ADDENDUM TO MEMORANDUM REPORT NO. 206

REVISED ESTIMATE OF THE COSTS OF CONVERTING THE LEGACY DATUMS WITHIN THE REGION TO NEW NATIONAL DATUMS

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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ADDENDUM TO
MEMORANDUM REPORT
NUMBER 206

REEVALUATION OF PROCEDURES FOR DATUM CONVERSIONS

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TABLE OF CONTENTS

ADDENDUM TO SEWRPC MEMORANDUM REPORT NO. 206

Appendices

LIST OF TABLES

LIST OF FIGURES

Figure Page

ADDENDUM TO SEWRPC MEMORANDUM REPORT NO. 206

INTRODUCTION

In response to questions raised by some practicing surveyors and land information system managers concerning the continued use of the legacy datums within the Region, in 2012 the Commission prepared Memorandum Report No. 206 entitled "*Estimate of Costs of Converting the Foundational Elements of the Land Information and Public Works Management Systems in Southeastern Wisconsin from Legacy to New Datums*." The report described the legacy and new datums in use within the seven-county planning Region. The report also described the regional control survey network and attendant topographic and cadastral mapping that together provide the foundational elements for the creation of parcel-based land information and public works management systems within the Region. In response to specific requests from some land information system managers, the report presented a procedure for converting the legacy datums within the Region to the newer datums and presented an estimate of the cost of such conversion meeting land and engineering survey accuracy standards. Given the high cost of the conversion, and the lack of evidence of any significant monetary benefit that might accrue from a conversion, the report recommended the continued use of the legacy datums within the Region. Despite these findings, some practicing land surveyors and land information system managers continue to express desires to pursue such a conversion.

Given this continued concern about datum conversion within the Region, and the significant changes in surveying technology that have taken place since the publication of Memorandum Report No. 206, in early 2015 the Commission undertook a reevaluation of the procedures for, and attendant costs of, conversion. This addendum presents the findings of that reevaluation, set forth more fully in an additional appendix – Appendix C – to Memorandum Report No. 206. As such this addendum and attendant appendix are intended to constitute an integral part of Memorandum Report No. 206. Proper consideration of this addendum and attendant appendix requires also consideration of Memorandum Report No. 206 published in 2012.

DEVELOPMENT OF NEW PROCEDURES

Horizontal Control

The procedure for the conversion of the horizontal control survey network within the Region from the legacy to the new datums as proposed in Memorandum Report No. 206, was based upon the technology available in 2012 to provide a high order of accuracy in the converted control survey network. The conversion procedure utilized a series of static Global Positioning System (GPS) observations[1] to provide new primary and secondary control survey networks within the Region. Based upon these networks, new state plane coordinate positions on the North

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[1]*Static global positioning system observations utilize two or more receivers simultaneously receiving data from the system satellites. These data include dual-frequency carrier phase measurements that in effect represent distances. Post processing of the simultaneous measurements provide precise vectors from which coordinate positions are computed. Static observations require positions to be occupied and attendant data observed for significant periods of time—ranging from approximately 15 minutes to one hour.*

American Datum of 1983 (NAD 83) could then be obtained by occupying all of the corners for further GPS observations. The procedure, while providing a high level of accuracy in the new position data, was costly – probably prohibitively so considering the lack of known offsetting benefits.

A significant change in survey technology has occurred since the completion of SEWRPC Memorandum Report No. 206. This change warranted the reconsideration of the survey procedure recommended in that memorandum for the conversion of the control survey network within the Region from the legacy to the newer datums. That change included the completion of the Continuously Operating Reference Stations (CORS) network within the State of Wisconsin, coupled with the development and acceptance of Virtual Reference Station (VRS) Technology.[2] This technology eliminates the need to rely upon static GPS observations for the datum conversion work. The use of Virtual Reference Station technology thus eliminates the need for measurements to be made simultaneously using a roving GPS receiver and an attendant base station or stations. It also eliminates the need for extended observation times at the occupied stations. These two changes—while continuing to require occupation of stations in the control survey network with a roving receiver—present significant increases in the efficiency of the field survey work, with attendant significant reductions in cost. Moreover, the Commission staff has developed a procedure which minimizes the number of control survey stations within subareas of the Region which must be occupied by a roving GPS receiver to carry out the necessary horizontal datum conversion survey work. This procedure combines field observations on a carefully selected minimum number of control survey stations in a survey area—such as a U.S. Public Land Survey System township—with measurement data collected in the original control surveys conducted within the Region, using these data to compute the coordinate positions on the remaining unoccupied stations in the survey area. This procedure is described in the attached Appendix C.

Vertical Control

The foregoing sections of this addendum apply to the datum conversion issues relating to the horizontal control survey network within the Region. A similar problem exists relating to the vertical control survey network within the Region. The elevation data provided by the Commission legacy vertical control survey network are based upon the National Geodetic Vertical Datum of 1929 (NGVD 29) formerly known as Mean Sea Level Datum. The National Geodetic Survey (NGS) in 1977, began a new adjustment project that became the new vertical datum, the North American Vertical Datum of 1988 (NAVD 88). As is the case for horizontal positions, no precise mathematical relationship exists between the legacy and new vertical datums. In 1995, the Commission retained Mr. Earl F. Burkholder, PLS, PE, Consulting Geodetic Engineer, to address the issue of conversions between the elevations on NGVD 29 and the orthometric heights on NAVD 88. The orthometric heights determined during the establishment of NAVD 88 are now referred to as NAVD 88 (1991) orthometric heights, to differential those heights from heights determined by subsequent vertical adjustments.[3] The findings and recommendations of Mr. Burkholder were set forth in SEWRPC Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin*, published in December 1995.

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[2]*Virtual Reference Station technology consisting of a system of hardware and software designed to facilitate real-time global positioning system measurements based on a network of reference stations known as Continuously Operating Reference Stations—performing the role as base stations in static global positioning surveys. The network of receivers is linked to a computation center, and each station contributes its raw data to help create network-wide models necessary to provide accurate positioning of the roving receiver. The primary benefit of the technology is that it permits real-time kinematic positioning using a single rover in the field while achieving centimeter-level accuracy.*

[3]*Orthometric heights "tagged" as NAVD88 were based on the original adjustment of NAVD 88 which was published by NGS in 1991. Since 1995 there have been subsequent adjustments of the vertical control network in southern Wisconsin. Therefore, orthometric heights determined by the 1991 adjustment are now labeled as NAVD 88 (1991). Subsequent adjustments in 2004, 2007, and 2012 are labeled as NAVD 88 (2004), NAVD 88 (2007), and NAVD 88 (2012), respectively. The current NGS datasheet does not allocate space for the inclusion of vertical adjustment tags. However, the adjustment date can be found in the data sheet under text describing the manner in which the various epochs of orthometric heights were determined by NGS.*

The technical report notes that three options then existed for determining the relationship between the two datums. The most costly options would be to resurvey all of the more than 11,000 bench marks within the Region on the new datum. Another option, also costly, was to abstract all control leveling data from existing records and readjust all of the control leveling networks within the Region to the new datum. The third option was would be to employ a program, VERTCON, specifically developed by the NGS to permit conversion of orthometric height and elevation data between NGVD 29 and NAVD 88 (1991). The technical report documents the performance of VERTCON against surveyed orthometric heights and elevations on common bench marks within the Region.

The technical report concludes that VERTCON could be used to convert orthometric height and elevation data between the two datums on a point-by-point basis to achieve Second-Order, Class II accuracies—the class used by the Commission to establish bench mark elevations within the Region. The report further describes how VERTCON could be used to convert elevations between the two datums on an areawide basis. The report used the new datum data as published by the NGS for the 435 NGS (former U.S. Coast and Geodetic Survey) bench marks within the Region as a check on the performance of VERTCON within the Region. The new datum elevations for those bench marks were developed by NGS using original differential leveling data retained in NGS files. As a part of the work accomplished for the preparation of SEWRPC Technical Report No. 35, using VERTCON orthometric height and elevation data were computed for points located on a 10,000-foot State Plane Coordinate system grid overlaid on the Region. The grid point differences were used to develop an iso-hypsometric map of the Region, which map has served height and elevation conversions within the Region well for a period of 20 years.

A significant change in the status of vertical control within the Region has occurred since the completion and publication of Technical Report No. 35. More specifically, the Wisconsin Department of Transportation (WisDOT) in conjunction with NGS completed the Wisconsin Height Modernization Program (WI-HMP) within the Region. This program provided high-order orthometric height data on a carefully distributed network of substantially monumented bench marks. Within the Region the WI-HMP increased the number of bench marks having accurate orthometric height data on NAVD 88 from 435 to 460 bench marks. However, under WI-HMP only about one-half of the 435 bench marks used in the conversion methodology presented in SEWRPC Technical Report No. 35 could be found and used. The other one-half which could not be found were assumed to have been destroyed. The elevation data for approximately 60 percent of the remaining approximately 50 percent of the bench marks were readjusted under WI-HMP to NAVD 88 (2012), thus negating the use of VERTCON within the Region.

Given that VERTCON is not consistent with the readjustment of the entire vertical survey control network in the Region accomplished under WI-HMP, and given that VERTCON was used in the methodology set forth in SEWRPC Technical Report No. 35, and further given the uncertainties involved in the potential recovery of the 435 NGS bench marks used the development of the iso-hypsometric map presented in SEWRPC Technical Report No. 35, it is proposed that a new conversion between the legacy and new vertical datum be developed based upon use of the 460 available WI-HMP stations. Given the density of the Commission legacy vertical control network within the seven-county Region, it is now possible to transfer by field survey elevations referred to the legacy datum to the WI-HMP stations thus providing accurate, surveyed determined comparisons between the elevations on NGVD 29 and the orthometric heights on NAVD 88 (2012). Such transfer should require no more than the completion of approximately one-half mile of high-order differential level lines for each transfer. Using the bench marks having dual data a new iso-hypsometric map of the Region can be prepared. This map can then be used to transfer orthometric heights and elevations between the two datums to Second-Order, Class II accuracy standards. The description of the procedure to be used to create the new iso-hypsometric map is essentially duplicated in the appendix to this report, together with an estimate of the costs entailed.

SUMMARY AND CONCLUSION

This document is intended to comprise an addendum to SEWRPC Memorandum Report No. 206, *Estimate of the Costs of Converting the Foundational Elements of the Land Information and Public Works Management Systems in Southeastern Wisconsin from Legacy to New Datums,* October 2012. This document is intended to be considered within the context of that report. Since the completion of that report, the Commission has continued to receive specific requests from some land surveyors and some County Land Information Officers to reevaluate the procedures for, and the attendant costs of converting the legacy datum within the Region as presented in Memorandum Report No. 206. This addendum presents the findings of that reevaluation in the form of an additional appendix—Appendix C—to Memorandum Report No. 206.

As a part of the reevaluation, the Commission staff developed revised procedures for horizontal and vertical datum conversion within the Region. The procedure for horizontal datum conversion minimizes the number of control survey stations within the subareas of the Region which must be occupied by a GPS receiver to obtain coordinate positions in the new datum. This procedure combines field observations on a carefully selected minimum number of control survey stations in a survey area with measurement data collected in the original control surveys conducted within the Region, using these data to compute the coordinate positions on the new datum of the remaining unoccupied stations in the survey area. This procedure is described in the attached Appendix C.

The Commission staff also developed a revised procedure for conversion of the legacy vertical datum within the Region to the newer NAVD 88. This procedure utilizes the WI-HMP network completed within the Region. The procedure is also described in the attached appendix.

The procedure developed for the conversion of the horizontal datum within the Region reduces the cost of that conversion from the approximately $2.3 million estimated in SEWRPC Memorandum Report No. 206 to approximately $400,000 for the Region as a whole. The procedure could be carried out by subareas of the Region – one such subarea being the survey township. The cost of conversion per township is estimated at approximately $7,600.00

These conversion costs, which logically would have to be borne by those county land information systems that desired a conversion, appear reasonable. These costs are shown by county in the following table.

Estimated Cost by County of Horizontal Datum Conversion

County	Cost Estimate[a]
Kenosha	$40,896
Milwaukee	35,396
Ozaukee	36,040
Racine	51,120
Walworth	85,256
Washington	63,640
Waukesha	87,852
Total	$400,200

[a]*These costs assume that the entire county is included in a single project done by SEWRPC.*

The benefits of the conversion of the horizontal datum remain largely intangible. However, the conversion using this procedure developed by the Commission staff would have one very important, although intangible benefit; namely, this conversion would retain the relative positions of all of the control survey stations within the Region as given by the legacy lengths and bearings of the quarter-section lines, thus preserving the integrity of the legacy horizontal control survey network within the Region. This benefit may be considered sufficient to warrant the relatively modest cost of the horizontal data conversion.

The procedure developed for the conversion of the vertical datum within the Region reduces the cost of that conversion from the approximately $4.5 million estimated in SEWRPC Memorandum Report No. 206 to approximately $300,000 for the Region as a whole. This conversion should be carried out for the Region as a whole in order to ensure consistent conversion factors throughout the Region across both natural boundaries such as watershed boundaries and across civic boundaries such as municipal and county boundaries. The cost of the conversion would have to be borne by the county land information systems within the Region on the basis of an agreed upon distribution of the cost among those systems. One such distribution of costs by county is set forth below.

Estimated Cost by County of Vertical Datum Conversion

County	Cost Estimate[a]
Kenosha	$31,185
Milwaukee	27,249
Ozaukee	26,641
Racine	38,452
Walworth	64,792
Washington	49,048
Waukesha	65,398
Total	$302,768

[a]Cost allocations to county based on area.

Based upon the findings presented in this addendum, it is recommended that each of the individual county land information systems within the Region determine if they want to proceed with the conversion of the horizontal datum now in use within the Region from NAD 27 to NGVD 83 (2011). If it is determined to proceed, the work could be accomplished by the Commission under contract to the land information systems concerned. In each case the work and cost could be spread over a 3-year period.

Similarly, with respect to the conversions of vertical heights from NGVD 29 to NAVD 88 (2012), the land information systems would have to decide whether or not to proceed. In this case, however, the conversion should be made for the Region as a whole. Therefore, all seven county land information systems would have to agree to proceed, and further would have to agree upon a distribution of the cost. If agreement were reached, the work could be done by the Commission under contract to all seven county land information systems.

The estimated costs of horizontal datum conversion presented in this addendum relate to only one of the four foundational elements of any good parcel-based land information or public works management system. Each of the other three foundational elements – the map projection, the topographic maps for ground truth, and the parcel based cadastral maps will require recompilation, or in the alterative some form of adjustment if those elements are to be useable with coordinate positions on the new datum. Such coordinate positions cannot be plotted on the map projection, or on the existing topographic and cadastral maps of the legacy systems. The conversion of the other three foundational elements of the existing systems will constitute by far, the major portion of the costs of the conversion as set forth in SEWRPC Memorandum Report No. 206.

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APPENDICES

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Appendix C

REVISED PROCEDURES FOR COSTS OF DATUM CONVERSIONS

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Appendix C

TO SEWRPC MEMORANDUM REPORT NO. 206

INTRODUCTION

The seven-county Southeastern Wisconsin Region has an extensive and accurate network of both horizontal and vertical control survey stations. The integrated horizontal and vertical control survey stations are comprised of the 11,985 U.S. Public Land Survey System (USPLSS) corners within the Region and accessories thereto. The horizontal network is referenced to the North American Datum of 1927 (NAD 27), while the vertical network is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). The survey methods used to create the horizontal control network ranged from using theodolites and tellurometers to using Global Positioning System (GPS) instrumentation. The survey methods used to create the vertical control network ranged from using differential spirit leveling with invar rods read optically to using coded invar rods read automatically by the level instrument.

The introduction of newer technologies, especially the use of GPS instrumentation, has made the use of the legacy control survey network inconvenient when relating to newer datums created by the Federal government. The Commission continues to maintain the legacy control survey network in five of the seven counties comprising its Region and continues to monitor the use of the network within those counties. From time to time the Commission retains consultants to develop processes and/or mathematical formulas to assist surveyors, public works engineers, and other users in the use of the networks. However, some county land information system managers continue to request that the Commission investigate the means by which the legacy networks could be converted to newer datums and to estimate the attendant costs.

This appendix proposes new methods for converting the Commission legacy horizontal datum, from NAD 27 to the latest newer datum and adjustment—the North American Datum of 1983 with the National Adjustment of 2011, (NAD 83 (2011)), and for converting the legacy vertical datum from the NGVD 29 to the North American Vertical Datum of 1988 adjustment of 2012, (NAVD 88 (2012)), and to do so cost effectively.

METHODOLOGY FOR CONVERSION OF HORIZONTAL CONTROL

The Commission staff has developed a method for the conversion of its legacy horizontal control survey coordinate positions to the new horizontal datum while maintaining the relative positions of the legacy control survey stations, and maintaining the original accuracy standards of the network. The method utilizes the measurements made in the creation of the legacy horizontal control survey network within the Region and minimizes the number of field observations required to position the control survey stations on the new datum and

on the corresponding map projection. As already noted, the legacy network utilizes monumented corners of the USPLSS as control survey stations and, in effect, recreates the USPLSS within the Region tying that system to the National geodetic control system.

The datum conversion method developed by the Commission staff can be applied by subareas of the Region as small as six square miles in extent, although more practical subareas would consist of USPLSS townships, or of entire counties. When applied at the township level, the method requires field observations to obtain the coordinate positions of the township corners on the new datum together with such observations on a carefully selected number of control survey stations—approximately eight—consisting of section and quarter-section corners within the township. Four of the eight corners could be the four corners marking the exterior boundaries of a six-section SEWRPC Control Survey Summary Diagram (CSSD) used by the Commission to display the legacy control survey network. Having determined the coordinate positions on the new datum of approximately 12 USPLSS corners—the coordinates of the remaining 157 corners are computed using the lengths of the quarter-section lines and the interior angles of the quarter sections within the township as determined in the legacy survey. This computation consists of a least squares adjustment[1] of the network within the township.

Upon completion of the determination of the coordinate positions of all of the stations—USPLSS corners—within the area concerned, a small random sample of stations would be selected and the coordinate positions of these stations determined by additional field observations, thus providing a check on the accuracy of the completed conversion. If discrepancies exceeding the desired accuracy standards are found appropriate adjustments or further field measurements would have to be made.

The method developed by the Commission staff significantly reduces the cost entailed in datum conversion from such costs entailed in application of the conversion method proposed in SEWRPC Technical Report No. 206. Importantly, the method preserves the integrity of the legacy control survey network within the Region, maintaining the relative positions in the form of quarter-section-line lengths and bearings as determined in the creation of the legacy network, and does so within the accuracy standards of that network.

Field Observations

As noted, the conversion method requires the conduct of a limited number of field observations to determine the coordinate positions on the new datum of a carefully selected number of existing legacy stations. The necessary field observations would be made using state-of-the-art GPS instrumentation and procedures.

The Wisconsin Department of Transportation (WisDOT) completed a network of Continuous Operating Reference Stations (WISCORS) within the Region and the State in 2015. These stations within and adjacent to the Region are shown on Figure 1, and serve as the primary control network within the Region, replacing the old First- and Second-Order triangulation and base line stations. Satellite measurements permit the creation of a mathematical model that supports an online processing technology known as Virtual Reference Station (VRS) technology. This technology permits real-time positioning without the need for base stations and with minimal observation times while achieving centimeter-level accuracy. The VRS[2] technology is proposed to serve as the basis of the field measurements needed to determine horizontal positions in the new datum.

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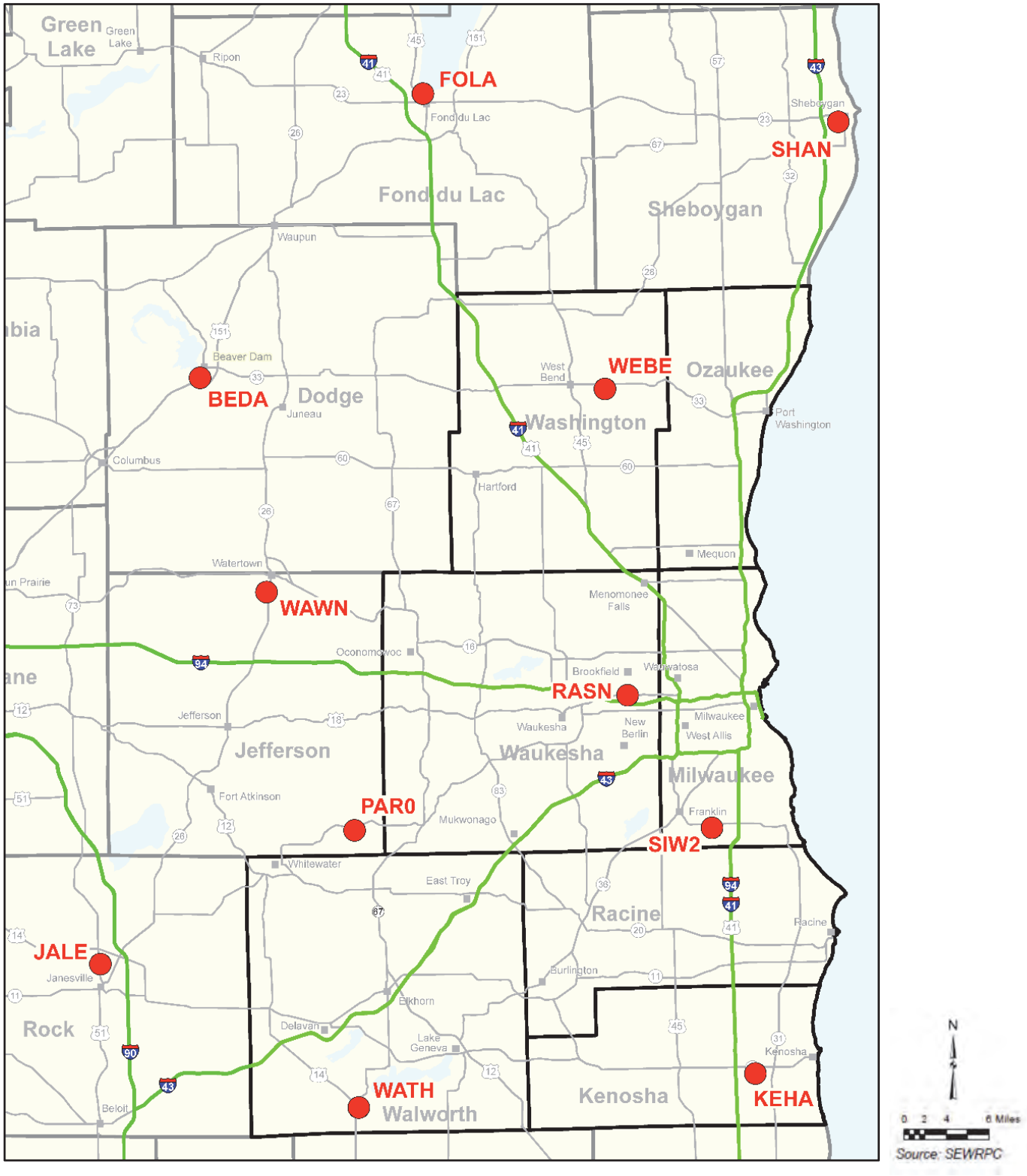
[1]*The term "least squares adjustment" refers to a mathematical procedure based on the theory of probability that derives the statistically most likely coordinate location of points defined by multiple measurements in a network. Moreover, a least squares adjustment defines a best-fit solution for weighed measurements finding a minimum for the sum of the squares of the measurement residuals. A measurement residual is the amount needed to correct a measurement for it to fit into the best-fit solution found by the least squares adjustment.*

[2]*For definition of VRS technology see Footnote 2, page 2, of Addendum.*

Figure 1

WISCORS STATIONS IN AND ADJACENT TO THE SOUTHEASTERN WISCONSIN REGION



The following protocol would be followed in making the necessary field observations:

1. For each of the control survey stations—USPLSS corners—to be occupied, a copy of the SEWRPC "Record of U.S. Public Land Survey Control Station" (dossier sheet) shall be obtained.

2. The dossier sheet shall be used to recover the station, and a minimum of two of the tie distances from the station to witness marks shown on the dossier sheets shall be measured to ensure that the station has not been disturbed.

3. The following potential sources of error shall be considered and adjusted for in the measurement process: positional dilution of precision (PDOP), number of satellites visible, mask angle, potential multipath, and solar activity.

4. Each observation shall have a minimum duration of 5 seconds using a 1-second epoch rate.

5. At the end of the observation, the antenna of the instrument shall be set near the ground so a complete loss of satellite lock occurs. The antenna shall then be repositioned over the monument for an additional observation.

6. A minimum of three observations shall be made at each station occupied. The second and third direct observation shall also have at a minimum a duration of 5 seconds using a 1-second epoch rate.

7. Steps 5 and 6 shall be repeated as necessary to obtain the desired minimum of three observations.

8. The Root Mean Square Error (RMSE) of the three observations shall be calculated for each coordinate component (Northing, Easting, and Elevation) at each of the stations occupied using the following equation.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}[Average_i - Check_i]^2}{N}}$$

Average$_i$ = Average position of the Northing, Easting, or Elevation at the USPLSS Corner

Check$_i$ = Northing, Easting, or Elevation value from the individual GPS observations at a USPLSS Corner

N = Number of observations at a USPLSS corner

9. The computed RMSE for the Northing, Easting, and Elevation components shall not exceed the following:

   Northing 0.06 foot
   Easting 0.06 foot
   Elevation 0.09 foot

10. Additional observations shall be performed as required to meet the maximum allowable RMSE. Any combination of observations may be used to achieve the acceptable RMSE, provided all coordinate components (Northing, Easting, and Elevation) are used in the solution.

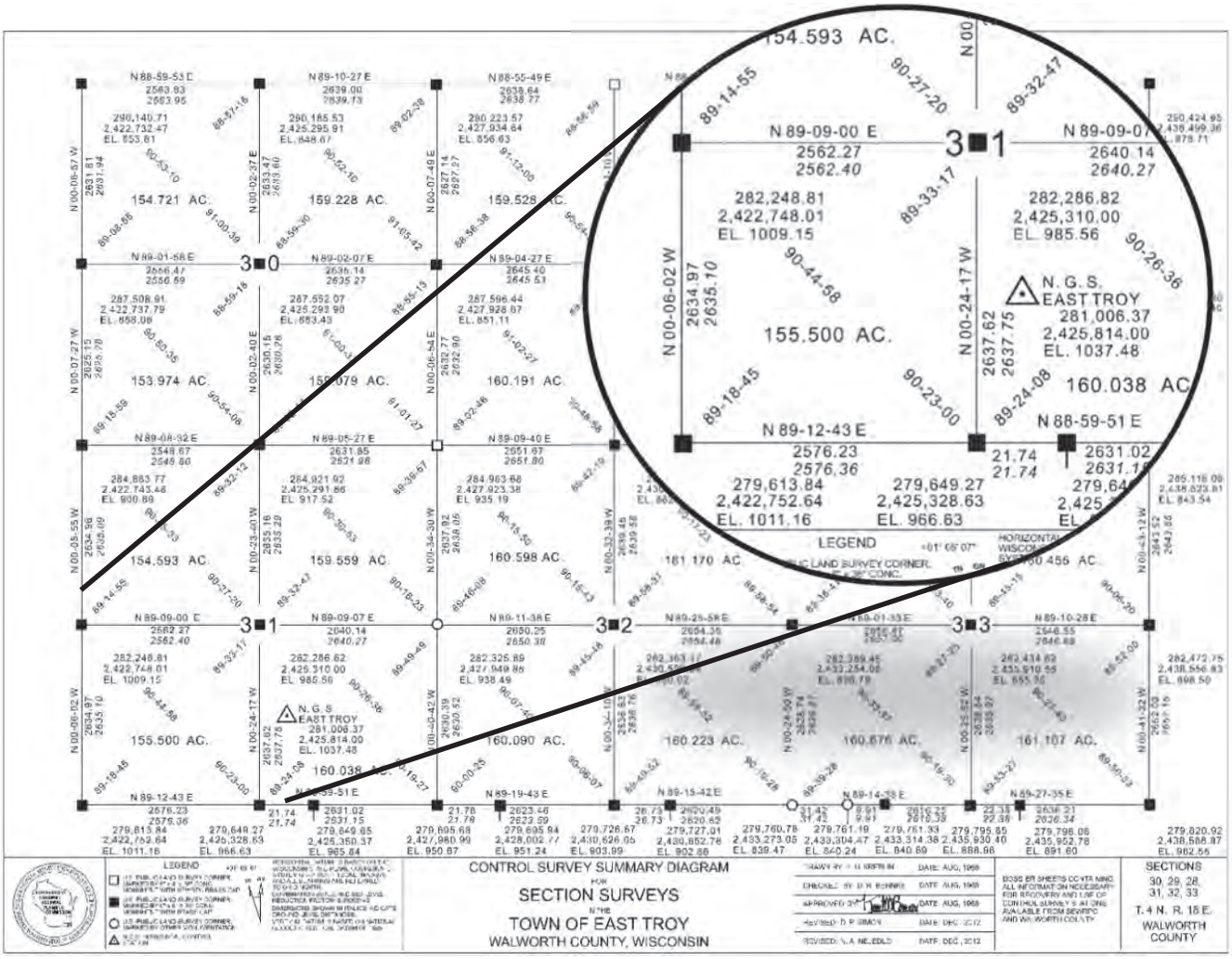
Computations

Two major computation phases are involved in the proposed horizontal datum conversion methodology. The first phase consists of the extraction of legacy system information. The second phase consists of a least squares adjustment converting the legacy positions to the new datum.

The use of legacy system information is considered the most significant feature of the proposed methodology. The use of this information will not only serve to reduce costs, but will assist in validating the control station positioning, and serve to identify any issues that might arise in the conversion process such as not achieving the desired accuracy standards in a part of the network.

Figure 2

TYPICAL SEWRPC CONTROL SURVEY SUMMARY DIAGRAM



Source: SEWRPC.

The information from the legacy system required is found on CSSD. The first and most important piece of such information consists of the published grid distance between stations – USPLSS Corners. Also required are the interior angles between quarter-section lines. The angles will be extracted so that at corners of the quarter sections the interior angles are read clockwise. Figure 2 provides an example of a CSSD, and of the information that will be extracted for use in a least squares adjustment of the network.

Using the station – corner – identification system that is described in the next section (See Figure 3), Table 1 illustrates the format of the values to be extracted from CSSD to be used in the least squares adjustments.

Once the legacy spatial measurements have been extracted from the CSSDs, the second phase of the computations—the least squares adjustment—can be carried out. The complexity entailed in the management of compilations relating a control survey network consisting of almost 12,000 stations makes a single adjustment impractical. It is therefore, proposed to break the conversion compilations into manageable segments consisting of subareas of the Region. As already noted, these areas could be as small as six square miles, or as large as a county. A survey township would constitute a particularly practical subarea. Individual adjustments would be performed working serially so adjacent subarea boundary corners can be constrained to fit from previous adjustments.

Table 1

FORMAT OF INPUT TO LEAST SQUARE ADJUSTMENT

Code (A: Angle)	Backsight – At – Foresight	Angle (Degrees – Minutes – Seconds)
A	0418144-0418169-0418168	89-18-45
A	0418145-0418144-0418169	90-44-58
A	0418168-0418145-0418144	89-33-17
A	0418169-0418168-0418145	90-23-00
A	0418145-0418168-0318012	89-24-08
Code (D: Distance)	From - To	Grid Distance (US Survey Feet)
D	0418144-0418169	2634.97
D	0418144-0418145	2562.27
D	0418169-0418168	2576.23
D	0418145-0418168	2637.62
D	0418168-0318012	21.74

Source: SEWRPC.

The first step in the least squares computation is to constrain the legacy control positions. This provides verification of the accuracy of the legacy control survey network as documented by each CSSD and the completeness of the input of the spatial measurements. After acceptance of the CSSD spatial measurements, additional CSSDs can be added to the network until the defined adjustment area has been completed.

Once the individual areas have been completed in this manner, a final step prior to incorporating the new positional data is the application of an effective weighting strategy. This is critical given the use of legacy measurements integrating with the precise GPS field observed positioning. An effective strategy will allow displacement of the differences (measurement residuals) found between the measurement types, and account for the numerous possible measurement paths between unconstrained USPLSS corners. The algorithms in a least squares adjustment provide a rigorous means for this. Tolerance and weights could change once the network design is applied to the entire subarea concerned. However, a typical half mile length, the weight assigned for the grid distance would be 0.03 foot and interior angle at 30 arc seconds. USPLSS corner positions (new datum positons) that have been observed but not constrained in the network adjustment would be assigned weights of 0.1 foot (both Northing and Easting).

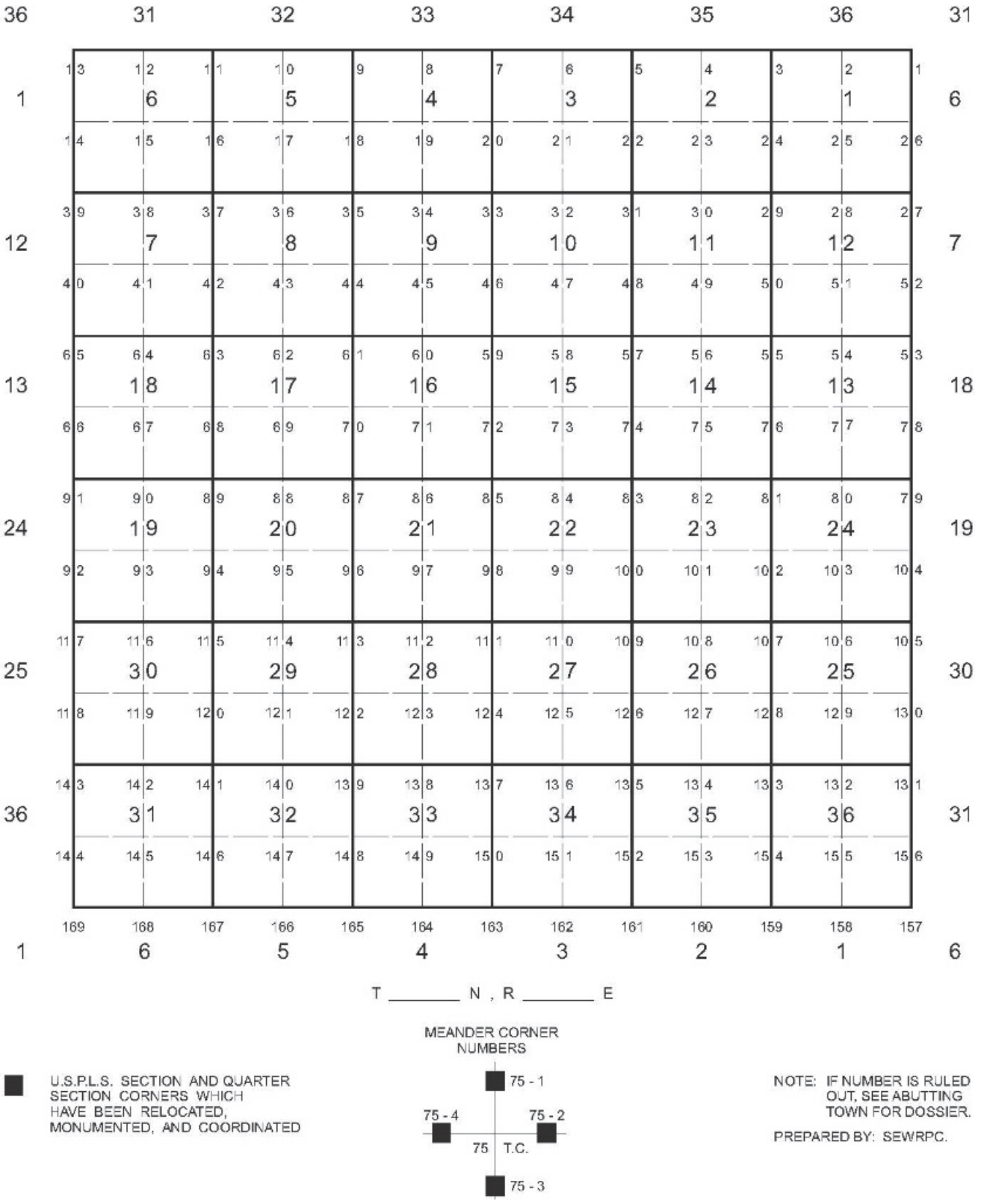
CONTROL SURVEY STATION NUMBERING

A control survey station numbering system will be required that provides a unique numeric identification for each control survey station in the network throughout the Region. This will allow stations to be used in multiple adjustments without conflict or duplication in the control networks. It is proposed to use the Commission's long-standing numbering system for this purpose. That system is illustrated in Figure 3.

Under the Commission system, the number identifying each station, while unique within each township, it is not unique for corners located along common range lines between two townships, or for common corners along township lines. The Commission system would be modified by adding a prefix to each corner number specifying the township and range. Corners along the eastern and southern boundaries of every township would be numbered

Figure 3

PROPOSED CONTROL SURVEY STATION – USPLSS CORNER – NUMBERING SYSTEM



Source: SEWRPC.

according to the normal township numbering system. However, corners along the northern and western boundaries would be numbered using the numbers of the corners in the adjacent township. This provides a unique number for every corner and eliminates the possibility of corners having two numbers as would be the case if numbered by individual township. The northern boundaries of townships containing closing corners would be numbered as followed by the Commission system aside from the added town and range prefix.

DEMONSTRATION APPLICATION OF METHODOLOGY

A demonstration application of the horizontal datum conversion methodology developed by the Commission staff was carried out in July 2015. A typical 6-square-mile area consisting of Sections 28 through 33 in Township 4 North, Range 18 East, Town of East Troy, Walworth County, was selected for the demonstration.

The legacy data for the demonstration area are shown on Figure 4. The monuments marking four corners of the area, together with the monument marking the Southwest corner of Section 29 which is near the center of the area, were occupied and the coordinate positions of these corners on NAD 83 (2011) were determined by a GPS survey. The survey was conducted in accordance with the protocol set forth in this appendix. The newly determined coordinate positions for these five corners are shown on Figure 5.

The ground level lengths of the quarter-section lines within the area, together with the interior angles of the quarter sections, were extracted from the legacy data shown on the diagram comprising Figure 4. The ground level lengths of the quarter-section lines were reduced to grid lengths using the combination elevation and scale reduction factor for the State Plane Coordinate System based upon the new datum. A least square adjustment of the network was then used to compute the State Plane Coordinates[3] of the remaining 30 stations—corners—within the area. The resulting values are shown on the diagram comprising Figure 5. The grid distances and bearings of the one-quarter section lines on the new datum were then determined by inverse computation from the new coordinate values. The grid distances were then converted to ground level distances using the combination factor for the new coordinate system. The areas of the quarter-sections were computed using the new ground level distances and bearings of the quarter-section lines. These results are also shown on the diagram comprising Figure 5.

Examination of the two diagrams comprising Figures 4 and 5 will show that the maximum change in the ground level length of the quarter-section lines between the legacy and new datums was 0.13 foot. The maximum change in the bearings of the quarter-section lines was 7 seconds of arc. The maximum change in the computed areas of the one-quarter sections was 0.011 acre.

Seven of the computed USPLSS corners were selected for an independent performance evaluation. These corners are identified on the diagram comprising the Figure 5. The monuments marking these corners were occupied and the coordinate position of these corners on the new datum determined by GPS survey. A comparison of the computed and the surveyed values is provided in Table 2. The maximum difference in the coordinate values of 0.23 foot falls well within the desired accuracy standard specified for the legacy network within the Region.

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[3]*The NAD 83 state plane coordinate values are defined in meters. For this appendix the metric values were converted to feet using the ratio of 39.37 inches per meter exact to 12 inches per U.S. Survey Foot, which approximates 1 meter equaling 3.280833333 U.S. Survey Feet.*

Table 2

NAD83/2011 COMPUTED POSITIONS VERSUS GPS OBSERVED INDEPENDENT POSITIONS

	Computed		GPS Observed (July 23, 2015)			Delta (USFT)	
USPLSS Corner	Northing (USFT)	Easting (USFT)	Northing (USFT)	Easting (USFT)		Northing	Easting
0418123	287,734.64	2,404,333.97	287,734.73	2,404,333.98		0.09	0.01
0418150	282,482.37	2,407,019.81	282,482.60	2,407,019.82		0.23	0.01
0418167	279,705.08	2,396,443.96	279,705.12	2,396,443.88		-0.04	0.08
			GPS Observed (March 5, 2015)				
0418115	290,233.03	2,396,397.43	290,233.00	2,396,397.53		-0.03	0.10
0418116	290,194.98	2,393,758.74	290,194.87	2,393,758.84		-0.11	0.10
			GPS Observed (February 9, 2015)				
0417130	287,518.28	2,391,200.65	287,518.24	2,391,200.67		-0.04	0.02
0418131	284,893.05	2,391,206.35	284,893.08	2,391,206.29		0.03	-0.06
				Average:		0.03	0.01
				Maximum Difference:		0.23	0.10
				Minimum Difference:		-0.11	-0.08
				Standard Deviation:		0.11	0.07

Source: SEWRPC.

METHODOLOGY FOR CONVERSION OF VERTICAL CONTROL

The foregoing text deals only with the datum conversion relating to horizontal positions. As noted in the addendum to which this appendix is attached, a similar problem exists relating to the vertical control survey network within the Region. The elevation data provided by the legacy vertical control survey network are based upon the NGVD 29. The National Geodetic Survey in 1977, began a new adjustment project that became the new vertical datum, the North American Vertical Datum of 1988 (NAVD 88). As is the case for horizontal positions, no precise mathematical relationship exists between the legacy and new datums. The Commission in 1995, published SEWRPC Technical Report No. 35, *Vertical Datum Differences in Southeastern Wisconsin.* That report provided a means for converting elevations from the legacy datum to the new datum and provided an iso-hypsometric map to facilitate the conversion of orthometric heights and elevations from one datum to the other. The iso-hypsometric map provided in SEWRPC Technical Report No. 35 was based on the interpolation of datum differences computed for points located on a 10,000-foot grid using VERTCON. The validity of VERTCON was checked by using the datum differences at the 435 NGS (former U.S. Coast and Geodetic Survey) bench marks within the Region as published by NGS.

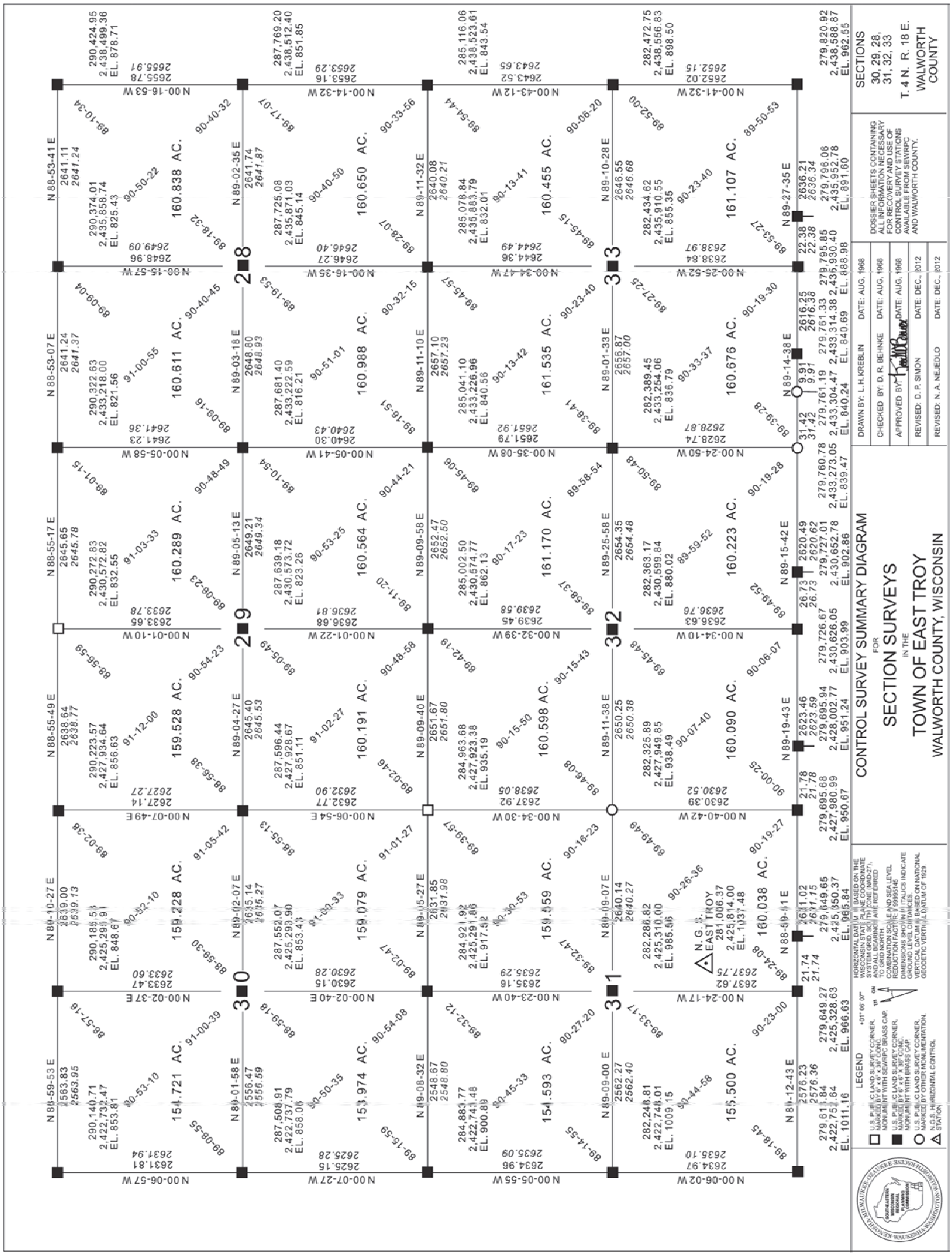
Since the completion of SEWRPC Technical Report No. 35, the Wisconsin Department of Transportation (WisDOT) in conjunction with NGS completed the Wisconsin Height Modernization Program (WI-HMP) within the Region. This program provided high-order orthometric height data on a carefully distributed network of substantial monumented bench marks. The locations of these bench marks are shown on Figure 6. The orthometric heights determined for these bench marks are referred to NAVD 88 (2012).

It is proposed to effect the conversion of elevations between the legacy and new datum by establishing accurate, measured legacy datum elevations on each of the 460 height modernization stations within the Region, thus, establishing an accurate, measured relationship between the two datums on each of the stations. The legacy datum elevations would be established by differential level surveys connecting the Commission legacy bench marks to the height modernization stations. Such transfer should involve no more than the survey of approximately one-half mile of high-order differential level lines for each transfer.

Using the accurate differences between the two datums as determined by actual differential level survey for each datum, a new iso-hypsometric map of the Region can be prepared. This map may be expected to be more accurate than the map provided in SEWRPC Technical Report No. 35. This map can then be used to transfer orthometric heights and elevations between the two datums to Second-Order, Class II accuracy standards.

Figure 4

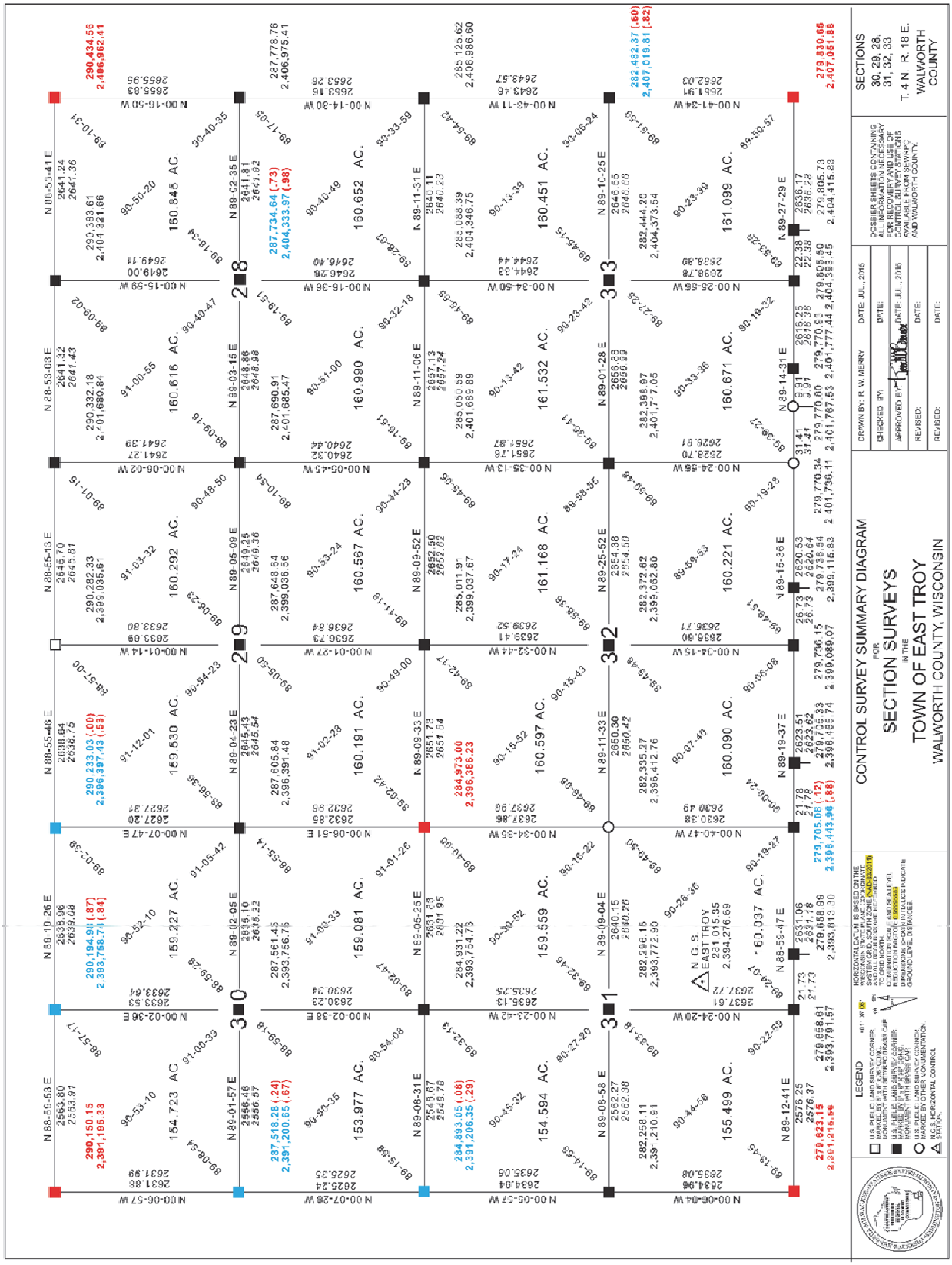
SEWRPC CONTROL SURVEY SUMMARY DIAGRAM – NAD 27



Source: SEWRPC.

Figure 5

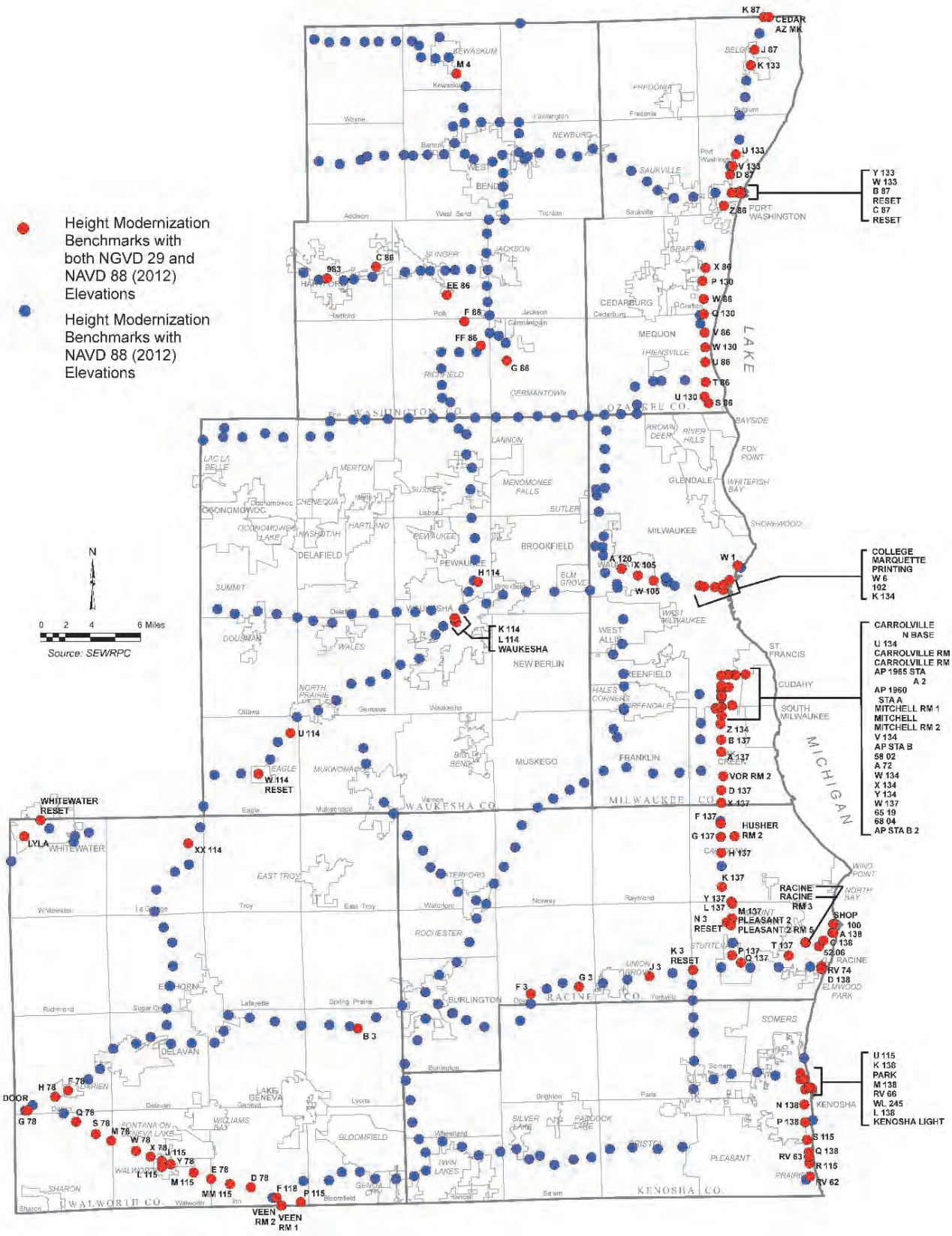
SEWRPC CONTROL SURVEY SUMMARY DIAGRAM – NAD 83 (2011)



Source: SEWRPC.

Figure 6

WISCONSIN HEIGHT MODERNIZATION BENCH MARKS WITHIN THE SOUTHEASTERN WISCONSIN REGION



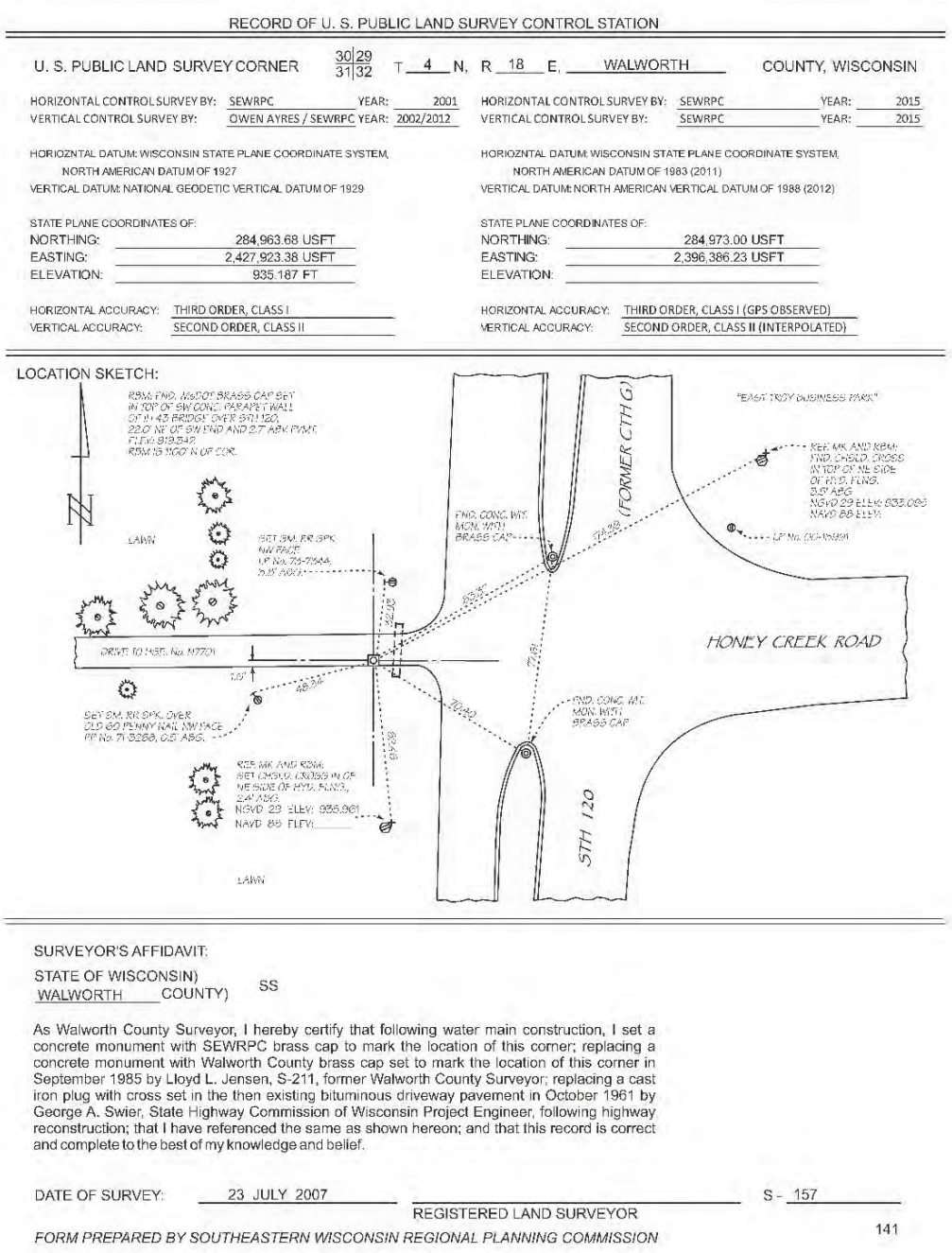
Source: SEWRPC.

REVISED "RECORD OF USPLSS CONTROL STATION" DOCUMENTS

The Commission has prepared and maintains a document known as "Record of U.S. Public Land Survey Control Station" for each of the more than 11,000 control survey stations – USPLSS corners within, and in a few cases, adjacent to the Region. These documents are commonly referred to as "dossier" sheets. As a control survey station is converted from the legacy to the new datums, a new dossier sheet will have to be provided. A revised format will be required for the dossier sheets and a proposed format is provided in Figure 7. The proposed format provides for the display of dual horizontal positions and vertical heights of the station.

Figure 7

REVISED "RECORD OF U.S. PUBLIC LAND SURVEY CONTROL STATION"



RECORD OF U. S. PUBLIC LAND SURVEY CONTROL STATION

U. S. PUBLIC LAND SURVEY CORNER 30|29 / 31|32 T 4 N, R 18 E, WALWORTH COUNTY, WISCONSIN

HORIZONTAL CONTROL SURVEY BY:	SEWRPC YEAR: 2001	HORIZONTAL CONTROL SURVEY BY:	SEWRPC YEAR: 2015
VERTICAL CONTROL SURVEY BY:	OWEN AYRES / SEWRPC YEAR: 2002/2012	VERTICAL CONTROL SURVEY BY:	SEWRPC YEAR: 2015
HORIOZNTAL DATUM:	WISCONSIN STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM OF 1927	HORIOZNTAL DATUM:	WISCONSIN STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM OF 1983 (2011)
VERTICAL DATUM:	NATIONAL GEODETIC VERTICAL DATUM OF 1929	VERTICAL DATUM:	NORTH AMERICAN VERTICAL DATUM OF 1988 (2012)
STATE PLANE COORDINATES OF:		STATE PLANE COORDINATES OF:	
NORTHING:	284,963.68 USFT	NORTHING:	284,973.00 USFT
EASTING:	2,427,923.38 USFT	EASTING:	2,396,386.23 USFT
ELEVATION:	935.187 FT	ELEVATION:	
HORIZONTAL ACCURACY:	THIRD ORDER, CLASS I	HORIZONTAL ACCURACY:	THIRD ORDER, CLASS I (GPS OBSERVED)
VERTICAL ACCURACY:	SECOND ORDER, CLASS II	VERTICAL ACCURACY:	SECOND ORDER, CLASS II (INTERPOLATED)

LOCATION SKETCH:

SURVEYOR'S AFFIDAVIT:

STATE OF WISCONSIN) SS
WALWORTH COUNTY)

As Walworth County Surveyor, I hereby certify that following water main construction, I set a concrete monument with SEWRPC brass cap to mark the location of this corner; replacing a concrete monument with Walworth County brass cap set to mark the location of this corner in September 1985 by Lloyd L. Jensen, S-211, former Walworth County Surveyor; replacing a cast iron plug with cross set in the then existing bituminous driveway pavement in October 1961 by George A. Swier, State Highway Commission of Wisconsin Project Engineer, following highway reconstruction; that I have referenced the same as shown hereon; and that this record is correct and complete to the best of my knowledge and belief.

DATE OF SURVEY: 23 JULY 2007 _____ S - 157
REGISTERED LAND SURVEYOR

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

141

Source: SEWRPC.

COSTS

The costs of the various major work elements involved in datum conversion were estimated separately for the horizontal and vertical components of the work entailed. The costs were developed by analyzing the major work elements of each of the two conversions.

For the horizontal datum conversion, six major work elements were considered:

1. The extraction of the data required from the legacy control survey network. These data include the location and monumentation of existing control survey stations—USPLSS corners; the lengths of the quarter-section lines; the interior angles of the quarter-sections; and attendant combination scale and sea level reduction factors.
2. The necessary field observations including the recovery of a set of carefully located and distributed legacy control survey stations and the conduct of the GPS observations on these stations as required to determine the coordinates of the stations concerned referred to NAD 83 (2011).
3. The determination of the coordinate positions of all of the other stations in the network concerned utilizing the data extracted from the legacy network.
4. Selection of an approximately 10 percent sample of the stations having computed coordinates for occupation and GPS survey to check the coordinate values of the selected stations.
5. Preparation of new "Record of U.S. Public Land Survey Control Station" document—dossier sheet—for each of the control survey stations concerned.
6. Preparation and publication of a project completion report.

For each of these major work elements, estimates were made of the direct and indirect labor costs, of the associated overhead costs, and an allowance for contingencies. These costs are set forth in Table 3. The costs of such items as mileage, equipment, and report preparation would need to estimated on a job-by-job basis, assuming that the Commission performs the work entailed. Estimates were made of the cost of implementation of the horizontal datum conversion for the seven-county Region as a whole; and for implementation by subarea—namely by survey township. These costs are presented in Tables 3 through 5. In any consideration of these costs estimates, it should be recognized that precise estimates, of the costs of completion of the work by a specific county, or by specific subarea, are possible only on the basis of a more detailed study design for the conduct of the work by the area concerned. Consequently, the costs of the work elements set forth in the Tables 3 through 5 must be considered tentative and changes in the allocation of costs to work elements must be expected as the work proceeds. It should be noted that if the datum conversion is implemented by subarea, the cost of completing a larger area, such as a county or the Region, as a whole, will be somewhat higher.

The costs of the work would have to be borne by those individual county land information systems that desire the horizontal datum conversion to be completed. Work could be accomplished for the county as a whole or by subareas, particularly survey townships. The estimated cost by county is provided in Table 4 and by typical township in Table 5.

For the vertical datum conversion, four major work elements were considered:

1. The high-order differential level circuits required to determine accurate elevations referred to NGVD 29 for each of the 460 Height Modernization stations within the Region. The total length of the level lines was estimated at approximately 250 miles.
2. The computation of the surveyed vertical datum differences at each of the 460 height modernization stations.
3. Preparation of a new iso-hypsometric map of the Region by interpolation of the datum differences found at the 460 height modernization stations.
4. Preparation and publication of a project completion report.

Table 3

COST ESTIMATE – HORIZONTAL DATUM CONVERSION - SEVEN COUNTY REGION

Description	Cost
Extraction of Legacy Measurements	$49,600
Field Observations	
• Labor	179,520
Contingency for Additional Field Observations and Time for Inclusion into Least-Squares Adjustments	19,680
Determination of Coordinate Positioning using selected NAD83/2011 field observation and extracted legacy measurements	33,000
Preparation of new "Record of U.S. Public Land Survey Control Station" documents and Control Survey Summary Diagrams	118,400
Total	$400,200[a]

[a]*Vehicle mileage and equipment costs must be estimated on a job-by-job basis; therefore, no line items are included for these costs in the table.*

Source: SEWRPC.

Table 4

COST ESTIMATE – HORIZONTAL DATUM CONVERSION – INDIVIDUAL COUNTY

Description	Cost						
	Kenosha County	Milwaukee County	Ozaukee County	Racine County	Walworth County	Washington County	Waukesha County
Extraction of Legacy Measurements	$5,080	$4,400	$4,400	$6,360	$10,520	$7,960	$10,880
Field Observations • Labor	18,240	16,200	15,960	23,040	38,400	28,800	38,880
Contingency for Additional Field Observations and Time for Inclusion into Least-Squares Adjustments	1,920	1,500	1,800	2,520	3,840	3,240	4,860
Determination of Coordinate Positioning using selected NAD83/2011 field observation and extracted legacy measurements	3,520	2,640	3,520	4,400	7,040	4,400	7,480
Preparation of new "Record of U.S. Public Land Survey Control Station" documents and Control Survey Summary Diagrams	12,136	10,656	10,360	14,800	25,456	19,240	25,752
Individual County Total	$40,896 [a]	$35,396 [a]	$36,040 [a]	$51,120 [a]	$85,256 [a]	$63,640 [a]	$87,852 [a]

[a]*Vehicle mileage and equipment costs must be estimated on a job-by-job basis; therefore, no line items are included for these costs in the table.*

Source: SEWRPC.

For each of these major work elements, estimates of the costs were made in the same manner as for the horizontal datum conversion work.

As a practical matter, the work entailed in vertical datum conversion should be completed for the Region as a whole. These costs are presented in Table 6. The costs of the work would have to be borne by the individual county land information systems. The costs could be distributed among the counties on the basis of any system agreed to by the seven-county land information systems. One such possible system would utilize the proportional area that each county comprises of the Region. The application of this system is illustrated in Table 7.

Table 5

COST ESTIMATE - HORIZONTAL DATUM CONVERSION - TYPICAL TOWNSHIP

Description	Cost
Extraction of Legacy Measurements	$ 960
Field Observations • Labor	3,600
Contingency for Additional Field Observations and Time for Inclusion into Least-Squares Adjustments	720
Determination of Coordinate Positioning using selected NAD83/2011 field observation and extracted legacy measurements	880
Preparation of new "Record of U.S. Public Land Survey Control Station" documents and Control Survey Summary Diagrams	1,480
Total	$7,640[a]

[a]*Vehicle mileage and equipment costs must be estimated on a job-by-job basis; therefore, no line items are included for these costs in the table.*

Source: SEWRPC.

Table 6

COST ESTIMATE – VERTICAL DATUM CONVERSION - SEVEN COUNTY REGION

Description	Cost Breakdown
High Order Differential Level Circuits to Determine Accurate NGVD 29 Elevations on 460 Height Modernization Bench Marks within Region	$177,408
Compilation and Computations Supporting the Vertical Differences of the Height Modernization Bench Marks	26,400
Preparation of new Iso-Hypsometric Map	8,800
Preparation and Publication of Project Completion Report	13,200
Preparation of new "Record of U.S. Public Land Survey Control Station" documents and Control Survey Summary Diagrams	76,960
Total	$302,768

Source: SEWRPC.

Table 7

COST ESTIMATE - VERTICAL DATUM CONVERSION - INDIVIDUAL COUNTY

Description	Percent of Regional Area	Cost
Kenosha County	10.3	$31,185
Milwaukee County	9.0	27,249
Ozaukee County	8.8	26,644
Racine County	12.7	38,452
Walworth County	21.4	64,792
Washington County	16.2	49,048
Waukesha County	21.6	65,398
Total	100.0	$302,768

Source: SEWRPC.

Appendix D

MINUTES OF AUGUST 21, 2015
SEWRPC TASK FORCE ON DATUM CONVERSION

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Minutes
Meeting of the Technical Task Force Created by SEWRPC to
Review the Preliminary Draft of an Addendum to SEWRPC Memorandum Report No. 206

DATE: August 21, 2015

TIME: 8:30 a.m.

PLACE: Southeastern Wisconsin Regional Planning Commission
Racine Conference Room
W239 N1812 Rockwood Drive
Waukesha, WI 53187

Members Present:

Kurt W. Bauer, PE, PLS, AICP, Chairman..... Executive Director Emeritus, SEWRPC, County Surveyor, Kenosha, Milwaukee, Walworth, and Waukesha Counties
Earl F. Burkholder, PS,PE .....Consulting Geodetic Engineer
Robert W. Merry, PLS .....Chief Surveyor, SEWRPC
Glen R. Schaefer, PE, PLS ..... Captain, NOAA Corps (Retired), also Former Geodetic Engineer, Wisconsin Department of Transportation
Phillip C. Evenson .....Special Projects Advisor, SEWRPC

Commission Staff:

Debra A. D'Amico ..... Executive Secretary, SEWRPC
Recording Secretary to Task Force

Guests Present:

None

CALL TO ORDER AND ROLL CALL

Chairman Bauer called the meeting to order at 8:35 a.m. Roll call was taken and a quorum was declared present.

INTRODUCTION

Chairman Bauer welcomed the Task Force Members to the Commission offices, and on behalf of the Commission, thanked the members of the Task Force for their willingness to serve on the Task Force, and to make their experience and knowledge available to the Commission as a public service. Chairman Bauer noted that all of the Task Force members had also been members of the Task Force that had reviewed Memorandum Report No. 206.

Charge to Task Force

Chairman Bauer indicated that the Commission's charge to the Task Force was to conduct a critical review of the preliminary draft of an addendum to SEWRPC Memorandum Report No. 206, *Estimate of Costs of Converting the Foundational Elements of the Land Information and Public Works Management Systems in Southeastern Wisconsin from Legacy to New Datums,* October 2010, and to recommend any needed changes to the findings and recommendations set forth in the addendum.

Mr. Evenson asked what prompted the need for the preparation of the addendum. In reply, Chairman Bauer indicated that the Commission staff was aware of a continuing interest in datum conversion on the part of some County Land Information Officers. This interest existed regardless of the findings and recommendations set forth in Memorandum Report No. 206. As noted in the introduction of the draft addendum, given this continuing interest and the changes in technology that have taken place since the publication of Memorandum Report No. 206, the Commission staff, early in 2015, undertook a reevaluation of the procedures for, and attendant costs of, datum conversion.

PROPOSED REVIEW PROCEDURE

Chairman Bauer indicated that in accordance with long established Commission practice, the procedure proposed to be followed in the conduct of the Task Force Work was to collegially review on a page-by-page basis the preliminary draft of the addendum and attached appendix. He noted that all members of the Task Force had been provided with a copy of the draft of the addendum for review prior to the meeting along with a copy of Memorandum Report No. 206 which the document is intended to revise in part.

Chairman Bauer indicated it was hoped that the Task Force could complete its work in a single meeting. The proceedings of that meeting would be set forth in minutes of the meeting. A copy of those minutes would then be provided to all Task Force members for review, and the Task Force members would be asked to indicate their approval or conditional approval of the minutes or to request a second meeting to act on the minutes. The work of the Task Force would be completed when the minutes of the meeting had been approved.

REVIEW OF PRELIMINARY DRAFT OF ADDENDUM

The Task Force then undertook a page-by-page review of the preliminary draft of the addendum and attached appendix, the draft of the addendum proper being dated July 7, 2015, and the draft of the

attached appendix being dated July 30, 2015. The following comments were raised, discussed, and acted upon in the meeting.

Captain Schaefer distributed an annotated copy of the addendum and appendix on which he had noted suggested changes. He noted that the proposed changes were concerned primarily with the format, or presentation, and not with the technical substance of the document. He indicated that he would address the latter in the course of the meeting. Upon review of the suggested changes, it was the consensus of the Task Force that all of Captain Schaefer's suggested changes as set forth in the annotations made on the copy of the document distributed by Captain Schaefer be included in the final draft of the document.

Chairman Bauer indicated that the Commission staff, in consultation with Mr. Burkholder, had developed what is believed to be two new and unique procedures for the conversion of the legacy horizontal and vertical datums in use within the Region to the new Federal datums. He indicated further that the procedures were possible only because of the high quality of the existing control survey network within the Region. He noted further that the addendum proper, in effect, constituted an introduction to the attached appendix. The details of the proposed procedures and the attendant costs of implementation were set forth in the appendix. He then asked for comments on the first page of the addendum.

Mr. Evenson suggested that the date of the completion of the CORS network within and immediately adjacent to the Region be given in the text. Captain Schaefer indicated that it was not possible to cite a single date as marking the completion of the CORS network because that network was completed in phases. Mr. Merry noted that the entire network became operational in just the past year, although portions of the network became operational at various preceding dates. After some further discussion, it was the consensus of the Task Force that a specific date for the completion of the CORS network within the Region not be added to the text.

Chairman Bauer asked for comments on page 2; there being none, then on page 3 of the addendum proper. Captain Schaefer noted that on page 3 of his annotated copy, he had provided a paragraph providing some additional background information on the creation of the North American Vertical Datum of 1988 by the National Geodetic Survey. Mr. Evenson observed that it would be useful to include this information in the addendum. After some further discussion, it was the consensus of the Task Force that a footnote be prepared by the Commission staff incorporating the background information provided by Captain Schaefer in his annotation.

[Secretary's Note: The following footnote was prepared by the Commission staff for addition to the addendum:

> [3]*Orthometric heights "tagged" as NAVD 88 were based on the original adjustment of NAVD 88 which was published by NGS in 1991. Since 1995 there have been subsequent adjustments of the vertical control network in southern Wisconsin. Therefore, orthometric heights determined by the 1991 adjustment are now labeled as NAVD 88 (1991). Subsequent adjustments in 2004, 2007, and 2012 are labeled as NAVD 88 (2004), NAVD 88 (2007), and NAVD 88 (2012), respectively. The current NGS Data Sheet does not allocate space for the inclusion of vertical adjustment tags. However, the adjustment date can be found in the Data Sheet under text describing the manner in which the various epochs of orthometric heights were determined by NGS.*

The reference for the footnote would be given in the 12th line of the first full paragraph on page 3 after the phrase, "by subsequent vertical adjustments.[3]"]

Chairman Bauer then asked for comments on page 4; there being none; then on page 5 of the addendum. Chairman Bauer noted that the inclusion of the paragraph quoted from Memorandum Report No. 206 was problematic as far as the Commission staff was concerned.[1]

A lengthy discussion then ensued concerning the "pros" and "cons" of including this paragraph. Upon the conclusion of the discussion, it was the consensus of the Task Force to eliminate the paragraph concerned from the text, and furthermore, to strike the paragraph which begins on the bottom of page 5 and carries over to the top of page 6 together with the second full paragraph on page 6, and to substitute the following wording for the last two sentences of the first full paragraph on page 5: "This document is intended to be considered within the context of that report. Since the completion of that report, the Commission has continued to receive specific requests from some County Land Information Officers to reevaluate the procedures for, and the attendant costs of, converting the legacy datums within the Region as presented in

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[1]*The subject paragraph is the first paragraph under the heading: "Summary and Conclusions" on page 13 of Memorandum Report No. 206.*

Memorandum Report No. 206. This addendum presents the findings of that reevaluation in the form of an additional appendix—Appendix C—to Memorandum Report No. 206."

Chairman Bauer then asked for any additional comments on pages 5 and 6; there being none; then on page 7. Mr. Evenson suggested that a reason should be provided as to why the conversion of the vertical datum within the Region should be accomplished for the Region as a whole rather than by subareas as is suggested for the horizontal datum. After some discussion, it was a consensus of the Task Force that the second sentence of the last paragraph on page 7 be revised to read as follows: "The conversion should be carried out for the Region as a whole in order to maintain uniformity across both natural boundaries, such as watershed boundaries, and across civil boundaries, such as municipal and county boundaries."

Chairman Bauer asked for comments on page 8. Mr. Evenson noted that the table on page 8 should be revised to list the counties in alphabetical order.

Chairman Bauer indicated that this completed the review of the addendum proper and asked the Task Force to consider approval of that document as amended by the actions taken at the meeting for publication. The members of the Task Force were unanimous in their approval of the addendum proper as amended for publication.

[Secretary's Note: The meeting was adjourned at 12 noon for lunch and reconvened at 12:30 p.m.]

REVIEW OF PRELIMINARY DRAFT OF APPENDIX C

Chairman Bauer directed the attention of the Task Force to Appendix C. He noted that the Task Force review was critical to ensuring that the detailed procedures proposed for the conversion of the horizontal and vertical datums within the Region were technically sound and that the attendant cost estimates were reasonable.

Chairman Bauer then asked for comments on page 1 of the appendix; and there being none, then on page 2.

In answer to a question by Mr. Evenson, Chairman Bauer indicated that the use by the Commission of a six-section control survey summary diagram dates back to the very beginning of the Commission's

control survey program in the very early 1960s. The six-section size was simply dictated by the paper sheet size available and a scale which would make the diagrams easily readable.

Chairman Bauer asked for comments on page 3. Mr. Merry, referring to the eighth line of the second full paragraph, indicated that the word "precision" used should be changed to "accuracy" as indicated by Captain Schaefer's annotations.

Captain Schaefer called attention to the footnote on page 3 and asked whether the addendum would be published with the appendix. Chairman Bauer indicated that the two documents would indeed be published together. A lengthy discussion then ensued about the protocol to be followed in making field observations as that protocol was listed on pages 3, 4, and 5. The discussion did not, however, lead to any proposed changes in the protocol.

Chairman Bauer then asked for comments on pages 4 and 5. Mr. Burkholder and Captain Schaefer indicated their endorsement of the protocol as listed.

Chairman Bauer then asked for comments on page 6 of the appendix. In answer to a question by Mr. Burkholder, Chairman Bauer indicated that conceptually the procedure developed for the conversion of the horizontal datum, in effect, regards the legacy lengths and interior angles of the quarter sections as measurements to be used in conjunction with field observations to determine in NAD 83 (2011) of a limited number of control stations to compute the coordinates of the remaining stations in the area being considered. He noted that in the procedure, the ground level distances given on the legacy control survey summary diagrams are reduced to grid level using NAD 88 State plane coordinate system combination factors. The computations are then accomplished on that grid level.

In answer to a question by Mr. Evenson, Mr. Merry indicated that the extraction of the data from the legacy diagrams would be done manually. In answer to a further question by Mr. Burkholder, Mr. Merry noted that the weighting strategy proposed to be used quickly identifies any network strain—that is discrepancies—and permits the troublesome measurements to be quickly identified and corrected.

Chairman Bauer then asked for comments on pages 7 and 8. Captain Schaefer suggested that the wording of the first two sentences on the page be changed to read as follows: "Extracting the relevant data from the control survey summary diagrams, as such diagrams are illustrated in Figure 2, permits tables such as Table 1 to be constructed for use in the least squares adjustment."

Chairman Bauer asked for comments on page 9. Captain Schaefer indicated that the figure number cited in the last line of the second full paragraph should be “5” not “4.” He also suggested that the word “typical” be inserted before the phrase “6 square mile area” in the second line of the first full paragraph on the page. Mr. Merry noted that the footnote reference should be assigned to the word “coordinates” in the beginning of the sixth line of the last partial paragraph on the page.

Mr. Evenson suggested that the footnote on page 9 needed revision to read properly. Mr. Merry suggested the following wording: “The NAD 83 state plane coordinate values are defined in meters. For this appendix the metric values were converted to feet using the ratio of 39.37 inches per meter exact to 12 inches per U.S. Survey Foot, which approximates 1 meter equaling 3.280833333 U.S. Survey Feet.”

Chairman Bauer then asked for comments on page 10; there being none, then on pages 11 and 12. Captain Schaefer noted that the coordinates for the center of Section 28 were in error and should be corrected.

Chairman Bauer then asked for comments on page 13. There being none; then on page 14. Captain Schaefer noted that the term “NAVD 88” used in the legend to Figure 6 should be changed to NAVD 88 (2012).

Chairman Bauer then asked for comments on page 15. Captain Schaefer suggested that a section heading be made consistent with the document title given on Figure 7. Captain Schaefer suggested that the class of survey notation be dropped from the accuracy notations under both the horizontal and vertical designations and that, where the horizontal coordinates were not field measured, the accuracy order be indicated as computed as opposed to observed. Chairman Bauer noted that with respect to vertical accuracy, the terms used should be observed and interpolated as appropriate, interpolation referring to the use of the proposed iso-hyposometric map.

Chairman Bauer asked for comments on page 16. Chairman Bauer noted that in the first line of the second full paragraph the number of work elements referred should be “6” not “5.”

Chairman Bauer then asked for comments for page 17. Captain Schaefer noted that in the last sentence of the first full paragraph the table numbers should be changed from “3” to “4,” and from “4” to “5.” He also noted that in the first line of the second paragraph, the number of major work elements should be changed from “3” to “4.”

Chairman Bauer then asked for comments on page 18; there being none, then on page 19. Mr. Evenson suggested that the table on page 19 was unnecessarily detailed and should be simplified by eliminating the columns given for material and hours leaving only the cost column under each County.

Chairman Bauer called for comments on page 20. Mr. Evenson suggested that Table 5 be changed by eliminating line items for vehicle mileage and equipment costs and adding a footnote stating, "Vehicle mileage and equipment costs must be estimated on a job-by-job basis; therefore, no line items are included for these costs in the table."

Conclusion and Adjournment

There being no further questions or comments, Chairman Bauer indicated that this completed the review of the appendix to the addendum proper and asked the Task Force to consider approval of that appendix as amended by the actions taken at the meeting for publication. The members of the Task Force were unanimous with their approval for the appendix as amended for publication.

Chairman Bauer indicated that the Task Force members would receive a preliminary draft of the minutes for review and comment and requested to indicate to the Commission staff their approval or conditional approval of the minutes or request a second meeting to act on the minutes. The work of the Task Force would be completed when the minutes of the meeting had been approved. A final copy of the minutes, as approved by the Task Force, will be published as Appendix D with the addendum.

Chairman Bauer once more thanked the Task Force members for their diligent review of the addendum and its appendix, and for their contribution of their time, knowledge, and experience as a public service to the work of the Commission.

The meeting was adjourned at 2 p.m.

Respectfully submitted,

Debra A. D'Amico
Task Force Recording Secretary

[Secretary's Note: The foregoing minutes were approved by the Task Force by electronic communication ballot, the last ballot being retained on September 3, 2015.]