRELIMINARY DRAFT OF BURKHOLDER REPORT
AS PRESENTED TO THE COMMITTEE
AT THE MEETING HELD ON
NOVEMBER 16, 2007

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Draft….Draft… Draft….Draft… Draft….Draft… Draft….Draft…

Staff Memorandum for the

Southeastern Wisconsin Regional Planning Commission
Waukesha, Wisconsin

Recommendations for Protecting Commission Investment in the System of Horizontal and Vertical Survey Control Networks Throughout the Seven-County Region

by:

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Consulting Geodetic Engineer
Las Cruces, New Mexico 88003

October, 2007

Table of Contents

List of Acronyms and Abbreviations

1.	CBN	Cooperative Base Network - CORS stations operated by others but data sent to NGS.
2.	Commission	Southeastern Wisconsin Regional Planning Commission.
3.	CORPSCON	Program written by U.S CORPS of Engineers for coordinate and datum transformations.
4.	CORS	Continuously Operating Reference System - permanent GPS receiver installation.
5.	DoD	The U.S. Department of Defense
6.	ECEF	Earth-centered Earth-fixed - rectangular geocentric coordinates used by DOD for GPS.
7.	FBN	Federal Base Network - CORS stations maintained by the NGS
8.	FGDC	Federal Geographic Data Committee - interagency organization responsible for the NSDI
9.	Galileo	Satellite positioning system being built by the European community.
10.	Geoidxx	Geoid height interpolation programs published by the NGS in 19XX and 20XX.
11.	GLONASS	Russian satellite navigation system similar to the U.S. GPS system
12.	GNSS	Global Navigation Satellite System - includes GPS, Glonass, and Galileo systems
13.	GPS	Global Positioning System - satellite system built by U.S. DOD and used worldwide.
14.	HTDP	Horizontal Time Dependent Program used by NGS to move data epoch to epoch.
15.	IGLD(55) and (85)	The International Great Lakes Datum developed jointly by U.S. & Canadian scientists.
16.	ITRF	International Terrestrial Reference Frame - international scientific community global datum.
17.	NAD27	North American Datum of 1927 - horizontal datum established by the NGS
18.	NAD83	North American Datum of 1983 - horizontal datum established by the NGS
19.	NAD83(86)	Original NAD83 values as computed and published in 1986.
20.	NAD83(91)	NAD83 values published by the NGS in 1991.
21.	NAD83(97)	NAD83 values published by the NGS in 1997.
22.	NAD83(NSRS2007)	NAD83 values published by the NGS in 2007
23.	NAD83(xx)	Subsequent NAD83 values as published in the year 19XX.
24.	NADCON	Program written by NGS to perform datam conversions NAD27 to NAD83
25.	NAVD88	North American Vertical Datum of 1988 - published and maintained by the NGS
26.	NGS	National Geodetic Survey - responsible for national survey control network.
27.	NGVD29	National Geodetic Vertical Datum of 1929 - vertical datum published by the NGS
28.	NOAA	National Oceanic & Atmospheric Administration - parent agency to the NGS
29.	NSDI	National Spatial Data Infrastructure - the underlying framework of spatial data policies.
30.	NSRS	National Spatial Reference System - combined horizontal/vertical survey control network.
31.	Region	The seven-county area served by the SEWPRC.
32.	RTK	Real-time kinematic - mode of using GPS to establish survey positions in real time.
33.	RTN	Real-time Network of GPS CORS stations providing support for real-time positioning.
34.	SEWRPC	Southeastern Wisconsin Regional Planning Commission
35.	USC&GS	U.S. Coast & Geodetic Survey - predecessor to the NGS
36.	USGS	United States Geological Survey - responsible for national mapping program in the US.
37.	VERTCON	Program written by NGS to perform datum conversion NGVD29 to NAVD88.
38.	WGS84	World Geodetic System of 1984 - datum used by DoD for GPS. Fixed on center of mass.
39.	WHM	Wisconsin Height Modernization program
40.	WISDOT	The Wisconsin Department of Transportation

Introduction

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) has, for over 40 years, promulgated establishment of horizontal and vertical survey control networks within the seven-county region. Those networks serve as a framework for the conduct of land and engineering surveys; for the preparation of large-scale topographic and cadastral maps; and as a foundation for the creation of parcel-based land and public works information systems within the region. Dividends on that investment have been significant in terms of orderly infrastructure development, efficient land administration policies, and avoided costs. However, technological developments need to be assessed in terms of compatability with established policies and operational procedures. Such advancements include issues such as computer databases, transition from analog to digital data storage, spatial information management, global positioning system (GPS) measurements, and other tools for generating, analyzing, and using spatial data.

Executive Summary:

Given that Commission established networks of horizontal and vertical survey control are in place and provide a reliable foundation for many spatial data activities throughout the region, it is important for the Commission to recognize the value of that investment and to review recent technological developments in terms of compatability with the existing databases and current policies/procedures. To that end, the Commission established a "Technical Advisory Committee on the Review and Reevaluation of the Regional Control Survey Program" with a charge to:

- Critically review and reevaluate the status and continued utility of the Commission control survey network.

- Recommend any needed changes in the network and in the means for its perpetuation, maintenance and use; and

- Recommend the Commission's role, if any, in the perpetuation, maintenance and use of the network and identify any attendant funding requirements and sources.

The Technical Advisory Committee (see Appendix A) has met, discussed issues, raised questions, offered suggestions, and provided insight into the issues, concerns, and priorities addressed in this report. The Committee is convinced of the continuing need for the control survey network to support land and engineering surveys within the Region and agrees that the survey control networks should continue to serve as the foundational framework for automated parcel based land and public works information systems within the Region.

Recommendations:

The Commission is to be commended for identifying the need and taking steps to protect the investment in the basic horizontal and vertical survey control networks in the seven-county Region. These recommendations are made in recognition of the value of the existing networks, wide-spread reliance on Commission established survey control by spatial data users in various disciplines, the capability of newer positioning technologies, and requests from external users for the Commission to establish compatibility between existing survey control and the recently updated horizontal and vertical datums, the NSRS(2007) as published by the National Geodetic Survey (NGS).

Specific recommendations include:

1. As opposed to using GPS observations and satellite orbit parameters as published by others, the Commission should continue to place primary reliance on the published positions of stable survey monuments as established throughout the Region. Furthermore, the Commission should continue to replace and to re-survey the positions of those monuments that are inadvertently distrubed or destroyed.

2. The Commission should continue the established policy of basing the horizontal survey control network on the North American Datum of 1927 (NAD27) and the vertical network on the National Geodetic Vertical Datum of 1929 (NGVD29). Given the investment in existing horizontal and vertical control databases, the proven quality of those control values, and continued reliance on those datums by spatial data users within the seven-county region, the cost (in terms of resources, efficiency, convenience, and good will) of migrating to the newer North American Datum of 1983 (NSRS2007), and to the North American Vertical Datum of 1988 (NAVD88) currently far outweighs the benefits associated with making such a change.

3. Recognizing advances in positioning technology and the subsequent impact of those advances on many uses of spatial data (digital data files and hard-copy maps), the Commission should pursue development of transformation procedures by which bi-directional conversions between the NAD27 and NAD83(NSRS2007) horizontal datums and the NGVD29 and NAVD88 vertical datums can be accomplished. The procedures should be well defined, technically defensible, and easy to use. Developing bi-directional transformations is a major portion of this report and cost estimates for developing those transformations are included in a subsequent section of this report.

4. The Commission should develop an on-going training and up-dating program whereby procedures involving new technology (e.g. GPS, CORS, and RTN) can be incorporated into the standard spatial data flow affecting both internal and

external users. Of particular interest, the Wisconsin Department of Transportation (WISDOT) has devoted significant resources to Wisconsin height modernization (WHM) both throughout the state and within the seven-county Region. GPS measurements and improved geoid modeling procedures have been proven to be more cost effective than traditional geodetic leveling for establishing orthometric heights in specific cases. The Commission should be aware of that capability because, if used competently, it can be more effective than tradional leveling for establishing reliable orthometric heights on new benchmarks.

5. The Commission should renew its commitment to the user community by re-emphasizing the value of the survey control networks to the spatial data user community. Education and outreach efforts should be developed that highlight the benefits of having the horizontal and vertical control networks in place and relied upon by various disciplines within the Region. It would be appropriate for the Commission to sponsor a yearly (or bi-yearly) forum to inform the user community (both internal and external) on policies regarding use of Commission established survey control network and on technical issues relating to use of new technology.

6. The Commission should continue to participate in the broader professional community by developing and publishing technical papers related to the value and benefits of using a well-controlled digital spatial database.

Monumentation

A survey monument is an object, either natural or man-made, that has been surveyed and precisely located. In years gone by a natural monument could be called for as the top of a mountain, the course of a stream, a tree, or an identifiable rock outcrop. As survey methods and measurements improved, natural monuments have given way to man-made monuments such as an "x" chisled into a concrete pad to mark a survey point; pipes, rods, or axles driven into the ground to mark a property corner; or railroad spikes driven into power poles to serve as a benchmark. Even better, appropriately enscribed brass tablets are embedded into concrete or grouted into bedrock outcrops; stainless steel rods are driven deep into the ground; or a huge pedestal is erected to mark a particular location. Several criteria for survey monuments are:

- The monument must be stable. If the survey mark is located in unconsolidated fill, on the side of a hill subject to lateral movement, set on a stream bank that erodes away, or set in such a manner that it is subject to frost heave, then the value of any surveyed position for the mark is severely compromised and the usefulness of the mark is destroyed.

- A good survey monument must be permanent. Cases exist in which a cedar post has been retrived from a swamp and positively identified as the mark set over 100

years ago by a surveyor who carefully described its location. Although impressive, such an example is not an argument for wood survey monuments. More typically, a permanent monument is constructed of non-ferrous metal and built such that a very specific point on the object is identified as being the survey mark.

- A good survey monument is also readily accessible. In years gone by, geodetic survey markers were located on hills or mountain tops from which other distant points could be viewed. However the value of a survey monument is enhanced if the monument is also located in proximity to where it is to be used. In recent years, GPS surveying has been used to transfer remote and/or hill-top positions to more convenient locations - often on public property or rights-of-way where they are easily reachable by normal vehicular traffic.

- The value of a good survey monument is also enhanced to the extent the site is free of obstacles (trees, buildings, etc) which prevent line of sight to other objects.

Stated differently, the ideal survey monument is one that is located close to where it is needed, is accessible, is permanent, is stable, and has reliable survey control associated with it. In the big picture, survey monuments provide end users reliable convenient access to the horizontal and vertical datums adopted for use in a given area. Nationally, the adopted datums are the National Spatial Reference System (NSRS). Within the seven-county Region the datums include both the NAD27/NGVD29 and the NSRS.

At this point, a distinction should be made between geodetic control monuments and survey monuments intended to mark property corners. Their purposes, although quite similar, are somewhat different. A geodetic marker is intended to provide the end user ready access to the overall geodetic datums while the property corner is intended to delineate property boundaries. Prior to GPS surveying, geodetic surveys were marked with substantial permanent objects. Each monument location was also carefully chosen for stability to protect the investment required to establish the geodetic monument. On the other hand, markers for property corners are set on the corner, whether convenient or not, and off-sets are only used when it is impossible to set a marker on the actual property corner. Property corners are typically marked with iron rods driven in the earth and are admittedly not as permanent as a typical geodetic marker.

Survey monuments are also called for in legal descriptions of real property and a fundamental tenent of land ownership is that an original undistrubed monument controls the location of associated property lines even if current measurements are inconsistent with the stated surveyed location of the monument. Even though this line of reasoing leads to broader issues of relative positioning (monuments and coordinate differences) and absolute positioning (coordinates), several points of which to be aware include:

- The role of the surveyor is to collect, evaluate, and present evidence. That evidence may include records of prior surveys, knowledge of local history and

practice, measurements and retracements, and any other information having an impact on the correct determination of the intent of the parties.

- Sometimes it is very difficult to prove that a found monument is undistrubed.

- When the surveyed location of section corners and property corners have been defined by state plane coordinates (as is generally the case throughout the seven-county region) then the ambiguity of any subsequently resurveyed location can be enormously reduced. Evaluation of the evidence can be very straightforward because of the excellent agreement between the record and current measurements.

- It is now possible using current GPS equipment and measurements to duplicate the location of any published state plane coordinate within a small tolerance. Access to the NSRS no longer depends upon the location, stability, permanence, or configuration of a survey monument. The state plane coordinate position (and to a lesser degree elevations) can be determined from measurements to the satellites within the framework of the defined datum.

In that latest scenario, the observation is made that the satellite orbits have effectively replaced the monument on the ground as end-user access to the NSRS. In either case a competent surveyor is able to establish and/or re-establish the known position of a corner within practical tolerances – say within 0.05 to 0.10 feet. However, it is often much easier for a lay person (a neighbor or the courts) to understand the location of a property corner related to a visible nearby geodetic survey control monument or other physical feature (such as roads, fences, or streams) than to believe the numbers generated from an electronic gadget collecting signals from orbiting satellites.

There is a long-standing legal history involving priority of coordinates and monuments with regard to definition of property lines. Although GPS technology can be used to show remarkable agreement between record positions and surveyed positions, it is viewed as prematue to question the importance or the legal stature of the called-for monument. In the big picture, the GPS surveyed location of a geodetic control monument or a property corner can be accomplished with similar ease and efficiency. But, just because a property corner can be competently located with GPS independent of a nearby geodetic control monument does not mean that is the way everyone should do it. Prudent policy should continue to honor the well established principle that the undistrubed monument is the prima-facie evidence. As practice continues to evolve, the agreement between a monument-based location and the satellite-derived location should fall within the combined positional tolerance of both sources. Resolving discrepancies between record and measurement should be part of the standard procedures for evaluating and using the best available evidence.

Multiple Datums

A datum is a reference to which other values are related. Historically, in surveying there are horizontal datums and vertical datums. They are separate in that a horizontal datum is referenced to parallels of latitude and meridians of longitude but a vertical datum is understood to be referenced to mean sea level. Scientific definitions are more exacting and it is said that horizontal datums are ultimately referenced to Earth's center of mass while vertical datums are referenced to an equipotential surface known as the geoid (approximated by mean sea level).

The National Geodetic Survey (NGS), formerly known as the U.S.Coast & Geodetic Survey, is a component of the National Oceanic and Atmospheric Administration (NOAA) and is the agency reponsible for establishing and maintaining the surveying datums in the United States. The NGS is a small agency but, since the early 1800's, has enjoyed a proud tradition of conducting high caliber surveys to establish precise geodetic positions on both horizontal and vertical control monuments throughout the United States. A brief summary of horizontal datums was written by Joe Dracup, former Chief Geodesist for the USC&GS, as:

> *In 1879 the first national datum was established and identified as the New England Datum. Station PRINCIPIO in Maryland, about midway between Maine and Georgia, the extent of the contiguous triangulation was selected as the initial point with its position and azimuth to TURKEY POINT determined from all available astronomical data, i.e. 56 determinations of latitude, 7 of longitude, and 72 for azimuth.*
>
> *Later its position was transferred to station MEADES RANCH in Kansas and the azimuth to WALDO by computation through the triangulation. The Clarke Spheroid of 1866 was selected as the computational surface for the datum in 1880, replacing the Bessel spheroid of 1841 used after 1843. Prior to 1843, there is some evidence that the Walbeck 1819 spheroid was employed.*
>
> *The datum was renamed the U.S. Standard Datum in 1901 and in 1913 the North American Datum (NAD) as Canada and Mexico adopted the system. In 1927 an adjustment of the first-order triangulation of the U.S., Canada and Mexico was began and completed about 1931. The end result was the North American Datum of 1927 (NAD27).*

A similar history of the vertical datums was written by Ralph Moore Berry (1976), former Assistant to the Director of NGS, who notes that the National Geodetic Vertical Datum of 1929 is identical to the Mean Sea Level Datum of 1929 except for the name change to avoid the implication that a "zero" elevation provides a reliable distinction between what is land and what is ocean. No benchmark elevations or names of stations were changed – only the name of the datum was changed.

The survey control networks currently utilized by the Commission in the seven-county region are based upon the North American Datum of 1927 (NAD27) for horizontal and the National Geodetic Vertical Datum of 1929 (NGVD29) for vertical.

In the normal conduct of their duties, the NGS has readjusted and up-dated both the horizontal and vertical datums in the United States – including the State of Wisconsin. Several realizations of the updates include:

- A horizontal datum update from NAD27 to the North American Datum of 1983. The completion happened in 1986 so the datum is known as the NAD83(86).

- A horizontal datum update in 1991 based upon improved positions as a result of using GPS technology. The update is state specific and known as NAD83(91).

- A horizontal datum update in 1997 based upon an improved 3-D GPS survey. That update is also state specific and known as NAD86(97).

- Scientific agencies within Canada and the United States have long collaborated on elevation issues in Canada and the upper midwest. The International Great Lakes Datum (IGLD) was established in 1955 in recognition of the continuing rebound of the Earth's crust in the greater Hudson Bay region in response to removal of the crustal loading since the most recent ice age. A separate issue is that conventional orthometric heights do not accurately reflect hydraulic gradients for the Great Lakes System. The IGLD was designed to use dynamic heights in place of orthometric heights and the IGLD was intended to be readjusted every 30 years or so to reflect the on-going crustal rebound. Those issues and changes, although small, do affect elevations as used in the SEWRPC Region.

- Following readjustment of the horizontal datum published in 1986, the NGS turned their attention to updating the vertical datum in the United States. The new vertical datum adjustment is known as the North American Vertical Datum of 1988. From a big picture (and scientific) perspective, the NADV88 is superior to the NGVD29 because elevation differences between benchmarks (both locally and coast to coast) are more consistent than those of the NGVD29. And, an added advantage is the consistency established between the new NAVD88 and the IGLD85 due to the underlying geopotential numbers being the same on both datums. The difference is that NAVD88 publishes orthometric heights and while the IGLD publishes and use dynamic heights.

- In 2006 and 2007, NGS readjusted the entire National Spatial Reference System and combined the various state-specific adjustments into a single adjustment constrained to the national network of CORS stations whose positions are precisely known and continuously monitored. The adjustment provides 3-D consistency throughout the United States and avoids the state-specific localized adjustments conducted between 1986 and 2007. The latest readjustment is known as the NAD83(NSRS2007). The adjustment was completed in February 2007 but

the adjusted information has only recently become available on the published data sheets for published control points. With publication of the NAD83(NSRS2007) the datum is effectively a single 3-D datum with separate horizontal and vertical components available for use at the prerogative of the user.

- The Wisconsin Department of Transportation (WISDOT) has also conducted geodetic surveys – both horizontal and vertical – within the seven-county region and has conducted localized adjustments in conjunction with the NGS. Those results are available as part of the NGS database and eligibible to contribute to the realization of the the NSRS in the seven-county region.

Separately, the U.S. DoD is the agency that developed the GPS that has become the standard positioning system used all over the world. The datum used by GPS is the World Geodetic System of 1984 and includes both an ellipsoid and a formal datum definition. The GPS satellites physically orbit the Earth's center of mass and the intent of the DOD is for the datum to match the orbits as closely as practicable. That means the WGS84 datum origin is modified from time to time to reflect better knowledge of that center of mass. The various epochs of the WGS84 are numbered in GPS weeks starting 6 January 1980 and include WGS84(G730), WGS84(G873), and WGS84(G1150) which was implemented on 20 January 2002. Orbits of the GPS satellites are monitored continuously by the DoD and ephemerides are computed for the orbits – both predicted (known as broadcast) and historical (precise). Those orbit parameters are the basis of positions computed from GPS observations. The point is that WGS84 is governed by knowledge of the Earth's center of mass, that GPS signals are native to the WGS84, and that the U.S.DoD maintains the GPS for its declared purposes. It could be said that civilian communities worldwide are at the mercy of the US DoD with regard to continued use of GPS.

The international scientific community also monitors GPS satellite orbits and has defined the International Terrestrial Reference Frame (ITRF) which very closely matches the WGS84 but whose determination and use is separate from the U.S.DoD. The ITRF is designed for a global best fit and continental drift shows up in the positions determined within the ITRF. On the other hand, the NAD83 is fixed to the North American continent and, for practical puposes, the NAD83 moves with the North American plate. The NAD83 as a datum is very stable for areas, including the SEWRPC Region, within the United States. The NGS incorporates both ITRF and NAD83 in the positions published for the CORS stations and provides horizontal time dependent positioning (HTDP) software that can be used to translate positions from one epoch to another and between positions on the ITRF and NAD83.

The following is included for information purposes and judged to have little or no impact on the issues currently being discussed with regard to datums being used within the SEWRPC Region. The Russian GLONASS and the European Galileo systems use neither the WGS84 nor the NAD83 datums. To the extent that becomes an issue in the United States, the vendors deal with those issues and equipment marketed in the United States is designed to be used on either the NAD83 or the WGS84 datums.

All this background is offered for the purpose of better understanding the questions related to continued use of the NAD27 and NAVD88 datums within the SEWRPC Region. Ideally there would be a civilian datum which does not change and a military/scientific datum to serve other purposes. However, the problem is that the "civilian" datum is subject to periodic upgrades and that modern measurements obtained from GPS are inextractably linked to the WGS84 "military" datum. There is no "fixed" or mathematically defined relationship between the WDG84, the NAD83(NSRS2007), and the NAD29/NAVD88 and spatial data users, both internal and external to SEWRPC, find themselves in a position needing to deal with elements of both.

Scenario: For some it is already possible, but spatial data users in the near future will enjoy the luxury of carrying an instrument into the field that is capable of providing real-time positioning within 0.10 feet (3 centimeters). The same portable field equipment will also have storage capacity and processing capability to access the spatial data base. Apples and oranges (datums) do not mix. Without using some sort of transformation, it is not reasonable to expect values from the SEWRPC data base to be compatible with data collected with modern GPS units.

The problem to be avoided is for the end user to contend with datum issues instead of proceeding with productive work. Implemented appropriately, the datum issues will have been addressed behind the scenes and the spatial data user, both internal and external, will be able to engage in productive spatial data activities without needing to worry about datum issues.

Bi-directional transformations are proposed to be developed that will enable data to be transformed between NAD27/NGVD29 and the NAD83(NSRS2007) datums. No transformation will be perfect. But each of the two following alternatives is possible.

A. In the first case, the existing database values will be automatically and instantly converted to NAD83(NSRS2007) values within the field unit so that "record" values are compatible with those being obtained from the satellites orbiting the Earth's physical center of mass.

B. In the second case, the observed GPS values will be automatically (if directed by the user) and instantly converted to NAD27 and NGVD29 values so that the modern "GPS" values will be compatible with those currently residing in the SEWRPC database.

C. In either case, the "relative" differences between common points in both systems should be very similar. But, they will not be perfect due to known distortion existing within the NAD27 datum. For second and third order comparsions and for use in local civil infrastructure development and cadastral parcel definition, those comparisons should (and are expected to) be very acceptable. There will be a point where such procedures are not deemed acceptable for geodetic control

surveys. That level of spatial data integrity will need to be determined in testing the veracity of the transformations.

The same criteria also need to be applied to other field and office operations. A consistent policy needs to be applied so that all users know specifically what datum they are working with and what steps/decisions with regard to datum issues must be accomplished to achieve consistent results.

CORS, RTK and RTN

GPS positioning technology has matured to the point it is possible to determine horizontal and vertical positions within 0.5 feet in real-time. And, depending upon the level of sophistication applied the geodetic position of a point can be determined in 3 dimensions within 2-5 centimeters (about 0.1 to 0.2 feet) very economically. Even more precise geodetic positions are routinely possible using carrier phase GPS baselines to build a network tied to the NGS CORS.

Techniques and levels of accuracy typically attainable include:

		Within about
A.	Hand-held code-phase receivers operating in autonomous mode	5 m or 15 ft.
B.	WAAS corrected code-phase receivers	2-3 m or 10 ft
C.	Differentially corrected code-phase receivers – local	1-2 m or 8 ft
D.	Post processed code-phase differentially corrected	0.5 to 2 m or 6 ft
E.	RTK carrier phase single baseline over nominal distance	0.05 to 0.5 m or 1.5 ft
F.	RTK carrier phase multiple (redundant) baselines	0.01 to 0.2 m or 0.5 ft
G.	RTK carrier phase network solution	0.01 to 0.1 m or 0.3 ft
H.	OPUS dual frequency 2 hours of data – absolute position	0.02 to 0.05 m or 0.2 ft
I.	OPUS-RS single frequency 15 minutes of data	0.02 to 0.05 m or 0.2 ft
J.	Static carrier phase, either single baseline or network,	0.005 to 0.020 m or 0.02 ft

Traditional static GPS observations (1-2 hours of data in a network configuration with two independent occupations) can be used to determine the 3-D position of a survey monument within 1-2 cm (less than 0.10 feet). Sites with good sky visibility are required and data processing must be carefully monitored.

Possible equipment/observation scenarios include:

A. Autonomous position single receiver – typically hand-held.

B. Differentially corrected position from base (may be permanent) and remote units.

C. Static carrier phase observations to 2 or more instruments simultaneously. Post processing is required.

D. Real-time kinematic carrier phase positions obtained from base station and remote. Processing occurs in the remote unit and displays position in real time. This mode requires radio or cell phone communication between base and remote units.

E. Real-time network solution is based upon multiple permanent base stations configured in a local network that broadcast corrections to local remote units. High quality positions are available in real-time. Transportation Departments in the states of Ohio (2004) and Michigan (2005) were pioneers in the United States for investing in state-wide Real-Time Networks. In several other states (Texas and Virginia) private networks have been installed and supported on a user subscription basis. In other cities and metropolitian areas (e.g. Albuquerque and Atlanta), a smaller permanent GPS network serves the needs of local users. Getting a RTN set up and operational is no trivial undertaking but once established, seems to work quite well for the mutual benefit of subscribing users. Such networks, whether public or private, provide subscribing users the ability to position points precisely anywhere within the coverage of the network.

F. Dual frequency carrier phase data are collected for several hours and sent via email to NGS for processing. The results are typically sent back within minutes and provide an absolute position within about 0.05 to 0.10 meters. The solution is developed automatically without human intervention and based upon using data from the network of continuously operating reference stations (CORS).

G. Single frequency data sets as short as 15 minutes can be submitted to NGS for processing using a newer algorithm. Results are still be tested but indications are they are as good as regular OPUS solutions. However, the CORS stations must typically be closer to the new point being established. A general comment is that an OPUS solution is more time dependent while the OPUS-RS is more distance dependent to the CORS used in the solution.

Alternatives and Using GPS for Orthometric Heights

Several alternatives that could be selected by the Commission include:

1. "Do nothing" is probably best described as continuing to do what is being done now. That means that values in the database are NAD27 and NGVD29 and on-going development of the civil infrastructure, topographic mapping, cadastral overlays, flood plain studies, and other spatial data uses are based upon those datums. It also means that use of modern GPS positioning methods is hampered because those systems generate answers and solutions based upon the WGS84 and/or the NAD83. The problem is that satellites physically orbit the Earth's center of mass and GPS data/results are compatible with those datums.

2. An alternative would be to find a way to move the horizontal and vertical databases to the NAD83(NSRS2007) horizontal datum and the NAVD88 vertical datum. The advantage would be that issues of datum difference would disappear. This alternative would be technically possible but it would also be a very expensive undertaking. The benefits of making that transition would need to justify both the dollar cost and the inconvenience of the transition.

3. A more reasonable approach is to develop one or more bi-directional transformations that can be used to convert NAD27 values to NAD83(NSRS200) and NGVD29 values to NAVD88 values. Due to the distortions known to exist in the older datums, it is impossible to develop a closed form mathematical equation to be used for all points. If this alternative is selected, the following issues will need to be considered and addressed.

    a. Transformations can be used to convert NAD27 values to NAD83 values so that users are working with values that are compatible with GPS operations – including real-time positioning.

    b. Transformations can be used to convert NAD83 GPS derived values to NAD27 values so that data to be included in the existing database will be compatible with what is already there.

    c. Users could be permitted to choose and use either approach as dictated by the circumstance. This option provides the most flexibility and convenience but this option has the potential to be confusing because all users will need to be very specific about which datum they are using.

    d. It may be the position of the Commission to continue using NAD27 and NGVD29 for all internal uses and to provide the transformation procedures to external users and expect them to assume responsibility for any and all transformations. That makes it cleaner for internal operations but it will likely drive up the cost to the Commission to secure services of those using the modern positioning technology.

e. Current transformations as described in SEWERPC Technical Reports #34 and #35 were developed separately for horizontal and vertical datums. Given the NAD83(NSRS2007) is a 3-D datum, the transformation modeling for the current effort should be done with the 7-parameter Helmert transformation. The tools used in Technical Report #34 were valid for 2-D transformations but the Helmert transformations are specifically applicable for combining both the horizontal and vertical transformations into a single modeling operation. Once the Helmert transformation is completed (behind the scenes), subsequent steps will be identified so that the end user will be able to employ bi-directional horizontal and vertical transformations separately.

4. The remaining alternative is a huge step and, if done all at once, could be quite costly. But the potential benefits will likely make this alternative attractive at some point in the future. This alternative is not recommended at this time but listed in order to provide context and comparison for the other alternatives. The process is to convert the existing horizontal and vertical databases to an integrated 3-D database in which datum issues largely disappear because:

    a. All subsequent spatial data operations are based upon values stored in the integrated 3-D database.

    b. Each point is stored as absolute X/Y/Z coordinates along with a covariance matrix which provides reliable statistical information on spatial data accuracy.

    c. Any point pulled out of the database will have its positional accuracy immediately available in each of three dimensions. The user will be able to impose a filter of any (selectable) magnitude to decide what points to use or not use.

    d. The relative position of any point-pair is immediately available at the ground level of either end point (user choice) and the direction between points is referenced to the true meridian. Geodetic forward and back azimuths are both available.

    e. Another option is for the user to select any convenient Point-of-Begininng and all relative distances/directions are reported on the basis of a tangent plane through the selected P.O.B. This feature makes the issue of low distortion projection moot.

    f. Plotting topographic maps is facilitated by computing the relative local easting and northing from any selected P.O.B.

g. When working with relative values, datum issues are largely moot because datum issues are applicable to absolute coordinates.

h. The standard deviation of any computed distance, azimuth, or elevation is immediately avaliable if the covariance information has been stored in the 3-D database. Such data are (or can be) standard products of modern positioning technology and processing software.

Another issue deserving careful consideration is using GPS as the primary means by which to establish orthometric heights. The WISDOT has been engaged in the Wisconsin Height Modernization Program (WHM) for several years and has conducted operations within the seven-county Region as well as throughout the state. Information concerning those operations as they affect policies and procedures recommended to the Commission will be included in the final report.

Description and Cost of Developing Bi-Directional Transformations

The scope of developing bi-directional transformations is listed in two phases. It is anticipated that the conceptual framework described herein will first be tested and proven on a representative portion of data within the SEWRPC Region. Upon satisfactory completion of the testing, the proven process will be applied to the remainder of areas included within the SEWPRC Region.

The estimated cost for Phase I lasting from 6 to 12 months is $_____

The estimated cost for Phase II lasting for another 9 months is $_____

Givens:

1. First and Second Order control points within seven-county region on NAD27.
2. First and Second Order elevations within seven-county region on NGVD29 benchmarks

3. Published control values on CORS stations in seven-county region; 3-D. (Identify by name and location).
4. Published NAD83(NSRS2007) positions on same control points.

5. Published NAD83(NSRS2007) values on HARN points in the region.
6. Published NAVD88 first and second order elevations on existing benchmarks.

Tools:

1. Applicable software tools routinely available from the NGS include:

    a. Geoid96, Geoid99, Geoid03
    b. NADCON
    c. VERTCON
    d. HDTP
    e. OPUS
    f. OPUS-RS
    g. Other

2. Existing transformations procedures identified for NAD27 to NAD83(91).

    a. A Mathematical Relationship Between NAD27 and NAD83(91) State Plane Coordinates in Southeastern Wisconsin. SEWRPC Technical Report #34. 1994.

    b. Vertical Datum Differences in Southeastern Wisconsin, SEWRPC Technical Report #35.

Procedures envisioned developing the bi-directional transformations:

1. Inventory existing first (and maybe second) order horizontal control points within the seven county region.

2. Inventory existing first and second order benchmarks within the seven county region.

3. Identify sub-set of points holding both horizontal and vertical control.

4. Convert NGVD29 elevations to ellipsoid heights using Geoidxx.

5. Using NAD27 latitude/longitude and ellispoid heights, compute geocentric X/Y/Z values for such common stations. Estimate standard deviation for each component – easting, northing, and up.

6. Determine (high order) NAD83(NSRS2007) X/Y/Z coordinates for common points either from existing records or new GPS survey. The number of new points needed won't be known until we know what is available to work with. Standard deviations of NAD83(NSRS2007) points should be readily available and used as input.

7. Hold common points (with estimated standard deviations) in both datums and use in Helmert 7-parmeter transformation to solve for Tx, Ty, Tz, $R\omega$, $R\varphi$, $R\kappa$, and scale. This solution will also provide standard deviations of the solved parameters.

8. Evaluate the scope (area coverage) for which those parameters provide acceptable results. This will be done by carefully conducted "blind tests" to verify level of accuracy achieved by the transformation. Note, it is known that distortions exist between the older NAD27 datum and the newer NAD83(NSRS2007) datum. This is analogous to the procedures used for the previous transformations 10 years ago. We were able to determine acceptable transformations for the seven-county region using 14 different sets of parameters.

9. The previous (1994) project determined parameters for horizontal transformations only. By using the Helmert transformation we will be able to model horizontal and vertical distortions simultaneously. It would be possible to develop separate horizontal and vertical models but the Helmert transformation is mathematically rigorous and well defined for the 3-D X/Y/Z environment.

10. Once the Helmert transformation parameters are determined, it will be possible to model separate horizontal and vertical procedures for local provable use. X/Y/Z values will be converted to latitude/longitude/ellipsoid height. Those latitude/longitude values will be converted to NAD83(NSRS2007) state plane coordinates and ellipsoid heights will be converted to NAVD88 orthometric heights. Length units will be users selectable – presumably U.S. Survey feet. An estimate of the accuracy will be available from the statistics of the transformation process.

    A. For horizontal, the local transformations will look very similar to those developed in 1994.

    B. For vertical, the local transformation will be very close to that obtained by using Vertcon. The difference will be that geoid modeling will be used twice – once in converting NGVD29 orthometric heights to (NAD27) ellipsoid heights and again when converting NAD83(NSRS2007) ellipsoid heights to NAVD88 orthometric heights. Note, this item will need careful testing to document the level of acceptability.

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A Mathematical Relationship Between NAD27 and NAD83(91) State Plane Coordinates in Southeastern Wisconsin, SEWRPC Technical Report No. 34, December 1994

Vertical Datum Differences in Southeastern Wisconsin, SEWPRC Technical Report No. 35, December, 1995.

Definition of a Three-Dimensional Spatial Data Model for Southeastern Wisconsin, prepared by Earl F. Burkholder, January 1997.

RTN-101 – A series of articles by Gavin Schrock, LS published in American Surveyor magazine.

Part 1 - September 2006	An introduction to Network Corrected Real-Time GPS/GNSS
Part 2 - October 2006	An Introduction to Network Corrected Real-Time GPS/GNSS
Part 3 - November 2006	Communications – Making that First Rover Connection
Part 4 - December 2006	On-Grid – An Initiative in Support of TRN Development
Part 5 - March 2007	Reference Station Communications
Part 6 - April 2007	Network Connected Real-Time GPS/GNSS (Tips and Tricks)
Part 7 - May 2007	Technological Approaches to Network-based Corrections

The On-Grid Initiative by Galvin Schrock, LS; March 2006, Prepared for the American Congress on Surveying & Mapping and the National Society of Professional Surveyors, Washington State Reference Network.

Southeastern Wisconsin Regional Planning Commission

Notice of Third Meeting and Agenda

TECHNICAL ADVISORY COMMITTEE ON THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

DATE: February 15, 2008

TIME: 9:00 A.M.

PLACE: Regional Planning Commission Offices
Commissioners' Conference Room
W239 N1812 Rockwood Drive
Waukesha, WI

AGENDA:

1. Roll Call
2. Consideration of Revised Minutes of the Meeting of July 25, 2007 (copy enclosed.)
3. Consideration of Minutes of the Meeting of November 16, 2007 (copy enclosed.)
4. Consideration of Revised Draft Report Entitled "Review and Reevaluation of the Regional Control Survey Program" (copy enclosed.)
5. Consideration of Staff Memorandum on Vertical Survey Control for Kenosha County Federal Emergency Management Agency Flood Hazard Mapping Program (copy enclosed.)
6. Consideration of Date and Time of Next Meeting
7. Adjournment

Kurt W. Bauer
Chairman

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MINUTES OF THE THIRD MEETING

TECHNICAL ADVISORY COMMITTEE
FOR THE REVIEW AND REEVALUATION OF THE
REGIONAL CONTROL SURVEY PROGRAM

DATE: February 15, 2008

TIME: 9:00 a.m.

PLACE: Commissioners' Conference Room
Regional Planning Commission Offices
W239 N1812 Rockwood Drive
Waukesha, Wisconsin

Members Present

Kurt W. Bauer Chairman	Executive Director Emeritus, SEWRPC, County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
John M. Bennett	City Engineer-Director of Public Works, City of Franklin
John P. Casucci	Survey Land Development Manager, R.A. Smith National, Inc.
Harold S. Charlier	Executive Director, Wisconsin Society of Land Surveyors
Michael R. Duckett	President, Duckett Group; Executive Director, Southeastern Wisconsin Professional Baseball District
John T. Ellingson	Wisconsin State Geodetic Advisor, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Geodetic Survey
Thomas M. Grisa	Director of Public Works, City of Brookfield
Gregory G. High	Director; Architectural, Engineering and Environmental Services; Milwaukee County Department of Transportation and Public Works
Marcia G. Lindholm	Civil Engineer Senior, City of Milwaukee Department of Public Works
Cecil F. Mehring	Former Manager of Planning and Engineering Services, Racine County Department of Public Works
George E. Melcher	Director of Planning and Development, Kenosha County
Robert W. Merry	Chief Technical Officer, Aero-Metric, Inc.
Glen R. Schaefer	Geodetic Engineer, Wisconsin Department of Transportation
Thomas J. Tym	Head, Technology Services Department, Ruekert-Mielke, Inc.
William T. Wambach	Former District Director, District 1, Wisconsin Department of Transportation

Members Absent

Kent B. Pena	State GIS Coordinator, U.S. Department of Agriculture Natural Resources Conservation Service
Daniel R. Talarczyk	Survey Services Supervisor, Milwaukee Metropolitan Sewerage District

Guest Present

Donald G. Dittmar	Manager, Land Information Systems Division, Waukesha County Department of Parks and Land Use

Staff Present

Earl F. Burkholder	Consulting Geodetic Engineer
Donald P. Simon	Chief Planning Illustrator, SEWRPC; Deputy County Surveyor for Kenosha, Milwaukee, Walworth, and Waukesha Counties
Lynn G. Heis	Staff Secretary, SEWRPC

CALL TO ORDER AND ROLL CALL

Chairman Bauer called the meeting to order at 9:00 a.m. Roll call was taken by circulating an attendance signature sheet, and a quorum was declared present.

CONSIDERATION OF REVISED MINUTES OF THE MEETING OF JULY 25, 2007.

Chairman Bauer noted that copies of the revised minutes of the first meeting of the Technical Advisory Committee for the Review and Reevaluation of the Regional Control Survey Program held on July 25, 2007, had been distributed to all members of the Committee for review prior to the meeting.

Chairman Bauer called attention to the Secretary's Note on page 5 of the minutes of the second meeting of the Committee. That note indicated that because the minutes of the meetings of the Committee are proposed to be appended to Mr. Burkholder's final report to the Commission; and, contrary to long-established Commission policy, the minutes of the first meeting held on July 25, 2007, were revised in their entirety to reflect all of the changes directed to be made in the initial draft of those minutes by the Committee at the meeting held on November 16, 2007; the revised minutes were therefore now being submitted to the Committee for consideration and approval.

Chairman Bauer noted that Mr. Schaefer had been of great help in completing the minutes of the Committee meetings, freely giving of his time, knowledge, and experience to review of the preliminary drafts of the minutes with particular emphasis on assuring the technical validity as well as to the quality of the text. Mr. Schaefer, he said, deserved much of the credit for the quality and completeness of the minutes.

There being no corrections, the revised draft of the minutes of the first meeting of the Committee held on July 25, 2007, were approved as submitted on a motion by Mr. Grisa, seconded by Mr. Bennett and carried unanimously.

CONSIDERATION OF MINUTES OF THE MEETING OF NOVEMBER 16, 2007.

Chairman Bauer noted that copies of the minutes of the second meeting of the Technical Advisory Committee for the Review and Reevaluation of the Regional Control Survey Program had been distributed to all members of the Committee for review prior to the meeting. He asked the Committee to consider approval.

Mr. Tym called attention to the third line of the last paragraph on page 2 indicating that the phrase "pen ultimate" should be one word "penultimate." Mr. Schaefer called attention to the second line of the second paragraph on page 3 indicating that "National Geodetic Vertical Datum" should be corrected to "North American Vertical Datum." Mr. Tym called attention to the fifth line of the fourth paragraph on page 6 indicating that the phrase "U. S. Public Sand Survey system" should be corrected to read "U. S. Public Land Survey System." Mr. Tym called attention to the third line of the second paragraph on page 9 indicating that "bi-directional" should be corrected to read "bidirectional." He also noted, that there were other places in the minutes where the term concerned had been hyphenated, and that this should be corrected throughout the minutes.

Mr. Tym called attention to the Secretary's Note on page 13 noting that the map referred to occurred on page 15 and not 14. Mr. Grisa called attention to the first line of the second paragraph on page 18 indicating that the word "nothing" should be changed to "noting." Mr. Wambach called attention to the fourth line of page 19 indicating that the term "relayed" should be corrected to "relaid." He also called attention to the sixth line of the second paragraph on page 19 indicating that the term "line" should be struck. Finally, he indicated that the term "inability" in the penultimate line of the first partial paragraph on page 23 should be changed to "instability." Mr. Schaefer noted that the last word in this partial paragraph should be changed from "axes" to "axis."

There being no further corrections or additions, the minutes of the second meeting of the Committee held on November 16, 2007, were approved as amended on a motion by Mr. Melcher, seconded by Mr. Grisa, and carried unanimously.

Chairman Bauer noted that since these minutes were to be appended to Mr. Burkholder's final report, following the practice instituted for the minutes of the meeting of July 25, 2007, a corrected copy of the minutes of the November 16, 2007, meeting would be prepared for attachment to Mr. Burkholder's report.

CONSIDERATION OF REVISED DRAFT REPORT ENTITLED "REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM."

Chairman Bauer noted that copies of the revised draft of Mr. Burkholder's report had been distributed to all members of the Committee for review prior to the meeting. He then asked Mr. Burkholder to undertake a page-by-page review of the revised report. The following comments were made, questions raised, and actions taken in the course of the review.

Mr. Charlier called attention to page 3 of the draft report suggesting that the article "the" be removed from the definitions of acronyms Numbers 4 DOD, 16 IGLD (55) and (85), 33 Region, and 44 WisDOT. After a brief discussion, it was further agreed that whether or not the article concerned was to be used with the terms concerned in the text of the report would be determined on the basis of the context.

Mr. Schaefer suggested, and the Committee concurred, that the definition of the first acronym - CBN - be given simply as "Cooperative Base Network." He suggested further, and the Committee agreed, that acronym Number 6 FBN be defined simply as "Federal Base Network." Mr. Schaefer further suggested, and the Committee agreed, that the definition for acronym Number 3 CORS be changed to read as "Continuously Operating Reference Stations - permanent GPS receiver installations."

Mr. Schaefer suggested, and the Committee concurred, that acronym Number 16 - "IGLD 55 and 85" be separated to read as follows with the succeeding acronyms being renumbered: Number 16 - IGLD 55 International Great Lakes Datum of 1955 developed jointly by the United States and Canada. Number 17 IGLD 85 - International Great Lakes Datum of 1985 developed jointly by the United States and Canada. Mr. Schaefer further suggested, and the Committee agreed, that the phrase "for Wisconsin" be added to the definitions for acronyms Number 21 - NAD 83 (1991) and Number 22 - NAD 83 (1997), and that the phrase "and resulting from a National readjustment," be added to acronym Number 23 - NAD 83 (2007). Mr. Schaefer also

suggested, and the Committee concurred, that the word "subsequent" be struck from the definition for acronym Number 24 - NAD 83 (xxxx), and that the definition for acronym Number 25 NADCON be revised to read "Program written by NGS to perform data conversions between NAD 27 and NAD 83." Mr. Schaefer went on to explain that the NADCON program was written to perform data conversions between NAD 27 and NAD 83. Subsequently, he said, what had originally been called "NAD 83" was renamed to "NAD 83 (1986)" and an option added to the program to convert from NAD 83 (1986) to HPGN; HPGN referring to adjustments done in different years in different states; the datum/adjustment for HPGN being NAD 83 (1991) in Wisconsin. He noted that NADCON does not have the capability to convert between NAD 27 and NAD 83 (1991) directly; but if the original program and the option program are considered one rather than two, then a loose interpretation could be that NADCON provides conversion between NAD 27 and NAD 83 (1991) even though it is two steps using different algorithms.

Mr. Schaefer suggested, and the Committee concurred, that two acronyms be inserted as Numbers 28 and 29 with the subsequent acronyms being renumbered accordingly; the additional acronyms being Number 28 - NAVD 88 (1991) - original adjustment of the new national vertical datum for Wisconsin; and Number 29 - NAVD 88 (2007) – "Adjustment of the new national vertical datum resulting from the Wisconsin Height Modernization Program." Mr. Schaefer suggested further, and the Committee concurred, that the definition for acronym Number 40 be revised to read as "Program written by NGS to perform vertical datum conversions between NGVD 29 and NAVD 88." Mr. Schaefer observed that the conversion was in fact between NGVD 29 and NAVD 88 (1991) and not between NGVD 29 and NAVD 88 (2007).

Mr. Schaefer called attention to acronym Number 43 and suggested that to be consistent with WisDOT's utilization, this acronym be written as "WI-HMP." Mr. Schaefer noted that the report contained exhibited inconsistencies regarding the form of terms, and suggested that throughout the report, when referring to a survey monument, the term "bench mark" be used not benchmark as had been agreed to at earlier meetings. Similarly, he said, the term "bi-directional" be consistently used as one word without hyphenation.

In response to a question raised by Mr. Burkholder, a brief discussion ensued concerning the need for length, and content of the section of the report on monumentation. Chairman Bauer, Messrs. Mehring and Wambach supported retention of the text concerned and the Committee agreed.

Mr. Ellingson suggested, and the Committee agreed, that the last sentence of the first unnumbered paragraph on page 5 be changed to read as follows: "within the seven-county Region, the datums in use include both NAD 27, NGVD 29, and the new datums of the NSRS."

Mr. Tym objected to the second numbered paragraph on page 6 as written, noting that within the context that paragraph referred to property corners, broadly defined, and not just to U.S. Public Land Survey corners, yet stated that it was possible to locate such corners using satellite observation derived coordinate values. This, he said, implied that there is an existing database of coordinates for such corners, which was clearly not the case. It may be possible, he said, to reestablish in this manner U. S. Public Land Survey corners for which accurate coordinates have previously been determined, but this was clearly not the case for the vast majority of existing real property boundary corners.

A lengthy discussion ensued in which Chairman Bauer agreed with Mr. Tym, but noted that where newer land survey plats and certified survey maps had been properly tied to the Commission promulgated control survey system, State Plane Coordinates were available for the block and lot corners as platted.

Mr. Schaefer observed that the numbered paragraph concerned was linked to the first unnumbered paragraph on page 6 and indicated that, in his opinion, the first sentence of that paragraph was confusing and required revision.

Mr. Charlier agreed with Mr. Tym noting that although State Plane Coordinates were available for all of the U.S. Public Land Survey corners within the SEWRPC Planning Region, many surveyors will begin land surveys at the monumented U.S. Public Land Survey corners, ignoring the known State Plane Coordinate values, and assuming arbitrary coordinate values to the monument corners as a basis for the particular land survey being conducted. Consequently, he said, the resulting coordinates of the property corners concerned are not related directly to the State Plane Coordinate System. Mr. Casucci agreed and indicated further that his firm now utilizes county coordinate systems coordinates as a basis for work.

Mr. Wambach noted that the argument for utilizing coordinates in place of monuments to identify real property boundary survey corners was not only in his opinion unsound, but was an old one. He noted that a paper published in the September 1970 issue of the American Society of Civil Engineers Journal of Surveying and Mapping contained a paper by Robert T. Howe, Professor of Civil Engineering, University of Cincinnati, in which he promoted the use of coordinates in place of monuments. Clearly, he said, the argument has over the almost 40 years since publication of Professor Howe's paper made little or no impression on the courts which are the ultimate determiners of real property boundary line locations and therefore of land survey practices.

Upon the conclusion of this discussion, it was agreed that the paragraph originally numbered three on page 6 be unnumbered and revised to read as follows: "It is now possible using currently available GPS equipment and measurements, to replicate in the field the location of any point for which State Plane Coordinate values have been previously determined, and to do so within a tolerance of less than one centimeter. The State Plane Coordinate positions, and to a lesser degree elevations, can be determined from measurements made to the orbiting satellites. Although such precise positioning is possible, the issue of datums must be addressed."

It was further agreed that the first sentence of the next paragraph should be revised to read as follows: "It may be argued that coordinates derived from measurements to orbiting satellites have effectively replaced monumented positions as a way for the end users to gain access to data in the NSRS."

Mr. Charlier called attention to the second sentence of the fourth full paragraph on page 6 suggesting that the phrase "it is viewed as premature" be changed to "it is inappropriate." The Committee agreed.

Mr. Schaefer called attention to the third line of the last paragraph on page 6, and recommended that the word "mean" be struck from the phrase. He noted that the title "National Vertical Datum of 1929" was currently used in place of the older title "Sea Level Datum of 1929," and that the word "mean" was not in the older datum title or definition.

Mr. Schaefer called attention to the four numbered paragraphs on page 7 dealing with vertical datums, and suggested that these be revised as necessary to reflect the agreed upon formats of the acronyms and terms concerned. More specifically, he suggested, that the article "the" be dropped from the leads into the statements numbered 1, 2, and 3; and that the statement Number 2 be revised to read as follows: "NAVD 88 is based upon one primary bench mark elevation and very precise differential level circuits covering the United States from coast to coast and border to border. This datum has been designated by WisDOT as NAVD 88 (1991)." He suggested that the third numbered statement be rewritten to read as follows: "NAVD 88 (2007) is a more recent adjustment of the national vertical survey control network based upon observations made in Wisconsin under the WisDOT Height Modernization Program. The entire SEWRPC planning Region has been included in that program." The Committee agreed.

Mr. Ellingson suggested, and the Committee agreed, that the word "sheer" be struck from the first sentence of the first full paragraph on page 7.

Mr. Schaefer noted that the names of the acronym notations utilized on page 8 were not in the format agreed upon, and should all be revised accordingly.

Mr. Charlier called attention to the tenth line of the last paragraph on page 9; indicating that the word "obrits" should be corrected to "orbits."

Mr. Bauer called attention to the last sentence in the first paragraph on page 10 and suggested that the sentence be changed to read as follows: "NGS incorporates both ITRF and NAD 83 in the positions published for the CORS network." Messrs. Ellingson and Schaefer agreed with the proposed change; Mr. Schaefer noting that the NGS software program referenced in the original version of this sentence is applicable only west of Longitude 111 degrees West and cannot be used in this Region.

Mr. Schaefer called attention to the second full paragraph on page 11, suggesting that the last sentence of that paragraph be rewritten and that an additional sentence be added so as to read as follows: for example, NAD 27 coordinate values should desirably be expressed in U.S. survey feet, while NAD 83 coordinate values should desirably be expressed in meters. Nevertheless, some practioners and agencies, including WisDOT, express NAD 83 coordinate values in feet, giving rise to potential confusion and mistakes.

Mr. Wambach suggested that the word "to" be struck from the lead-in phrase under the major heading on page 13.

Mr. Tym called attention to the last paragraph on page 14 and suggested that the first sentence be revised to read as follows: "Another alternative - the conversion of the existing database to an integrated three dimensional database - would be a huge step and, whether done all at once or incrementally, would be very costly." The Committee agreed.

Mr. Schaefer called attention to the second sentence of the penultimate paragraph on page 15, and suggested that this sentence be revised to read, "WisDOT has been engaged in the Height Modernization Program for several years."

In his description of the text on page 16 concerning the use of GPS to establish orthometric heights, Mr. Burkholder suggested the addition of a figure illustrating the concepts involved. Chairman Bauer indicated that the figure which Mr. Burkholder apparently had in mind was often technically incorrect as presented in trade magazines and even peer reviewed journals; the commonly reproduced but incorrect version, ignoring the fact that the orthometric height, being measured along the normal to the geoid, does not lie along the normal to the ellipsoid, which is used to determine ellipsoid heights. Chairman Bauer indicated that he would provide a correct version of the envisioned figure.

[Secretary's Note: The envisioned figure illustrating the relationships between the topographic surface of the earth, the geoid and the reference ellipsoid is provided below, and is intended to be referenced in Mr. Burkholder's report.]

Figure 1

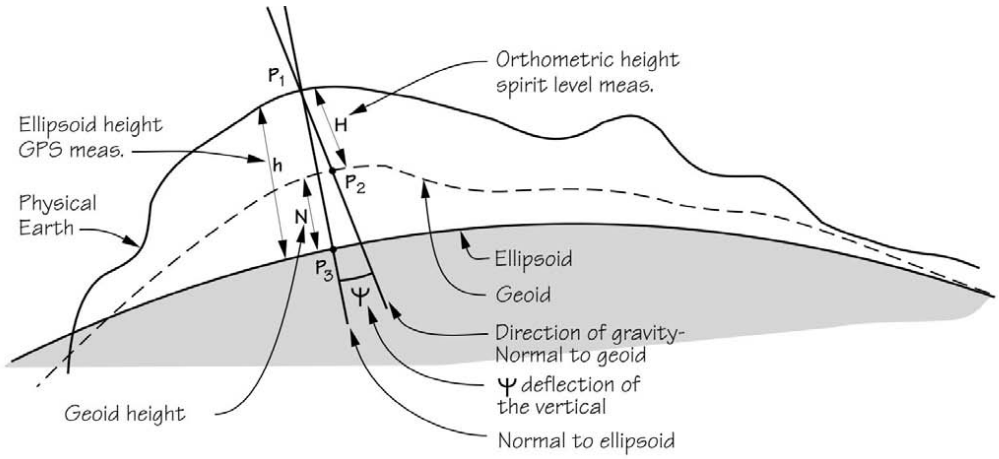

Fig. 1 Relationships between the topographic surface of the earth, the geoid and a reference ellipsoid

Source: Kurt W. Bauer, PE, RLS, AICP, and SEWRPC.

Chairman Bauer noted that the fourth equation on page 16 was in fact, an approximation, which ignored the effect of the deflection of the vertical on the height distances concerned. He suggested, and the Committee agreed, that this factual situation be described in Mr. Burkholder's report by the addition of a short paragraph following the fourth equation on page 16.

Mr. Charlier called attention to the first line on page 17 indicating that the word "be" be inserted as the penultimate word of the line.

Mr. Burkholder noted that the cost for Phase II of the proposed development work as listed on page 17 could not be accurately estimated until the completion of Phase I. Chairman Bauer accordingly suggested that the word "preliminary" be inserted before the word "estimated" in the fourteenth line on page 17.

In answer to a question by Mr. Charlier, Mr. Burkholder indicated that the "givens" listed on page 17 were indeed intended to be the published values for the existing First- and Second-Order

NAD 27 stations within and adjacent to the Region, and the NGVD 29 bench marks within the Region. No field measurement was envisioned at this time although this assumption may change as the work proceeds. Mr. Duckett suggested, and the Committee agreed, that the word "published" should be inserted in the definition of the first two givens listed on page 17. Mr. Ellingson suggested, and the Committee concurred that the phrase "including on WisDOT Height Modernization Program control stations" be inserted at the end of the third given. Mr. Schaefer noted that in the phrase First and Second Order, hyphens should be placed between the words First and Second, and the word Order. This practice, he said, should be followed throughout the report.

Mr. Schaefer called attention to the list of "tools" on page 17 and suggested that the software tool listed under (1a) be identified as "GEOID03" and other geoid models. In this respect, Mr. Merry cautioned that it was important that the proper software be utilized in all work since there could be significant differences between elevations if the height separations involved are based upon the wrong ellipsoid.

Mr. Schaefer suggested, and the Committee agreed, that if the HTDP and ADJUST software programs were not intended to be used in the development program, they should be dropped from the list of tools.

Mr. Schaefer called attention to the first numbered item on page 18 and suggested that it be revised to read as follows: "Existing transformation procedures identified for NAD 27 to NAD 83 (1991) and NGVD 29 to NAVD 88 (1991) are set forth in the following publications: a. SEWRPC Technical Report No. 34, *A Mathematical Relationship Between NAD27 and NAD83(91) State Plane Coordinates in Southeastern Wisconsin,* December 1994, and b. SEWRPC Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin,* December 1995.

Ms. Lindholm suggested removing the parenthesis in the second procedure listed on page 18 and correctly hyphenating and capitalizing the identification of the order of the bench marks. Mr. Charlier agreed and indicated that the words "of published" should be inserted after the word inventory in Procedures Nos. 1 and 2 in place of the word "existing."

Mr. Schaefer indicated that the term "GEOID 03" in the description of the fifth proposed procedure on page 18 should be corrected to "GEOID03." This same correction, he said, should be made in three places on page 11, and in one place on page 19.

Mr. Schaefer called attention to the fifth listed procedure on page 18 and asked Mr. Burkholder to explain how GEOID03 was intended to be used since, he noted, GEOID03 is related to NAD 83 and NAVD 88 and not to NAD 27 and NGVD 29. Mr. Burkholder responded that in considering the procedure to be followed, he had considered the potential use of various geoids and their associated datums, but came to the preliminary conclusion that the best and most consistent results would be obtained by using a common geoid model at both ends of the transformation process, and that his initial inclination was to use GEOID03 as that common geoid in the development of the transformation equations. Mr. Schaefer then observed that one of the ways to determine geoid height is to find for a given horizontal location the algebraic difference between an ellipsoid height measured using GPS and an orthometric height determined by differential leveling. If, he said, different ellipsoids are used in this process; either the orthometric height or the ellipsoid height concerned will result in different vertical positions. Mr. Burkholder responded that the model process was intended to use the best data from each of what are

acknowledged to be two different ellipsoids and fit the data together however imperfectly, it being impossible to do so with mathematical precision. He indicated further, that he had discussed the proposed procedure with other geodesists, including geodesists on the staff of NGS and remained convinced that the proposed approach is a valid one.
Mr. Schaefer noted that the spelling of the word "parameter" should be corrected in the description of Procedure 8 on page 18. He further noted that in the description of Procedures 9 and 10 on pages 18 and 19 the apostrophes should be removed from the references to the1990s.

Mr. Schaefer called attention to the description of Procedure 11 on page 19, and indicated that the term "NAVD 88" in the fifth line of the description should be changed to "NAVD 88 (2007)"; that the last term in the description of Procedure 11a be changed to NAD 83 (1991); that in the first sentence of the description of Procedure 11b the term "Vertcon" be changed to "VERTCON"; and the term "NAVD 88" in the second sentence be changed to "NAVD 88 (2007)."

The meeting was adjourned at 12 o'clock noon for lunch and reconvened at 12:30 p.m.

After reconvening the meeting, Chairman Bauer reported that Mr. Duckett had indicated to him that a prior work commitment required him to leave the meeting at noon; that when the final Committee vote is taken on the approval of Mr. Burkholder's report, he would like to be recorded as voting in favor of the approval. He indicated that he believed the report to be technically sound with good recommendations to the Commission; although he believed that the text could in appropriate places, including in the Concluding Recommendations section, be strengthened with respect to the need for the continued maintenance of the monuments marking the U.S. Public Land Survey corners within the Region. Specifically, he had indicated, that a strengthened version of Recommendation No. 2 on page 20 should, in his opinion, become the first recommendation with the original recommendation becoming the second. Chairman Bauer observed that if the Committee concurred with Mr. Duckett's suggestion, Recommendation No. 3 as set forth on page 20 should then become Recommendation No. 2 and the original Recommendation No. 1 would become Recommendation No. 3.

Mr. Charlier indicated that Mr. Duckett had also discussed this matter with him before leaving the meeting and that based upon that discussion, Mr. Charlier believed that the recommendations could remain essentially as drafted by Mr. Burkholder. Upon brief discussion the Committee agreed that the recommendations should remain in the order and essentially as drafted by Mr. Burkholder.

Mr. Schaefer questioned the proposed procedure as described in Item 11A on page 19 for the reasons which he had previously raised concerning the different ellipsoids that would be involved. Mr. Schaefer indicated that although it may turn out that the proposed procedure in effect "works," it will be important during the procedure development process to carefully review the results of applications of the preliminary equations to assure that the theoretical inconsistencies raised actually proves to be insignificant in the modeling process.

A lengthy discussion then ensued upon the conclusion of which the Chairman suggested, and the Committee agreed, that the text of the report be expanded to indicate that the proposed procedure involved an approximation and that the results would require careful testing and consideration to ensure that the transformation procedure developed actually performs at a level of accuracy adequate for land surveying and public works engineering applications. In this respect he said, it should be noted that the modeling process is in effect, an empirical approach and although not strictly rigorous, can provide excellent results.

In answer to a question by Mr. Bennett, Mr. Burkholder indicated that the end product of the recommended development work would consist of an algorithm that could be used to make the desired bidirectional transformations. He would, he said, provide to the Commission the proven and well documented software. With this software the Commission staff would be able to enter coordinate and elevation data based upon NAD 27 and NGVD 29 and obtain corresponding coordinate and elevation data based upon NAD 83 (2007) and NAVD 88 (2007) and to also do so conversely.

Mr. Schaefer suggested that the transformation procedure could be provided to users in the form of a spreadsheet set up for a limited number of points - for example 10 - so that it would be possible to readily make transformations for a single or multiple set of points.

Mr. Merry observed that the method should supply the parameters necessary for the transformations and that it should be possible to use these with any software. He indicated that the parameters should permit the user to readily convert, for example, coordinates and elevations from a WisDOT value based upon NAD 83 (2007) and NAVD 88 (2007) to corresponding coordinates and elevations based upon NAD 27 and NGVD 29; to perform the same transformations for field observations made utilizing GPS, and to transform information based upon NAD 27 and NGVD 29 to the newer datums for use in the field.

Mr. Wambach raised the issue of the use of the Wisconsin County Coordinate System (WCCS) within the seven-County Region. He noted that the impetus for the creation of the system had come from WisDOT and observed that when he was a District Director with the Department he had strenuously opposed the creation and use of this system as being technically unsound and had recommended the continued use of the State Plane Coordinate system as created by the former U.S. Coast and Geodetic Survey at the specific request of state highway agencies. Chairman Bauer agreed with Mr. Wambach that the creation and use of the WCCS represented poor professional practice, and noted that the problems, complication and confusion presented by the use of the WCCS had been discussed at the first meeting of the Committee.

A lengthy discussion ensued in which Mr. Casucci indicated that his firm, as indicated earlier by Mr. Charlier, had utilized arbitrary coordinate systems in the conduct of land surveys, but more recently had begun to use the County Coordinates systems as a basis for their land surveying work. Chairman Bauer noted that this raised, in addition to the datum issues, the issue of the use of a different coordinate system. He indicated that, in his opinion, better practice would be to use the State Plane Coordinate system which would place all of his firm's surveys on the same coordinate system and datums as the Commission's control survey network, and make the work of his firm compatible with the parcel-based land information and public works management systems being developed by the counties and local units of government within the region. He observed further that many county and local land subdivision control ordinances required that land subdivision plats and certified survey maps be tied to the Commission promulgated horizontal survey control network utilizing the U.S. Public Land Survey corner monumentation and State Plane Coordinate values available through that system.

Mr. Mehring objected to Mr. Casucci's firm's approach and indicated that, in his opinion, the counties within the Region should legislate that the State Plane Coordinate System and the NAD 27 and NGVD 29 datums be used within the seven-county Region. One of the original purposes of the Commission's and county effort to create a control survey network within the Region, he said, was to provide a single control survey network and related coordinate and elevation data system that would be uniformly used by all surveyors and engineers practicing

within the Region. He suggested that the adoption of such county legislation be included as a recommendation within the report. Chairman Bauer responded that while he agreed fully with Mr. Mehring's observation, he questioned whether the counties had the legal authority to mandate the use of a specific coordinate system or to prohibit the use of other coordinate systems within their jurisdiction.

Mr. Casucci indicated that he was not proposing the adoption by the Commission of the County Coordinate System, but suggesting that as surveyors occupy monumented U.S. Public Land Survey system corners and obtain coordinates for those corners using GPS technology, those coordinate values be transmitted to the Commission for recording and future use together with information on the coordinates system and datums used in obtaining the coordinates concerned. In this way, he said, a great deal of valuable field observations would be captured for use in the event that in the more distant future a decision is made to shift to the newer datums or to the County Coordinate Systems.

Mr. Mehring questioned the value of such collected data since there would be no practical way for the Commission to exercise quality control of the field observations. Chairman Bauer agreed with Mr. Mehring and indicated further that it was likely, as indicated by Mr. Charlier's earlier statement on their practices of his then firm, that most land surveyors in private practice tended to use either the State Plane Coordinates System in their work, or arbitrary coordinate systems as well as arbitrary vertical datums. In this respect Chairman Bauer asked Mr. Casucci how his field crews obtained county coordinate values for monumented U.S. Public Land Survey corners within the Region since the only published coordinates for such corners are State Plane Coordinates on the NAD 27. Mr. Ellingson responded for Mr. Casucci, indicating that if a surveyor intended to use county coordinates in conjunction with GPS surveys, they would utilize either the NAD 83 (1991) or NAD 83 (2007) adjustments, would occupy WisDOT established control points for which latitude and longitude are known with a base station unit and then use a roving unit to gather coordinate positions on points of interest. Chairman Bauer responded that he was aware of the procedure that Mr. Ellingson described. He indicated that that procedure would be largely unnecessary if the commission's control network and coordinates were used as intended and as necessary for land subdivision plat and certified survey map preparation within the Region. Chairman Bauer indicated further that the County Coordinate Systems within the State, had recently been revised and republished so that, to add to the confusion, two different sets of County Coordinate values may appear in the records. Mr. Schaefer noted that the differences between the two sets of coordinate values will usually be in the order of one to three millimeters.

Mr. Merry observed that fundamentally all of the field measurements made utilizing GPS technology were based upon latitude and longitude and those spherical coordinates could be readily converted to State Plane Coordinates on both the old and newer datums, to County Coordinates, and to Universal Transverse Mercator coordinates. Obtaining consistent orthometric heights, he acknowledged, was more complex and difficult using GPS technology.

Mr. Tym also expressed objection to the use of the County Coordinate systems indicating that the use of these systems provided needless complexity and confusion with respect to the continued development and use of the parcel-based land information and public based works management systems within the Region. He noted that the County Coordinate Systems were discontinuous at the County boundaries and provided an absurd problem, as for example, near the common corners of three or four counties.

Mr. Mehring expressed concern that under Mr. Casucci's suggestion, and at some cost, the Commission would be compiling a set of information for each control survey station without having any way of knowing which of the various coordinate values recorded and provided to the Commission was the right one. He noted that within Racine County, he was aware of a case of a U.S. Public Land Survey corner for which there were 23 documented locations; none of them the same, and suggested that the same situation would arise with respect to the usefulness of Mr. Casucci's suggested compilation of field survey values.

Mr. Ellingson indicated that as a former County surveyor he was surprised at the example corner location problem which Mr. Mehring had described and agreed that the same kind of problem could occur with respect to the multiple coordinate values that would be collected for a given corner under Mr. Casucci's suggestion. This and other problems, he said, could be resolved by the Commission if Mr. Casucci's suggestion was adopted. In this respect, Mr. Ellingson suggested that it might be possible for the Commission to create a spreadsheet for any of the approximately 12,000 U. S. Public Land Survey corners within the Region that were occupied by local surveyors whenever they are using GPS and the Wisconsin High Accuracy Reference Network (HARN) in the course of their survey work. Each time a surveyor submitted a set of coordinate values determined by GPS measurement for a monumented corner, together with information on the date, the name of the surveyor submitting the data, the coordinate values, the datum used in determining the coordinate values, and the field procedure used would be recorded together with perhaps, other pertinent information. He indicated that after a number of values - for example, a dozen - had been submitted, an averaged NAD 883 (2007 position should be available that in most cases would be accurate to within 0.02' to 0.05', relative to the National Spatial Reference System (NSRS). This method would be valid for surveyed positions obtained from local surveyors using any of the following methods: GPS referenced to the Wisconsin HARN, GPS work referenced to the Wisconsin Real Time Network (RTN) or GPS positions calculated using OPUS solutions from the National Geodetic Survey (NGS) website. After enough positions were gathered on a particular mark to enable the Commission to obtain a satisfactory averaged position, surveyors would no longer need to supply new observations to the Commission for that survey mark. Often-visited marks might be done in a month or two, while seldom-used marks might take much longer to accumulate enough submittals.

Chairman Bauer responded that the Commission now had "pretty good" State Plane Coordinate values for each of the 11,753 U.S. Public Land Survey corners within the Region; the coordinate values having been determined by surveys that fully met NGS Third-Order, Class I standards, thus providing relative positions at an accuracy of one part in 10,000 or better. Indeed, he said, 40 years of experience, and literally thousands of field measurements, indicated that the relative positions of the U.S. Public Land Survey corners which comprised the horizontal control survey network within the Region, ranged from an actual minimum relative error of about one part in 18,000 to less than one part in 50,000.

Mr. Ellingson observed that the NSRS positions eventually collected under Mr. Casucci's suggestion would assist in refining the mathematical model used at some future date to determine the relationship between the Commission's existing control survey network and the newer NSRS datums in both horizontal and vertical survey applications. He noted that he thought Mr. Casucci's method could be accomplished for a very low cost and that it would eventually provide a great benefit to the Commission. He indicated that the surveying technology is rapidly changing, noting for example that NGS plans to obtain new gravity observations throughout the United States in order to develop a better geoid model and that this would further support the use of GPS technology in vertical survey applications.

Chairman Bauer indicated that the Commission had addressed the issue of the need to change datums in a report prepared by Mr. Burkholder in 1997 entitled "Definition of a Three-Dimensional Spatial Data Model for Southeastern Wisconsin," and had concluded that the older datums should remain in use until a truly dimensional earth centered X, Y, Z, coordinate system becomes available - the kind of system that has been proposed nationally by Mr. Burkholder.

Chairman Bauer then asked Mr. Burkholder how the kind of collected data being suggested might be used 20 to 50 years from now to create a new three-dimensional datum within the Region. Mr. Burkholder responded that existing spatial data tends to lose its value when it becomes easier and cheaper to collect new data than it is to retrieve and utilize existing older data. Consequently, it was his opinion, he said, that it would be more cost effective to collect any needed additional data at such time as a datum conversion was undertaken.

Chairman Bauer observed that while it may become feasible, at some future date, to convert the horizontal positions and heights of the Commission control survey stations to a new earth centered X, Y, Z coordinate system, the problem of how such conversion would relate to the existing parcel-based Land Information and Public Works Management Systems within the Region would remain. He observed that the seven constituent counties and probably about half of the 147 municipalities within the Region, and such special purpose units of government as the Milwaukee Metropolitan Sewerage District have already developed massive data banks based upon the NAD 27 and NGVD 29 datums and related State Plane Coordinates values and orthometric heights. The data collected and placed in these systems, he said, includes among others, street address, ownership; assessed valuation; land use; soils; flood hazard; location of sanitary and storm sewers and related manholes and fittings; water mains and related valves, hydrants, and fittings; telecommunication and lighting cables; street and highway pavement edges and related traffic control signs and signals; and much more. There are literally millions of pieces of information contained in these systems, he said, and more is being added virtually on a daily basis. If the control survey system on which these information systems are founded is converted to other datums, or to an earth centered X, Y, Z coordinate system, the addition of new geographically related data to the data banks through field surveys would for practical reasons have to involve conversions of the positions back to the existing older datums. Mr. Burkholder agreed, and indicated that land information system technicians use absolute positions to describe where "things" are, while surveying and engineering technicians use relative positions of "points" in their work. Therefore, he said, the need will always exist to make the two types of data - absolute and relative - compatible, and the proposed bidirectional transformation method would accomplish this.

Mr. Tym agreed that future datum conversions would create problems for the existing developing land information and public works management systems within the Region. He noted that with respect to the utility infrastructure, for example, the systems contained locations for every single manhole on the sewer systems and for the water supply systems the location of every single, hydrant, valve and fitting together with attendant elevations and information on size, condition, and status of maintenance.

Mr. Bennett agreed with Mr. Tym, and reiterated his objection to the suggestion, and indeed to the entire discussion, indicating that as a municipal engineer, he needs and wants one set of coordinate values for each of the basic survey control stations - the monumented U.S. Public Land Survey corners - within his approximately 36-square mile municipality and that the

Commission control survey network provides that single number for each corner. His staff, he said, had no trouble utilizing GPS technology with the City's known CORS station to obtain horizontal position data related to NAD 27.

Mr. Wambach observed that Mr. Burkholder had expressed the opinion that perhaps very little of the information proposed to be collected would be useful at a future date since it would be more cost effective to collect any needed new field observations at such distant future time at which a datum conversion was considered.

Mr. Melcher observed that the discussion of this issue had occupied almost an hour and a half and that, in his opinion, it was time for the Committee to act with respect to a resolution of the issue. Chairman Bauer accordingly suggested that Mr. Casucci move for the adoption of his suggestion.

Mr. Casucci then moved to add a Recommendation No. 7 to Mr. Burkholder's report that would request the Commission to develop and implement a procedure for the capture through the submission by practicing land surveyors within the Region of GPS determined coordinate positions for the Commission's monumented U.S. Public Land Survey corners; the submitted coordinate positions being accompanied by pertinent information to be determined, including the datums utilized. The motion was seconded by Mr. Ellingson. The motion failed on a vote of four in favor and eight opposed; with Messrs Casucci, Charlier, High, and Merry voting in favor, and Ms. Lindholm; Messrs. Bennett, Grisa, Mehring, Melcher, Schaefer, Tym and Wambach voting opposed; and Mr. Ellingson abstaining.

Mr. High called attention to the concluding recommendations beginning on page 19 and indicated that given Mr. Duckett's comments to the Chairman and Mr. Charlier, and given his own experience with appointed and elected public officials, such as those to which the report will ultimately be addressed, he believed that the recommendations needed careful editing in order to clearly state and strengthen the recommendations.

A lengthy discussion ensued after which Chairman Bauer observed that the report contained four particularly important recommendations: (1) The monumentation marking the U.S. Public Land Survey system corners within the Region be maintained in order to definitively perpetuate the location of those corners; (2) The system of bench marks providing orthometric heights in the immediate vicinity of each U.S. Public Land Survey corner be maintained; (3) The Commission promulgated and monumented horizontal and vertical control networks within the Region continue to be related to the NAD 27 and NGVD 29 datums; and (4) A method for the bidirectional transformation of coordinates between NAD 27 and NAD 83 (2007), and between NGVD 29 and NAVD 88 (2007) be developed and made available for ready use within the Region.

Based upon the discussion, Mr. Schaefer suggested changing the format of the recommendations to introduce each numbered recommendation by a short title or lead-in phrase which concisely captures the essence of the recommendation. The remainder of the text in each numbered recommendation could then remain essentially as submitted.

Mr. Mehring noted that while the report as drafted was addressed to the Commission, its recommendations would also be in effect addressed to the constituent counties and this should be acknowledged in the wording of the concluding recommendations, as for example he said, "the Commission in cooperation with its constituent counties should."

There being no further comments or questions, Mr. Melcher moved to approve Mr. Burkholder's report as amended for publication and transmission to the Commission. Mr. Wambach seconded the motion, which carried unanimously.

CONSIDERATION OF STAFF MEMORANDUM ON VERTICAL SURVEY CONTROL FOR KENOSHA COUNTY FEDERAL EMERGENCY MANAGEMENT AGENCY FLOOD HAZARD MAPPING PROGRAM.

Chairman Bauer noted that copies of a Commission staff memorandum (copy attached) concerning the vertical survey control to be used in the completion of the Kenosha County Federal Emergency Management Agency Flood hazard mapping program had been distributed to all members of the Committee for review prior to the meeting. He noted that this memorandum was being provided to the Committee at the request of the Commission Executive Director for the Committee's information and to solicit any comments that the Committee might have on the memorandum.

The Chairman then reviewed the memorandum with the Committee. The following comments were made, questions raised and actions taken in the course of the review.

Mr. Melcher observed that all of the large scale topographic mapping covering all of Kenosha County - at a scale of 1 inch = 100 feet or 1 inch = 200 feet with 1-foot or 2-foot vertical contour intervals, respectively, – were based upon NGVD 29 as are the County of Kenosha, City of Kenosha, and Village of Pleasant Prairie land information and public works management systems. Consequently, he said, the County believes it extremely important that the new FEMA flood hazard maps be based upon NGVD 29. Accordingly, he moved that the Committee be placed on record as fully supporting the Commission's position with respect to this matter as set forth in the staff memorandum concerned. The motion was seconded by Mr. Wambach.

Mr. Charlier noted that the FEMA procedural memorandum provided that if a community remained with NGVD 29, Federal funding may not be available in the future to update the flood hazard maps. Chairman Bauer and Mr. Melcher indicated that there was no Federal funding available at this time for this purpose, and given past performance probably would never be.

Mr. Schaefer noted that given the density of the NGVD 29 bench marks within the county as illustrated on Exhibit II attached to the memorandum, the Commission's position with respect to this issue was supportable.

The motion then carried unanimously, with, however, Mr. Ellingson abstaining.

AJOURNMENT AND DISSOLUTION OF COMMITTEE

There being no further business to consider, Chairman Bauer noted that the Committee's action on the revised draft report entitled "Review and Reevaluation of the Regional Control Survey Program" concluded its work.

The Committee's final report to the Commission would consist of a revised copy of the draft report, and the approved minutes of the Committee meetings. He noted that the first meeting of the Committee was held on July 25, 2007; and that the Committee had held three meetings to complete its work. He expressed his sincere appreciation on behalf of himself, the Commission staff, and the Commission to the Committee members for the contribution of their time,

knowledge, and experience to the work of the Commission, all as a public service; and noted that such service was in the finest tradition of how government was and should be conducted in Wisconsin.

He noted that all of the Committee members would receive a copy of the minutes of this meeting; a copy of the final report; and a self-addressed postcard by which each Committee member will be asked to vote on approval of the minutes of this meeting. He noted that the worst possible outcome of the postcard poll would be a majority of no votes, in which case the Committee would have to be reconvened to collegially consider approval of the minutes.

He noted that in some cases the Commission does not act to dissolve an Advisory Committee upon completion of its work, but asks the Committee to continue to serve through implementation of the Committee recommendations. In the case of this Committee, the Commission may ask selected members to serve as a Task Force to work with Mr. Burkholder on the development of the recommended bidirectional datum transformation methods.

Chairman Bauer then indicated that a motion would be in order to adjourn sine die and to recommend its own dissolution to the Commission. This was done on a motion by Mr. Charlier, seconded by Mr. Wambach, and carried unanimously. The meeting was adjourned at 2:40 p.m.

Respectfully Submitted,

Lynn G. Heis
Committee Secretary

KWB/lgh
04/14/08
#134871 v2 - C/S - Minutes 3rd Meeting

APPENDIX TO MINUTES OF THE THIRD MEETING OF THE TECHNICAL ADVISORY COMMITTEE MEETING FOR THE REVIEW AND REEVALUATION OF THE REGIONAL CONTROL SURVEY PROGRAM

Secretary's Note: Consideration of the minutes of the February 15, 2008 meeting of the Technical Advisory Committee Meeting for the Review and Reevaluation of the Regional Control Survey program was accomplished by means of a post card ballot. The minutes were approved with 16 aye votes and one conditional aye vote. The conditional vote was cast by Mr. Ellingson who asked that some additional text be added to pages 16 and 17 of the minutes more fully explaining his support for Mr. Casucci's proposal that as surveyors occupy monumented U.S. Public Land Survey system corners and obtain coordinates for those coordinates using GPS technology, those values be transmitted to the Commission for recording and future use. The requested text has been added to the minutes as requested by Mr. Ellingson.

	Member	Approve as Presented	Approve Conditionally	Disapprove	Abstain
1.	Kurt W. Bauer	X			
2.	John M. Bennett	X			
3.	John P. Casucci	X			
4.	Harold S. Charlier	X			
5.	Michael R. Duckett	X			
6.	John T. Ellingson		X		
7.	Thomas M. Grisa	X			
8.	Gregory G. High	X			
9.	Marcia G. Lindholm	X			
10.	Cecil F. Mehring	X			
11.	George E. Melcher	X			
12.	Robert W. Merry	X			
13.	Kent B. Pena	X			
14.	Glen R. Schaefer	X			
15.	Daniel R. Talarczyk	X			
16.	Thomas Tym	X			
17.	William T. Wambach	X			
	TOTAL	16	1		

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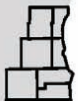

MEMORANDUM

TO: SEWRPC Technical Advisory Committee on the Review and Reevaluation of the Regional Control Survey Program

FROM: Philip C. Evenson, Executive Director

DATE: January 30, 2008

SUBJECT: VERTICAL SURVEY CONTROL FOR KENOSHA COUNTY FEDERAL EMERGENCY MANAGEMENT AGENCY FLOOD HAZARD MAPPING PROGRAM

INTRODUCTION

The purpose of this memorandum is to apprise the Commission Technical Advisory Committee on the Review and Reevaluation of the Regional Control Survey Program of the Commission's proposed position with respect to the vertical datum to be used in the completion of the new Federal Emergency Management Agency (FEMA) Flood Insurance Study for Kenosha County. That study, Study No. 55059CV001A, is presently being conducted, and a preliminary draft flood insurance study report dated July 31, 2007, has been released. That preliminary report proposes to use NAVD 88 as the vertical datum for the flood hazard mapping.

Attached as Exhibit I is a copy of the FEMA Procedure Memorandum No. 41 concerning the use of vertical datums, together with pertinent exhibits from the draft flood insurance study report for Kenosha County. You will note that the FEMA memorandum provides for the issuance of a waiver permitting the continued use of NGVD 29 for new flood insurance studies. The Commission intends to work with Kenosha County and the incorporated communities within the County -- the City of Kenosha, and the Villages of Pleasant Prairie, Paddock Lake, Silver Lake, Twin Lakes and Genoa City -- to obtain the waiver.

The Commission's position in this matter is being taken for the following reasons:

1. All of the hydrologic and hydraulic studies and related costly stream flow and stage simulation modeling, and all of the supporting inventory data including channel cross section and bridge waterway opening data, together with supporting large scale topographic mapping – 1 inch equals 100 feet and 1 inch equals 200 feet scale, 1 foot and 2 feet vertical contour interval – are based upon NGVD 29. The regulatory flood elevations developed by the Commission for the study are all related to NGVD 29.

2. A dense network of vertical control benchmarks exists within Kenosha County, this benchmark network being based upon NGVD 29. As shown on the attached Exhibit II, surveyors and engineers engaged in the use and administration of the new FEMA maps are never more than approximately one-quarter mile from a NGVD 29 benchmark, meeting Second Order Class II standards. The corresponding paucity of benchmarks carrying accurate NAVD 88 elevations is also illustrated on Exhibit II.
3. FEMA's proposal to use a uniform conversion of -0.3 feet between NGVD 29 and NAVD 88 is an approximation – the value varying throughout the County - unsuitable for application in accurate surveying and engineering. Accurate surveys are required to delineate flood hazard areas in the field. In fact, there is no definitive accurate relationship between NGVD 29 and NAVD 88. The approximate difference between the two datums may be expected to be a source of potential confusion and error if two datums are used within Kenosha County, a situation which has already occurred within the Village of Pleasant Prairie. Resolution of the developmental and environmental problems created by the confusion in this situation was costly and time consuming.
4. FEMA has already released new flood insurance studies based upon NGVD 29 under its mapping modernization program for Milwaukee County, Ozaukee County and Waukesha County within the SEWRPC seven-county planning area. It is highly desirable to maintain uniformity with respect to control survey datums used within the seven-county planning area.
5. In the conduct of the Des Plaines River watershed study the Commission coordinated the work with that being done in Northeastern Illinois by the U.S. Army Corps of Engineers. The Corps work utilized the NGVD 29 datum in their work.
6. Flood hazard area delineation aside, the public and private development communities which are involved in development project initiation and execution base the project plans and supporting data, including final grades and related earth work calculations, utility elevations, drainage way elevations, and building foundation and floor elevations, all on a common datum – in Kenosha County NGVD 29.
7. No benefit would accrue to the County, local governments, or to the private sector to base a single data set – flood hazard data – on a different datum than the datum currently in widespread use within the County.