

HORIZONTAL AND VERTICAL SURVEY CONTROL IN SOUTHEASTERN WISCONSIN

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Special acknowledgement is due Mr. Earl F. Burkholder, Consulting Geodetic Engineer; and Mr. Donald P. Simon, SEWRPC Principal Planning Draftsman, for their contribution to this report.

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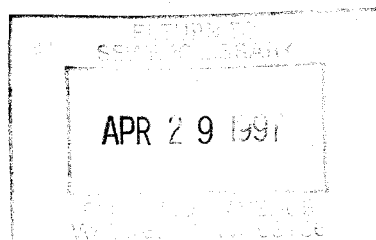
HORIZONTAL AND VERTICAL SURVEY CONTROL
IN SOUTHEASTERN WISCONSIN

Prepared by the
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August 25, 1996

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. The wide extent to which this recommended survey control system has been adopted and applied within the seven-county Region provides tangible evidence that regional planning carried out on a voluntary, cooperative basis can be effective, and that desirable areawide objectives can indeed be attained through the individual but coordinated efforts of the many individual governmental entities operating within the Region.

The importance of the recommended system of survey control itself, and of the potential benefits which will accrue from application of the system, cannot be overemphasized. Application of the recommended system of survey control not only provides a sound, permanent basis for the efficient conduct of land and engineering surveys of all kinds throughout the seven-county Region, but also serves to abate many costly and vexing problems concerning the location and description of real property boundaries that plague landowners, realtors, attorneys, abstractors, assessors, land surveyors, civil engineers, and planners within the Region. Its application, moreover, prepares the way for the eventual modernization of land records within the Region and the creation of a parcel-based, computerized, land information system.

The basic survey data obtained through application of the recommended survey control system are of direct use to land surveyors and civil engineers in private practice and to private utility corporations, as well as to public planning and engineering agencies operating within the Region. In order to make these data more readily available to all potential users, the Commission in 1968 issued SEWRPC Technical Report No. 7, collating all of the survey data which had then been obtained within the Region through application of the system in a single reference volume. That SEWRPC Technical Report No. 7 constituted a useful document was clearly indicated by the fact that the supply of 500 copies of the report published was soon exhausted. Yet an average of almost 500 inquiries per year are received by the Commission relating to the survey data provided in the report. Accordingly, it was decided to republish the report and in 1990 a second edition was issued.

This, the third edition of SEWRPC Technical Report No. 7, collates and presents all of the control survey data obtained to date within the Region through application of the Commission-recommended survey control system. Any errors noted in the original and second editions have been corrected in this third edition. Moreover, since the control survey system has continued to be expanded within the Region, the third edition now contains control survey data for 8,653 U. S. Public Land Survey corners and for 1,867 square miles of area.

The third edition of SEWRPC Technical Report No. 7 also contains a description of provisions made by the Commission to accommodate those who desire to use Commission published horizontal and vertical survey data on the North American Datum of 1983 (91), and on the North American Vertical Datum of 1988, respectively. Two separate studies were conducted by the Commission during 1994 and 1995 and reports prepared in each case that provide efficient computational methods by which conversions from the North American Datum of 1927 and the National Geodetic Vertical Datum of 1929 to the aforereferenced datums can be made at a documented level of accuracy adequate for control survey purposes. Those reports are referenced in Chapter III and summarized in Appendix G of this report.

Although every effort has been made to ensure the accuracy of the data presented in this report, the massive scope of the survey programs involved in the collection of the data and the complexities involved in the collation of the data make it highly probable that some errors remain in the published work. Users of the data are, therefore, requested to bring any errors that may be found through application of the data to the attention of the Commission staff so that, as supplements to this report are issued from time to time, these errors may be corrected.

Respectfully submitted,



Kurt W. Bauer
Executive Director

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Chapter I

INTRODUCTION

In February 1964, the Southeastern Wisconsin Regional Planning Commission published SEWRPC Planning Guide No. 2, entitled Official Mapping Guide.¹ That guide contained a description of a unique system of survey control, which was recommended to governmental agencies operating within Southeastern Wisconsin as a framework for the compilation of large-scale topographic and cadastral base maps, and as a basis for the conduct of land and engineering surveys within the seven-county Southeastern Wisconsin Region.

This recommended system of survey control has since been widely adopted and applied within the Region. As of September 1996, the counties and municipalities shown on Map 1, as well as the Regional Planning Commission itself, have adopted and applied the recommended survey control system within the Region as an integral part of extensive, large-scale, floodland, transportation corridor, and general municipal base mapping programs. In addition, the Wisconsin Department of Transportation has utilized the recommended system of survey control as a basis for highway corridor study efforts within southeastern Wisconsin; the Milwaukee Metropolitan Sewerage District has utilized the system as a basis for flood control and stormwater drainage management efforts within the District and its contract service areas; and the Wisconsin Department of Natural Resources has utilized the system as a basis for flood hazard mapping within the Region. Consequently, as of September 1, 1996, the recommended survey control system has been

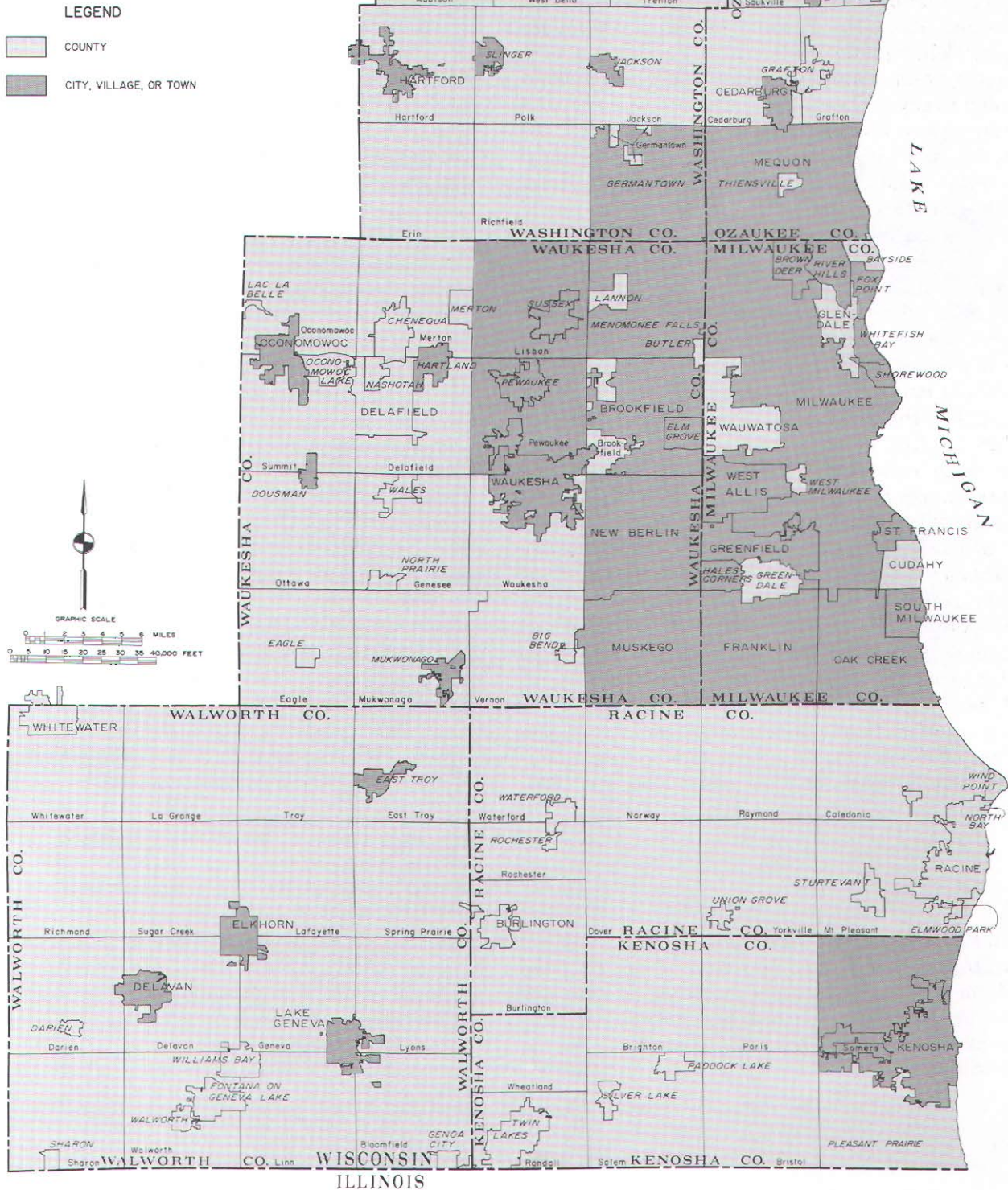
extended throughout 1,867 square miles, or 69 percent, of the 2,689-square-mile Region; and 8,653 U. S. Public Land Survey section and quarter-section corners, or 75 percent of all such corners in the Region, have been relocated, monumented, and positioned accurately and precisely on the State Plane Coordinate System. In addition, as of September 1, 1996, work was underway which will extend the recommended survey control system into an additional 65 square miles of area within the Region and which will result in the relocation, monumentation, and coordination of an additional 249 U. S. Public Land Survey section and quarter-section corners. Thus, the recommended survey control system will shortly have been extended over a total area of 1,932 square miles, or about 72 percent of the 2,689-square-mile Region, and 8,902 U. S. Public Land Survey corners, or about 76 percent of all such corners in the Region, will have been relocated, monumented, and positioned on the State Plane Coordinate System (see Map 2, Figure 1, and Table 1).

The Commission recommended survey control system is of use to attorneys, abstractors, appraisers, land surveyors, civil engineers, and planners in private practice, and to private utility corporations; as well as to governmental agencies, such as county, town, city, and village assessment, planning, engineering, and land information departments; county and state transportation departments; sewerage, airport, harbor, and park and planning commissions; and soil and water conservation districts. It was, therefore, believed desirable to collate all of the survey data obtained to date through application of the Commission recommended system and to publish these data in a single report for ready use by interested public and private interests and agencies. This report has been designed so that it can be readily amended; and as the survey control system is further extended within the Region, supplements providing data on the extensions are intended by the Commission to be issued in a form which can be readily incorporated into this report.

¹*SEWRPC Planning Guide No. 2, (Second Edition) Official Mapping Guide, was revised and reissued in June 1996. The basic concepts and principles set forth in the second edition of this guide have remained unchanged from those set forth in the first edition.*

Map 1

**MUNICIPALITIES PARTICIPATING
IN LARGE-SCALE TOPOGRAPHIC
MAPPING AND RELATED CONTROL
SURVEY PROGRAMS IN THE
REGION: SEPTEMBER 1996**



The large-scale topographic and cadastral base mapping and related control survey system recommended by the Commission has, as of January 1996, been implemented within the Region by 7 counties, 21 cities, 19 villages, and 3 towns, as well as by the Regional Planning Commission itself. In addition, the system has been utilized by the Wisconsin Department of Transportation, the Wisconsin Department of Natural Resources, and the Milwaukee Metropolitan Sewerage District, in highway corridor drainage and flood control planning and engineering, and in flood hazard mapping programs.

Source: SEWRPC.

**LARGE-SCALE TOPOGRAPHIC MAPPING
AND RELOCATION, MONUMENTATION,
AND COORDINATION OF U. S. PUBLIC
LAND SURVEY CORNERS
SEPTEMBER 1, 1996**

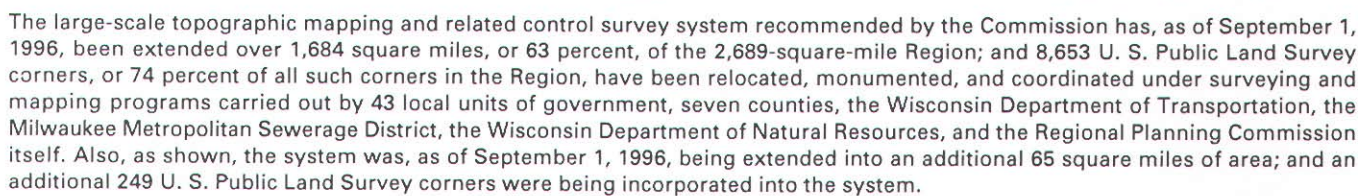
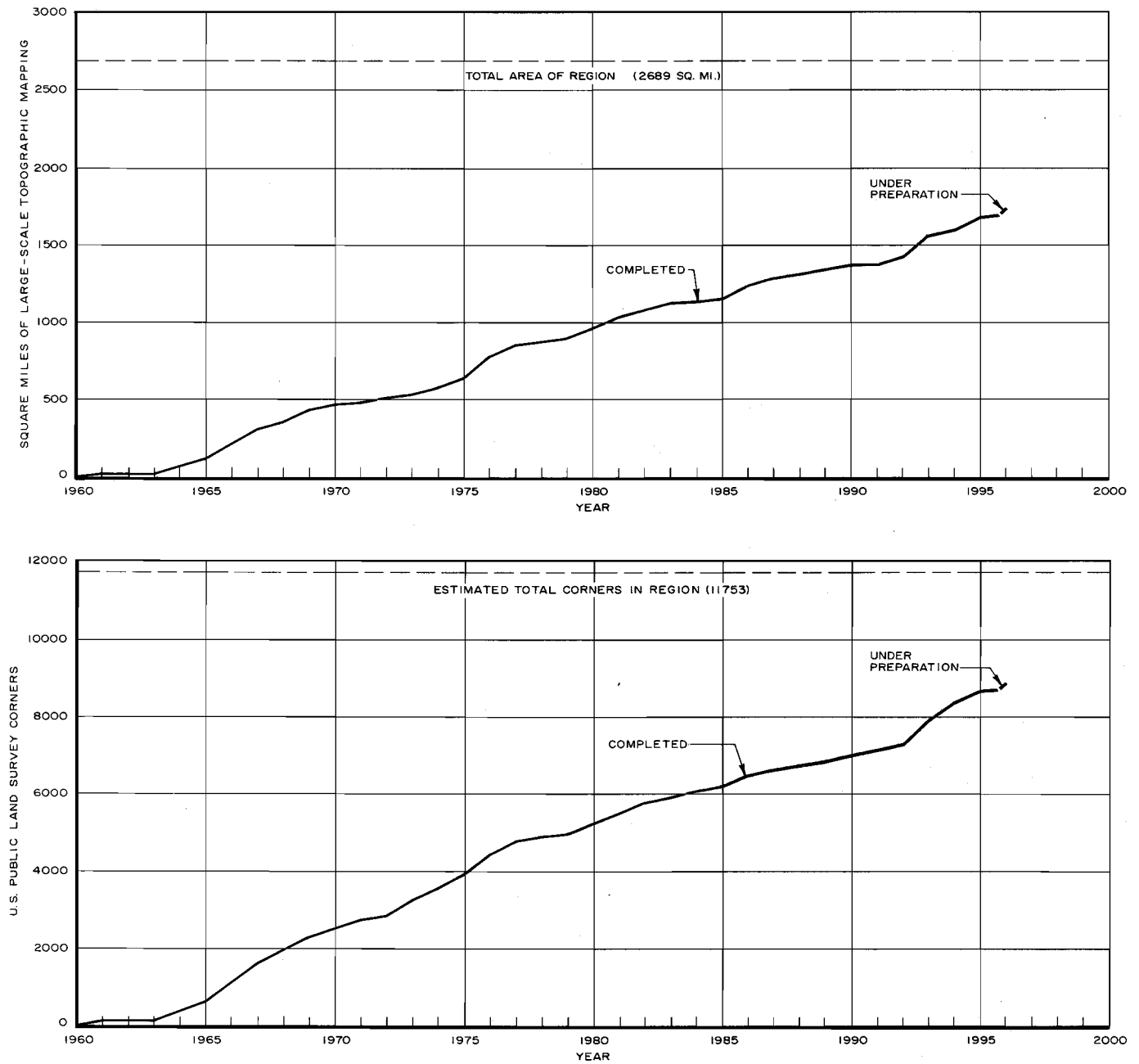


Figure 1

STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND U. S. PUBLIC LAND SURVEY SECTION AND QUARTER-SECTION CORNER RELOCATION, MONUMENTATION, AND COORDINATION IN THE REGION: SEPTEMBER 1, 1996



Source: SEWRPC.

Table 1

**LARGE-SCALE MAPPING AND RELOCATION, MONUMENTATION, AND
COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS: SEPTEMBER 1, 1996**

County	Total Area (square miles)	Area (square miles) of Large-Scale Topographic Mapping Completed							
		Wisconsin Department of Transportation	SEWRPC	County	Milwaukee Metropolitan Sewerage District	Local ^a	Multi- Agency	Total	Percent
Kenosha	278	--	27.75	236.25	--	14.00	--	278.00	100.00
Milwaukee	242	--	11.00	102.00	49.50	77.00	2.50	242.00	100.00
Ozaukee	234	26.75	24.25	43.25	--	17.50	--	111.75	47.76
Racine	340	--	25.50	314.50	--	--	--	340.00	100.00
Walworth	578	30.25	--	61.75	--	24.00	--	116.00	20.07
Washington	436	1.50	22.75	--	--	89.25	9.00	122.50	28.10
Waukesha	581	1.25	78.75	248.50	--	145.25	--	473.75	81.54
Region	2,689	59.75	190.00	1,006.25	49.50	367.00	11.50	1,684.00	62.63

NOTE: Includes only those areas of the Region for which large-scale topographic maps have been prepared and throughout which U. S. Public Land Survey corners have been relocated, monumented, and coordinated utilizing SEWRPC-recommended procedures. Area shown indicates original large-scale topographic mapping programs. Of the 59.75 square miles originally mapped under WisDOT programs, 15.50 square miles have been updated by other agencies. Of the 190.00 square miles originally mapped under SEWRPC programs, 84.75 square miles have been updated by other agencies. Of the 1,006.25 square miles originally mapped under county programs, 2.00 square miles have been updated by other agencies. Of the 367.00 square miles originally mapped under local programs, 174.25 square miles have been updated by other agencies.

^aIncludes 21 cities, 19 villages, and three towns.

County	Estimated Total Corners ^a	Number of U. S. Public Land Survey Corners Which Have Been Relocated, Monumented, and Coordinated							
		Wisconsin Department of Transportation	SEWRPC	County	Milwaukee Metropolitan Sewerage District	Local ^b	Multi- Agency	Total	Percent
Kenosha	1,203	58	168	914	--	63	--	1,203	100.00
Milwaukee	1,065	72	184	132	159	492	26	1,065	100.00
Ozaukee	1,064	143	179	146	3	110	--	581	54.61
Racine	1,478	--	172	1,306	--	--	--	1,478	100.00
Walworth	2,503	296	--	420	--	121	11	848	33.88
Washington	1,905	150	164	539	--	428	51	1,332	69.92
Waukesha	2,535	78	463	1,009	--	596	--	2,146	84.65
Region	11,753	797	1,330	4,466	162	1,810	88	8,653 ^c	73.62

^aThe estimated number of corners for each county was determined by assigning standard and closing corners to the respective county concerned and by alternately assigning common corners to the two or more counties concerned.

^bIncludes 21 cities, 19 villages, and three towns.

^cBecause of the need to set witness corners, these 8,653 U. S. Public Land Survey corners, including the centers of the sections, are marked by 8,805 monuments.

Source: SEWRPC.

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Chapter II

BASIC CONCEPTS

INTRODUCTION

Southeastern Wisconsin is one of the large urban regions of the United States. The seven counties comprising the Region—Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha—have a combined area of about 2,689 square miles, or about 5 percent of the total area of the State. As of January 1, 1996, however, these counties had a resident population of about 1.88 million persons, or about 37 percent of the total population of the State. These seven counties provided about 1.11 million jobs, or about 38 percent of the total jobs in the State, and contain real property worth about \$81 billion as measured in equalized valuation, or about 40 percent of all of the tangible wealth of the State. There were 147 cities, villages, and towns within the seven-county Region, which increasingly functions as a single socio-economic unit.

The Region is a dynamic one marked by a rapidly changing land use pattern and attendant need for changes in the supporting highway, transit, sewerage, water supply, stormwater drainage, park and open space, and other public facilities and services. Much of the new urban development within the Region is occurring in a highly scattered diffused pattern at medium and low population densities, with a concomitant need to coordinate land use and supporting public works facility development over large areas of the Region.

The type of development and redevelopment occurring within the Region has generated, and may be expected to continue to generate, 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; the transfer of title to land and improvements; and the assessment and appraisal of real property. The proper planning and design of urban and rural land development projects and of the public works facilities which support such development projects require constant attention to two factors: the land itself, with its topography and other physical characteristics, and the boundaries of real property ownership. Full information concerning these two factors is essential if land is to be properly

converted to urban use and if urban public works to serve such converted land are to be soundly conceived and effectively executed. The need to provide this information, in turn, generates a basic need for survey control within the Region, both as a basis for the production of adequate topographic and cadastral maps and as a basis for the proper execution of engineering and land surveys which can be fully coordinated on an areawide basis.

Increasingly, topographic and cadastral maps within the Region are being produced in computer reproducible and manipulatable digital form. Subsequently, these digital maps form the basis for the development within the Region of costly county and local automated, parcel-based, land information systems. Therefore, the survey control and related map projections on which the topographic and cadastral maps are constructed have become more important than ever. The technical adequacy and reliability of the automated, parcel based, land information systems being developed within the Region depends in large part upon the control survey system which provides the foundation of the automated base maps involved. That control survey system must combine horizontal and vertical positioning into a single integrated digital data base. The control survey system and the related topographic and cadastral maps must be carefully designed to support a wide range of user needs without discriminating against past practice.

SURVEY CONTROL

The establishment of a basic system of survey control is essential to any accurate mapping effort. This control consists of a framework of points whose horizontal and vertical positions on the surface of the earth have been accurately established by field surveys and to which the map details are adjusted and against which such details may be checked. The survey control system used should be carefully designed to fit the specific needs of the particular mapping project being undertaken.

It is essential that this survey control system meet two basic design criteria if the maps based upon it are to be effective planning and engineering tools. First, it must permit the accurate correlation of

real property boundary line information with topographic and topographically related data. Second, it must be permanently monumented on the ground so that lines on the maps may be accurately reproduced in the field when planned land use developments and supporting public works projects reach the construction stage. That is to say, for municipal planning and engineering purposes the survey control system must be such as to provide not only finished maps which accurately reflect both topographic and cadastral field conditions, but maps having lines which can be readily and accurately reproduced upon the ground as well.

The establishment of a basic system of survey control is essential not only to accurate mapping efforts but also to the proper conduct of engineering and land surveys. A survey control system which meets basic large-scale map requirements should also meet basic engineering survey requirements, since both requirements are based upon principles derived from application of the science of measurement. Real property boundaries, however, are a creation of the law; and any system of survey control which is to be useful to a land surveyor must be properly founded in principles derived from application of real property law as well as from application of the science of measurement.

U. S. Public Land Survey System

Real property law in Wisconsin has its origins in England, where the problem of locating real property was based upon the use of monuments and adjoining. Transfers of title to real property had to be made in writing; and where the written legal description of the property involved was capable of more than one interpretation, the courts gradually evolved a set of precedents which eventually formed the common law of boundaries. This body of law carried over, almost intact, into colonial America and eventually into Wisconsin. In the first public land survey act¹ and in all subsequent

acts, the Congress of the United States retained the best features of the English common law of boundaries virtually intact, superimposing upon that body of law systematic land survey procedures. Under the public land survey acts and subsequent court decisions and administrative decrees, the public domain was surveyed, monumented, and platted before patents were issued; legal descriptions were by reference to a plat; lines actually run and marked on the ground controlled boundaries; adjoining were respected; and the body of law in effect at the moment a deed was issued was controlling and made forever a part of the deed. Unlike scientific and engineering surveys which are made for the collection of information and which can be amended to meet improved standards or changing conditions, the original government land survey in an area cannot be ignored, repudiated, altered, or corrected so long as it controls rights vested in lands affected.

The U. S. Public Land Survey System is one of the finest systems ever devised for describing and marking land. It provides a basis for a clear, unambiguous title to land, together with the physical means by which the description incorporated in that title can be related to the land described. The system is ingenious, being simple and easy to comprehend and administer, and without it the nation would have been unquestionably poorer.

The "rectangular" land survey system has one serious flaw. Its use requires the perpetuation of the monuments set in the original government public land surveys. The position of these monuments on the surface of the earth, however, were not established precisely in the conduct of those surveys. Yet, the proven location of the original corners remains essential to the unambiguous definitions of all real property boundary lines controlled by those corners. Subsequent surveys are therefore required to relate the original public land survey corner locations to a scientifically established map projection and attendant geodetic survey control network. This makes the preservation of the monuments marking the U. S. Public Land Survey corners extremely important. Time and the activities of man, however, have served to destroy many of these monuments within the Region; and many more such monuments are in danger of being destroyed in the years ahead under the impact of further land use development and redevelopment within the Region.

As good a survey system as the U. S. Public Land Survey System is, its continued value depends upon

¹The first ordinance for the disposal of the public lands was adopted by the United States Congress on May 20, 1785, and laid down principles of action in operation to the present time. The act grew out of recommendations made by a four-man committee headed by, later to be President of the United States, Thomas Jefferson. The first public land surveys under the rectangular system were executed in eastern Ohio in 1786, and have since been extended to well over 2.8 million square miles of public land area. Thus, a vast monumented cadastral net has been created which provides a simple and definite form of land identification.

the perpetuation of its monuments. Without such perpetuation, the System degenerates into little more than a paper record, beyond the power of the surveyor to transform into a pattern of points and lines marked on the ground without the aid of court decisions prescribing how conflicting real property boundary descriptions and survey discrepancies are to be construed and interpreted. A great need, therefore, exists within the Region, not only to protect and perpetuate the existing U. S. Public Land Survey corners, but to remonument obliterated corners, to relocate and monument lost corners, and to relate all of these corners to a scientifically sound map projection and geodetic survey control network so that these corners can be readily used in large-scale topographic, as well as cadastral mapping efforts, and in the conduct of engineering and land surveys on a day-to-day basis in an efficient manner.

State Plane Coordinate System

A strictly scientific survey control system designed to provide the basic control for all Federal topographic and hydrographic mapping operations exists separately from the U. S. Public Land Survey System in the triangulation and traverse stations established by the U. S. Coast and Geodetic Survey (USC and GS).² The monumented triangulation and traverse stations established by this agency comprise a nationwide network connecting thousands of monumented points whose positions on the surface of the earth in terms of latitude and longitude are known with such accuracy and precision that any station, if its monument be destroyed, can be restored within very close tolerances to its original position by surveys initiated from other triangulation or traverse stations in the national geodetic control net. Such restoration by geodetic survey methods, however, requires a degree of training and experience, and

the use of methods and survey equipment not historically available to or utilized by municipal engineers and land surveyors.

In order to make the national geodetic survey control network more readily available for local use, the USC and GS in 1933 devised the State Plane Coordinate System. In Southeastern Wisconsin the state plane coordinate grid is based upon the Lambert conformal conic projection and is officially referred to as the Wisconsin State Plane Coordinate System, South Zone. This system transforms the spherical coordinates—that is, the latitudes and longitudes—of the stations established in the national geodetic survey into rectangular coordinates on a plane surface mathematically related to the spheroid on which the spherical coordinates of latitude and longitude have been determined. The State Plane Coordinate System is devised so that the effect of the distortion inherent in the projection of the curved surface of the earth's spheroid onto the plane used for the rectangular grid is always less than 1 part in 10,000.

The State Plane Coordinate System thus permits local engineers and surveyors to connect surveys by simple, well-established plane surveying methods to the extensive network of precisely located triangulation and traverse stations of the national geodetic survey. If the location of a point is defined by stating X and Y coordinates on the state plane coordinate grid, then the location of that point is also defined by its corresponding latitude and longitude on the spheroid of reference. If either position is known, the other can be defined by mathematical computation. So, too, with the lengths and bearings of lines. Thus, the precise location on the earth's surface of all survey stations and landmarks established in local engineering and land surveys can be accurately described by stating their coordinates referred to the common origin of the state plane coordinate grid. Once plane coordinates are established for any landmark, these coordinates may become the best available evidence of the position of the original landmark, should the physical monument be lost, and thus afford a ready and accurate means for its restoration.

Computations using the grid data are simple, being made with the ordinary formulas of plane surveying; yet through the State Plane Coordinate System, the exact correlation between grid values and geodetic values is known. The mutual relationships which make it practicable to pass with mathematical precision from a spherical to a plane coordinate system make it also practicable to utilize

²The U. S. Coast and Geodetic Survey, established in 1807, had been the Federal agency responsible for the extension of geodetic control surveys, first along the coast lines, and later throughout the territory of the United States. Over the years, the work of this agency became a standard of excellence in the area of geodetic control surveys. A reorganization of the U. S. Department of Commerce resulted, unfortunately, in a change in the name of this once well-known agency, so that Federal geodetic survey responsibilities are now assigned to an agency known as the National Geodetic Survey (NGS) of the National Oceanic and Atmospheric Administration of the U. S. Department of Commerce.

the precise scientific data of the national geodetic control survey net for the referencing and control of local engineering and land surveys. A limitation on such use is, however, imposed by the relatively wide-spaced locations of the basic triangulation and traverse stations of the national geodetic survey and the difficulties often encountered in the recovery and use of these stations. This limitation, which was once severe, has been mitigated, but not eliminated, by the development of global positioning system technology.

LEGISLATION

The State Legislature has recognized through formal legislative action both the importance of perpetuating the U. S. Public Land Survey System and the importance of promoting the use of the State Plane Coordinate System. Some of the legislative action in this respect is of long standing, while other action is of quite recent origin.

Historically, the Wisconsin Statutes have assigned to the county surveyor and to the city and village engineers the responsibility for perpetuating the U. S. Public Land Survey System.³ Under Section 59.63 of the 1993-1994 Wisconsin Statutes, perpetuation of the section corners and lines in an area was to be undertaken by the county surveyor in response to a formal application by a majority of all of the resident landowners in the area.

Historically, the Statutes provided that the application was to be made to the town board, but more recently the Statutes provide that the application be made to the circuit judge for the county in which the land affected is situated. The circuit judge then holds a hearing on the application; and if subsequent to the hearing the proposed work is approved by the judge, the county clerk notifies the county surveyor to proceed to make the required surveys

³Pursuant to Section 59.635(7) of the 1993-1994 Wisconsin Statutes, registered land surveyors employed by the Wisconsin Department of Transportation or county highway department may act, incidental to their employment, in the capacity of the county surveyor or city or village engineers with respect to the preservation and perpetuation of landmarks, witness monuments, and corner posts located along state trunk, county trunk, and town highways. Pursuant to Sections 59.60(1)(b) and (2); and 59.635(2)(a), (b), and (3), the Executive Director of the Regional Planning Commission acts in the capacity of County Surveyor for Milwaukee County.

and locations. The cost of the work is apportioned by the county clerk among the parcels of land involved on the basis of area, and the funds to cover the cost are collected in the same manner as other real property taxes.

The Statutes also clearly prohibit the removal or destruction of any monument marking a corner of the U. S. Public Land Survey System or the covering of such a monument so as to make it inaccessible for use without first providing for the perpetuation of the corner location concerned. Under the Statutes, the party wishing to move or cover a monument marking a U. S. Public Land Survey corner must serve written notice upon the county surveyor of the county, and upon the city or village engineers of the cities and villages in which the monument may be located. The county surveyor or the city or village engineer then undertakes the survey work necessary to perpetuate the corner location concerned.⁴ The cost of the work undertaken in response to the notice is presumably borne by the county, city, or village in which the landmark is located. Penalties are provided, in the form of a fine of up to \$1,000 and imprisonment of up to one year, for the removal or destruction of any monument marking a corner of the U. S. Public Land Survey System. In addition, a person who removes, destroys, or covers any such monument is liable for the payment of damages to the county, city, or village in which the monument is located, with the amount of the damages being equal to the additional expenses incurred because of the removal, destruction, or covering.

⁴Prior to the Laws of 1969, the State Statutes provided that the work required to perpetuate the corner locations could be done by the county surveyor or by the city or village engineer. Chapter 499, Section 9, Laws of 1969, changed the Statutes to read that the necessary work shall be performed either by the county surveyor himself, or by a deputy, or by the city or village engineer. In addition, the Statutes were amended to require that the engineer file a true and correct copy of the survey notes documenting the work with the county surveyor. This legislative history has been construed to indicate that the city and village engineers are no longer authorized to make independent surveys under Section 59.635(2) of the 1993-1994 Wisconsin Statutes, whereas the engineers had such powers prior to 1969. The engineers apparently must now act under the supervising authority of the county surveyor in this area, the engineers serving as the agents of the county surveyor in the matter of corner perpetuation.

It should be noted that the older provisions of the Statutes referred to above provide for an ad hoc approach to the perpetuation of the U. S. Public Land Survey System in that action on needed perpetuation work was initiated either on the petition of affected landowners or on the notice by a party who wishes to move or cover a survey monument. Section 59.635(8) of the 1993-1994 Wisconsin Statutes, more recently enacted, provides a more systematic means for the perpetuation of the U. S. Public Land Survey System. Under this provision of the Statutes, county boards may authorize the county surveyor to establish or reestablish and reference each year at least 5 percent of all the U. S. Public Land Survey corners originally established in the county so that within 20 years or less all such corners would be perpetuated. The cost of such work is to be paid out of the county road and bridge fund or other county fund should the county board so direct. As of January 1, 1991, the County Boards of all seven counties within the Southeastern Wisconsin Region have, in effect, authorized their county surveyors to systematically establish or reestablish and reference the U. S. Public Land Survey corners within each county, and in so doing implement the system of survey control recommended in SEWRPC Planning Guide No. 2, Official Mapping Guide. These important efforts by the counties to perpetuate the U. S. Public Land Survey System within the Region have been undertaken in accordance with land records modernization plans adopted by each county board.⁵

The State Legislature has also recognized the importance of the State Plane Coordinate System. Section 236.18 of the 1993-1994 Wisconsin Statutes, entitled "Wisconsin Coordinate System," describes the State Plane Coordinate System as it applies to the State of Wisconsin, and makes the use of this system as a supplement to the U. S. Public Land Survey System permissive. Section 59.61 of the 1993-1994 Wisconsin Statutes, entitled "How Bearings Expressed in Surveys" specifically provides that in all surveys bearings shall be expressed with reference to, among four other options, the Wisconsin Coordinate System.

CONCLUSION

From the foregoing brief discussion of the U. S. Public Land Survey and State Plane Coordinate Systems, it is apparent that two essentially unrelated survey control systems have been established in the Southeastern Wisconsin Region by the federal government. One of these—the U. S. Public Land Survey System—is founded in the legal principles of real property description and location and was designed primarily to provide a basis for the accurate location and conveyance of ownership rights in land. The other—the State Plane Coordinate System—is founded in the science of geodesy and was designed primarily to provide a basis for high-precision mapping operations and for the conduct of scientific and engineering surveys over large areas of the earth's surface. Both systems have inherent limitations for municipal planning and engineering use. The survey control system recommended by the Commission combines these two separate survey systems into one integrated system ideally suited for municipal planning and engineering use, for the preparation of large-scale topographic and cadastral maps, and for the creation of technically sound automated, parcel-based, land information systems.

⁵See: SEWRPC Community Assistance Planning Report No. 139, A Land Information System Plan for Walworth County, April 1992; SEWRPC Community Assistance Planning Report No. 177, Feasibility Study for a Milwaukee County Automated Mapping and Land Information System, October 1989; SEWRPC Community Assistance Planning Report No. 184, A Land Information System Plan for Washington County, March 1992; SEWRPC Community Assistance Planning Report No. 185, A Plan for the Creation of an Automated Mapping and Parcel-Based Land Information System for Kenosha County, August 1990; SEWRPC Community Assistance Planning Report No. 193, A Land Information System Plan for Waukesha County, April 1991; and SEWRPC Community Assistance Planning Report No. 194, A Land Information System Plan for Racine County, August 1991.

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Chapter III

RECOMMENDED SYSTEM OF SURVEY CONTROL

INTRODUCTION

A unique system of survey control based upon both the U. S. Public Land Survey System and the national geodetic control survey network has been proposed and promulgated by the Regional Planning Commission as a practical basis for the compilation of large-scale topographic and cadastral maps within the Region and as a basis for the conduct of engineering and land surveys. The establishment of such a control system requires the relocation and monumentation of all U. S. Public Land Survey section and quarter-section corners, including the centers of sections, within the area to be mapped or surveyed, and the utilization of these corners as stations in third-order, class I traverse and second-order, class II level nets (see Appendix E), both nets being tied to the national geodetic control survey networks. It is essential that the control surveys meet at least these orders of accuracy if the resulting control nets are to have permanent utility in subsequent land and public works engineering survey work. Changes in technology since the integrated control survey system was first proposed by the Commission in 1964—including importantly the introduction of global positioning system technology—have reduced the cost of both horizontal and vertical control surveys and permit higher orders of accuracy to be achieved at reasonable costs. The accuracies provided by the Commission recommended specifications, however, are adequate for large-scale topographic and cadastral mapping, land surveying, and public works engineering purposes, as well as for the creation of automated, parcel-based land information systems. The horizontal control network establishes 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 themselves; while the level network establishes reliable elevations above National Geodetic Vertical Datum of 1929 (NGVD) of the monuments marking the U. S. Public Land Survey corners and of certain accessories thereto.

ADVANTAGES OF THE RECOMMENDED SYSTEM

Such a system of control has the following important advantages:

1. It provides a consistent and accurate system of control for real property boundary line mapping as well as for topographic mapping. Since the boundaries of the original government land subdivision form the basis for all subsequent property divisions and boundaries within the Region, the accurate reestablishment of the quarter-section lines and corners permits, within the required limits of accuracy and precision, the compilation of property boundary line maps, as well as the compilation, by the usual photogrammetric methods, of topographic maps. Moreover, these property boundary line maps can then be readily and accurately updated and extended into newly developing areas, since all new land subdivision plats must, by law, be tied to corners established in the U. S. Public Land Survey, and since the accuracy of these plats can be readily controlled by local subdivision regulations.¹
2. It provides a common system of control for both topographic and real property boundary line (cadastral) maps. By relocating the U. S. Public Land Survey corners and accurately placing them on the State Plane Coordinate System, it becomes at once possible to prevent the future loss of these corners and to accurately correlate property boundary line information with topographic details supplied by aerial mapping. This placing of property boundary and topographic data on a common datum is essential to sound mapping for municipal planning and engineering purposes; yet such a common system of survey control has been rarely used in the past. The attainment of such a common system has been an objective of the Commission for over 30 years. The establishment of state plane coordinates

¹See *SEWRPC Planning Guide No. 1, Land Development Guide*, pages 51-52 and 72-73, for provisions recommended to be included in a model local subdivision control ordinance relating to survey accuracy and the use of the State Plane Coordinate System in the preparation of certified survey maps and land subdivision plats.

for the U. S. Public Land Survey corners permits the transfer of details supplied by aerial mapping, including hypsometry, to property boundary line maps by simple overlay methods. Great savings in office research time are made possible during the planning and design phases of municipal public works projects by having all available information—topography, property boundaries, survey control—accurately correlated on one map. Moreover, such complete and correlated information and control make possible the consideration and analysis of many alternate routes for such public works facilities as drainage and flood control works, trunk sewers, water transmission lines, and major trafficways, and of many alternative solutions to drainage, sewerage, water supply, and transportation problems.

3. It provides an extremely practical and fully integrated horizontal and vertical control network readily usable by both private and public surveyors and engineers for all subsequent survey work within the urban area. The control system outlined places a monumented, recoverable control station of known position on both the U. S. Public Land Survey and State Plane Coordinate Systems and provides a known elevation, at half-mile intervals throughout the area covered. This monumented control net not only expedites such engineering surveys as are made almost daily, year in and year out, by public works agencies for planning, design, and construction layout purposes, but also correlates and coordinates all of the survey work throughout the entire area. In this regard, the control system outlined is particularly valuable in providing a common system of control for the precise location and mapping of underground utilities, both public and private.
4. For the first time, it 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. It thus provides the basis for the ultimate use of state plane coordinates in boundary descriptions, and the eventual creation of a modern system of automated, parcel-based, land information system. The fact that the control survey system utilized requires the permanent monumentation of U. S. Public

Land Survey corners does much in itself to stabilize real property boundaries, and makes the control net of great value to private land surveyors. Indeed, the proposed control net provides the first meaningful system of survey control available to the land surveyor.

In the past, property corners in many urban areas were not adequately monumented and, therefore, readily susceptible to loss. Points of beginning for legal descriptions were altogether too often dependent upon unmonumented corners, or upon street and road intersections, that could not be precisely relocated. The accurate retracement of property boundaries under such conditions is extremely difficult and expensive, and the accurate mapping of such boundaries by public agencies is nearly impossible. Moreover, the uncertainties of title and accompanying litigation resulting from such conditions become more and more unsatisfactory as urbanization intensifies and land values increase. By relocating and adequately monumenting the U. S. Public Land Survey corners and then accurately and precisely placing these corners on the State Plane Coordinate System, many of these difficulties can be eliminated. By utilizing this control, local land surveyors can, without changing their methods of operation or incurring any additional expense, "automatically" tie all of their surveys to the State Plane Coordinate System and thereby to the national geodetic survey; and all bearings used in land surveys, plats, and legal description will be directly referenced to grid north, and thereby to geodetic north.

If the use of the State Plane Coordinate System is to be encouraged, it is essential that the system be made practically available through the Commission recommended control survey system to local land surveyors. While the State Plane Coordinate System was devised by the USC and GS in the early 1930s, it was not recognized in Wisconsin law until 1963. Historically, it was extremely rare for land surveyors and municipal engineers—and even for State highway engineers—who were generally unfamiliar with both the system and the methods necessary to carry geodetic control down to the property or facility being surveyed to utilize the State Plane Coordinate System. By making state plane coordinates readily available to the land

surveyor and municipal engineer through the U. S. Public Land Survey System, which the land surveyor and municipal engineer understands and employs constantly, the use of the State Plane Coordinate System has been practically achieved within the Region through the Commission recommended control survey system.

It should be stressed that use of the Commission recommended control survey system and attendant state plane coordinates does not come at the expense of adequate monumentation, perpetuation, or recordation of the U. S. Public Land Survey corners. Instead, the system is used to identify and document in perpetuity the remonumented location of the U. S. Public Land Survey corners and accessories to these corners while, at the same time making the advantages of the State Plane Coordinate System available for use in the resolution of land and public works engineering survey problems. Use of the recommended system does not supplant the U. S. Public Land Survey System, but serves to revitalize that system, making it an even better basis for land surveying and cadastral mapping, as well as for topographic mapping and engineering surveying.

5. It permits lines drawn on attendant large-scale maps—whether these lines represent the limits of land to be reserved for future public use, the limits of land to be taken for immediate public use, the limits of districts to which public land use regulations are to be applied, or the location and alignment of proposed public works projects—to be accurately and precisely reproduced upon the ground at the time of plan implementation or facility construction.
6. It is readily adaptable to newer surveying techniques and methodologies, such as the electronic collection and storage of digital information and the integration of horizontal and vertical control into a combined three dimensional data base. The system is also highly cost effective compared to other urban survey control systems.

The recommended system of survey control becomes particularly cost effective when carried out as an integral part of a photogrammetric

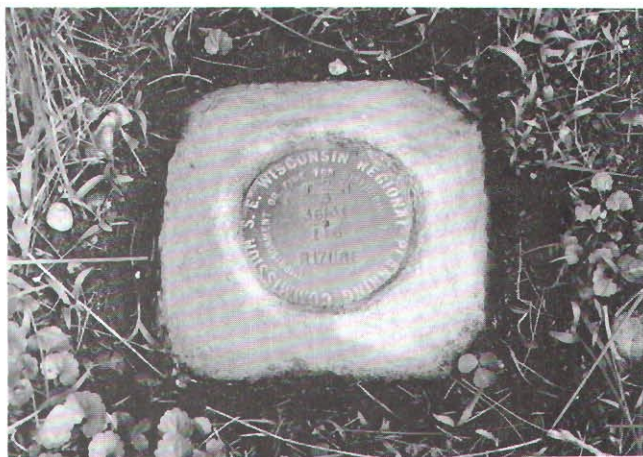
mapping program. When it is realized that the cost of control surveys executed in the usual manner for aerial topographic mapping projects can account for one-quarter to one-third of the total cost of the finished maps, and when it is further realized that this control is largely unrecoverable and unusable by local engineers and surveyors, the real economy of utilizing a control system such as recommended by the Regional Planning Commission becomes apparent. By allocating to the control survey work a relatively small additional amount of the total resources that might be available for mapping, far more effective and useful finished maps can be obtained, and a valuable and permanently useful system of survey control can be concurrently provided. The only significant increases in costs actually assignable to the control system proposed are relatively small and are solely those incurred for the relocation and monumentation of the U. S. Public Land Survey corners and for the small amount of additional survey control work required to coordinate these corners. Experience indicates that this amounts to approximately 20 percent of the total cost of an urban mapping project, a very small increase in the total cost when weighed against the benefits to be derived. Where the recommended control network is in place, the cost of ground control for mapping is greatly reduced or entirely eliminated.

TECHNICAL PROCEDURES AND REQUIREMENTS

As already noted, the proposed survey control system has been, to date, widely utilized within the Region as a basis for the preparation of large-scale topographic and cadastral maps by the Regional Planning Commission; the Wisconsin Department of Transportation; the Milwaukee Metropolitan Sewerage District; the Wisconsin Department of Natural Resources; Kenosha, Milwaukee, Ozaukee, Racine, and Waukesha Counties; and various cities, villages, and towns. Virtually identical specifications have been prepared by the Regional Planning Commission to govern the work at the request of the state, areawide, county, and local units and agencies of government undertaking the work. Separate specifications are provided for the preparation of the topographic maps in both traditional hard copy form and in digital form. These specifications are reproduced in Appendix A. They require that finished, photogrammetrically compiled topographic maps be furnished, to National Map

Figure 2

TYPICAL MONUMENT USED TO MARK U. S. PUBLIC LAND SURVEY CORNER



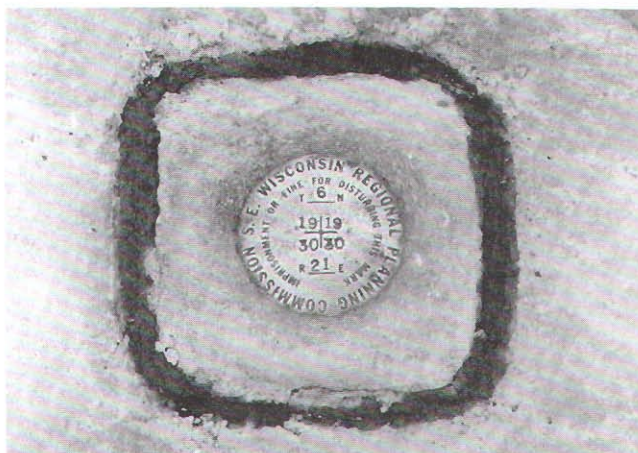
This photograph shows a survey monument of the type referenced in this report, as installed in the field to mark a U. S. Public Land Survey corner. Where such corners fall in fields or other open areas, the monuments are set with the top of the monument at or near the surrounding surface of the ground and are referenced to at least four witness marks.

Source: SEWRPC.

Accuracy Standards,² at a scale of 1 inch equals 100 feet, with a vertical contour interval of two feet, or in some cases, at a scale of 1 inch equals 200 feet, with a vertical contour interval of two feet, and that these maps be based upon the Commission-recommended survey control system. The specifications also require that reproducible copies of the partially finished topographic maps be made on dimensionally stable base material at a stage when these maps show only the quarter-section lines and corners and related control survey data, the intersections of the grid lines for the Wisconsin State Plane Coordinate system at 5-inch intervals, and certain relevant cultural and hydrographic features. These partially completed topographic map sheets are provided as base maps for the later preparation of cadastral maps under separate contracts. Specifications governing the preparation of the cadastral maps are reproduced in Appendix B. Again, separate specifications are provided for the preparation of the cadastral maps in both traditional hard copy form, and in digital form.

The specifications governing the work underway or completed to date require that the monuments

²The National Map Accuracy Standards referenced are reproduced in Appendix F of this report.



This photograph shows a survey monument of the type referenced in this report, as 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.

placed to mark the relocated U. S. Public Land Survey corners consist of 36-inch-long precast reinforced concrete monuments having engraved brass caps imbedded in the tops. The monuments are usually set flush with or slightly below the surrounding surface, although in some off-road situations the monuments may be set slightly above the surface (see Figure 2, and Appendix A, Exhibit D). Past practices recognized by the Commission as an acceptable alternative included the installation of monuments substantially below the surface of roadways in cast iron hand holes. This practice is no longer sanctioned by the Commission nor the Wisconsin Department of Transportation for reasons of safety. The hand hole covers were sometimes not secured to the hand hole frames after use by surveyors and engineers, and have caused damage to vehicles. The cast iron hand hole installations have also been found to collect road salts and other chemicals, thereby sometimes causing the rapid deterioration of the concrete monuments. Finally, the cast iron hand hole installations have also been found to fill with standing water and ice making use without damage to the monuments difficult. The brass caps are stamped at the time of setting with the corner notation—quarter section, township, and range. Other types of monuments have been used on an experimental basis, including

TYPICAL RECORD OF U. S. PUBLIC LAND SURVEY CONTROL STATION

U. S. PUBLIC LAND SURVEY CORNER 717 T 5 N, R 21 E, MILWAUKEE COUNTY, WIS.
1818
GEODETIC SURVEY BY: AERO-METRIC ENGINEERING, INC. YEAR: 1993

STATE PLANE COORDINATES OF: QUARTER SECTION CORNER
NORTH 334,727.42
EAST 2,520,078.71
ELEVATION OF STATION: 800.549

HORIZONTAL DATUM: WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE
VERTICAL DATUM: NATIONAL GEODETIC VERTICAL DATUM OF 1929

CONTROL ACCURACY: THETA ANGLE: + 1-20-02
HORIZONTAL: THIRD ORDER, CLASS I VERTICAL: SECOND ORDER, CLASS II

LOCATION SKETCH:

Bearing: S 00-18-33 E
To Center of Sec. 18-5-2

SURVEYOR'S AFFIDAVIT: As County Surveyor, I hereby certify that I set a concrete monument with SEWRPC brass cap to mark this corner; replacing a broken 5-inch-diameter concrete monument and subsurface remnants of a cut limestone monument then marking this corner; said concrete monument with cast iron plug with cross having been set to mark this corner in August 1989 by Gerald B. Inman, S-891; replacing a 2-inch-diameter iron pipe set over said remnant limestone monument to mark this corner at the ground surface in September 1944 by Gustav R. Erdman, S-19; said limestone monument having been set to mark this corner in 1878 by Jonathan C. Crounse, Surveyor; replacing in turn a wood post set to mark this corner in June 1836 by Elisha Dwell, Deputy United States Surveyor, in the conduct of the original United States Public Land Survey; that I referenced the same as shown herein; and that this record is correct and complete to the best of my knowledge and belief. The tie distance of 41.75 feet to the southwest corner of the house as shown hereon was measured and recorded by Mr. Crounse as 63 links (41.58 feet). Since Mr. Crounse recorded his measurement to the nearest link (± 0.33 foot), the recorded and measured distances are considered to be in agreement.

DATE OF SURVEY: 29 April 1992

REGISTERED LAND SURVEYOR

S - 157

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Typical dossier sheet prepared for each control survey station setting forth all information necessary for recovery and use of the station such as: the State Plane coordinates of the corner, the elevation of the monument, a location sketch, a detailed description, and a Surveyor's affidavit.

Source: SEWRPC.

commercially manufactured cast iron and plastic pipe monuments. With the exception of very long driven steel pipe monuments used in unstable wetland areas, these other types of monuments have not proven to provide successful installations over time.

The monuments placed are referenced by ties to at least four witness marks. The specifications require that the land surveyor employed in the remonumentation provide a dossier sheet—a U. S. Public Land Survey monument record—for each U. S. Public Land Survey corner located and monumented in order to permit its ready recovery and use. The dossier sheets are prepared on 8 1/2-inch by 11-inch drafting film. In addition to identifying the corner, the sheets provide a sketch for each station showing the monument erected in relation to the salient features of the immediate vicinity; all witness monuments, together with the attendant ties to the corner; the coordinates of the corner; its public land survey description; the bench mark elevation of the monument; the elevation of a supplementary bench mark in the immediate vicinity of the monument; and where practicable the bearing to an azimuth mark visible from the station (see Figure 3). The dossier sheet contains a surveyor's affidavit indicating whether the corner was restored through acceptance of a found perpetuated location or through acceptance of an obliterated evidence location; or was reestablished by lost corner proportionate measurement; and describing any record evidence, monument evidence, occupational evidence, testimonial evidence, or other material evidence considered in the location, and whether the monument was found as placed. The affidavit is to identify any material discrepancies between the corner as restored or reestablished and the corner as previously located. These dossier sheets are recorded with

the city or village engineer; the county surveyor; the County Highway Department; the Wisconsin Department of Transportation District Office; or SEWRPC, and are thereby made available as public documents to all land surveyors and engineers in the area.

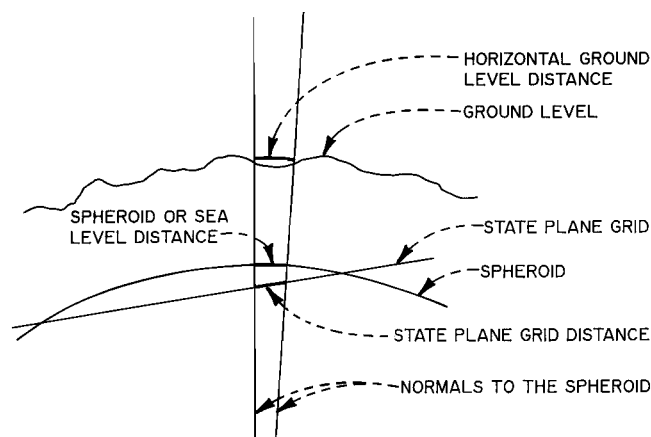
The finished topographic maps, in addition to showing the usual contours, spot elevations, cultural and hydrographic detail, and coordinate grid ticks, show, in their correct position and orientation, all quarter-section lines and corners established in the field surveys. The angle between geodetic and grid bearing is noted on each sheet, as is the equation between any specified local datum and National Geodetic Vertical Datum of 1929 (see Map 3).

It is recognized that the recorded dimensions and orientation of real property boundaries to be plotted on the base maps sheets in the construction of cadastral maps (see Map 4) may not always agree with the horizontal control survey data shown on those sheets, since most property descriptions were written using field survey data obtained prior to the relocation of section and quarter-section corners and completion of a high-order horizontal survey control network tied to the Wisconsin State Plane Coordinate System. Furthermore, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and, in the past, widely adhered to in other property boundary surveys is 1 part in 3,000, as compared to the third-order, class I survey accuracy of 1 part in 10,000 specified for the recommended horizontal control surveys. For these and other reasons, overlapping, or separated property boundary descriptions do exist. In order to precisely record these overlaps and gaps, the specifications require that the cadastral maps record all dimensions contained in the official records on file with the County Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlaps or gaps shall, in addition, be shown as mapped lines. Overlaps or gaps of less than 2.5 feet are evident only from an examination of the recorded property line dimensions.

It is also recognized that the recorded dimensions of real property boundaries represent "ground level" distances determined by conventional plane surveying techniques; while the control survey data are determined by geodetic surveying techniques and represent distances on the State Plane Coordinate grid—a map projection fitted to the spheroid of reference—and grid which may be thought of as being at sea level. For this reason the ground level dimensions of one-quarter section lines are also shown on the maps, those distances being determined by appropriate application of a combination factor for the area concerned which is the

Figure 4

RELATIONSHIP OF GROUND LEVEL DISTANCES TO STATE PLANE GRID DISTANCES



The following definitions are applicable:

- **Scale Factor** The state plane grid distance divided by the spheroid or sea-level distance
- **Sea-Level Reduction Factor** The spheroid or sea-level distance divided by the horizontal ground level distance
- **Combination Scale and Sea-Level Reduction Factor** The product of the scale factor and the sea-level reduction factor, so that the state plane grid distance equals the horizontal ground level distance times the combination scale and sea-level reduction factor

Source: SEWRPC.

product of the scale factor and the elevation factor. The relation of ground level distances to state plane grid distances is illustrated by Figure 4. The lengths of all real property boundary lines are shown on the cadastral maps as ground level lengths. This technically inconsistent and anomalous convention is used to preserve on the cadastral maps the lengths of the property boundaries recorded on land subdivision plats, certified survey maps, and other plats of survey. Except within the area shown on Map 5 on page 26, the differences in the dimensions at ground level and at sea level on the grid differ within the Region by no more than 0.01 foot per 100 feet. The area shown on Map 5, which encompasses about 700 square miles, or 26 percent of the total area of the Region, lies at elevations at which the differences between the ground level and grid distances may exceed 0.01 foot per 100

feet. With respect to the control survey accuracy diagrams presented in Appendix C of this report, the differences concerned will exceed 0.01 feet per 100 feet for those diagrams that have a combination scale and sea level reduction factor of less than 0.99990000. Those differences, however, even in the area concerned do not exceed 0.016 foot per 100 feet, or about one part in 6,000.

All of the work necessary to execute the control surveys and provide the finished topographic maps has been done on a negotiated contract basis with photogrammetric and control survey engineering firms. In this regard, it was considered essential to retain photogrammetric and control survey engineers familiar with high-order field survey methods and procedures, and with the attendant geodetic survey computations and adjustments, and whose crews were properly equipped with the necessary survey instruments. Electronic distance measuring devices, such as geodimeters, were and are employed in the control survey work, as well as high-order angle and elevation measuring instruments, such as Wild T-2 theodolites and Zeiss automatic levels. More recently, total station instruments and global positioning technology have also been used in the control survey work. Indeed, historically, the recommended control system became economically feasible only through the introduction of the newer survey instrumentation, particularly the electronic distance-measuring devices.

Although the specifications governing the work make the photogrammetric engineer responsible for overall supervision and control of the topographic mapping work, as well as for the quality of the finished maps, they require that the actual relocation of the public land survey corners be done by a local land surveyor employed as a subcontractor by the photogrammetric engineer, or employed under a direct contract with the agency administering the program. The specifications thereby recognize that this portion of the work requires expert knowledge of local survey custom and boundary and title law, as well as the assembly and careful analysis of all authoritative survey information such as title documents, subdivision plats, survey records, and, of cardinal importance, existing monumentation and occupation in order to arrive at the best possible determination of the location of the public land survey corners. The land survey portion of the control survey work requires a very high degree of professional competence, since many of the public land survey corners within the Region fall under the Federal definition

of either obliterated or lost corners. The importance of the land survey phases of the total work program and its impact on property boundaries throughout the area can hardly be overemphasized.

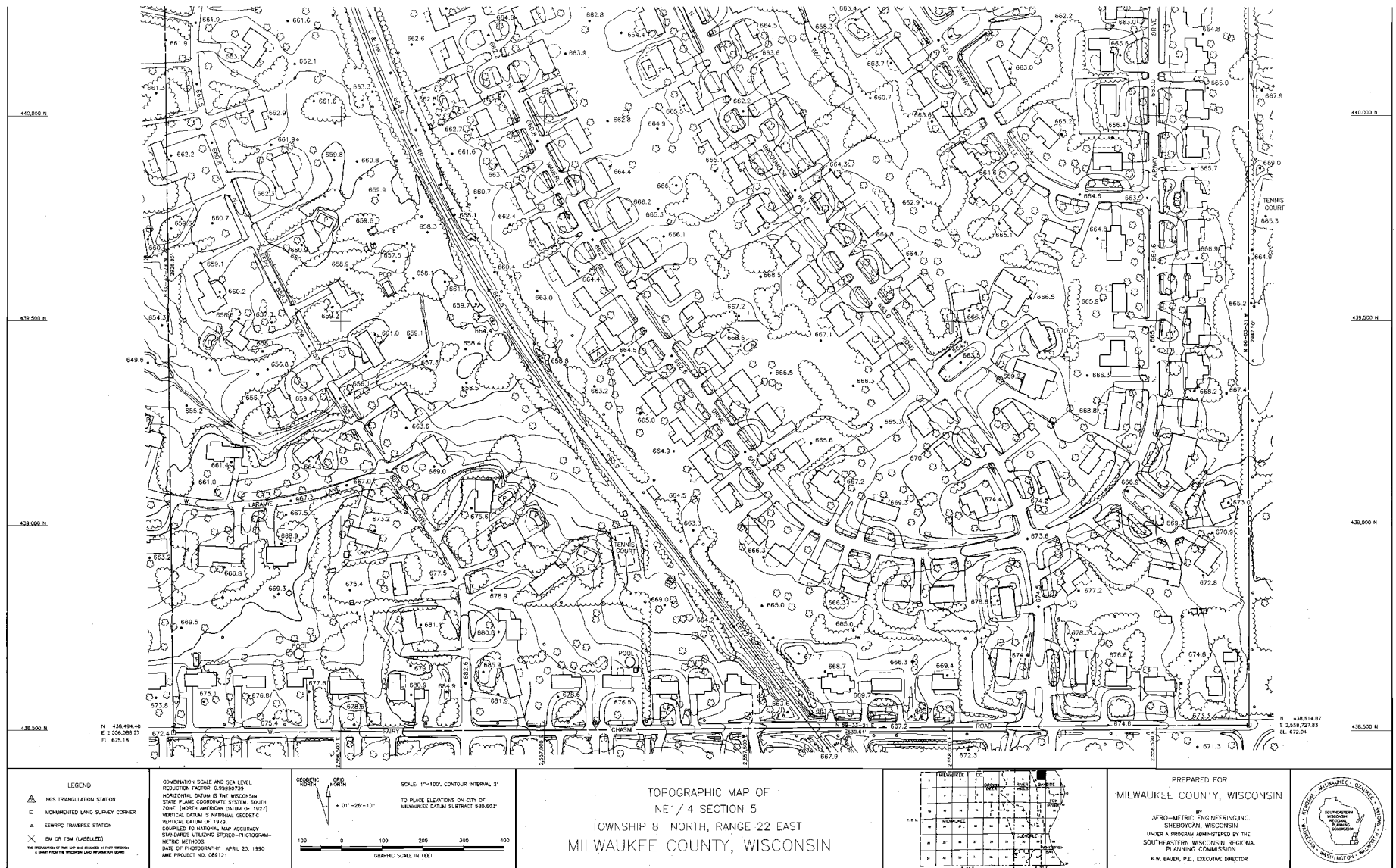
HORIZONTAL AND VERTICAL DATUM CONSIDERATIONS

The geodetic positions of the triangulation stations used to establish state plane coordinates on the remonumented U. S. Public Land Survey corners within the Region were established and published by the U. S. Coast and Geodetic Survey (USC and GS), the predecessor agency to the National Geodetic Survey (NGS). Those positions were determined through a readjustment of the then existing triangulation network covering the entire United States. The readjustment, while completed in 1931, created the datum known as the North American Datum of 1927 (NAD-27). That datum provides a set of adjusted geodetic positions for the triangulation stations expressed in latitude and longitude, and defined by their relationship to a centrally located USC and GS triangulation station in Kansas known as station "Meades Ranch." The computations were performed using the Clarke Spheroid of 1866 as the mathematical model best fitting the geoid underlying the North American continent.

As already noted, to make the national horizontal control survey network more readily available for use by land surveyors and public works engineers unfamiliar with geodetic as opposed to plane surveying practices, the USC and GS devised the State Plane Coordinate System. Also as already noted, in Southeastern Wisconsin the state plane coordinate grid is based upon the Lambert conformal conic projection. The Lambert conic conformal map projection is one of several such projections which can be used to transform geodetic coordinates expressed in latitude and longitude into equivalent plane coordinates on a mapping grid. Parameters for a Lambert conformal conic projection to cover the southern portion of Wisconsin were selected in the 1930s by the USC and GS; and plane coordinates, known as Wisconsin State Plane Coordinates—South Zone, were computed for each geodetic triangulation station within the Region. These state plane coordinates, based upon the NAD-27 and included in this report, define the location of the Commission recommended survey system and have been used throughout the Region by all those adopting the Commission recommended control survey.

Map 3

TYPICAL LARGE-SCALE TOPOGRAPHIC MAP PREPARED IN ACCORDANCE WITH COMMISSION-RECOMMENDED SPECIFICATIONS



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 vertical contour interval of two feet. These maps show the U. S. Public Land Survey corners, the monuments erected at these corners, and the grid lengths and bearings of the quarter-section lines, as well as the usual topographic and cultural features of the landscape.

Source: Milwaukee County Automated Mapping and Land Information System (MCAMLIS) and SEWRPC.

TYPICAL CADASTRAL MAP PREPARED IN ACCORDANCE WITH COMMISSION-RECOMMENDED SPECIFICATIONS



Typical large-scale cadastral map constructed as an overlay to its companion large-scale topographic map. These maps show the U. S. Public Land Survey corners, the monuments erected at these corners, and the grid lengths and bearings of the 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 tax assessment key numbers.

Source: Milwaukee County Automated Mapping and Land Information System (MCAMLIS) and SEWRPC.

In 1976, the National Geodetic Survey undertook another readjustment of the National Control Survey Network. The results of the readjustment were published as the North American Datum of 1983 (NAD-83). One of the reasons this readjustment was undertaken was to resolve distortions in the National Control Survey Network created by attempts to fit new triangulation and traverse data into the network. Another reason was to shift the entire geodetic control survey network to a global datum that would meet military needs relating to navigation, and intercontinental ballistic missile targeting, guidance, and control. Such a global datum was also desired for certain earth science applications. A different mathematical ellipsoid—known as the Geodetic Reference System of 1980 was chosen on the basis of the best fit for the entire earth, instead of a best fit for the North American continent as was done when the Clarke spheroid was selected. The readjustment was completed in 1986 and NAD-83 values for all first and second order geodetic control survey monuments were published by the National Geodetic Survey. The geographic positions of control survey station monuments on NAD-83 are significantly different from the positions on NAD-27 varying by more than 10 feet in latitude and by more than 40 feet in longitude within the Region. The relative positions of the stations, however, and therefore the bearings and distances between the stations, remain essentially unchanged.

The establishment of NAD-83 was a 10-year effort, and according to a National Academy of Science study published in 1971, was intended to “preclude the need for another adjustment for about half a century.” Ironically, new satellite based global positioning system technology was developed and was being introduced by the time the NAD-83 data were published in 1986. This new technology made it possible to make more precise measurements than those reflected in the newly published geodetic network to which these measurements were expected to be attached. Consequently, a decision was made to provide another geodetic survey reference network within Wisconsin, that network being based on global positioning system technology and known as the Wisconsin High Accuracy Reference Network (HARN). That network was completed in 1991 by the Wisconsin Department of Transportation and the National Geodetic Survey. Revised positions for all first and second order control survey stations were again published. The original NAD-83 values are now known as NAD-83(86), values while the

HARN values are known as NAD-83(91) values. The geographic positions of control survey station measurements on NAD-83(91) are significantly different from the positions on NAD-27 and NAD-83. The differences between NAD-27 and NAD-83(91) vary by more than 11 feet in latitude, and by almost 40 feet in longitude, as shown on Maps G-1 and G-2 of Appendix G of this report.

The National Geodetic Survey also completed a national readjustment of elevations based upon differential leveling circuits run throughout North America. What was known as the Sea Level Datum of 1929 was, in 1976, renamed the National Geodetic Vertical Datum of 1929 (NGVD-29). Known elevations on this datum were not changed; only the name of the datum was changed to eliminate the implication that true mean sea level could be determined by starting with the known elevation of the datum of a published benchmark and running a differential level survey to the zero elevation; this approach having important implications for delineating wetlands in ocean coastal areas. The differential leveling circuits throughout the United States, Canada, and Mexico, however, were also readjusted and new benchmark elevations published on a new datum known as the North American Vertical Datum of 1988 (NAVD-88). The elevations of benchmarks on NAVD-88 differ by up to 0.4 foot within South-eastern Wisconsin from the elevations on NGVD-29. The differences in elevations between adjacent benchmarks, however, remain essentially unchanged.

In considering the issue as to whether or not surveys within the Region should be converted to NAD-83(91) for horizontal control, or to NAVD-88 for vertical control, it is important that two facts be clearly understood:

1. The use of NAD-83(91) and NAVD-88 will not result in more accurate or precise topographic or cadastral maps within the Region. Neither does publication of a new national datum degrade the quality of maps based upon NAD-27. The accuracy and precision of such maps are determined by the specifications governing the refinements and preparation of the maps, and by the scale of the maps themselves. In this respect, the term “accuracy” is used to mean conformance with ground truth; and the term “precision” is used to mean the degree of refinement of underlying measurements.

2. There is no accurate and precise method for mathematically converting NAD-27 based control survey data to NAD-83 or NAD-83(91), nor for converting NGVD-29 elevations to NAVD-88 elevations. In each case, the difference between the datums varies from place-to-place in a way which defies exact mathematical definition. Although the difference between the datums can be approximated by mathematical modeling, the uncertainty of that difference contains both random and systematic errors which cannot be completely eliminated.

Because there is no known precise mathematical relationship between the various datums, the conversion between the datums at a level of accuracy which maintains the integrity of the control survey data can be accomplished only by one of three procedures. The most rigorous procedure, although prohibitively impractical even with modern data collection methods, would be to resurvey the location of all secondary control survey stations—that is, of all monumented public land survey corners, and of all vertical benchmarks comprising the Commission recommended control survey network—tying the new surveys to the Federally published positions on the new datums of the primary horizontal and vertical geodetic control stations. Another procedure, also considered unrealistic, would be to abstract the records of the survey measurements accumulated within the Region during the past almost 35 years, and to recompute coordinates and elevations for the secondary control stations throughout the seven-county Region, referencing the computations to the repositioned primary stations. A third method, described in Appendix G to this report, is to in effect model the relationship between the datums within the Region, thereby establishing computational routines that can be used to convert both horizontal coordinates and vertical elevations from one datum to the other. The computational routines must be able in the conversion to preserve the integrity of the data being converted for survey control.³

The horizontal survey control network of over 8,500 monumented U. S. Public Land Survey corners on the NAD-27, and the vertical secondary benchmark network containing an even greater number of monumented benchmarks on the NGVD-29, constitute the foundation of the Commission recommended system of survey control. These monuments have been established, sur-

veyed, and documented over a period of almost 35 years and provide a specific connection between the coordinates, elevations, bearings, and distances shown on the topographic and cadastral maps contained in the public records, and the corresponding points, lines and features on the ground. The system is well conceived, well designed, well built, and used, and provides a proven basis for the conduct of land and public works engineering surveys, for the preparation of large-scale cadastral and topographic maps, and for the development of parcel-based land information systems within the seven-county Region. The accumulated value of the system is incalculable.

Part of the value of a computer data base for land records and spatial information lies in the ability of various users to share data. To do that, the data must be compatible. In cases where the data are not compatible, they either can not be used or must be converted. Computer format is one form of compatibility, but the compatibility considered here is that of datums. The Commission and other users who have adopted the Commission-recommended survey system have built an enormous data base represented by the topographic and cadastral maps based upon the NAD-27 horizontal datum and upon the NGVD-29 vertical datum. And, the quality of information on those maps, determined by enforcement of rigorous specifications for measurements and map preparation, establishes the value of the spatial information for both present and future generations.

The Commission, well aware of the reasons for readjusting the national horizontal and vertical

³*Computational methods have been developed by the National Geodetic Survey for the conversion of State Plane Coordinates between the NAD-27 and the NAD-83. Experience to date, however, indicates that these generalized conversion methods may be expected to provide results which have an accuracy ranging from about 0.5 to about 3 feet. While this level of accuracy may be adequate for certain mapping functions, it is not adequate for the maintenance of the integrity of a control survey network. Accordingly, the Commission has developed its own computational methods for the conversion of data between the NAD-27 and the NAD-83(91) datums. The Commission has also tested and documented a methodology for the conversion of elevations between the NGVD-29 and the NAVD-88.*

control networks and for defining new datums, is not aware of any positional problems in either the NAD-27 datum or the NGVD-29 datum, or in the related survey control networks as these networks exist within the Region, whereby the accuracies specified in the Commission-recommended control survey system cannot be attained, or whereby the use of the spatial information on topographic and cadastral maps or, in related data bases, would be adversely affected. Since no known benefits to local users of the control survey system within the Region would be realized by a conversion to the NAD-83(91) and NAVD-88, the Commission intends to continue use of the NAD-27 and NGVD-29 datums within the Region. This issue is considered in somewhat greater depth in Appendix G.

Notwithstanding, the Commission is also aware of benefits to be realized by sharing compatible data with other users. Therefore, two separate

studies were conducted and reports were prepared for the expressed purpose of providing specific documentation and recommended procedures for converting between both the horizontal and vertical datums within the seven-county Region. Summarized in Appendix G, SEWRPC Technical Report No. 34, A Mathematical Relationship Between NAD-27 and NAD-83(91) State Plane Coordinates in Southeastern Wisconsin, provides a simple efficient method to convert state plane coordinates from one datum to the other; while SEWRPC Technical Report No. 35, Vertical Datum Differences in Southeastern Wisconsin, includes several methods of different accuracies for converting elevations from one datum to another. Using these documented procedures, anyone desiring to use spatial data referenced to the NAD-27 or NGVD-29 can readily convert same to NAD-83(91) or NAVD-88, respectively. In each case the procedures are also reversible.

Chapter IV

THE CONTROL SURVEY DATA

A collation of all of the survey control data collected to date within the Region through application of the Commission-recommended system of survey control is presented in Appendix C to this report. Appendix C is divided into seven sections, one for each county. The first page of each section consists of a county index map on which are indicated the areas covered by large-scale topographic maps and throughout which the U. S. Public Land Survey corners have been relocated, monumented, and coordinated under programs completed to date. In addition, areas and corners currently under contract are indicated.

The actual control survey information is presented in a series of control survey summary diagrams, each diagram covering six U. S. Public Land Survey sections. Each diagram is keyed to the county index map presented earlier in the section by U. S. Public Land Survey section, town, and range numbers. The diagrams show the computed sea level-grid length, and the grid bearings of the exterior boundaries of each quarter section surveyed, all monuments erected; 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 bench mark elevations of all monuments set; and the basic control stations established by the U. S. Coast and Geodetic Survey and utilized to tie the public land survey corners to the geodetic control datum, together with the coordinates of those stations. The angle between geodetic and grid bearing is noted,¹ as is the combination scale and

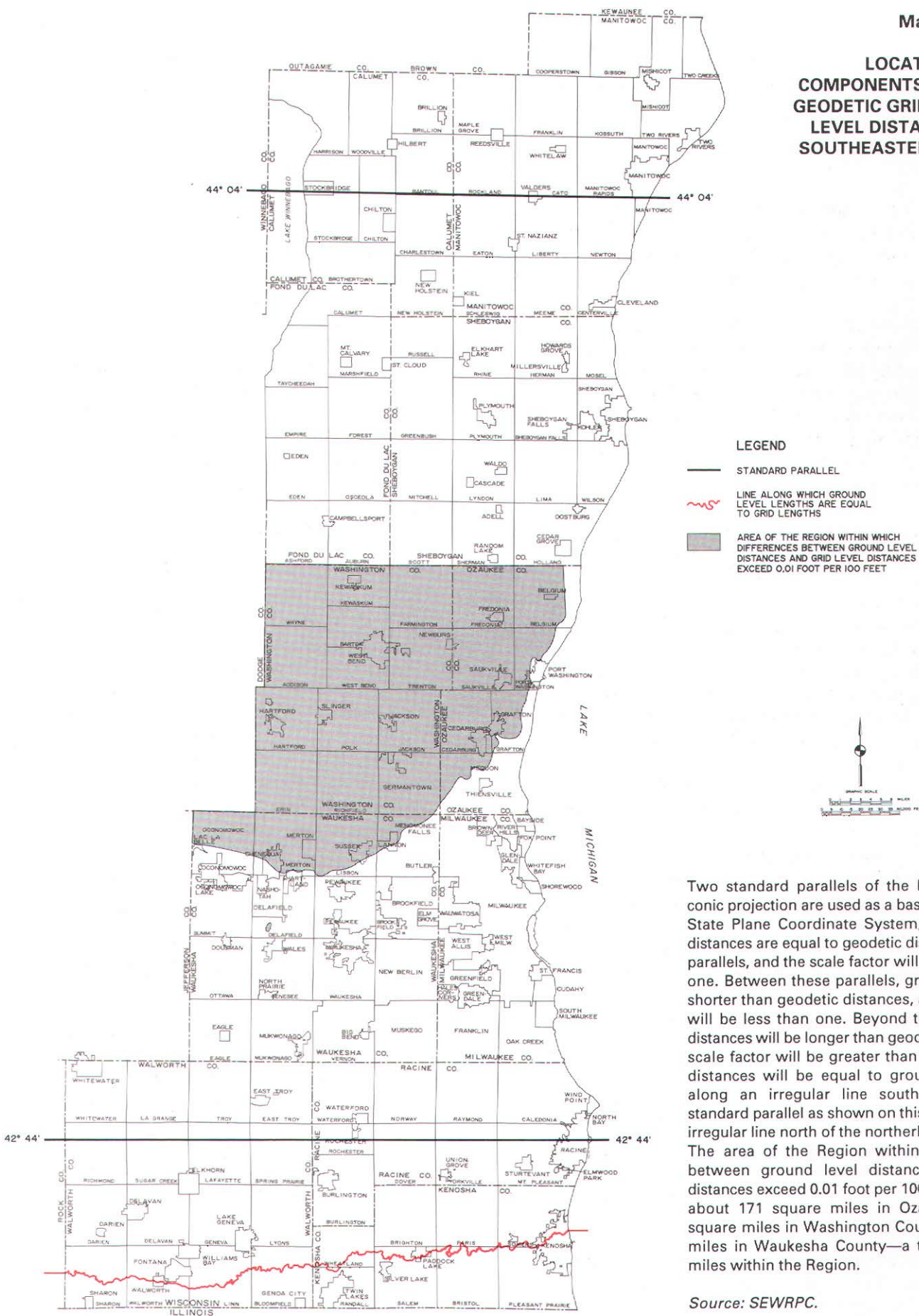
theta angle. Usually this angle will be of no concern to the local engineer or surveyor using the State Plane Coordinate System since he will ordinarily be utilizing strictly plane surveying methods. Sometimes, however, it may be desirable to know the difference between geodetic and grid bearings for the purpose of obtaining a check on a computed value or for the purpose of providing directional orientation in certain special-purpose surveys. The precise theta angle has been computed for each U. S. Public Land Survey section or quarter-section corner and is given on the control survey station dossier sheet for the corner. At a lesser level of accuracy, the average theta angle is listed on each control survey summary diagram for the area covered by the diagram.

It should also be noted here that it has been common surveying practice to distinguish between bearings obtained through astronomical observations and those obtained through the use of the magnetic compass, so that the terms "true north" and "magnetic north" are often found in legal descriptions and on survey plats. The term "true" is an imprecise one, and it is recommended that it not be used. Instead, the more definitive terms of "astronomic," "geodetic," or "grid" should be used. It is further recommended that generally all surveys within Southeastern Wisconsin be referenced to "geodetic" north by the application of the theta angle correction to the grid bearings given on the control summary diagrams contained in this report. Geodetic bearings will differ slightly from astronomic bearings determined by solar or stellar observations by a small angle known as the "LaPlace correction." The LaPlace correction within Southeastern Wisconsin is estimated to be generally less than five seconds of arc and can be neglected for most survey applications. Anyone wishing to obtain a LaPlace correction for a station may transmit a request to the Director of the National Geodetic Survey, giving the latitude and longitude of the station. LaPlace corrections can also be computed using a program called DEFLEC 93 available from the National Geodetic Survey. Finally, it should be noted that the term "geographic" includes both astronomic and geodetic bearings and is therefore less precise than either term.

¹In placing a survey on a system of plane rectangular coordinates, all bearings are referred to the same meridian. Since geodetic meridians actually converge toward the poles, grid bearings will differ from geodetic bearings except at the grid origin or other points along the single meridian of reference. On the Lambert grid used as a basis for the Wisconsin State Plane Coordinate System, the angle between geodetic and grid north is known as the

Map 5

LOCATION OF COMPONENTS RELEVANT TO GEODETIC GRID AND GROUND LEVEL DISTANCES WITHIN SOUTHEASTERN WISCONSIN



Two standard parallels of the Lambert conformal conic projection are used as a basis for the Wisconsin State Plane Coordinate System, South Zone. Grid distances are equal to geodetic distances along these parallels, and the scale factor will be equal to exactly one. Between these parallels, grid distances will be shorter than geodetic distances, and the scale factor will be less than one. Beyond these parallels, grid distances will be longer than geodetic distances and the scale factor will be greater than one. Sea level grid distances will be equal to ground level distances along an irregular line south of the southerly standard parallel as shown on this map, and along an irregular line north of the northerly standard parallel. The area of the Region within which differences between ground level distances and grid level distances exceed 0.01 foot per 100 feet encompasses about 171 square miles in Ozaukee County, 436 square miles in Washington County, and 93 square miles in Waukesha County—a total of 700 square miles within the Region.

Source: SEWRPC.

sea level reduction factor used to convert grid to horizontal ground level distances.² The theta angle

²Since the geodetic data determined by the national control survey—the latitudes and longitudes of points and the lengths and bearings of lines—are sea level data, it follows that surveys that are to be adjusted to stations of the national control survey must first be reduced to a sea level base. Furthermore, the State Plane Coordinate grid is based upon a map projection. Since a spherical surface cannot be developed into a plane surface without some distortion, grid distances will vary from geodetic distances. For the Lambert conformal conic projection used as a basis for the Wisconsin State Plane Coordinate System, South Zone, this variation will be nil along the two standard parallels, on which the conic projection cuts the spheroid. Along these parallels, one of which traverses the Region through central Racine and northern Walworth Counties along parallel of latitude 42° 44' North and the other of which traverses the State through central Manitowoc and Calumet Counties along parallel of latitude 44° 04' North (see Map 5), grid distances will be exactly equal to geodetic distances, and the scale factor will be equal to exactly one. Between these two standard parallels, grid distances will be shorter than geodetic distances, the scale is termed to be too small, and the scale factor will be less than unity (one). Beyond these standard parallels, grid distances will be longer than geodetic distances, the scale is termed to be too large, and the scale factor will be greater than unity (one). Thus, to convert a horizontal ground level-measured distance to its corresponding grid distance on the State Plane Coordinate System, two steps are necessary: 1) correction for grid scale, and 2) reduction to sea level. This reduction, however, may be performed in a single operation through application of a combination scale and sea level reduction factor. The average value of this combination scale and sea level reduction factor has been computed for the area covered by each control survey summary diagram and, within normal land and public works engineering surveying tolerances, may be applied directly as given in this report to convert horizontal measured ground level distances to sea level grid distances or sea level grid distances to horizontal ground distances. It should be noted that since the combination scale and sea level reduction factor includes the sea level reduction, it will not be equal to one along the standard parallel through the Region, but along an irregular line south of the standard parallel through central Kenosha and southern Walworth Counties as shown on Map 5.

and combination scale and sea level reduction factor, as shown on the diagrams, are computed for the coordinated one-quarter section corner nearest the geographic centers of the six-section area of each diagram. In the use of the summary diagrams, it must be understood that slightly different distance conversions may result depending upon whether the combination scale and sea level reduction factor given on the diagram is used, or whether a combination scale and sea level reduction factor computed specifically for a given line is used. Similarly, the theta angle will vary across the summary diagrams and this variation may exceed one minute of arc. In addition, the diagrams indicate the area in acres of the U. S. Public Land Survey quarter sections surveyed, as computed using ground level distances (see Figure 5).

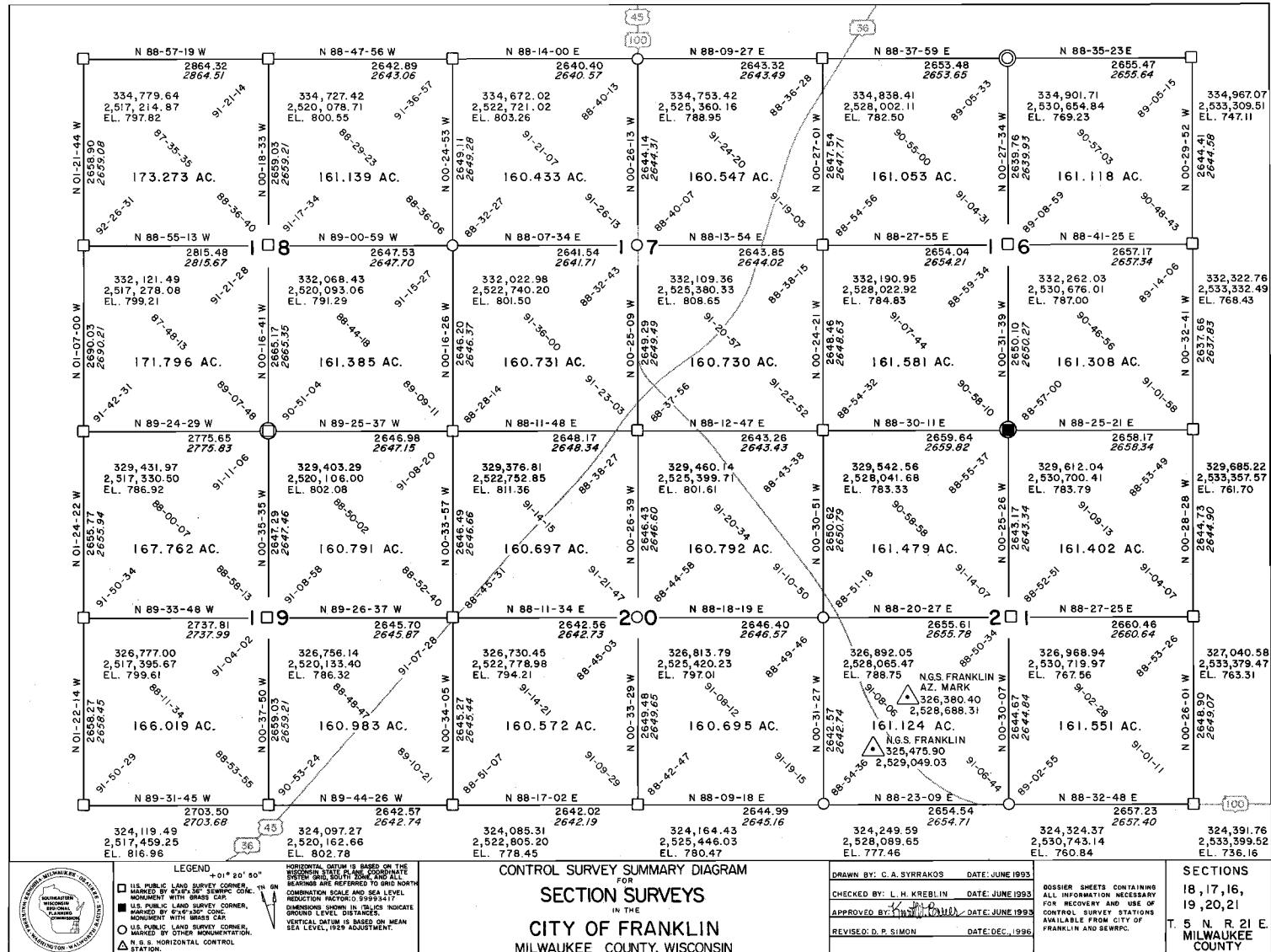
The control survey summary diagrams are intended to provide all of the information necessary to prepare base maps, to make engineering and land survey office computations and analyses, and to plan field surveys. The elevations of the U. S. Public Land Survey corner monuments should not be used in the field unless they have been checked against the applicable reference bench marks set for each corner as indicated on the dossier sheet.

Following the control survey summary diagrams in each county section, additional diagrams are provided by township and range showing the location and identification of all traverse stations established under control survey programs completed to date. The specifications governing the horizontal control survey work require the preparation of a dossier sheet—a control survey station record—for each traverse station established in order to permit its ready recovery and use. The dossier sheets are prepared on 8 ½-inch by 11-inch paper. In addition to identifying the station, the sheets provide a sketch of each station showing the salient features of the immediate vicinity; ties to reference marks; the coordinates of the station; the combination scale and sea level reduction factor; the theta angle; and the bearings and distances to other stations, including U. S. Public Land Survey corners, visible from the station (see Figure 6). These dossier sheets are filed in the Commission offices, and are thereby made available as public documents to users of the control survey system.

The Commission maintains in its files a copy of the dossier sheet for each of the U. S. Public Land Survey corners that have been relocated, monumented, and coordinated under programs completed to date to Commission specifications. A number

Figure 5

TYPICAL CONTROL SURVEY SUMMARY DIAGRAM



An example of a control survey summary diagram for a six-square-mile area showing the grid and 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 one-quarter section corners; the elevations of all monuments set; the National Geodetic Survey 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 geodetic and grid bearing for the six-square-mile area; and the average combination scale and sea level reduction factor for the six-square-mile area.

Source: SEWRPC.

Figure 6

SAMPLE DOSSIER SHEET FOR A TRAVERSE STATION

STATION: 1341

HORIZONTAL CONTROL DATA

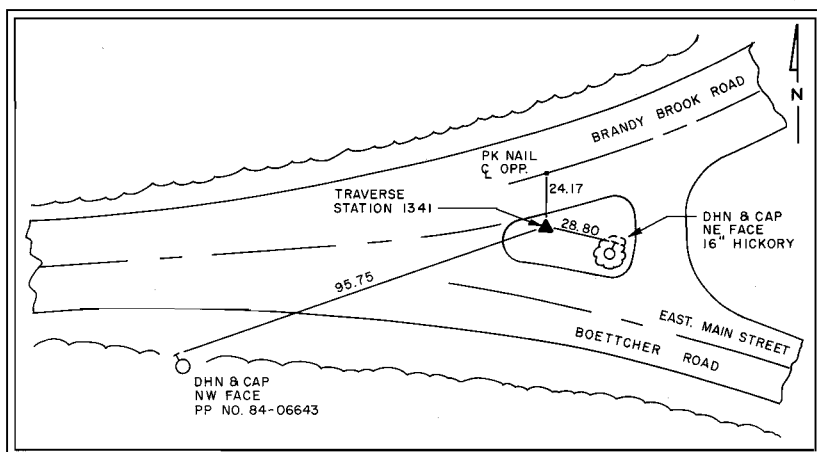
AYRES
ASSOCIATES

SET BY : Owen Ayres & Associates Inc.
2445 Darwin Road
Madison, WI 53704-3192, (608)249-0471

PROJECT : WAUKESHA CO 1994 T6-7N, R18E NO. 139.00 STATION : 1341
3RD ORDER CL. 1 TRAVERSE STATE : WISCONSIN
TYPE OF MARK : #5 REBAR & CAP YEAR SET : 1994 COUNTY : WAUKESHA
WISCONSIN 1927 SYSTEM OF PLANE COORDINATES WISCONSIN SOUTH Zone
COMBINATION FACTOR : 0.99991344 QUADRANGLE : HARTLAND
NORTHING : 370,058.500' EASTING : 2,436,485.865' THETA ANGLE : + 1° 7' 16"

To Station	North Azimuth	Bearing	Grid Distance
1340	257° 22' 6"	S 77° 22' 6" W	772.62'
1342	100° 37' 50"	S 79° 22' 10" E	777.42'
1439	53° 4' 9"	N 53° 4' 9" E	671.53'

LOCALITY: About 300' North and 1100' West from the Southwest quarter-corner of Section 3, T.6 N., R.18 E. The Station is a No. 5 Rebar & Cap and is set 0.3' below ground.



Source: SEWRPC.

field surveys. These dossiers sheets not only show the monuments marking the stations or corners to be used in relation to the salient features of the immediate vicinity, but show ties to witness monuments; where practicable, the bearing to an azimuth mark and brief description of the azimuth mark; and, most importantly, for all U. S. Public Land Survey corners a surveyor's affidavit placing the current monument in the historical chain of monumentation for the corner. The dossier sheets are also useful in more precisely locating the U. S. Public Land Survey corners on aerial photographs for use in the ratioing and rectification of the photographs. In this manner the only distortion remaining in the photographs is that due to relief, and the photographs can be readily used for such purposes as the conduct of land use inventories. The dossier sheets are also useful in the production of orthophotographs to national map accuracy standards, and in the production of large-scale topographic and cadastral maps.

If, in the use of the control survey stations, any differences are noted between actual conditions and conditions as shown on the applicable dossier sheet, the Commission should be contacted so that appropriate steps can be taken to correct the sheet involved.

Supplementary vertical survey control has been provided in certain areas of the Region through the establishment of second-order, class II level nets by the Regional Planning Commission as a part of its comprehensive watershed and areawide water quality planning efforts. These supplementary data

located in the bottom right corner of each dossier sheet is keyed to a numbering system which assigns a number to each U. S. Public Land Survey corner in a survey township in a regular serpentine fashion, as shown in Figure 7.

The conduct of field surveys may be expedited by use of the control survey station recovery, or dossier, sheets for each actual corner to be used in the

are summarized in Appendix D, which consists of county maps showing the location of the supplementary bench marks—that is, bench marks which are not also U. S. Public Land Survey corners—established under the various Commission work programs. Copies of dossier sheets similar to that shown in Appendix D, Figure D-1, corresponding to each numbered bench mark shown on the county maps are on file in the Commission offices.

With respect to vertical survey control, it should be noted that, unfortunately, there are many datum surfaces presently in use within the Region to which survey elevations are referred. Commission studies have indicated that 11 communities use City of Milwaukee datum for which a definite conversion factor to NGVD is known; and 24 other communities utilize various local datum surfaces for which definite conversion factors to NGVD factors are also known (see Table 2). Some communities do not specify any datum for use within the community, while some communities may use more than one datum surface for surveys in different areas of the community. As a result, confusion often exists about the relationship between elevations referred to the various datum surfaces in use within the Region. Planning and engineering analyses of all kinds, particularly such analyses related to water resources management and water control facilities, and the exchange of engineering data between communities, are unnecessarily complicated and the chance for error is needlessly increased.

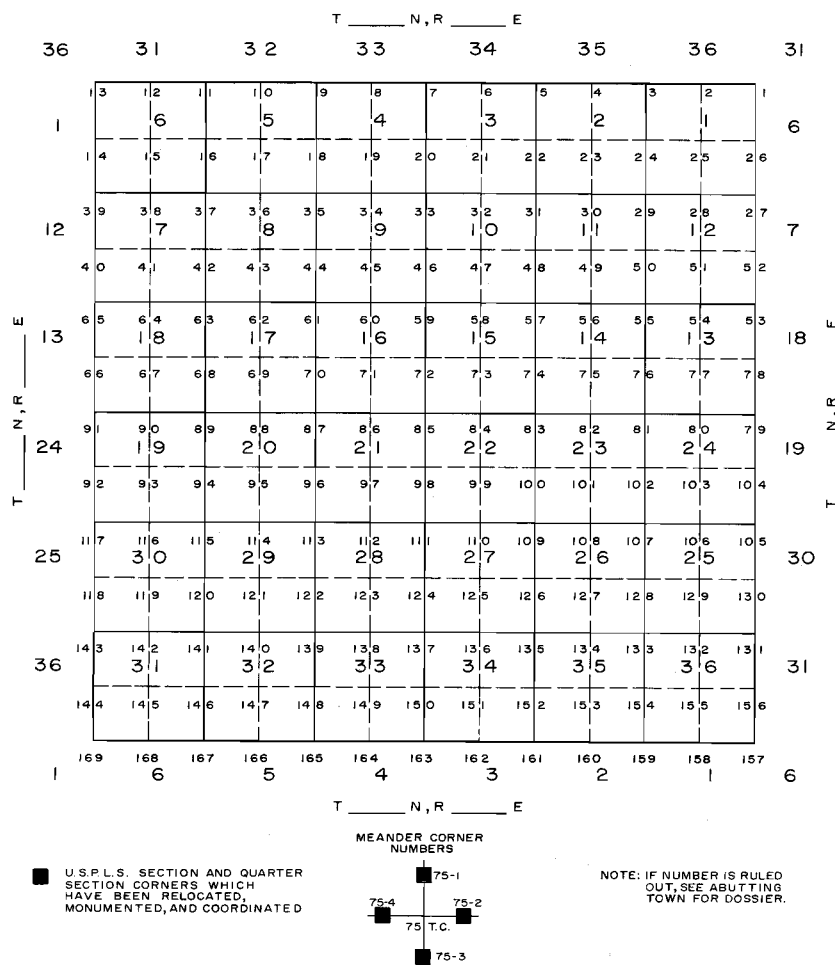
The four most common datum surfaces in use within the Region are the City of Milwaukee datum (CMD); the U. S. Army Corps of Engineers Lake Michigan low water datum (LWD); the International Great Lakes datum (1955 and 1985 adjustments) (IGLD-55 and IGLD-85); and the National Geodetic Vertical Datum-1929 adjustment (NGVD-29), the latter being the datum surface recommended for universal use throughout the Region by the Regional Planning Commission.³

³The reference surface recommended for use in all vertical control surveys within the Region by the Regional Planning Commission is properly known as National Geodetic Vertical Datum of 1929 and is properly abbreviated NGVD. This same reference surface was formerly known as Sea Level Datum of 1929 and was abbreviated SLD. This datum is the North American standard for heights arrived at

Figure 7

INDEX FOR RECORD OF DOSSIERS

INDEX FOR RECORD OF CONTROL SURVEY STATIONS IN THE TOWN OF:



Source: SEWRPC.

by the U. S. Coast and Geodetic Survey after a continental adjustment in 1929 using national level nets to relate mean sea levels at 26 tide stations along the coasts of the United States and Canada. Because the origin of this datum surface involved analysis of mean sea levels at 26 stations, the datum was commonly, although incorrectly, referred to as mean sea level datum (MSLD) instead of sea level datum (SLD). The term MSLD, therefore, should not be used. True mean sea level at any given location on a sea coast is the simple average of all of the hourly readings of the heights of water at the location over a period of 18.6 years. As such, it is a local datum surface and is not identical to NGVD.

The relationships between these four datum surfaces are shown graphically and by equation in Figure 8. Because the International Great Lakes Datum is a dynamic rather than an orthometric datum, the equations between elevations on that datum and National Geodetic Vertical Datum of 1929 will vary within the Region. Therefore, Figure 8 provides equations for the Kenosha, Milwaukee, Port Washington, and Racine areas.⁴

The basic survey data contained in this report generally, and specifically in Appendix C, should have permanent value for map compilation, office computation and analyses, and the conduct of

ongoing survey work within the Region. As additional survey data are collected, new and updated control survey summary diagrams, traverse station diagrams, and county index maps will be published by the Commission.

⁴*For additional information on the International Great Lakes Datum and its relationship to other datums in use within the Southeastern Wisconsin Region, see "Lake Levels and Datum Differences," SEWRPC Technical Record, Vol. 4, No. 5, December 1989.*

Table 2

**RELATIONSHIP OF VERTICAL SURVEY REFERENCE DATUM SURFACES
TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD-29)**

Municipality or Agency	Value to be Added to Elevations Referenced to Local Datum to Reference Those Elevations to NGVD-29 (feet)
International	
International Great Lakes Commission (IGLD-55)	
At Kenosha	1.28
At Milwaukee.....	1.34
At Port Washington	1.18
At Racine	1.26
International Great Lakes Commission (IGLD-85)	
At Kenosha	0.42
At Milwaukee.....	0.53
At Port Washington	0.25
At Racine	0.39
Federal	
U.S. Army Corps of Engineers Lake Michigan Low Water Datum	
At Kenosha	578.08
At Milwaukee.....	578.14
At Port Washington	577.98
At Racine	578.06
Local	
Kenosha County	
City	
Kenosha.....	577.42
Village	
Silver Lake	660.1
Milwaukee County	
Milwaukee Metropolitan Sewerage District	580.603
Cities	
Cudahy.....	580.603
Franklin	580.56
Glendale.....	580.603
Greenfield	580.61
Milwaukee	580.603
Oak Creek.....	580.56
St. Francis.....	580.603
South Milwaukee.....	580.97
Wauwatosa	580.28
West Allis	580.56
Villages	
Bayside	580.603
Brown Deer	580.603
Fox Point.....	582.01
Greendale	580.56
Hales Corners	580.603
River Hills.....	580.603
Shorewood.....	580.603
West Milwaukee.....	580.603
Whitefish Bay.....	580.603

Table 2 (continued)

Municipality or Agency	Value to be Added to Elevations Referenced to Local Datum to Reference Those Elevations to NGVD-29 (feet)
Ozaukee County Cities Mequon Port Washington Villages Grafton Saukville.....	 580.52 577.01 615.49 0.13
Racine County Cities Burlington Racine..... Villages Elmwood Park..... Sturtevant.....	 175.25 580.71 580.71 631.80
Walworth County Village East Troy.....	 657.43
Washington County City West Bend Village Jackson.....	 871.16 0.55
Waukesha County Cities Muskego Waukesha Village Mukwonago.....	 580.60 780.558 752.55

NOTE: This table is not intended to be an “all inclusive” list of local datums in use within the Region, but is instead a list of local datums known by the Commission to be in use at the time of this publication.

The Cities of Wauwatosa and Waukesha values have been revised per information provided from City Staff as of July 13, 2011.

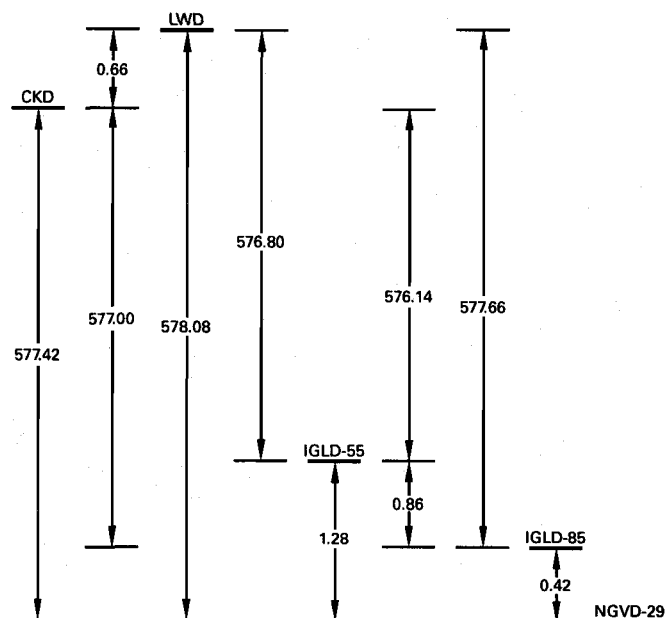
Source: SEWRPC.

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Figure 8

RELATIONSHIP BETWEEN SELECTED VERTICAL SURVEY CONTROL DATUM SURFACES

RELATIONSHIP AT KENOSHA, WISCONSIN BETWEEN SELECTED VERTICAL SURVEY CONTROL DATUM SURFACES



COMPUTATION OF NGVD-29 GIVEN CKD, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{NGVD-29} &= \text{CKD} + 577.42 \\ \text{NGVD-29} &= \text{LWD} + 578.08 \\ \text{NGVD-29} &= \text{IGLD-55} + 1.28 \\ \text{NGVD-29} &= \text{IGLD-85} + 0.42 \end{aligned}$$

COMPUTATION OF CKD GIVEN NGVD-29, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{CKD} &= \text{NGVD-29} - 577.42 \\ \text{CKD} &= \text{LWD} - 0.66 \\ \text{CKD} &= \text{IGLD-55} - 576.14 \\ \text{CKD} &= \text{IGLD-85} - 577.00 \end{aligned}$$

COMPUTATION OF LWD GIVEN NGVD-29, CKD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{LWD} &= \text{NGVD-29} - 578.08 \\ \text{LWD} &= \text{CKD} + 0.66 \\ \text{LWD} &= \text{IGLD-55} - 576.80 \\ \text{LWD} &= \text{IGLD-85} - 577.66 \end{aligned}$$

COMPUTATION OF IGLD-55 GIVEN NGVD-29, CKD, LWD, OR IGLD-85

$$\begin{aligned} \text{IGLD-55} &= \text{NGVD-29} - 1.28 \\ \text{IGLD-55} &= \text{CKD} + 576.14 \\ \text{IGLD-55} &= \text{LWD} + 576.80 \\ \text{IGLD-55} &= \text{IGLD-85} - 0.86 \end{aligned}$$

COMPUTATION OF IGLD-85 GIVEN NGVD-29, CKD, LWD, OR IGLD-55

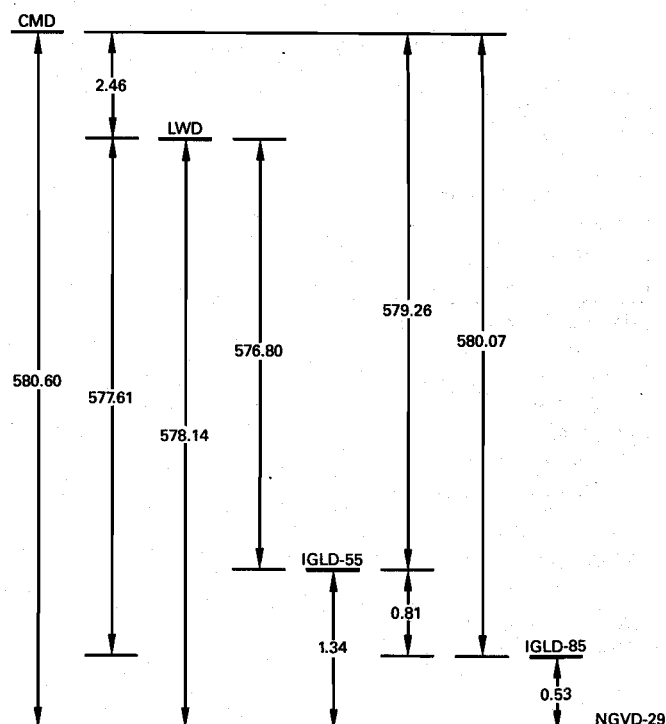
$$\begin{aligned} \text{IGLD-85} &= \text{NGVD-29} - 0.42 \\ \text{IGLD-85} &= \text{CKD} + 577.00 \\ \text{IGLD-85} &= \text{LWD} + 577.66 \\ \text{IGLD-85} &= \text{IGLD-55} + 0.86 \end{aligned}$$

NGVD-29 REPRESENTS NATIONAL GEODETIC VERTICAL DATUM OF 1929.
CKD REPRESENTS CITY OF KENOSHA DATUM.
LWD REPRESENTS LAKE MICHIGAN LOW WATER DATUM (CHART DATUM).
IGLD-55 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1955 ADJUSTMENT.
IGLD-85 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1985 ADJUSTMENT.

NOTE: BECAUSE THE NGVD-29 AND THE NAVD-88 ARE NOT PARALLEL SURFACES, METHODS FOR CONVERTING POSITIONS BETWEEN THE TWO DATUMS MUST DEPEND UPON COMPARATIVE MODELING. IT IS NOT, THEREFORE, POSSIBLE TO RELATE ELEVATIONS OF ONE DATUM EXACTLY TO ELEVATIONS OF THE OTHER DATUM BY USE OF AN AREAWIDE EQUATION.

Source: SEWRPC

RELATIONSHIP AT MILWAUKEE, WISCONSIN BETWEEN SELECTED VERTICAL SURVEY CONTROL DATUM SURFACES



COMPUTATION OF NGVD-29 GIVEN CMD, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{NGVD-29} &= \text{CMD} - 580.60 \\ \text{NGVD-29} &= \text{LWD} - 578.14 \\ \text{NGVD-29} &= \text{IGLD-55} - 1.34 \\ \text{NGVD-29} &= \text{IGLD-85} - 0.53 \end{aligned}$$

COMPUTATION OF CMD GIVEN NGVD-29, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{CMD} &= \text{NGVD-29} + 580.60 \\ \text{CMD} &= \text{LWD} + 2.46 \\ \text{CMD} &= \text{IGLD-55} + 579.26 \\ \text{CMD} &= \text{IGLD-85} + 580.07 \end{aligned}$$

COMPUTATION OF LWD GIVEN NGVD-29, CMD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{LWD} &= \text{NGVD-29} - 578.14 \\ \text{LWD} &= \text{CMD} - 2.46 \\ \text{LWD} &= \text{IGLD-55} - 576.80 \\ \text{LWD} &= \text{IGLD-85} - 577.61 \end{aligned}$$

COMPUTATION OF IGLD-55 GIVEN NGVD-29, CMD, LWD, OR IGLD-85

$$\begin{aligned} \text{IGLD-55} &= \text{NGVD-29} + 1.34 \\ \text{IGLD-55} &= \text{CMD} + 579.26 \\ \text{IGLD-55} &= \text{LWD} + 576.80 \\ \text{IGLD-55} &= \text{IGLD-85} - 0.81 \end{aligned}$$

COMPUTATION OF IGLD-85 GIVEN NGVD-29, CMD, LWD, OR IGLD-55

$$\begin{aligned} \text{IGLD-85} &= \text{NGVD-29} - 0.53 \\ \text{IGLD-85} &= \text{CMD} + 580.07 \\ \text{IGLD-85} &= \text{LWD} + 577.61 \\ \text{IGLD-85} &= \text{IGLD-55} + 0.81 \end{aligned}$$

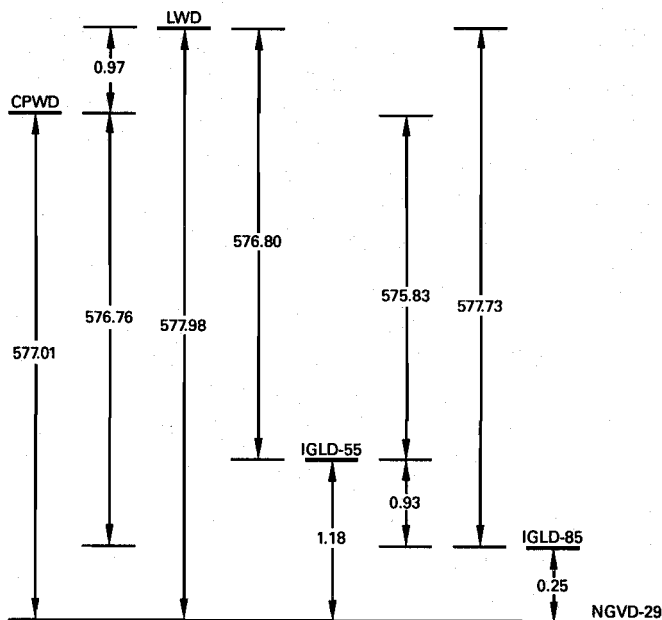
NGVD-29 REPRESENTS NATIONAL GEODETIC VERTICAL DATUM OF 1929.
CMD REPRESENTS CITY OF MILWAUKEE DATUM.
LWD REPRESENTS LAKE MICHIGAN LOW WATER DATUM (CHART DATUM).
IGLD-55 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1955 ADJUSTMENT.
IGLD-85 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1985 ADJUSTMENT.

NOTE: BECAUSE THE NGVD-29 AND THE NAVD-88 ARE NOT PARALLEL SURFACES, METHODS FOR CONVERTING POSITIONS BETWEEN THE TWO DATUMS MUST DEPEND UPON COMPARATIVE MODELING. IT IS NOT, THEREFORE, POSSIBLE TO RELATE ELEVATIONS OF ONE DATUM EXACTLY TO ELEVATIONS OF THE OTHER DATUM BY USE OF AN AREAWIDE EQUATION.

Source: SEWRPC

Figure 8 (continued)

**RELATIONSHIP AT PORT WASHINGTON,
WISCONSIN BETWEEN SELECTED VERTICAL
SURVEY CONTROL DATUM SURFACES**



COMPUTATION OF NGVD-29 GIVEN CPWD, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{NGVD-29} &= \text{CPWD} + 577.01 \\ \text{NGVD-29} &= \text{LWD} + 577.98 \\ \text{NGVD-29} &= \text{IGLD-55} + 1.18 \\ \text{NGVD-29} &= \text{IGLD-85} + 0.25 \end{aligned}$$

COMPUTATION OF CPWD GIVEN NGVD-29, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{CPWD} &= \text{NGVD-29} - 577.01 \\ \text{CPWD} &= \text{LWD} - 0.97 \\ \text{CPWD} &= \text{IGLD-55} - 575.83 \\ \text{CPWD} &= \text{IGLD-85} - 576.76 \end{aligned}$$

COMPUTATION OF LWD GIVEN NGVD-29, CPWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{LWD} &= \text{NGVD-29} - 577.98 \\ \text{LWD} &= \text{CPWD} - 0.97 \\ \text{LWD} &= \text{IGLD-55} - 576.80 \\ \text{LWD} &= \text{IGLD-85} - 577.73 \end{aligned}$$

COMPUTATION OF IGLD-55 GIVEN NGVD-29, CPWD, LWD, OR IGLD-85

$$\begin{aligned} \text{IGLD-55} &= \text{NGVD-29} - 1.18 \\ \text{IGLD-55} &= \text{CPWD} + 575.83 \\ \text{IGLD-55} &= \text{LWD} + 576.80 \\ \text{IGLD-55} &= \text{IGLD-85} - 0.93 \end{aligned}$$

COMPUTATION OF IGLD-85 GIVEN NGVD-29, CPWD, LWD, OR IGLD-55

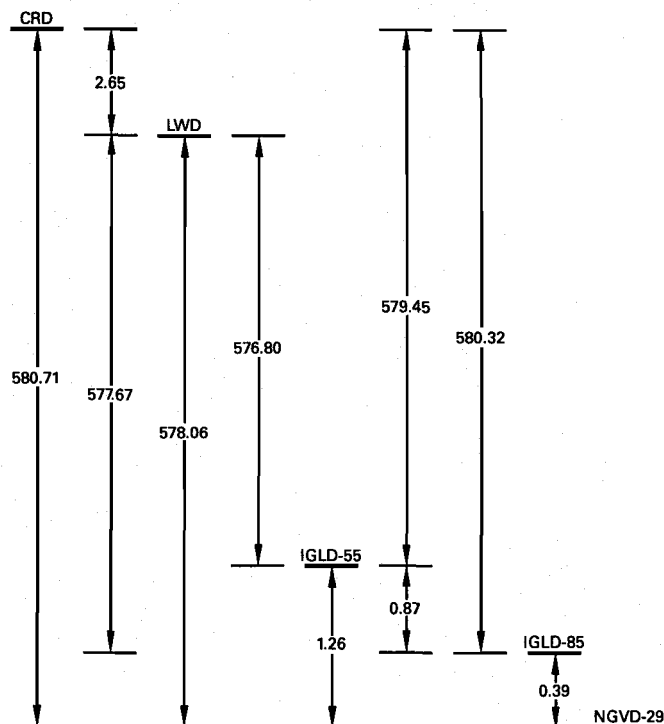
$$\begin{aligned} \text{IGLD-85} &= \text{NGVD-29} - 0.25 \\ \text{IGLD-85} &= \text{CPWD} + 576.76 \\ \text{IGLD-85} &= \text{LWD} + 577.73 \\ \text{IGLD-85} &= \text{IGLD-55} + 0.93 \end{aligned}$$

NGVD-29 REPRESENTS NATIONAL GEODETIC VERTICAL DATUM OF 1929.
CPWD REPRESENTS CITY OF PORT WASHINGTON DATUM.
LWD REPRESENTS LAKE MICHIGAN LOW WATER DATUM (CHART DATUM).
IGLD-55 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1955 ADJUSTMENT.
IGLD-85 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1985 ADJUSTMENT.

NOTE: BECAUSE THE NGVD-29 AND THE NAVD-88 ARE NOT PARALLEL SURFACES, METHODS FOR CONVERTING POSITIONS BETWEEN THE TWO DATUMS MUST DEPEND UPON COMPARATIVE MODELING. IT IS NOT, THEREFORE, POSSIBLE TO RELATE ELEVATIONS OF ONE DATUM EXACTLY TO ELEVATIONS OF THE OTHER DATUM BY USE OF AN AREAWIDE EQUATION.

Source: SEWRPC

**RELATIONSHIP AT RACINE,
WISCONSIN BETWEEN SELECTED VERTICAL
SURVEY CONTROL DATUM SURFACES**



COMPUTATION OF NGVD-29 GIVEN CRD, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{NGVD-29} &= \text{CRD} + 580.71 \\ \text{NGVD-29} &= \text{LWD} + 578.06 \\ \text{NGVD-29} &= \text{IGLD-55} + 1.26 \\ \text{NGVD-29} &= \text{IGLD-85} + 0.39 \end{aligned}$$

COMPUTATION OF CRD GIVEN NGVD-29, LWD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{CRD} &= \text{NGVD-29} - 580.71 \\ \text{CRD} &= \text{LWD} - 2.65 \\ \text{CRD} &= \text{IGLD-55} - 579.45 \\ \text{CRD} &= \text{IGLD-85} - 580.32 \end{aligned}$$

COMPUTATION OF LWD GIVEN NGVD-29, CRD, IGLD-55, OR IGLD-85

$$\begin{aligned} \text{LWD} &= \text{NGVD-29} - 578.06 \\ \text{LWD} &= \text{CRD} + 2.65 \\ \text{LWD} &= \text{IGLD-55} - 576.80 \\ \text{LWD} &= \text{IGLD-85} - 577.67 \end{aligned}$$

COMPUTATION OF IGLD-55 GIVEN NGVD-29, CRD, LWD, OR IGLD-85

$$\begin{aligned} \text{IGLD-55} &= \text{NGVD-29} - 1.26 \\ \text{IGLD-55} &= \text{CRD} + 579.45 \\ \text{IGLD-55} &= \text{LWD} + 576.80 \\ \text{IGLD-55} &= \text{IGLD-85} - 0.87 \end{aligned}$$

COMPUTATION OF IGLD-85 GIVEN NGVD-29, CRD, LWD, OR IGLD-55

$$\begin{aligned} \text{IGLD-85} &= \text{NGVD-29} - 0.39 \\ \text{IGLD-85} &= \text{CRD} + 580.32 \\ \text{IGLD-85} &= \text{LWD} + 577.67 \\ \text{IGLD-85} &= \text{IGLD-55} + 0.87 \end{aligned}$$

NGVD-29 REPRESENTS NATIONAL GEODETIC VERTICAL DATUM OF 1929.
CRD REPRESENTS CITY OF RACINE DATUM.
LWD REPRESENTS LAKE MICHIGAN LOW WATER DATUM (CHART DATUM).
IGLD-55 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1955 ADJUSTMENT.
IGLD-85 REPRESENTS INTERNATIONAL GREAT LAKES DATUM, 1985 ADJUSTMENT.

NOTE: BECAUSE THE NGVD-29 AND THE NAVD-88 ARE NOT PARALLEL SURFACES, METHODS FOR CONVERTING POSITIONS BETWEEN THE TWO DATUMS MUST DEPEND UPON COMPARATIVE MODELING. IT IS NOT, THEREFORE, POSSIBLE TO RELATE ELEVATIONS OF ONE DATUM EXACTLY TO ELEVATIONS OF THE OTHER DATUM BY USE OF AN AREAWIDE EQUATION.

Source: SEWRPC

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APPENDICES

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Appendix A

DETAILED SPECIFICATIONS FOR AERIAL PHOTOGRAPHY, MONUMENTATION, CONTROL SURVEYS, AND TOPOGRAPHIC MAPPING

Appendix A-1

DETAILED SPECIFICATIONS FOR AERIAL PHOTOGRAPHY, MONUMENTATION, CONTROL SURVEYS, AND ONE INCH EQUALS 100 FEET SCALE TRADITIONAL TOPOGRAPHIC MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for photogrammetric mapping services, including aerial photography, topographic mapping, and accompanying control surveys and control survey monumentation. The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. PHOTOGRAPHY

A. General

The Engineer shall perform the necessary flying and photography to provide photographic coverage of an area approximately _____ square miles in extent shown on the sketch map attached hereto as Exhibit "A." The Engineer may sublet this phase of the work to a qualified and experienced firm specializing in aerial photography. The _____, however, retains the right to approve or reject any or all such firms which the Engineer may wish to engage.

B. Scale

The flight height above the average elevation of the ground shall be such that the negatives will have an average scale of one inch equals five hundred feet (1" = 500'). Negatives having a departure from the specified scale by more than 5 percent because of tilt or abrupt changes in flying altitude may be rejected. The photography shall be suitable for compilation of the topographic maps specified herein, and the mapping flight height shall not vary from 3,000 feet above mean terrain by more than 5 percent.

C. Overlap

The overlap shall be sufficient to provide full stereoscopic coverage of the area to be mapped. The endlap shall average 63 percent plus or minus 5 percent. Endlap of less than 58 percent or more than 68 percent in one or more negatives shall be cause for rejection of the negatives in which such deficiency or excess occurs unless, within a stereoscopic pair, endlap exceeding 68 percent is necessary in areas of low ground elevation to attain the minimum 58 percent endlap in adjacent areas of high ground elevation. Wherever there is a change in direction of the flight lines, vertical photography on the beginning of a forward section shall endlap the photography of a back section by 100 percent. Any negatives having sidelap of less than 20 percent or more than 55 percent may be rejected.

D. Tilt

Negatives made with the optical axis of the aerial camera in a vertical position are desired. Tilt of any negative by more than three degrees, an average tilt of more than one degree for the entire project, or tilt between any two successive negatives exceeding four degrees may be cause for rejection.

E. Crab

Crab in excess of three degrees may be cause for rejection of the flight line of negatives or portions thereof in which such crab occurs.

F. Quality

The photographs shall be clear and sharp in detail and of average uniform density. They shall be free from clouds, cloud shadows, light streaks, static marks, or other blemishes which would interfere with their intended use. Except upon prior written authorization to the contrary by the _____, all photography shall be taken when the area to be mapped is free of snow, before foliation, and at such time as to ensure a minimum solar angle of 30 degrees.

G. Camera

For topographic and contour mapping, photography shall be exposed with a distortion-free six-inch focal length precision aerial mapping camera equipped with a between-the-lens element shutter to produce negatives nine inches by nine inches in size. The Engineer shall furnish the _____ with a precision camera calibration report prepared by the National Bureau of Standards for the camera to be used.

H. Contact Prints

The contact prints from the vertical negatives shall be printed on double-weight semi-matte paper of suitable contrast.

I. Photo Index

Photo indices shall be prepared by directly photographing on safety base film at a convenient scale the assembly of contact prints from all indexed and evaluated prints used. One photo index map reproduced on cronopaque or other approved dimensionally stable base material shall be delivered to the _____. The photo index shall carry a suitable title, scale, and north point.

J. Delivery of Photography

One set of contact print photographs on double-weight semi-matte paper at a scale of one inch equals five hundred feet (1" = 500') shall be furnished the _____ upon completion of this contract.

K. Ownership of Negatives

All negatives shall become the property of the _____ and shall be delivered to the _____ upon completion of this contract.

III. CONTROL SURVEYS

A. General

The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the necessary horizontal and vertical control surveys and control survey monumentation as specified herein.

B. Horizontal Control

1. The horizontal control survey work shall include the recovery or relocation and monumentation of all U. S. Public Land Survey corners, including section and one-quarter-section corners, "centers" of sections, and meander corners, throughout and along the exterior of the approximately _____ square mile area to be mapped. These corners, totaling _____ in all, are indicated on the sketch map attached hereto as Exhibit "A." If the original U. S. Public Land Survey corners are not recoverable, the Engineer shall determine the status thereof under U. S. Public Land Office definitions and shall follow the prescribed procedures of that Office in their relocation. In any case, the original land survey corners and corners as aforementioned shall be monumented and witnessed as provided under Section III E herein.
2. All field work with respect to the location and relocation of all the aforementioned corners shall be based upon, and include the assembly of, all authoritative information, such as title documents, subdivision plats, private and public survey records, and existing monumentation and occupation, that may be useful in determining the actual location of the U. S. Public Land Survey lines and corners and all other corners, as well as the proper analysis of this information, to arrive at the best determination of the actual location of the said lines and corners. Proper performance in this regard depends largely upon a knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason, must be properly supervised by a competent and qualified registered land surveyor. The Engineer shall sublet this phase of the control survey work to a qualified and experienced land survey firm which regularly practices in the area to be mapped. The _____, however, retains the right to approve or reject any or all such local firms which the Engineer may wish to engage.
3. With regard to the location or relocation of the "center" of the section, that point which physical or other evidence indicates to be the "used or recognized center of the section" (occupied center) shall be located or relocated in accordance with paragraph 2 above and monumented as provided under Section III E 5 herein. When all sources of information have been explored and there is no evidence of an "occupied center," the Engineer, after approval by the _____, shall set and monument, in accordance with Section III E 5, the "true center" of the section. Such "true center" shall be that point at the intersection of straight lines joining opposite quarter corners.
4. The double corners along township lines shall be located or relocated and monumented in accordance with paragraphs 1 and 2 above; and the closing corners governing the location of the U. S. Public Land Survey lines in the northerly tier of one-quarter sections in Township _____ North, Range _____ East, shall be set on the straight lines connecting the section and one-quarter-section corners on the township line governing the location of the U. S. Public Land Survey lines in the southerly tier of one-quarter sections in Township _____ North, Range _____ East.
5. Having recovered or relocated and monumented all of the aforementioned corners in the approximately _____ square mile area specified, control survey traverses shall be run which utilize and incorporate all of the monumented corners as stations, to determine the coordinates of the said corners and the lengths and bearings of all the quarter-section lines. All coordinates shall be based upon the Wisconsin Coordinate System, South Zone (NAD-27); and sufficient survey connections shall be made to basic National Geodetic Survey (NGS) control stations of the NGS control network to permit the proper checks and adjustments to be made both in traverse lengths and bearings and in the coordinate values of the monumented U. S. Public Land Survey corners. Such ties shall originate and end at basic control stations for which closures are known and available or shall be run to make a closed and checked circuit. Upon prior approval of the _____, the Engineer may substitute other survey methods, such as triangulation, trilateration, or Global Positioning System Technology, for the above-specified traverses in order to determine the coordinates of the monumented corners and the lengths and bearings of all the quarter-section lines. Approval by the _____ of such substitute survey methods shall be based upon a review of detailed network layouts and procedures proposed to be followed by the Engineer.

The accuracy of the horizontal control surveys shall conform to the specifications for NGS third-order class I accuracy for traverse as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All field measurements shall be properly adjusted by NGS methods to provide closed traverses before traverse station coordinates are computed, the coordinates of the U. S. Public Land Survey corners are computed, and attendant lengths and bearings of the quarter-section lines are computed so as to form closed geometric figures for the quarter sections, and before the topographic mapping is undertaken.

Whenever the Engineer recovers and uses a NGS control survey station in the conduct of the control survey work he shall prepare a "Report on Condition of Survey Mark and Witness Marks" utilizing the standard form provided for this purpose by the NGS and forward the completed copy of the form to the NGS Washington Office, with a copy to the _____.

All supplemental control for photo mapping purposes shall be based upon the control net just described.

C. Vertical Control

The vertical control survey shall be based upon National Geodetic Vertical Datum, 1929 Adjustment, as established by the NGS, hereinafter referred to as "NGVD." Closed differential level circuits shall be run to establish permanent bench marks in the project area. All differential level circuits shall be of second-order class II accuracy as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All level circuits shall be properly adjusted for closure by NGS methods. Elevations shall be obtained for _____ monuments marking the U. S. Public Land Survey system corners throughout the area to be mapped, and these monuments shall serve as permanent bench marks. In addition, permanent reference bench marks shall be set along the differential level lines on such objects as bridge abutments and wing walls, headwalls of large culverts, water tables of large buildings, outcroppings of ledge rock, or any other stable objects which are unlikely to be displaced vertically. It is the intent of these specifications that one additional bench mark shall be established for, and tied horizontally to, each monumented U. S. Public Land Survey corner and shall be set so that the elevation of the corner monument may be readily verified from the additional permanent bench mark by a single differential level position. Supplementary vertical control for topographic mapping shall provide a minimum of four vertical control points in each stereoscopic model. The supplementary control points shall be established by field survey and shall be located at or near the four corners of the stereoscopic models used in topographic map preparation.

D. Control Survey Computation Data and Plats

The Engineer shall keep all field notes and office computations in a neat and orderly manner, clearly indexed, and open for inspection and checking during the course of the work. Upon completion and acceptance, the originals of all field notes and computations shall be furnished the _____ and shall become their property. The Engineer shall at all times before final acceptance of the work furnish instruments and assistance to a duly authorized agent of the _____ for such checking of field work and computations as may be deemed necessary by the _____.

1. The Engineer shall deliver to the _____ for final acceptance a diagram summarizing the control survey data. Exhibit "B" attached hereto illustrates the required form and content of this diagram. This diagram shall be prepared so as to cover six sets of six U. S. Public Land Survey sections within each Survey Township, the six sets covering Sections 1 through 3 and 10 through 12; 4 through 9; 13 through 15 and 22 through 24; 16 through 21; 25 through 27 and 34 through 36; and 28 through 33. The diagrams shall be prepared in

ink on dimensionally stable polyester base material having a minimum thickness of 0.004 inch and a working surface suitable for inking to a scale of one inch equals 1,200 feet (1" = 1,200'), and shall show correctly on its face:

- a. The exact grid length and bearing on the exterior boundaries of all the quarter sections. In addition, the ground level lengths of the exterior boundaries of all quarter sections, converted from National Geodetic Vertical Datum, shall be shown in distinctive lettering.
 - b. All corners established and monuments erected in the field in their proper positions and orientations. The material of which the monuments and bench marks are made shall be noted at the representation thereof or by legend.
 - c. The number of degrees, minutes, and seconds in the interior angles of all quarter sections.
 - d. The coordinates of all U. S. Public Land Survey corners surveyed.
 - e. The elevation of all U. S. Public Land Survey corners surveyed.
 - f. The section number, indicated at the center of each section.
 - g. All basic NGS control stations within, and adjacent to, the project area and to which the horizontal control surveys are tied, together with the coordinates of the NGS stations.
 - h. A north point based upon grid north. The angle between geodetic and grid north (theta angle) shall be shown and shall represent the value for the quarter section corner located at the center of each six-section sheet.
 - i. A combination factor, sea level and scale, for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the quarter section corner located at the center of each six-section sheet.
2. The Engineer shall provide for each secondary control station established (each U. S. Public Land Survey corner within the project area), for each traverse station established, and for each reference bench mark established which is not also a secondary control station, a dossier on 8 1/2-inch by 11-inch paper. Exhibit "C" attached hereto illustrates the required form and content for these dossiers. The following information shall be given for each station on the dossiers:
- a. Title giving the legal description of the corner by section, township, and range; or, for permanent reference bench marks which are not also secondary control stations and for traverse stations by assigned number and by the U. S. Public Land Survey quarter section, township, and range in which the bench mark or station is located.
 - b. A sketch showing the monumented control station in relation to the salient features of the immediate vicinity. Witness monuments set shall be shown together with their ties. A north point shall be properly located thereon. The names of adjoining streets, state trunk highways, and public lands shall be indicated. The bearing to an azimuth mark for the station shall be shown, together with a brief description of the azimuth mark.
 - c. The coordinates of each traverse station and each U. S. Public Land Survey corner and the bench mark elevation of the monument marking the corner and of the required reference bench mark referred to NGVD. For reference bench marks which are not also a secondary control station, only the bench mark elevation referred to NGVD need be given.
 - d. The angle between geodetic and grid north at the station (theta angle).
 - e. An affidavit by the land surveyor setting forth the classification assigned to the corner (existing, obliterated, or lost) during its recovery or relocation and the salient factors determining the location or relocation, with particular emphasis upon old monumentation and accessories thereto found and used in the relocation process.

E. Monumenting

The Engineer shall mark or monument each section and quarter-section corner surveyed as follows:

1. Where the corner falls within an existing surfaced traveled way, by drilling or cutting a neat hole in the pavement and setting a precast concrete monument in accordance with Exhibit "D."
2. Where the corner falls on an earth surface, by setting a precast concrete monument as shown in Exhibit "D."
3. Where the corner falls in a lake, stream, or inaccessible area, by setting a witness corner on the section or quarter-section line at a distance approved by the _____ away from the ordinary high water of the lake, the bank of the stream, or from an inaccessible area. Such witness corners shall be monumented by setting a precast concrete monument in accordance with Exhibit "D."
4. In all cases, the monuments erected shall be witnessed. Witness marks shall be selected for permanence and shall preferably consist of the corners of masonry or concrete structures or, of crosses cut in masonry or concrete structures, concrete curbs, walks, pavements, or bridge and culvert walls and structures. Railroad spikes set in trees and telephone or power poles may be acceptable, but where used in poles shall be set flush with the surface of the telephone or power poles and as low on the pole as practicable. In open fields, one-inch-diameter by 36-inch-long iron pipe may be used. At least four such witness marks shall be established for each corner and tied to the corner.
5. The monuments shall conform to the details shown in Exhibit "D" attached hereto. The brass caps of the monuments shall conform to the details shown in Exhibit "E" attached hereto and be stamped with the corner notation at the time of setting. The dies used to cast the brass caps shall become the property of the _____.
6. In addition to the foregoing, the Engineer shall establish one azimuth mark for each U. S. Public Land Survey section or quarter-section corner surveyed using wherever possible a well-defined, permanent, distant object of the landscape that can be clearly identified and described. Where it is not possible or practical to use such an object, a commercial survey monument of a design approved by the _____ may be substituted.

IV. TOPOGRAPHIC MAPS

A. General

The Engineer shall prepare topographic maps to National Map Accuracy Standards in the form of ink tracings of the original manuscripts on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. The area to be mapped, totaling _____ square miles, is shown on the sketch map attached hereto as Exhibit "A."

Base sheets suitable for the preparation of cadastral maps shall be provided. These sheets consist of reproducible tracings of the topographic map sheets showing all information required under Section IV B 2, 3, 4, 5, 6, 7, and 9 hereof, except pavements, curbs, walks, trails, fences, wooded areas, and other identifiable features.

B. Data to be Shown

The finished maps shall be drawn to a scale of one inch equals one hundred feet (1" = 100') and shall show correctly on each map face the following information:

1. Hypsography by contour lines having a vertical interval of two feet. All contours shall be drawn clear and sharp as continuous solid lines except through structures. Every fifth contour shall be accentuated and numbered. Elevations of saddles, kettles, summits, high points of all crests and low points of all sags in existing roadways, all existing road intersections, and all bridge decks at both ends of the bridge shall be shown as determined photogrammetrically, except where field elevations are available, to the nearest one-quarter contour interval. All contour lines and elevations shall be referred to National Geodetic Vertical Datum, 1929 Adjustment.
2. All planimetric details, such as pavements, curbs, walks, trails, railways, power lines, buildings, fences, wooded areas, and other identifiable features on the photography, shall be shown in their correct positions and orientation within the tolerances of these specifications.
3. All hydrographic features, such as marshes, lakes, streams, watercourses, and drainage ditches, shall be shown in their correct positions and orientation within the tolerances of these specifications.
4. All section and quarter-section lines and U. S. Public Land Survey corners established in the field surveys shall be shown in their correct position and orientation, together with their exact grid lengths and bearings. The material of which the monuments marking said corners are made shall be indicated by symbol and legend, together with the State Plane Coordinates and bench mark elevations of the corners.
5. A north point based upon grid north.
6. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located.
7. A base map projection consisting of the intersection of grid lines on the Wisconsin State Plane Coordinate System. Grid line intersection tick marks shall be drawn at five (5) inch intervals conforming to the even 500 foot interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
8. Such lettering as may be secured from available maps of the area or as may be furnished by the _____ relative to the names of salient geographic features. The names of all state and county trunk highways, public streets, and major streams and lakes shall be shown on the maps.
9. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.

C. Drafting

All drafting shall be to a high standard of workmanship. The map sheets shall be 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey quarter section. The title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. The topographic maps shall overlap the adjacent one-quarter sections by 50 feet beyond the section or one-quarter-section lines.

D. Precision and Accuracy Standards

1. The maps shall be prepared to National Map Accuracy Standards, and a certificate to this effect shall appear on the face of each map sheet.
2. Each grid line or tick shall be plotted on the finished map sheets within 1/100 of an inch of the true grid values.
3. Each horizontal control station, section corner, and quarter-section corner shall be plotted on the finished map sheets within 1/100 of an inch of the true position as expressed by the adjusted coordinates computed for the point.
4. Ninety percent of all well-defined planimetric features shall be plotted so that their position on the finished maps shall be accurate to within 1/30 of an inch of their true coordinate position, and no feature shall be more than 1/20 of an inch from its true position.
5. The contours shall faithfully express the relief detail and topographic forms within the tolerances of these specifications. Ninety percent of the elevations determined from the solid-line contours of the map shall have an accuracy with respect to true elevation of one-half contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one contour interval.
6. All spot elevations shown on the maps, other than elevations of vertical control stations, shall be shown to the nearest 0.5 foot. Ninety percent of all spot elevations shown on the maps shall have an accuracy with respect to true elevation of one-fourth contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one contour level.
7. The completed topographic maps shall be field checked by the _____. The Engineer shall furnish instruments and assistance to the _____ for such field checking. The field measurements shall be compared against the map data, and any map sheets that do not conform to National Map Accuracy Standards and the requirements of these specifications shall be corrected by the Engineer to fully meet the specified accuracy.

V. ITEMS TO BE DELIVERED

Upon completion the Engineer shall deliver to the _____ the following items:

- A. One set of reproducible original tracings on dimensionally stable polyester base material of the completed topographic maps of the project area as designated herein.
- B. One set of reproducible tracings on dimensionally stable polyester base material of the cadastral base sheets specified under Section IV A herein.
- C. One reproducible tracing of the control summary diagram specified under Section III D 1 herein.
- D. One set of reproducible tracings of the control station dossier sheets specified under Section III D 2 herein.
- E. One set of contact print aerial photographs specified under Section II J herein.
- F. One set of contact print aerial photographs with vertical and horizontal control identified thereon. These photos shall be printed as specified under Section II H herein.
- G. The original field notes and computations as specified under Section III D herein.
- H. One photo index as specified under Section II herein.
- I. The original aerial photograph negatives specified under Section II K herein.
- J. The patterns used to cast the brass caps for the survey monuments.

VI. DELIVERY DATES

- A. Photography
All photography shall be completed in the spring of _____. The contact prints and photo indices shall be delivered within 30 days after the completion of photography.
- B. Topographic Maps
All topographic maps and cadastral base sheets shall be delivered on or before _____.
- C. Control Survey Data
All control survey data shall be delivered on or before _____.

VII. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all photogrammetric and control survey engineering services necessary for the delivery of the complete, finished photography, control surveys and monumentation, and maps and all other materials and items specified herein. This total contract price shall consist of the lump sum prices listed below for integral portions of the work:

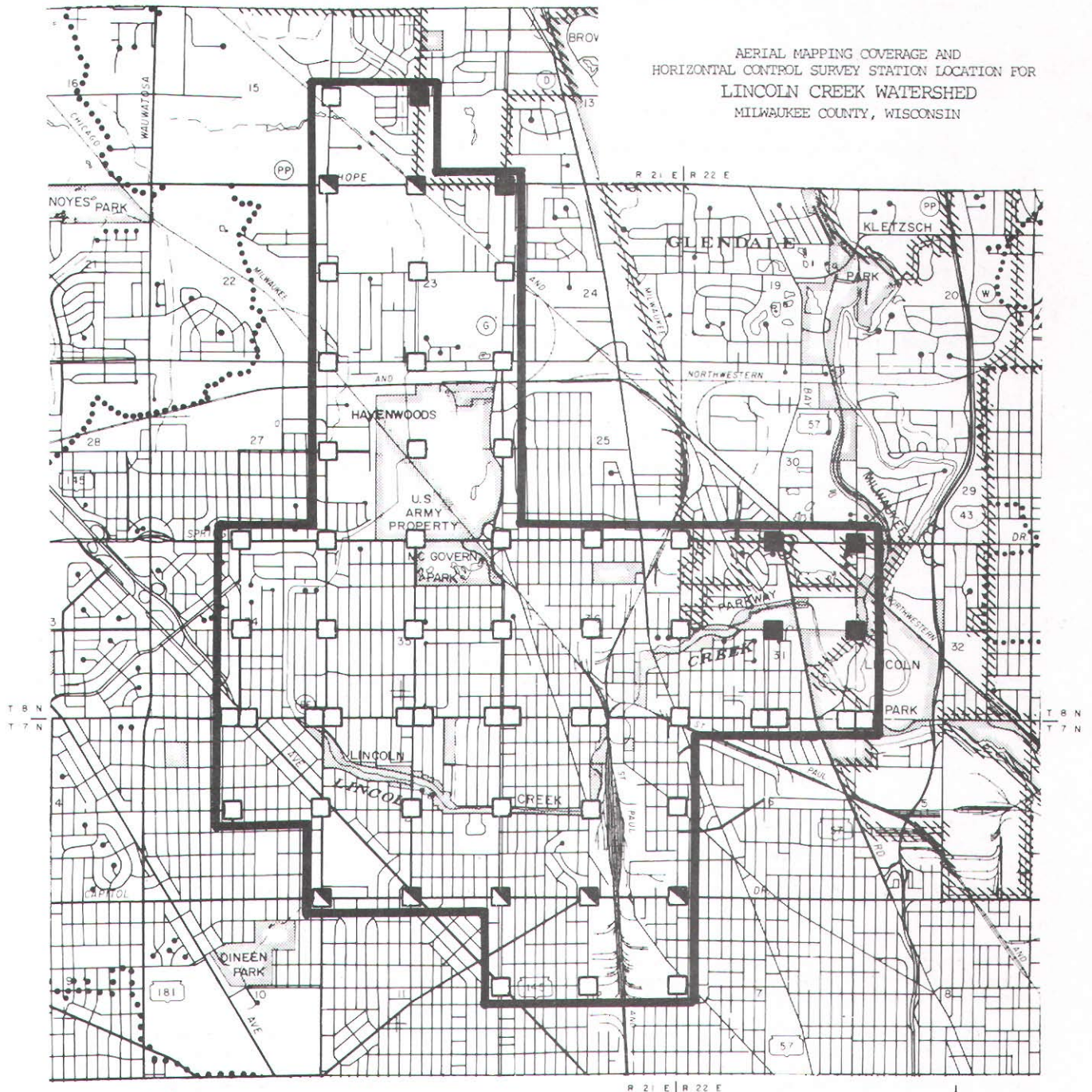
A. Aerial photography of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
B. Location, relocation and monumentation of _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
C. Vertical control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
D. Horizontal control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
E. Topographic mapping and cadastral base sheets of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
Total	\$ _____

The foregoing unit prices are provided solely as a basis for computing any adjustment in the total cost of the contract that may have to be made due to any changes in the scope of the work ordered in writing by the _____ during the conduct of the project, and as a basis for computing work progress payments to the Engineer under the project.



It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Engineer must submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.


Exhibit A


SAMPLE MAP SHOWING AERIAL MAPPING COVERAGE AND HORIZONTAL CONTROL SURVEY STATION LOCATION



LEGEND

-  U.S. Public Land Survey corners which have been previously relocated, monumented, and tied into both horizontal and vertical survey control networks.
-  U.S. Public Land Survey corners which are to be relocated, monumented, and tied into both horizontal and vertical survey control networks.

-  U.S. Public Land Survey corners which have been previously relocated and monumented but which are to be referenced and tied into both horizontal and vertical survey control networks.

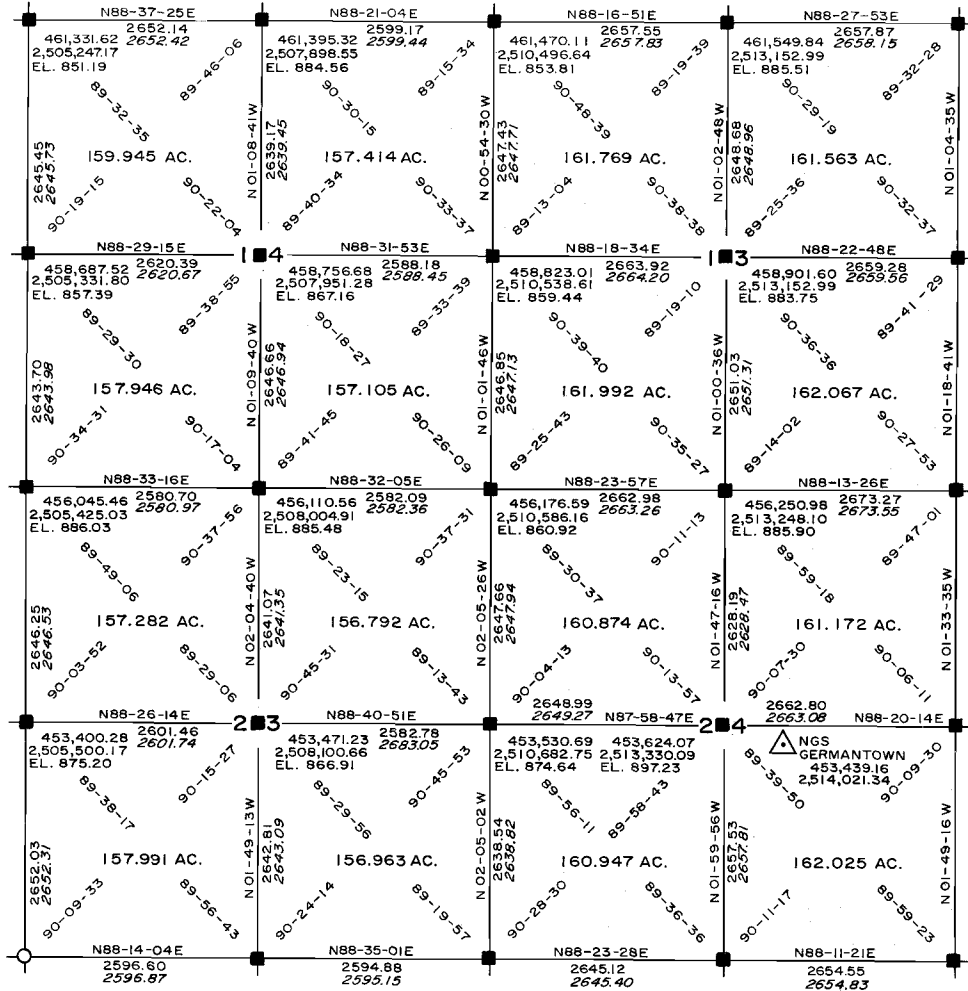
 Area for which aerial photography coverage is to be provided and throughout which new 1" = 100' scale, 2' contour interval, topographic maps are to be prepared.

Drawn by: L.H.K.
Approved by: K.W.B.
Date: October 15, 1985

1" = 4000'

Exhibit B

SAMPLE SHEET SHOWING PORTION OF REQUIRED HORIZONTAL AND VERTICAL CONTROL SURVEY DATA SUMMARY SHEET



DRAWN BY: L.H.K.
CHECKED BY: D.R.B.

NOT TO SCALE

APPROVED BY: K.W.B.
DATE: NOVEMBER 1967

Exhibit C

RECORD OF CONTROL SURVEY STATION FORM

RECORD OF U.S. PUBLIC LAND SURVEY CONTROL STATION

U.S. PUBLIC LAND SURVEY CORNER $\frac{1}{4}$ T. N. R. E. COUNTY, WIS.

GEODETIK SURVEY BY: YEAR:

STATE PLANE COORDINATES OF:
NORTH
EAST

ELEVATION OF STATION:

HORIZONTAL DATUM: WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE

VERTICAL DATUM: NATIONAL GEODETIK VERTICAL DATUM OF 1929

CONTROL ACCURACY: THETA ANGLE:

HORIZONTAL: VERTICAL:

LOCATION SKETCH:



SURVEYOR'S AFFIDAVIT:

STATE OF WISCONSIN) SS
COUNTY)

I HEREBY CERTIFY THAT

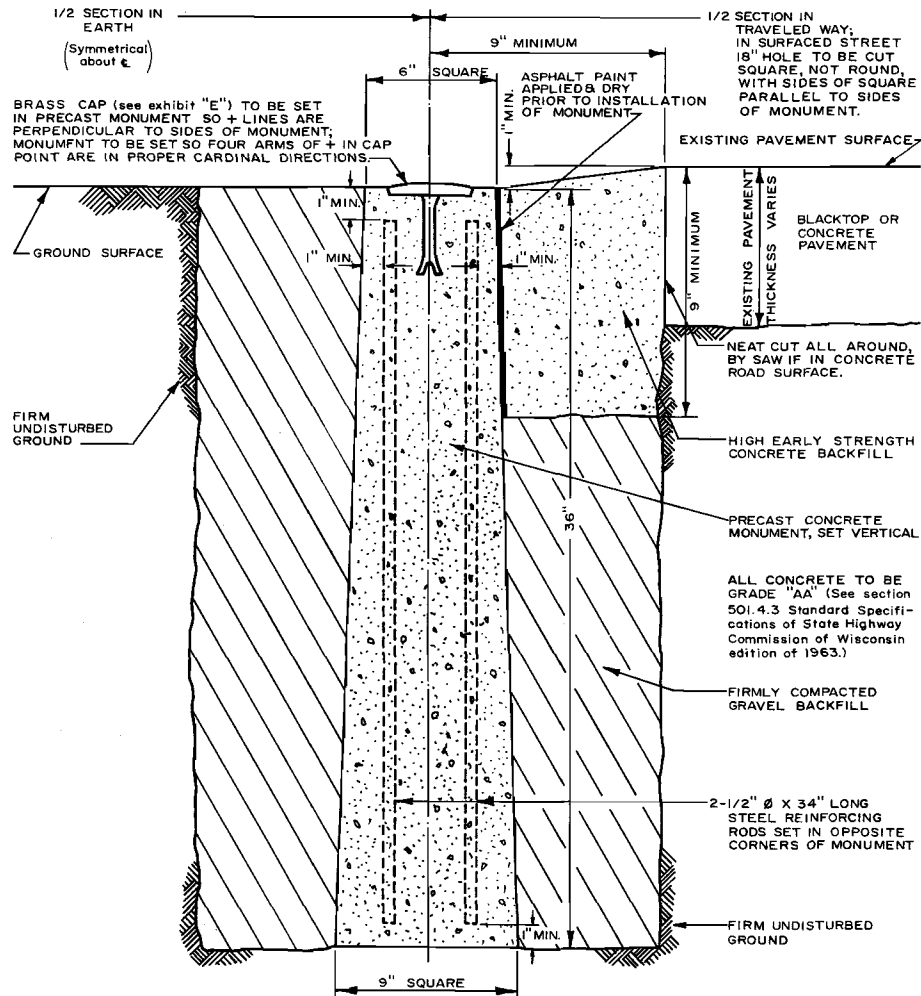
DATE OF SURVEY: S -

REGISTERED LAND SURVEYOR

FORM PREPARED BY SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Exhibit D

DETAIL OF MONUMENT AND MONUMENT INSTALLATION FOR SURVEY CONTROL STATIONS



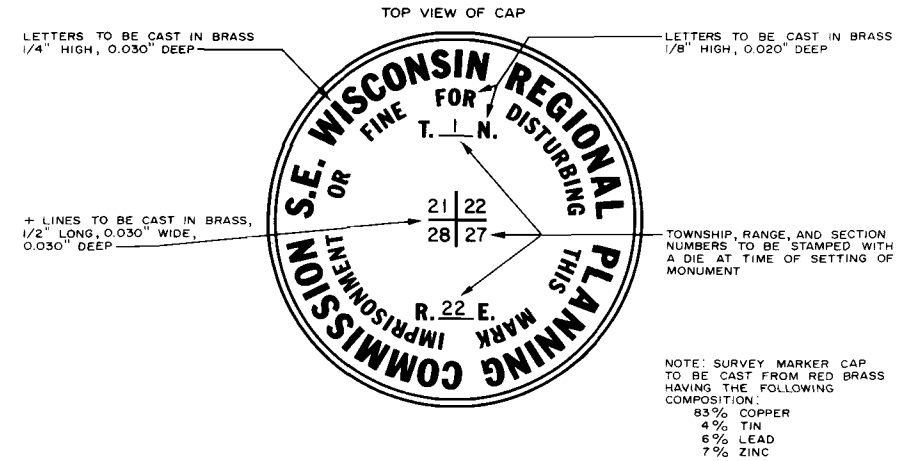
DRAWN BY: L.H.K.
CHECKED BY: D.R.B.

NOT TO SCALE

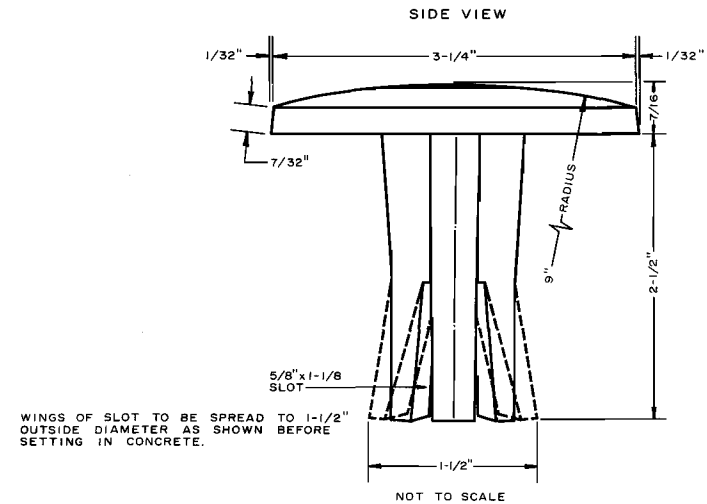
APPROVED BY: K.W.B.
DATE: NOVEMBER 1967

Exhibit E

DETAIL OF BRASS SURVEY MARKER FOR SURVEY CONTROL STATION MONUMENTS



DRAWN BY: D.P.S.
CHECKED BY: L.H.K.
APPROVED BY: K.W.B.
DATE: FEB. 22, 1986



Source: SEWRPC.

Source: SEWRPC.

Appendix A-2

DETAILED SPECIFICATIONS FOR AERIAL PHOTOGRAPHY, MONUMENTATION, CONTROL SURVEYS, AND ONE INCH EQUALS 200 FEET SCALE TRADITIONAL TOPOGRAPHIC MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for photogrammetric mapping services, including aerial photography, topographic mapping, and accompanying control surveys and control survey monumentation. The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. PHOTOGRAPHY

A. General

The Engineer shall perform the necessary flying and photography to provide photographic coverage of an area approximately _____ square miles in extent shown on the sketch map attached hereto as Exhibit "A." The Engineer may sublet this phase of the work to a qualified and experienced firm specializing in aerial photography. The _____, however, retains the right to approve or reject any or all such firms which the Engineer may wish to engage.

B. Scale

The flight height above the average elevation of the ground shall be such that the negatives will have an average scale of one inch equals eight hundred feet (1" = 800'). Negatives having a departure from the specified scale by more than 5 percent because of tilt or abrupt changes in flying altitude may be rejected. The photography shall be suitable for compilation of the topographic maps specified herein, and the mapping flight height shall not vary from 4,800 feet above mean terrain by more than 5 percent.

C. Overlap

The overlap shall be sufficient to provide full stereoscopic coverage of the area to be mapped. The endlap shall average 63 percent plus or minus 5 percent. Endlap of less than 58 percent or more than 68 percent in one or more negatives shall be cause for rejection of the negatives in which such deficiency or excess occurs unless, within a stereoscopic pair, endlap exceeding 68 percent is necessary in areas of low ground elevation to attain the minimum 58 percent endlap in adjacent areas of high ground elevation. Wherever there is a change in direction of the flight lines, vertical photography on the beginning of a forward section shall endlap the photography of a back section by 100 percent. Any negatives having sidelap of less than 20 percent or more than 55 percent may be rejected.

D. Tilt

Negatives made with the optical axis of the aerial camera in a vertical position are desired. Tilt of any negative by more than three degrees, an average tilt of more than one degree for the entire project, or tilt between any two successive negatives exceeding four degrees may be cause for rejection.

E. Crab

Crab in excess of three degrees may be cause for rejection of the flight line of negatives or portions thereof in which such crab occurs.

F. Quality

The photographs shall be clear and sharp in detail and of average uniform density. They shall be free from clouds, cloud shadows, light streaks, static marks, or other blemishes which would interfere with their intended use. Except upon prior written authorization to the contrary by the _____, all photography shall be taken when the area to be mapped is free of snow, before foliation, and at such time as to ensure a minimum solar angle of 30 degrees.

G. Camera

For topographic and contour mapping, photography shall be exposed with a distortion-free six-inch focal length precision aerial mapping camera equipped with a between-the-lens element shutter to produce negatives nine inches by nine inches in size. The Engineer shall furnish the _____ with a precision camera calibration report prepared by the National Bureau of Standards for the camera to be used.

H. Contact Prints

The contact prints from the vertical negatives shall be printed on double-weight semi-matte paper of suitable contrast.

I. Photo Index

Photo indices shall be prepared by directly photographing on safety base film at a convenient scale the assembly of contact prints from all indexed and evaluated prints used. One photo index map reproduced on cronopaque or other approved dimensionally stable base material shall be delivered to the _____. The photo index shall carry a suitable title, scale, and north point.

J. Delivery of Photography

One set of contact print photographs on double-weight semi-matte paper at a scale of one inch equals five hundred feet (1" = 500') shall be furnished the _____ upon completion of this contract.

K. Ownership of Negatives

All negatives shall become the property of the _____ and shall be delivered to the _____ upon completion of this contract.

III. CONTROL SURVEYS

A. General

The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the necessary horizontal and vertical control surveys and control survey monumentation as specified herein.

B. Horizontal Control

1. The horizontal control survey work shall include the recovery or relocation and monumentation of all U. S. Public Land Survey corners, including section and one-quarter-section corners, "centers" of sections, and meander corners, throughout and along the exterior of the approximately _____ square mile area to be mapped. These corners, totaling _____ in all, are indicated on the sketch map attached hereto as Exhibit "A." If the original U. S. Public Land Survey corners are not recoverable, the Engineer shall determine the status

thereof under U. S. Public Land Office definitions and shall follow the prescribed procedures of that Office in their relocation. In any case, the original land survey corners and corners as aforementioned shall be monumented and witnessed as provided under Section III E herein.

2. All field work with respect to the location and relocation of all the aforementioned corners shall be based upon, and include the assembly of, all authoritative information, such as title documents, subdivision plats, private and public survey records, and existing monumentation and occupation, that may be useful in determining the actual location of the U. S. Public Land Survey lines and corners and all other corners, as well as the proper analysis of this information, to arrive at the best determination of the actual location of the said lines and corners. Proper performance in this regard depends largely upon a knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason, must be properly supervised by a competent and qualified registered land surveyor. The Engineer shall sublet this phase of the control survey work to a qualified and experienced land survey firm which regularly practices in the area to be mapped. The _____, however, retains the right to approve or reject any or all such local firms which the Engineer may wish to engage.
3. With regard to the location or relocation of the "center" of the section, that point which physical or other evidence indicates to be the "used or recognized center of the section" (occupied center) shall be located or relocated in accordance with paragraph 2 above and monumented as provided under Section III E 5 herein. When all sources of information have been explored and there is no evidence of an "occupied center," the Engineer, after approval by the _____, shall set and monument, in accordance with Section III E 5, the "true center" of the section. Such "true center" shall be that point at the intersection of straight lines joining opposite quarter corners.
4. The double corners along township lines shall be located or relocated and monumented in accordance with paragraphs 1 and 2 above; and the closing corners governing the location of the U. S. Public Land Survey lines in the northerly tier of one-quarter sections in Township ____ North, Range ____ East, shall be set on the straight lines connecting the section and one-quarter-section corners on the township line governing the location of the U. S. Public Land Survey lines in the southerly tier of one-quarter sections in Township ____ North, Range ____ East.
5. Having recovered or relocated and monumented all of the aforementioned corners in the approximately ____ square mile area specified, control survey traverses shall be run which utilize and incorporate all of the monumented corners as stations, to determine the coordinates of the said corners and the lengths and bearings of all the quarter-section lines. All coordinates shall be based upon the Wisconsin Coordinate System, South Zone (NAD-27); and sufficient survey connections shall be made to basic National Geodetic Survey (NGS) control stations of the NGS control network to permit the proper checks and adjustments to be made both in traverse lengths and bearings and in the coordinate values of the monumented U. S. Public Land Survey corners. Such ties shall originate and end at basic control stations for which closures are known and available or shall be run to make a closed and checked circuit. Upon prior approval of the _____, the Engineer may substitute other survey methods, such as triangulation, trilateration, or Global Positioning System Technology, for the above-specified traverses in order to determine the coordinates of the monumented corners and the lengths and bearings of all the quarter-section lines. Approval by the _____ of such substitute survey methods shall be based upon a review of detailed network layouts and procedures proposed to be followed by the Engineer.

The accuracy of the horizontal control surveys shall conform to the specifications for NGS third-order class I accuracy for traverse as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All field measurements shall be properly adjusted by NGS methods to provide closed traverses before traverse station coordinates are computed, the coordinates of the U. S. Public Land Survey corners are computed, and attendant lengths and bearings of the quarter-section lines are computed so as to form closed geometric figures for the quarter sections, and before the topographic mapping is undertaken.

Whenever the Engineer recovers and uses a NGS control survey station in the conduct of the control survey work he shall prepare a "Report on Condition of Survey Mark and Witness Marks" utilizing the standard form provided for this purpose by the NGS and forward the completed copy of the form to the NGS Washington Office, with a copy to the _____.

All supplemental control for photo mapping purposes shall be based upon the control net just described.

C. Vertical Control

The vertical control survey shall be based upon National Geodetic Vertical Datum, 1929 Adjustment, as established by the NGS, hereinafter referred to as "NGVD." Closed differential level circuits shall be run to establish permanent bench marks in the project area. All differential level circuits shall be of second-order class II accuracy as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All level circuits shall be properly adjusted for closure by NGS methods. Elevations shall be obtained for ____ monuments marking the U. S. Public Land Survey system corners throughout the area to be mapped, and these monuments shall serve as permanent bench marks. In addition, permanent reference bench marks shall be set along the differential level lines on such objects as bridge abutments and wing walls, headwalls of large culverts, water tables of large buildings, outcroppings of ledge rock, or any other stable objects which are unlikely to be displaced vertically. It is the intent of these specifications that one additional bench mark shall be established for, and tied horizontally to, each monumented U. S. Public Land Survey corner and shall be set so that the elevation of the corner monument may be readily verified from the additional permanent bench mark by a single differential level position. Supplementary vertical control for topographic mapping shall provide a minimum of four vertical control points in each stereoscopic model. The supplementary control points shall be established by field survey and shall be located at or near the four corners of the stereoscopic models used in topographic map preparation.

D. Control Survey Computation Data and Plats

The Engineer shall keep all field notes and office computations in a neat and orderly manner, clearly indexed, and open for inspection and checking during the course of the work. Upon completion and acceptance, the originals of all field notes and computations shall be furnished the _____ and shall become their property. The Engineer shall at all times before final acceptance of the work furnish instruments and assistance to a duly authorized agent of the _____ for such checking of field work and computations as may be deemed necessary by the _____.

1. The Engineer shall deliver to the _____ for final acceptance a diagram summarizing the control survey data. Exhibit "B" attached hereto illustrates the required form and content of this diagram. This diagram shall be prepared so as to cover six sets of six U. S. Public Land Survey sections within each Survey Township, the six sets covering Sections 1 through 3 and 10 through 12; 4 through 9; 13 through 15 and 22 through 24; 16 through 21; 25 through 27 and 34 through 36; and 28 through 33. The diagrams shall be prepared in ink on dimensionally stable polyester base material having a minimum thickness of 0.004 inch and a working surface suitable for inking to a scale of one inch equals 1,200 feet (1" = 1,200'), and shall show correctly on its face:
 - a. The exact grid length and bearing on the exterior boundaries of all the quarter sections. In addition, the ground level lengths of the exterior boundaries of all quarter sections, converted from National Geodetic Vertical Datum, shall be shown in distinctive lettering.

- b. All corners established and monuments erected in the field in their proper positions and orientations. The material of which the monuments and bench marks are made shall be noted at the representation thereof or by legend.
 - c. The number of degrees, minutes, and seconds in the interior angles of all quarter sections.
 - d. The coordinates of all U. S. Public Land Survey corners surveyed.
 - e. The elevation of all U. S. Public Land Survey corners surveyed.
 - f. The section number, indicated at the center of each section.
 - g. All basic NGS control stations within, and adjacent to, the project area and to which the horizontal control surveys are tied, together with the coordinates of the NGS stations.
 - h. A north point based upon grid north. The angle between geodetic and grid north (theta angle) shall be shown and shall represent the value for the quarter section corner located at the center of each six-section sheet.
 - i. A combination factor, sea level and scale, for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the quarter section corner located at the center of each six-section sheet.
2. The Engineer shall provide for each secondary control station established (each U. S. Public Land Survey corner within the project area), for each traverse station established, and for each reference bench mark established which is not also a secondary control station, a dossier on 8 1/4-inch by 11-inch paper. Exhibit "C" attached hereto illustrates the required form and content for these dossiers. The following information shall be given for each station on the dossiers:
- a. Title giving the legal description of the corner by section, township, and range; or, for permanent reference bench marks which are not also secondary control stations and for traverse stations by assigned number and by the U. S. Public Land Survey quarter section, township, and range in which the bench mark or station is located.
 - b. A sketch showing the monumented control station in relation to the salient features of the immediate vicinity. Witness monuments set shall be shown together with their ties. A north point shall be properly located thereon. The names of adjoining streets, state trunk highways, and public lands shall be indicated. The bearing to an azimuth mark for the station shall be shown, together with a brief description of the azimuth mark.
 - c. The coordinates of each traverse station and each U. S. Public Land Survey corner and the bench mark elevation of the monument marking the corner and of the required reference bench mark referred to NGVD. For reference bench marks which are not also a secondary control station, only the bench mark elevation referred to NGVD need be given.
 - d. The angle between geodetic and grid north at the station (theta angle).
 - e. An affidavit by the land surveyor setting forth the classification assigned to the corner (existing, obliterated, or lost) during its recovery or relocation and the salient factors determining the location or relocation, with particular emphasis upon old monumentation and accessories thereto found and used in the relocation process.

E. Monumenting

The Engineer shall mark or monument each section and quarter-section corner surveyed as follows:

- 1. Where the corner falls within an existing surfaced traveled way, by drilling or cutting a neat hole in the pavement and setting a precast concrete monument in accordance with Exhibit "D."
- 2. Where the corner falls on an earth surface, by setting a precast concrete monument as shown in Exhibit "D."
- 3. Where the corner falls in a lake, stream, or inaccessible area, by setting a witness corner on the section or quarter-section line at a distance approved by the _____ away from the ordinary high water of the lake, the bank of the stream, or from an inaccessible area. Such witness corners shall be monumented by setting a precast concrete monument in accordance with Exhibit "D."
- 4. In all cases, the monuments erected shall be witnessed. Witness marks shall be selected for permanence and shall preferably consist of the corners of masonry or concrete structures or, of crosses cut in masonry or concrete structures, concrete curbs, walks, pavements, or bridge and culvert walls and structures. Railroad spikes set in trees and telephone or power poles may be acceptable, but where used in poles shall be set flush with the surface of the telephone or power poles and as low on the pole as practicable. In open fields, one-inch-diameter by 36-inch-long iron pipe may be used. At least four such witness marks shall be established for each corner and tied to the corner.
- 5. The monuments shall conform to the details shown in Exhibit "D" attached hereto. The brass caps of the monuments shall conform to the details shown in Exhibit "E" attached hereto and be stamped with the corner notation at the time of setting. The dies used to cast the brass caps shall become the property of the _____.
- 6. In addition to the foregoing, the Engineer shall establish one azimuth mark for each U. S. Public Land Survey section or quarter-section corner surveyed using wherever possible a well-defined, permanent, distant object of the landscape that can be clearly identified and described. Where it is not possible or practical to use such an object, a commercial survey monument of a design approved by the _____ may be substituted.

IV. TOPOGRAPHIC MAPS

A. General

The Engineer shall prepare topographic maps to National Map Accuracy Standards in the form of ink tracings of the original manuscripts on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. The area to be mapped, totaling _____ square miles, is shown on the sketch map attached hereto as Exhibit "A."

Base sheets suitable for the preparation of cadastral maps shall be provided. These sheets consist of reproducible tracings of the topographic map sheets showing all information required under Section IV B 2, 3, 4, 5, 6, 7, and 9 hereof, except pavements, curbs, trails, fences, wooded areas, and other identifiable features.

B. Data to be Shown

The finished maps shall be drawn to a scale of one inch equals one hundred feet (1" = 100') and shall show correctly on each map face the following information:

1. Hypsography by contour lines having a vertical interval of two feet. All contours shall be drawn clear and sharp as continuous solid lines except through structures. Every fifth contour shall be accentuated and numbered. Elevations of saddles, kettles, summits, high points of all crests and low points of all sags in existing roadways, all existing road intersections, and all bridge decks at both ends of the bridge shall be shown as determined photogrammetrically, except where field elevations are available, to the nearest one-quarter contour interval. All contour lines and elevations shall be referred to National Geodetic Vertical Datum, 1929 Adjustment.
2. All planimetric details, such as pavements, curbs, trails, railways, power lines, buildings, fences, wooded areas, and other identifiable features on the photography, shall be shown in their correct positions and orientation within the tolerances of these specifications.
3. All hydrographic features, such as marshes, lakes, streams, watercourses, and drainage ditches, shall be shown in their correct positions and orientation within the tolerances of these specifications.
4. All section and quarter-section lines and U. S. Public Land Survey corners established in the field surveys shall be shown in their correct position and orientation, together with their exact grid lengths and bearings. The material of which the monuments marking said corners are made shall be indicated by symbol and legend, together with the State Plane Coordinates and bench mark elevations of the corners.
5. A north point based upon grid north.
6. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located.
7. A base map projection consisting of the intersection of grid lines on the Wisconsin State Plane Coordinate System. Grid line intersection tick marks shall be drawn at five (5) inch intervals conforming to the even 500 feet interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
8. Such lettering as may be secured from available maps of the area or as may be furnished by the _____ relative to the names of salient geographic features. The names of all state and county trunk highways, public streets, and major streams and lakes shall be shown on the maps.
9. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.

C. Drafting

All drafting shall be to a high standard of workmanship. The map sheets shall be 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey section. The title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. The topographic maps shall overlap the adjacent sections by 100 feet beyond the section lines.

D. Precision and Accuracy Standards

1. The maps shall be prepared to National Map Accuracy Standards, and a certificate to this effect shall appear on the face of each map sheet.
2. Each grid line or tick shall be plotted on the finished map sheets within 1/100 of an inch of the true grid values.
3. Each horizontal control station, section corner, and quarter-section corner shall be plotted on the finished map sheets within 1/100 of an inch of the true position as expressed by the adjusted coordinates computed for the point.
4. Ninety percent of all well-defined planimetric features shall be plotted so that their position on the finished maps shall be accurate to within 1/30 of an inch of their true coordinate position, and no feature shall be more than 1/20 of an inch from its true position.
5. The contours shall faithfully express the relief detail and topographic forms within the tolerances of these specifications. Ninety percent of the elevations determined from the solid-line contours of the map shall have an accuracy with respect to true elevation of one-half contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one contour interval.
6. All spot elevations shown on the maps, other than elevations of vertical control stations, shall be shown to the nearest 0.5 foot. Ninety percent of all spot elevations shown on the maps shall have an accuracy with respect to true elevation of one-fourth contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one contour level.
7. The completed topographic maps shall be field checked by the _____. The Engineer shall furnish instruments and assistance to the _____ for such field checking. The field measurements shall be compared against the map data, and any map sheets that do not conform to National Map Accuracy Standards and the requirements of these specifications shall be corrected by the Engineer to fully meet the specified accuracy.

V. ITEMS TO BE DELIVERED

Upon completion the Engineer shall deliver to the _____ the following items:

- A. One set of reproducible original tracings on dimensionally stable polyester base material of the completed topographic maps of the project area as designated herein.
- B. One set of reproducible tracings on dimensionally stable polyester base material of the cadastral base sheets specified under Section IV A herein.
- C. One reproducible tracing of the control summary diagram specified under Section III D 1 herein.

- D. One set of reproducible tracings of the control station dossier sheets specified under Section III D 2 herein.
- E. One set of contact print aerial photographs specified under Section II J herein.
- F. One set of contact print aerial photographs with vertical and horizontal control identified thereon. These photos shall be printed as specified under Section II H herein.
- G. The original field notes and computations as specified under Section III D herein.
- H. One photo index as specified under Section II herein.
- I. The original aerial photograph negatives specified under Section II K herein.
- J. The patterns used to cast the brass caps for the survey monuments.

VI. DELIVERY DATES

- A. Photography
All photography shall be completed in the spring of _____. The contact prints and photo indices shall be delivered within 30 days after the completion of photography.
- B. Topographic Maps
All topographic maps and cadastral base sheets shall be delivered on or before _____.
- C. Control Survey Data
All control survey data shall be delivered on or before _____.

VII. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all photogrammetric and control survey engineering services necessary for the delivery of the complete, finished photography, control surveys and monumentation, and maps and all other materials and items specified herein. This total contract price shall consist of the lump sum prices listed below for integral portions of the work:

A. Aerial photography of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
B. Location, relocation and monumentation of _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
C. Vertical control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
D. Horizontal control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
E. Topographic mapping and cadastral base sheets of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
Total	\$ _____

The foregoing unit prices are provided solely as a basis for computing any adjustment in the total cost of the contract that may have to be made due to any changes in the scope of the work ordered in writing by the _____ during the conduct of the project, and as a basis for computing work progress payments to the Engineer under the project.

It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Engineer must submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Appendix A-3

DETAILED SPECIFICATIONS FOR AERIAL PHOTOGRAPHY, MONUMENTATION, CONTROL SURVEYS, AND ONE INCH EQUALS 100 FEET SCALE DIGITAL TOPOGRAPHIC MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for photogrammetric mapping services and digital map preparation, including aerial photography, topographic mapping, and accompanying control surveys and control survey monumentation. The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. PHOTOGRAPHY

A. General

The Engineer shall perform the necessary flying and photography to provide photographic coverage of an area approximately _____ square miles in extent shown on the sketch map attached hereto as Exhibit "A." The Engineer may sublet this phase of the work to a qualified and experienced firm specializing in aerial photography. The _____, however, retains the right to approve or reject any or all such firms which the Engineer may wish to engage.

B. Scale

The flight height above the average elevation of the ground shall be such that the negatives will have an average scale of one inch equals five hundred feet (1" = 500'). Negatives having a departure from the specified scale by more than 5 percent because of tilt or abrupt changes in flying altitude may be rejected. The photography shall be suitable for compilation of the topographic maps specified herein, and the mapping flight height shall not vary from 3,000 feet above mean terrain by more than 5 percent.

C. Overlap

The overlap shall be sufficient to provide full stereoscopic coverage of the area to be mapped. The endlap shall average 63 percent plus or minus 5 percent. Endlap of less than 58 percent or more than 68 percent in one or more negatives shall be cause for rejection of the negatives in which such deficiency or excess occurs unless, within a stereoscopic pair, endlap exceeding 68 percent is necessary in areas of low ground elevation to attain the minimum 58 percent endlap in adjacent areas of high ground elevation. Wherever there is a change in direction of the flight lines, vertical photography on the beginning of a forward section shall endlap the photography of a back section by 100 percent. Any negatives having sidelap of less than 20 percent or more than 55 percent may be rejected.

D. Tilt

Negatives made with the optical axis of the aerial camera in a vertical position are desired. Tilt of any negative by more than three degrees, an average tilt of more than one degree for the entire project, or tilt between any two successive negatives exceeding four degrees may be cause for rejection.

E. Crab

Crab in excess of three degrees may be cause for rejection of the flight line of negatives or portions thereof in which such crab occurs.

F. Quality

The photographs shall be clear and sharp in detail and of average uniform density. They shall be free from clouds, cloud shadows, light streaks, static marks, or other blemishes which would interfere with their intended use. Except upon prior written authorization to the contrary by the _____, all photography shall be taken when the area to be mapped is free of snow, before foliation, and at such time as to ensure a minimum solar angle of 30 degrees.

G. Camera

For topographic and contour mapping, photography shall be exposed with a distortion-free six-inch focal length precision aerial mapping camera equipped with a between-the-lens element shutter to produce negatives nine inches by nine inches in size. The Engineer shall furnish the _____ with a precision camera calibration report prepared by the National Bureau of Standards for the camera to be used.

H. Contact Prints

The contact prints from the vertical negatives shall be printed on double-weight semi-matte paper of suitable contrast.

I. Photo Index

Photo indices shall be prepared by directly photographing on safety base film at a convenient scale the assembly of contact prints from all indexed and evaluated prints used. One photo index map reproduced on cronopaque or other approved dimensionally stable base material shall be delivered to the _____. The photo index shall carry a suitable title, scale, and north point.

J. Delivery of Photography

One set of contact print photographs on double-weight semi-matte paper at a scale of one inch equals five hundred feet (1" = 500') shall be furnished the _____ upon completion of this contract.

K. Ownership of Negatives

All negatives shall become the property of the _____ and shall be delivered to the _____ upon completion of this contract.

III. CONTROL SURVEYS

A. General

The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the necessary horizontal and vertical control surveys and control survey monumentation as specified herein.

B. Horizontal Control

1. The horizontal control survey work shall include the recovery or relocation and monumentation of all U. S. Public Land Survey corners, including section and one-quarter-section corners, "centers" of sections, and meander corners, throughout and along the exterior of the approximately _____ square mile area to be mapped. These corners, totaling _____ in all, are indicated on the sketch map attached hereto as Exhibit "A." If the original U. S. Public Land Survey corners are not recoverable, the Engineer shall determine the status

thereof under U. S. Public Land Office definitions and shall follow the prescribed procedures of that Office in their relocation. In any case, the original land survey corners and corners as aforementioned shall be monumented and witnessed as provided under Section III E herein.

2. All field work with respect to the location and relocation of all the aforementioned corners shall be based upon, and include the assembly of, all authoritative information, such as title documents, subdivision plats, private and public survey records, and existing monumentation and occupation, that may be useful in determining the actual location of the U. S. Public Land Survey lines and corners and all other corners, as well as the proper analysis of this information, to arrive at the best determination of the actual location of the said lines and corners. Proper performance in this regard depends largely upon a knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason, must be properly supervised by a competent and qualified registered land surveyor. The Engineer shall sublet this phase of the control survey work to a qualified and experienced land survey firm which regularly practices in the area to be mapped. The _____, however, retains the right to approve or reject any or all such local firms which the Engineer may wish to engage.
3. With regard to the location or relocation of the "center" of the section, that point which physical or other evidence indicates to be the "used or recognized center of the section" (occupied center) shall be located or relocated in accordance with paragraph 2 above and monumented as provided under Section III E 5 herein. When all sources of information have been explored and there is no evidence of an "occupied center," the Engineer, after approval by the _____, shall set and monument, in accordance with Section III E 5, the "true center" of the section. Such "true center" shall be that point at the intersection of straight lines joining opposite quarter corners.
4. The double corners along township lines shall be located or relocated and monumented in accordance with paragraphs 1 and 2 above; and the closing corners governing the location of the U. S. Public Land Survey lines in the northerly tier of one-quarter sections in Township ____ North, Range ____ East, shall be set on the straight lines connecting the section and one-quarter-section corners on the township line governing the location of the U. S. Public Land Survey lines in the southerly tier of one-quarter sections in Township ____ North, Range ____ East.
5. Having recovered or relocated and monumented all of the aforementioned corners in the approximately ____ square mile area specified, control survey traverses shall be run which utilize and incorporate all of the monumented corners as stations, to determine the coordinates of the said corners and the lengths and bearings of all the quarter-section lines. All coordinates shall be based upon the Wisconsin Coordinate System, South Zone (NAD-27); and sufficient survey connections shall be made to basic National Geodetic Survey (NGS) control stations of the NGS control network to permit the proper checks and adjustments to be made both in traverse lengths and bearings and in the coordinate values of the monumented U. S. Public Land Survey corners. Such ties shall originate and end at basic control stations for which closures are known and available or shall be run to make a closed and checked circuit. Upon prior approval of the _____, the Engineer may substitute other survey methods, such as triangulation, trilateration, or Global Positioning System Technology, for the above-specified traverses in order to determine the coordinates of the monumented corners and the lengths and bearings of all the quarter-section lines. Approval by the _____ of such substitute survey methods shall be based upon a review of detailed network layouts and procedures proposed to be followed by the Engineer.

The accuracy of the horizontal control surveys shall conform to the specifications for NGS third-order class I accuracy for traverse as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All field measurements shall be properly adjusted by NGS methods to provide closed traverses before traverse station coordinates are computed, the coordinates of the U. S. Public Land Survey corners are computed, and attendant lengths and bearings of the quarter-section lines are computed so as to form closed geometric figures for the quarter sections, and before the topographic mapping is undertaken.

Whenever the Engineer recovers and uses a NGS control survey station in the conduct of the control survey work he shall prepare a "Report on Condition of Survey Mark and Witness Marks" utilizing the standard form provided for this purpose by the NGS and forward the completed copy of the form to the NGS Washington Office, with a copy to the _____.

All supplemental control for photo mapping purposes shall be based upon the control net just described.

C. Vertical Control

The vertical control survey shall be based upon National Geodetic Vertical Datum, 1929 Adjustment, as established by the NGS, hereinafter referred to as "NGVD." Closed differential level circuits shall be run to establish permanent bench marks in the project area. All differential level circuits shall be of second-order class II accuracy as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All level circuits shall be properly adjusted for closure by NGS methods. Elevations shall be obtained for ____ monuments marking the U. S. Public Land Survey system corners throughout the area to be mapped, and these monuments shall serve as permanent bench marks. In addition, permanent reference bench marks shall be set along the differential level lines on such objects as bridge abutments and wing walls, headwalls of large culverts, water tables of large buildings, outcroppings of ledge rock, or any other stable objects which are unlikely to be displaced vertically. It is the intent of these specifications that one additional bench mark shall be established for, and tied horizontally to, each monumented U. S. Public Land Survey corner and shall be set so that the elevation of the corner monument may be readily verified from the additional permanent bench mark by a single differential level position. Supplementary vertical control for topographic mapping shall provide a minimum of four vertical control points in each stereoscopic model. The supplementary control points shall be established by field survey and shall be located at or near the four corners of the stereoscopic models used in topographic map preparation.

D. Control Survey Computation Data and Plats

The Engineer shall keep all field notes and office computations in a neat and orderly manner, clearly indexed, and open for inspection and checking during the course of the work. Upon completion and acceptance, the originals of all field notes and computations shall be furnished to the _____ and shall become their property. The Engineer shall at all times before final acceptance of the work furnish instruments and assistance to a duly authorized agent of the _____ for such checking of field work and computations as may be deemed necessary by the _____.

1. The Engineer shall deliver to the _____ for final acceptance a diagram summarizing the control survey data. Exhibit "B" attached hereto illustrates the required form and content of this diagram. This diagram shall be prepared so as to cover six sets of six U. S. Public Land Survey sections within each Survey Township, the six sets covering Sections 1 through 3 and 10 through 12; 4 through 9; 13 through 15 and 22 through 24; 16 through 21; 25 through 27 and 34 through 36; and 28 through 33. The diagrams shall be prepared in ink on dimensionally stable polyester base material having a minimum thickness of 0.004 inch and a working surface suitable for inking to a scale of one inch equals 1,200 feet (1" = 1,200'), and shall show correctly on its face:
 - a. The exact grid length and bearing on the exterior boundaries of all the quarter sections. In addition, the ground level lengths of the exterior boundaries of all quarter sections, converted from National Geodetic Vertical Datum, shall be shown in distinctive lettering.

- b. All corners established and monuments erected in the field in their proper positions and orientations. The material of which the monuments and bench marks are made shall be noted at the representation thereof or by legend.
 - c. The number of degrees, minutes, and seconds in the interior angles of all quarter sections.
 - d. The coordinates of all U. S. Public Land Survey corners surveyed.
 - e. The elevation of all U. S. Public Land Survey corners surveyed.
 - f. The section number, indicated at the center of each section.
 - g. All basic NGS control stations within, and adjacent to, the project area and to which the horizontal control surveys are tied, together with the coordinates of the NGS stations.
 - h. A north point based upon grid north. The angle between geodetic and grid north (theta angle) shall be shown and shall represent the value for the quarter section corner located at the center of each six-section sheet.
 - i. A combination factor, sea level and scale, for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the quarter section corner located at the center of each six-section sheet.
2. The Engineer shall provide for each secondary control station established (each U. S. Public Land Survey corner within the project area), for each traverse station established, and for each reference bench mark established which is not also a secondary control station, a dossier on 8 1/2-inch by 11-inch paper. Exhibit "C" attached hereto illustrates the required form and content for these dossiers. The following information shall be given for each station on the dossiers:
- a. Title giving the legal description of the corner by section, township, and range; or, for permanent reference bench marks which are not also secondary control stations and for traverse stations by assigned number and by the U. S. Public Land Survey quarter section, township, and range in which the bench mark or station is located.
 - b. A sketch showing the monumented control station in relation to the salient features of the immediate vicinity. Witness monuments set shall be shown together with their ties. A north point shall be properly located thereon. The names of adjoining streets, state trunk highways, and public lands shall be indicated. The bearing to an azimuth mark for the station shall be shown, together with a brief description of the azimuth mark.
 - c. The coordinates of each traverse station and each U. S. Public Land Survey corner and the bench mark elevation of the monument marking the corner and of the required reference bench mark referred to NGVD. For reference bench marks which are not also a secondary control station, only the bench mark elevation referred to NGVD need be given.
 - d. The angle between geodetic and grid north at the station (theta angle).
 - e. An affidavit by the land surveyor setting forth the classification assigned to the corner (existing, obliterated, or lost) during its recovery or relocation and the salient factors determining the location or relocation, with particular emphasis upon old monumentation and accessories thereto found and used in the relocation process.
- E. **Monumenting**
The Engineer shall mark or monument each section and quarter-section corner surveyed as follows:
- 1. Where the corner falls within an existing surfaced traveled way, by drilling or cutting a neat hole in the pavement and setting a precast concrete monument in accordance with Exhibit "D."
 - 2. Where the corner falls on an earth surface, by setting a precast concrete monument as shown in Exhibit "D."
 - 3. Where the corner falls in a lake, stream, or inaccessible area, by setting a witness corner on the section or quarter-section line at a distance approved by the _____ away from the ordinary high water of the lake, the bank of the stream, or from an inaccessible area. Such witness corners shall be monumented by setting a precast concrete monument in accordance with Exhibit "D."
 - 4. In all cases, the monuments erected shall be witnessed. Witness marks shall be selected for permanence and shall preferably consist of the corners of masonry or concrete structures or, of crosses cut in masonry or concrete structures, concrete curbs, walks, pavements, or bridge and culvert walls and structures. Railroad spikes set in trees and telephone or power poles may be acceptable, but where used in poles shall be set flush with the surface of the telephone or power poles and as low on the pole as practicable. In open fields, one-inch-diameter by 36-inch-long iron pipe may be used. At least four such witness marks shall be established for each corner and tied to the corner.
 - 5. The monuments shall conform to the details shown in Exhibit "D" attached hereto. The brass caps of the monuments shall conform to the details shown in Exhibit "E" attached hereto and be stamped with the corner notation at the time of setting. The dies used to cast the brass caps shall become the property of the _____.
 - 6. In addition to the foregoing, the Engineer shall establish one azimuth mark for each U. S. Public Land Survey section or quarter-section corner surveyed using wherever possible a well-defined, permanent, distant object of the landscape that can be clearly identified and described. Where it is not possible or practical to use such an object, a commercial survey monument of a design approved by the _____ may be substituted.

IV. TOPOGRAPHIC MAPS

A. General

The Engineer shall prepare topographic maps to National Map Accuracy Standards in the form of ink tracings of the original manuscripts on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. The area to be mapped, totaling _____ square miles, is shown on the sketch map attached hereto as Exhibit "A."

Base sheets suitable for the preparation of cadastral maps shall be provided. These sheets consist of reproducible tracings of the topographic map sheets showing all information required under Section IV B 2, 3, 4, 5, 6, 7, and 9 hereof, except pavements, curbs, walks, trails, fences, wooded areas, and other identifiable features.

B. Data to be Shown

The finished maps shall be drawn to a scale of one inch equals one hundred feet (1" = 100') and shall show correctly on each map face the following information:

1. Hypsography by contour lines having a vertical interval of two feet. All contours shall be drawn clear and sharp as continuous solid lines except through structures. Every fifth contour shall be accentuated and numbered. Elevations of saddles, kettles, summits, high points of all crests and low points of all sags in existing roadways, all existing road intersections, and all bridge decks at both ends of the bridge shall be shown as determined photogrammetrically, except where field elevations are available, to the nearest one-quarter contour interval. All contour lines and elevations shall be referred to National Geodetic Vertical Datum, 1929 Adjustment.
2. All planimetric details, such as pavements, curbs, walks, trails, railways, power lines, buildings, fences, wooded areas, and other identifiable features on the photography, shall be shown in their correct positions and orientation within the tolerances of these specifications.
3. All hydrographic features, such as marshes, lakes, streams, watercourses, and drainage ditches, shall be shown in their correct positions and orientation within the tolerances of these specifications.
4. All section and quarter-section lines and U. S. Public Land Survey corners established in the field surveys shall be shown in their correct position and orientation, together with their exact grid lengths and bearings. The material of which the monuments marking said corners are made shall be indicated by symbol and legend, together with the State Plane Coordinates and bench mark elevations of the corners.
5. A north point based upon grid north.
6. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located.
7. A base map projection consisting of the intersection of grid lines on the Wisconsin State Plane Coordinate System. Grid line intersection tick marks shall be drawn at five (5) inch intervals conforming to the even 500 feet interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
8. Such lettering as may be secured from available maps of the area or as may be furnished by the _____ relative to the names of salient geographic features. The names of all state and county trunk highways, public streets, and major streams and lakes shall be shown on the maps.
9. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.

C. Digital Map File Organization and Specifications

The Engineer shall organize the digital map files in such a manner as to be able to create plotted digital topographic maps similar in appearance to the topographic maps historically prepared for the _____. This will require the preparation in digital form of a standard "map sheet" format, including appropriate title and legend information. The _____ shall furnish to the Engineer, as necessary, sample digital topographic map files as examples of the types of products to be prepared. These samples will illustrate the feature content, text size and placement, and the digital map file organization required for the delivered products. The samples may also provide the map border, legend, scale, and other map sheet elements needed by the Engineer for the completion of the digital topographic map files.

1. Map sheets plotted from the digital map files shall be approximately 36 inches by 36 inches in size when plotted at a scale of one inch equals one hundred feet (1" = 100'), and each sheet shall cover an entire U. S. Public Land Survey one-quarter section. The digital topographic map data for each one-quarter section shall overlap the adjacent one-quarter sections by 50 feet ground distance beyond the one-quarter section lines. The map title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. A north point based upon grid north shall be shown. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located. A certificate shall be included in the title block stating that the map meets National Map Accuracy Standards.
2. The Engineer shall deliver the digital topographic map files in GenaMap proprietary mapping software format, version 6.1 or later. All digital arc/node and text files shall be delivered in binary form and shall conform to the GenaMap file structure. This requires that all arc/node or vector maps exist in a "ZF04" directory structure, and that all text maps exist in a "ZF10" directory structure. All other GenaMap compatible digital files prepared by the Engineer for map creation or display shall exist in suitable directories within the GenaMap directory structure.
3. The Engineer shall deliver the digital topographic map files on one of the following two types of media: 1) 4-millimeter Digital Data Storage (DDS) DAT magnetic tape, either 60 or 90 meters in length, and compatible with the _____ computer system; or 2) 8-millimeter Data Cartridge magnetic tape, 112 meters in length, and compatible with the _____ computer system. The digital topographic map files shall be placed on the magnetic tape in a sequential file format, using common UNIX operating system commands. The Engineer shall establish the correct format and procedures for the transfer and deliver of the digital information on magnetic tape in consultation with the _____.
4. The digital arc/node or vector map files shall be provided to the _____ in two separate, distinct formats. The first format, called the 'Graphic Primitive' format, shall represent the digital vector map data as fundamental, unsymbolized feature information. All point features shall be encoded as points at x,y locations rather than as markers or cells. All line features shall be encoded as solid, unsymbolized lines rather than as patterned lines. This file format will provide a portion of the map feature information needed to create an unsymbolized graphic map database. The naming convention for files in this format shall be of the form "GRPtttrssq," where "tttrssq" are character designations for U. S. Public Land Survey township ("tt"), range ("rr"), section ("ss"), and one-quarter section ("q", numbered counter-clockwise beginning with the number 1 in the northeast quarter). For example, the file name of "GRP0122331" indicates a graphic primitive arc/node map for Township 1 North, Range 22 East, Section 33, northeast quarter.

The second format, called the 'Symbolized' format, shall be derived from the first format, and shall represent the digital vector map data as fully symbolized features. All point and line features shall be encoded in the file using the required symbols, cells, patterns, weights, and styles necessary such that the topographic and planimetric features plotted from these files would resemble in appearance the same

features from hardcopy topographic maps traditionally prepared by the _____. The naming convention for files in this format shall be of the form "SYMtrrssh," similar to the naming convention of the first format. For example, the file name of "SYM0122331" indicates a symbolized arc/node map for Township 1 North, Range 22 East, Section 33, northeast quarter.

5. The digital arc/node or vector map files shall be organized in such a manner that data elements can be selectively retrieved, manipulated, and displayed, either singly or in combination with other data elements. The categories of data elements within the file structure shall be as listed in Table 1, attached hereto. The table is made up of columns as described below.

The first column, "Data Element Group/Elements," identifies all data elements that shall be individually retrievable within the digital map file structure, as well as the major data element group to which each element belongs.

The second and third columns, "Feature Type," indicate whether the elements will be categorized as point or line features in the Graphic Primitive (GRP) and the Symbolized (SYM) map files. Certain topographic map features may be shown as Point symbols in the GRP file and as Line features in the SYM file. For example, an individual tree would be depicted as a single point at an x,y location in the GRP file, with this point feature having the tag "TREE." The same individual tree would be depicted as a group of line segments or arcs in the shape of a tree in the SYM file, with each line segment or arc having the tag "TREE."

The fourth column, "GenaMap Tag," indicates the primary label or tag to be given to the features in the digital map files. Tags consist of typographic punctuation marks and upper-case letters.

6. All text shall be included in a single GenaMap text map, which can be utilized with both the Graphic Primitive and Symbolized arc/node maps. All text in this map file shall be assigned GenaMap Font number 12. Text is to be placed without a slant unless otherwise noted in Table 2, attached hereto, described below. Text is to be tagged according to the specifications noted in Table 2, attached hereto, described below. Decimal points or periods in text strings shall not be used as substitutes for point symbols on the maps. The naming convention for the text map shall be of the form "TtrrsshT," where "trrssh" are character designations for U. S. Public Land Survey township ("tt"), range ("rr"), section ("ss"), and one-quarter section ("q," numbered counter-clockwise beginning with the number 1 in the northeast quarter). For example, the file name of "T0122331T" indicates a topographic text map for Township 1 North, Range 22 East, Section 33, northeast quarter.

Text characteristics for the features in the text map shall be as listed in Table 2, attached hereto. The table is made up of columns as described below.

The first column, "Data Element Group/Text Features," identifies all text which corresponds to the vector features in the major data element groups.

The second column, "Text Size," identifies the size for each text element. Text size is given in centimeters, and all text features have a height and width that are equal.

The third column, "GenaMap Tag," indicates the primary label or tag to be given to the text features in the digital map files.

7. Point, line, and area data symbolization and lettering styles and sizes shall be established by the Engineer in such a manner that any maps that may be plotted from the digital files will approach in appearance, insofar as is possible, maps historically prepared for the _____.
8. Contour lines, spot elevations, land/water contact lines, and similar types of mapped lines shall be digitally encoded in such a manner that their plotted appearance is virtually identical to that of traditional, drafted maps when plotted at the scale of one inch equals one hundred feet (1" = 100').

Contour lines shall be digitally encoded in the data structure of the digital topographic map files in a manner that parallels their method of compilation and use in traditional hardcopy topographic map production. That is, contour lines will not be topologically structured or topologically continuous in the digital topographic map files, but rather will exist as discontinuous, independent line segments, appropriately identified as set forth in Section IV.C.5., that, when plotted as appropriately symbolized lines, will be subject to interpretation by the map reader in the same manner that this interpretation occurs in the use of hardcopy topographic maps.
9. All continuous lines crossing map file boundaries shall have connectable points on the appropriate U. S. Public Land Survey one-quarter section lines in the adjoining files. These points shall have identical x and y values. In addition, all continuous lines crossing map file boundaries shall be "broken" at the one-quarter section lines. This means that all continuous lines that cross U. S. Public Land Survey one-quarter section lines shall be composed of two or more line segments so that one segment will terminate on the one-quarter section line and another continuing segment will begin at that identical x,y location on the one-quarter section line.
10. All computer software used by the Engineer in the preparation and transfer of the digital map files shall be capable of maintaining the full mathematical precision of the map projection grid and all horizontal control stations, section corners, and quarter-section corners contained in the digital map files. This may require the use of computer software written in double precision.
11. The Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927, shall be utilized as the coordinate system for the encoding of all digital map data elements.

D. Preparation of Finished Topographic Maps

The Engineer shall utilize digital plotting equipment having a minimum resolution of 400 DPI and capable of preparing finished topographic maps that approach in their overall appearance finished topographic maps prepared for the _____ by traditional hand-drafting techniques. The files prepared by the Engineer shall provide for plotted map sheets 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey one-quarter section. The title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. The finished topographic maps shall overlap the adjacent one-quarter sections by 50 feet ground distance beyond the one-quarter section lines.

The following procedures shall be employed in the development of the finished digital topographic map files and finished topographic maps:

1. The Engineer shall provide the vellum check plots of the topographic maps as specified by the _____.
2. The _____ shall conduct office editing and field checking of the topographic maps.
3. The _____ shall provide to the Engineer annotated paper prints of the topographic maps.

4. The Engineer shall revise the digital topographic map files to reflect the annotations shown on the topographic map prints.
5. Magnetic tapes of the corrected digital topographic map files together with the annotated prints shall be provided by the Engineer to the _____.
6. The digital topographic map files shall be checked by the _____ to determine compliance with the specifications.
7. Should the digital topographic map files be found by the _____ to meet the specifications, the _____ shall notify the Engineer to produce and deliver to the _____ the finished topographic maps on polyester film.
8. Should the digital topographic map files be found by the _____ to require further revisions to comply with the specifications, the _____ shall so notify the Engineer.
9. The Engineer shall then follow the procedures noted in paragraph number 4 and subsequent paragraphs to produce and deliver to the _____ the finished digital topographic map files and the finished topographic maps on polyester film.

E. Precision and Accuracy Standards

1. Both the digital map files and the finished topographic maps shall be prepared to meet National Map Accuracy Standards at the scale of one inch equals one hundred feet (1" = 100'), and a certificate to this effect shall appear on the face of each map sheet.
2. The map projection grid for the digital map files shall be constructed inside the computer memory through key entry procedures. This means that all Wisconsin State Plane Coordinate System grid interval lines and grid intersection points shall be encoded into the digital map files by means of precision keyboard entry techniques rather than by line digitization methods.
3. Each horizontal control station, section corner, and quarter-section corner contained in the digital map files shall be placed on the map projection grid through key entry of the adjusted coordinates computed for the point. The _____ shall furnish to the Engineer appropriate materials providing the x,y coordinate location of these features.
4. Ninety percent of all well-defined planimetric features shall be plotted so that their position in the digital map files and on the finished maps shall be accurate to within 1/30 of an inch of their true coordinate position and no feature shall be more than 1/20 of an inch from its true position.
5. The contours shall faithfully express the relief and topographic forms within the tolerances of these specifications. Ninety percent of the elevations determined from the solid-line contours of the map shall have an accuracy with respect to true elevation of one-half contour interval, based on a two-foot contour interval and no such elevations shall be in error by more than one contour interval.
6. All spot elevations shown on the maps, other than elevations of vertical control stations, shall be shown to the nearest 0.5 foot. Ninety percent of all spot elevations shown on the maps shall have an accuracy with respect to true elevation of one-fourth contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one-half contour interval.
7. The completed topographic maps shall be field checked by the _____. The Engineer shall furnish instruments and assistance to the _____ for such field checking. The field measurements shall be compared against the map data, and any map sheets that do not conform to National Map Accuracy Standards and the requirements of these specifications shall be corrected by the Engineer to fully meet the specified accuracy.

V. ITEMS TO BE DELIVERED

Upon completion the Engineer shall deliver to the _____ the following items:

- A. Three sets of digital map files specified under Sections IV.C.4 and IV.C.6 herein containing digital topographic data of the project area as designated herein. The three sets of files consist of the Graphic Primitive (GRP) arc/node map, containing unsymbolized vector data as described in Section IV.C.4; the Symbolized (SYM) arc/node map, containing fully symbolized point and line features as described in Section IV.C.4; and the Text map, containing all text features as described in Section IV.C.6.
- B. One set of "reverse reading" digital plots on vellum of the topographic maps of the project area as designated herein suitable for conducting the required office editing and field checking.
- C. One reproducible tracing of the control summary diagram specified under Section III.D.1 herein.
- D. One set of reproducible tracings of the control station dossier sheets specified under Section III.D.2 herein.
- E. One set of contact print aerial photographs specified under Section II.J herein.
- F. One set of contact print aerial photographs with vertical and horizontal control identified thereon. These photos shall be printed as specified under Section II.H herein.
- G. The original field notes and computations as specified under Section III.D herein.
- H. One photo index as specified under Section II herein.
- I. The original aerial photograph negatives specified under Section II.K herein.
- J. Two sets of reproducible original plots on dimensionally stable polyester base material of the completed topographic maps of the project area as designated herein.

VI. DELIVERY DATES

- A. Photography
All photography shall be completed in the spring of _____. The contact prints and photo indices shall be delivered within 30 days after the completion of photography.

- B. Topographic Maps and Digital Map Files
All topographic maps and digital map files shall be delivered on or before _____.
- C. Control Survey Data
All control survey data shall be delivered on or before _____.

VII. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all photogrammetric and control survey engineering services and all computer programming and computer operation services necessary for the delivery of the complete, finished photography, control surveys and monumentation, and maps and all other materials and items specified herein. This total contract price shall consist of the lump sum prices listed below for integral portions of the work:

A. Aerial photography of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
B. Location, relocation, and monumentation of _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
C. Vertical control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
D. Horizontal control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
E. Digital map file creation and topographic mapping of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
Total	\$ _____

The foregoing unit prices are provided as a basis for computing any adjustment in the total cost of the contract that may have to be made due to any changes in the scope of the work ordered in writing by the _____ during the conduct of the project, and as a basis for computing work progress payments to the Engineer under the project.

It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Engineer must submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Table 1

TOPOGRAPHIC MAPPING ELEMENTS FOR GENAMAP ARC/NODE MAPS

1" = 100' SCALE

Data Element Group/Element	Feature Type ¹		GenaMap Tag
	GRP	SYM	
<u>Map Sheet Elements</u>			
Map Border	L	L	MAP.BORDER
Map Trim Lines	L	L	TRIM.LINE
Map Logo	L	L	LOGO
Graphic Scale	L	L	BAR.SCALE
North Arrow	L	L	NORTH.ARROW
North Arrow Curve	L	L	NORTH.ARROW.CURVE
Map Legend Symbols	L	L	MAP.LEGEND.SYMBOL
Map Index Section Lines	L	L	INDEX.SECTION.LINE
Map Index County and Town Lines	L	L	INDEX.COUNTY.TOWNSHIP.LINE
Map Index City Boundary Lines	L	L	INDEX.CITY.BOUNDARY.LINE
Map Index Location Box	L	L	INDEX.LOCATION.BOX
<u>Geodetic and Geographic Reference Elements</u>			
NGS Triangulation Station Location	P	L	TRIANG.STATION
Traverse Station Location	P	L	TRAVERSE.STATION
Photo Center Location	P	L	PHOTO.CENTER
Bench Mark Location	P	L	BENCH.MARK
Wisconsin State Plane Coordinate Grid Intervals ²	P	L	GRID.TIC.OUT
Wisconsin State Plane Coordinate Grid Intersections ³	P	L	GRID.TIC.IN
U. S. Public Land Survey Corner	P	L	SECTION.CORNER
U. S. Public Land Survey Monuments	P	L	MONUMENT
U. S. Public Land Survey Section Line	L	L	SECTION.LINE
U. S. Public Land Survey Quarter-Section Line	L	L	QTR.SECTION.LINE
<u>Hydrographic Elements</u>			
Open Water Line ⁴	L	L	WATER.PONDED
Open Water Direction of Flow Arrow	P	L	WATER.FLOW
Single Width Water Line ⁵	L	L	WATER.NONPONDED
Marsh Boundary Line	L	L	MARSH.LINE
Marsh Symbol	P	L	MARSH.SYMBOL
<u>Planimetric Elements</u>			
Road Pavement/Curb Line	L	L	ROAD.PUBLIC
Road Median/Boulevard Line	L	L	ROAD.PUBLIC.MEDIAN
Private Pavement/Curb Line	L	L	ROAD.PRIVATE
Unimproved Road Line	L	L	ROAD.UNIMPROVED
Road Shield or Symbol	P	L	ROAD.PUBLIC.SYMBOL
Driveway Line (paved)	L	L	DRIVEWAY.PAVED
Driveway (unpaved)	L	L	DRIVEWAY.UNPAVED
Parking (paved)	L	L	PARKING.PAVED
Parking (unpaved)	L	L	PARKING.UNPAVED
Trail Line	L	L	TRAIL
Sidewalk Line	L	L	SIDEWALK
Fence Line	L	L	FENCE
Tower Footing	L	L	TOWER.FOOTING
Transmission Tower	L	L	TRANSMISSION.TOWER
Communications Tower	L	L	COMMUNICATIONS.TOWER

¹Indicates whether the feature is to be shown as a Point (P) symbol or a Line (L) symbol in the "Graphic Primitive" (GRP) and the "Symbolized" (SYM) digital map files.

²Grid intervals along the map sheet border of the area being mapped.

³Grid tics interior to and immediately adjacent to the U. S. Public Land Survey section and quarter-section lines of the area being mapped.

⁴Depicting open water boundaries (greater than 5' in width) for lakes, ponds, streams, watercourses, and drainage ditches.

⁵Depicting water bodies too narrow to show both edges (less than 5' in width) for streams, watercourses, and drainage ditches.

Table 1 (continued)

Data Element Group/Element	Feature Type		GenaMap Tag
	GRP	SYM	
Planimetric Elements (continued)			
Power/Telephone Pole Location	P	L	POLE.POWER/TELEPHONE
Light Pole Location	P	L	POLE.LIGHT
Railway Track Centerline	L	L	RAILROAD.CENTERLINE
Railway Signal	P	L	RAILROAD.SIGNAL
Railway (abandoned)	L	L	RAILROAD.ABANDONED
Building Roof/Foundation Outline	L	L	STRUCTURE
Ruins Foundation Outline	L	L	RUIN
Dam Line	L	L	DAM
Pier Line	L	L	PIER
Dock Wall Line	L	L	DOCK.WALL
Culvert (small)	P	L	CULVERT.SMALL
Culvert Line (large)	L	L	CULVERT.LARGE
Bridge Deck Line	L	L	BRIDGE.DECK
Bridge Wing/Retaining Wall Line	L	L	BRIDGE.WING
Aviation Runway/Taxiway Line (paved)	L	L	RUNWAY.PAVED
Aviation Runway/Taxiway Line (unpaved)	L	L	RUNWAY.UNPAVED
Cemetery	L	L	CEMETERY
Paved Slab	L	L	PAVED.SLAB
Open Storage, Pile, U/C	L	L	OPEN_STORAGE/PILE
Pipeline	L	L	PIPELINE
Overhead Structure	L	L	OVERHEAD.STRUCTURE
Patio, Deck	L	L	PATIO/DECK
Pool	L	L	POOL
Tank, Silo	L	L	TANK/SILO
Sign	P,L	L	SIGN
Substation Structure	L	L	SUBSTATION
Wall	L	L	WALL
Tree Location	P	L	TREE
Wooded Area Boundary Line	L	L	TREE.LINE
Park/Recreation Area Line	L	L	PARK/RECREATION.LINE
Other Planimetric Features	P,L	L	OTHER.FEATURE
Hypsometric Elements			
Accentuated Contour Elevation Line	L	L	CONTOUR.INDEX
Accentuated Contour Depression Line	L	L	DEPRESSION.INDEX
Accentuated Approx. Contour Elevation Line	L	L	CONTOUR.INDEX.APPROX
Accentuated Approx. Contour Depression Line	L	L	DEPRESSION.INDEX.APPROX
Unaccentuated Contour Elevation Line	L	L	CONTOUR.INTERMEDIATE
Unaccentuated Contour Depression Line	L	L	DEPRESSION.INTERMEDIATE
Unaccentuated Approx. Contour Elevation Line	L	L	CONTOUR.INTERMEDIATE.APPROX
Unaccentuated Approx. Contour Depression Line	L	L	DEPRESSION.INTERMEDIATE.APPROX
Spot Elevation Location	P	L	SPOT.ELEVATION

Table 2

TOPOGRAPHIC MAPPING TEXT FOR GENAMAP TEXT MAPS
1" = 100' SCALE

Data Element Group/Text Feature	Text Size ¹	GenaMap Tag
<u>Map Sheet Elements</u>		
Map Title	.40, .60	MAPSHEET.TXT
Map Legend Box Text	.26, .40	MAPSHEET.TXT
Graphic Scale Text	.20	MAPSHEET.TXT
North Arrow Text	.20	MAPSHEET.TXT
Map Legend Symbol Text	.20, .22	MAPSHEET.TXT
Map Index Text	.06, .10	MAPSHEET.TXT
<u>Geodetic and Geographic Reference Elements</u>		
NGS Triangulation Station Text	.20	TRIANG.STATION.TXT
Traverse Station Text	.20	TRAVERSE.STATION.TXT
Photo Center Text	.20	PHOTO.CENTER.TXT
Bench Mark Text	.20	BENCH.MARK.TXT
Wisconsin State Plane Coordinate Grid Text	.20	GRID.TIC.OUT.TXT
U. S. Public Land Survey Corner Coordinates	.20	SECTION.CORNER.TXT
U. S. Public Land Survey Monument Coordinates	.20	MONUMENT.TXT
U. S. Public Land Survey Section Bearing/Length	.20	SECTION.LINE.TXT
U. S. Public Land Survey Quarter-Section Bearing/Length	.20	QTR.SECTION.LINE.TXT
<u>Hydrographic Elements</u>		
Open Water Name Text	.25*	WATER.PONDED.TXT
Single Width Water Name Text	.25*	WATER.NONPONDED.TXT
Marsh Name Text	.25*	MARSH.TXT
<u>Planimetric Elements</u>		
Road Name Text	.25	ROAD.PUBLIC.TXT
Unimproved Road Name Text	.25	ROAD.UNIMPROVED.TXT
Driveway & Parking Text	.25	DRIVEWAY.PARKING.TXT
Trail Text	.25	TRAIL.TXT
Sidewalk Text	.25	SIDEWALK.TXT
Railway Name Text	.25	RAILROAD.CENTERLINE.TXT
Building Name Text	.25	STRUCTURE.TXT
Ruins Foundation Name Text	.25	RUIN.TXT
Dam Name Text	.25	DAM.TXT
Pier Name Text	.25	PIER.TXT
Dock Wall Name Text	.25	DOCK.WALL.TXT
Aviation Runway/Taxiway Name Text	.25	RUNWAY.TXT
Cemetery Text	.25	CEMETERY.TXT
Paved Slab Text	.25	PAVED.SLAB.TXT
Open Storage, Pile, U/C Text	.25	OPEN_STORAGE/PILE.TXT
Pipeline Text	.25	PIPELINE.TXT
Overhead Structure Text	.25	OVERHEAD.STRUCTURE.TXT
Pool Text	.25	POOL.TXT
Tank, Silo Text	.25	TANK/SILO.TXT
Sign Text	.25	SIGN.TXT
Substation Text	.25	SUBSTATION.TXT
Wall Text	.25	WALL.TXT
Park/Recreation Area Text	.25	PARK/RECREATION.TXT
Other Planimetric Feature Text	.25	OTHER.FEATURE.TXT
<u>Hypsometric Elements</u>		
Accentuated Contour Elevation Number	.25*	CONTOUR.INDEX.TXT
Accentuated Contour Depression Number	.25*	DEPRESSION.INDEX.TXT
Accentuated Approx. Contour Elevation Value	.25*	CONTOUR.INDEX.APPROX.TXT
Accentuated Approx. Contour Depression Value	.25*	DEPRESSION.INDEX.APPROX.TXT
Spot Elevation Value	.25	SPOT.ELEVATION.TXT
Water Surface Elevation Value	.25	SPOT.ELEVATION.WATER.TXT
U. S. Public Land Survey Corner Elevation	.20	SECTION.CORNER.ELEVATION.TXT

¹Text size is centimeters, text height and text width are equal. GenaMap font number 12 is to be used for all text. All text shall be placed without a slant, with the exception of the Hydrographic Element text and Hypsometric Element text indicated by "*" which is to be placed with a slant of -20.0 degrees.

Appendix A-4

DETAILED SPECIFICATIONS FOR AERIAL PHOTOGRAPHY, MONUMENTATION, CONTROL SURVEYS, AND ONE INCH EQUALS 200 FEET SCALE DIGITAL TOPOGRAPHIC MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for photogrammetric mapping services and digital map preparation, including aerial photography, topographic mapping, and accompanying control surveys and control survey monumentation. The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. PHOTOGRAPHY

A. General

The Engineer shall perform the necessary flying and photography to provide photographic coverage of an area approximately _____ square miles in extent shown on the sketch map attached hereto as Exhibit "A." The Engineer may sublet this phase of the work to a qualified and experienced firm specializing in aerial photography. The _____, however, retains the right to approve or reject any or all such firms which the Engineer may wish to engage.

B. Scale

The flight height above the average elevation of the ground shall be such that the negatives will have an average scale of one inch equals eight hundred feet (1" = 800'). Negatives having a departure from the specified scale by more than 5 percent because of tilt or abrupt changes in flying altitude may be rejected. The photography shall be suitable for compilation of the topographic maps specified herein, and the mapping flight height shall not vary from 4,800 feet above mean terrain by more than 5 percent.

C. Overlap

The overlap shall be sufficient to provide full stereoscopic coverage of the area to be mapped. The endlap shall average 63 percent plus or minus 5 percent. Endlap of less than 58 percent or more than 68 percent in one or more negatives shall be cause for rejection of the negatives in which such deficiency or excess occurs unless, within a stereoscopic pair, endlap exceeding 68 percent is necessary in areas of low ground elevation to attain the minimum 58 percent endlap in adjacent areas of high ground elevation. Wherever there is a change in direction of the flight lines, vertical photography on the beginning of a forward section shall endlap the photography of a back section by 100 percent. Any negatives having sidelap of less than 20 percent or more than 55 percent may be rejected.

D. Tilt

Negatives made with the optical axis of the aerial camera in a vertical position are desired. Tilt of any negative by more than three degrees, an average tilt of more than one degree for the entire project, or tilt between any two successive negatives exceeding four degrees may be cause for rejection.

E. Crab

Crab in excess of three degrees may be cause for rejection of the flight line of negatives or portions thereof in which such crab occurs.

F. Quality

The photographs shall be clear and sharp in detail and of average uniform density. They shall be free from clouds, cloud shadows, light streaks, static marks, or other blemishes which would interfere with their intended use. Except upon prior written authorization to the contrary by the _____, all photography shall be taken when the area to be mapped is free of snow, before foliation, and at such time as to ensure a minimum solar angle of 30 degrees.

G. Camera

For topographic and contour mapping, photography shall be exposed with a distortion-free six-inch focal length precision aerial mapping camera equipped with a between-the-lens element shutter to produce negatives nine inches by nine inches in size. The Engineer shall furnish the _____ with a precision camera calibration report prepared by the National Bureau of Standards for the camera to be used.

H. Contact Prints

The contact prints from the vertical negatives shall be printed on double-weight semi-matte paper of suitable contrast.

I. Photo Index

Photo indices shall be prepared by directly photographing on safety base film at a convenient scale the assembly of contact prints from all indexed and evaluated prints used. One photo index map reproduced on cronopaque or other approved dimensionally stable base material shall be delivered to the _____. The photo index shall carry a suitable title, scale, and north point.

J. Delivery of Photography

One set of contact print photographs on double-weight semi-matte paper at a scale of one inch equals five hundred feet (1" = 500') shall be furnished the _____ upon completion of this contract.

K. Ownership of Negatives

All negatives shall become the property of the _____ and shall be delivered to the _____ upon completion of this contract.

III. CONTROL SURVEYS

A. General

The Engineer shall furnish all labor, materials, and equipment necessary to complete properly the necessary horizontal and vertical control surveys and control survey monumentation as specified herein.

B. Horizontal Control

1. The horizontal control survey work shall include the recovery or relocation and monumentation of all U. S. Public Land Survey corners, including section and one-quarter-section corners, "centers" of sections, and meander corners, throughout and along the exterior of the approximately _____ square mile area to be mapped. These corners, totaling _____ in all, are indicated on the sketch map attached hereto as Exhibit "A." If the original U. S. Public Land Survey corners are not recoverable, the Engineer shall determine the status

thereof under U. S. Public Land Office definitions and shall follow the prescribed procedures of that Office in their relocation. In any case, the original land survey corners and corners as aforementioned shall be monumented and witnessed as provided under Section III E herein.

2. All field work with respect to the location and relocation of all the aforementioned corners shall be based upon, and include the assembly of, all authoritative information, such as title documents, subdivision plats, private and public survey records, and existing monumentation and occupation, that may be useful in determining the actual location of the U. S. Public Land Survey lines and corners and all other corners, as well as the proper analysis of this information, to arrive at the best determination of the actual location of the said lines and corners. Proper performance in this regard depends largely upon a knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason, must be properly supervised by a competent and qualified registered land surveyor. The Engineer shall sublet this phase of the control survey work to a qualified and experienced land survey firm which regularly practices in the area to be mapped. The _____, however, retains the right to approve or reject any or all such local firms which the Engineer may wish to engage.
3. With regard to the location or relocation of the "center" of the section, that point which physical or other evidence indicates to be the "used or recognized center of the section" (occupied center) shall be located or relocated in accordance with paragraph 2 above and monumented as provided under Section III E 5 herein. When all sources of information have been explored and there is no evidence of an "occupied center," the Engineer, after approval by the _____, shall set and monument, in accordance with Section III E 5, the "true center" of the section. Such "true center" shall be that point at the intersection of straight lines joining opposite quarter corners.
4. The double corners along township lines shall be located or relocated and monumented in accordance with paragraphs 1 and 2 above; and the closing corners governing the location of the U. S. Public Land Survey lines in the northerly tier of one-quarter sections in Township ____ North, Range ____ East, shall be set on the straight lines connecting the section and one-quarter-section corners on the township line governing the location of the U. S. Public Land Survey lines in the southerly tier of one-quarter sections in Township ____ North, Range ____ East.
5. Having recovered or relocated and monumented all of the aforementioned corners in the approximately ____ square mile area specified, control survey traverses shall be run which utilize and incorporate all of the monumented corners as stations, to determine the coordinates of the said corners and the lengths and bearings of all the quarter-section lines. All coordinates shall be based upon the Wisconsin Coordinate System, South Zone (NAD-27); and sufficient survey connections shall be made to basic National Geodetic Survey (NGS) control stations of the NGS control network to permit the proper checks and adjustments to be made both in traverse lengths and bearings and in the coordinate values of the monumented U. S. Public Land Survey corners. Such ties shall originate and end at basic control stations for which closures are known and available or shall be run to make a closed and checked circuit. Upon prior approval of the _____, the Engineer may substitute other survey methods, such as triangulation, trilateration, or Global Positioning System Technology, for the above-specified traverses in order to determine the coordinates of the monumented corners and the lengths and bearings of all the quarter-section lines. Approval by the _____ of such substitute survey methods shall be based upon a review of detailed network layouts and procedures proposed to be followed by the Engineer.

The accuracy of the horizontal control surveys shall conform to the specifications for NGS third-order class I accuracy for traverse as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All field measurements shall be properly adjusted by NGS methods to provide closed traverses before traverse station coordinates are computed, the coordinates of the U. S. Public Land Survey corners are computed, and attendant lengths and bearings of the quarter-section lines are computed so as to form closed geometric figures for the quarter sections, and before the topographic mapping is undertaken.

Whenever the Engineer recovers and uses a NGS control survey station in the conduct of the control-survey work he shall prepare a "Report on Condition of Survey Mark and Witness Marks" utilizing the standard form provided for this purpose by the NGS and forward the completed copy of the form to the NGS Washington Office, with a copy to the _____.

All supplemental control for photo mapping purposes shall be based upon the control net just described.

C. Vertical Control

The vertical control survey shall be based upon National Geodetic Vertical Datum, 1929 Adjustment, as established by the NGS, hereinafter referred to as "NGVD." Closed differential level circuits shall be run to establish permanent bench marks in the project area. All differential level circuits shall be of second-order class II accuracy as set forth in "Standards and Specifications for Geodetic Control Networks" prepared by the Federal Geodetic Control Committee. This publication is incorporated in these specifications by reference as though fully herein set forth. All level circuits shall be properly adjusted for closure by NGS methods. Elevations shall be obtained for _____ monuments marking the U. S. Public Land Survey system corners throughout the area to be mapped, and these monuments shall serve as permanent bench marks. In addition, permanent reference bench marks shall be set along the differential level lines on such objects as bridge abutments and wing walls, headwalls of large culverts, water tables of large buildings, outcroppings of ledge rock, or any other stable objects which are unlikely to be displaced vertically. It is the intent of these specifications that one additional bench mark shall be established for, and tied horizontally to, each monumented U. S. Public Land Survey corner and shall be set so that the elevation of the corner monument may be readily verified from the additional permanent bench mark by a single differential level position. Supplementary vertical control for topographic mapping shall provide a minimum of four vertical control points in each stereoscopic model. The supplementary control points shall be established by field survey and shall be located at or near the four corners of the stereoscopic models used in topographic map preparation.

D. Control Survey Computation Data and Plats

The Engineer shall keep all field notes and office computations in a neat and orderly manner, clearly indexed, and open for inspection and checking during the course of the work. Upon completion and acceptance, the originals of all field notes and computations shall be furnished the _____ and shall become their property. The Engineer shall at all times before final acceptance of the work furnish instruments and assistance to a duly authorized agent of the _____ for such checking of field work and computations as may be deemed necessary by the _____.

1. The Engineer shall deliver to the _____ for final acceptance a diagram summarizing the control survey data. Exhibit "B" attached hereto illustrates the required form and content of this diagram. This diagram shall be prepared so as to cover six sets of six U. S. Public Land Survey sections within each Survey Township, the six sets covering Sections 1 through 3 and 10 through 12; 4 through 9; 13 through 15 and 22 through 24; 16 through 21; 25 through 27 and 34 through 36; and 28 through 33. The diagrams shall be prepared in ink on dimensionally stable polyester base material having a minimum thickness of 0.004 inch and a working surface suitable for inking to a scale of one inch equals 1,200 feet (1" = 1,200'), and shall show correctly on its face:
 - a. The exact grid length and bearing on the exterior boundaries of all the quarter sections. In addition, the ground level lengths of the exterior boundaries of all quarter sections, converted from National Geodetic Vertical Datum, shall be shown in distinctive lettering.

- b. All corners established and monuments erected in the field in their proper positions and orientations. The material of which the monuments and bench marks are made shall be noted at the representation thereof or by legend.
 - c. The number of degrees, minutes, and seconds in the interior angles of all quarter sections.
 - d. The coordinates of all U. S. Public Land Survey corners surveyed.
 - e. The elevation of all U. S. Public Land Survey corners surveyed.
 - f. The section number, indicated at the center of each section.
 - g. All basic NGS control stations within, and adjacent to, the project area and to which the horizontal control surveys are tied, together with the coordinates of the NGS stations.
 - h. A north point based upon grid north. The angle between geodetic and grid north (theta angle) shall be shown and shall represent the value for the quarter section corner located at the center of each six-section sheet.
 - i. A combination factor, sea level and scale, for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the quarter section corner located at the center of each six-section sheet.
2. The Engineer shall provide for each secondary control station established (each U. S. Public Land Survey corner within the project area), for each traverse station established, and for each reference bench mark established which is not also a secondary control station, a dossier on 8 1/2-inch by 11-inch paper. Exhibit "C" attached hereto illustrates the required form and content for these dossiers. The following information shall be given for each station on the dossiers:
- a. Title giving the legal description of the corner by section, township, and range; or, for permanent reference bench marks which are not also secondary control stations and for traverse stations by assigned number and by the U. S. Public Land Survey quarter section, township, and range in which the bench mark or station is located.
 - b. A sketch showing the monumented control station in relation to the salient features of the immediate vicinity. Witness monuments set shall be shown together with their ties. A north point shall be properly located thereon. The names of adjoining streets, state trunk highways, and public lands shall be indicated. The bearing to an azimuth mark for the station shall be shown, together with a brief description of the azimuth mark.
 - c. The coordinates of each traverse station and each U. S. Public Land Survey corner and the bench mark elevation of the monument marking the corner and of the required reference bench mark referred to NGVD. For reference bench marks which are not also a secondary control station, only the bench mark elevation referred to NGVD need be given.
 - d. The angle between geodetic and grid north at the station (theta angle).
 - e. An affidavit by the land surveyor setting forth the classification assigned to the corner (existing, obliterated, or lost) during its recovery or relocation and the salient factors determining the location or relocation, with particular emphasis upon old monumentation and accessories thereto found and used in the relocation process.

E. Monumenting

The Engineer shall mark or monument each section and quarter-section corner surveyed as follows:

- 1. Where the corner falls within an existing surfaced traveled way, by drilling or cutting a neat hole in the pavement and setting a precast concrete monument in accordance with Exhibit "D."
- 2. Where the corner falls on an earth surface, by setting a precast concrete monument as shown in Exhibit "D."
- 3. Where the corner falls in a lake, stream, or inaccessible area, by setting a witness corner on the section or quarter-section line at a distance approved by the _____ away from the ordinary high water of the lake, the bank of the stream, or from an inaccessible area. Such witness corners shall be monumented by setting a precast concrete monument in accordance with Exhibit "D."
- 4. In all cases, the monuments erected shall be witnessed. Witness marks shall be selected for permanence and shall preferably consist of the corners of masonry or concrete structures or, of crosses cut in masonry or concrete structures, concrete curbs, walks, pavements, or bridge and culvert walls and structures. Railroad spikes set in trees and telephone or power poles may be acceptable, but where used in poles shall be set flush with the surface of the telephone or power poles and as low on the pole as practicable. In open fields, one-inch-diameter by 36-inch-long iron pipe may be used. At least four such witness marks shall be established for each corner and tied to the corner.
- 5. The monuments shall conform to the details shown in Exhibit "D" attached hereto. The brass caps of the monuments shall conform to the details shown in Exhibit "E" attached hereto and be stamped with the corner notation at the time of setting. The dies used to cast the brass caps shall become the property of the _____.
- 6. In addition to the foregoing, the Engineer shall establish one azimuth mark for each U. S. Public Land Survey section or quarter-section corner surveyed using wherever possible a well-defined, permanent, distant object of the landscape that can be clearly identified and described. Where it is not possible or practical to use such an object, a commercial survey monument of a design approved by the _____ may be substituted.

IV. TOPOGRAPHIC MAPS

A. General

The Engineer shall prepare topographic maps to National Map Accuracy Standards in the form of ink tracings of the original manuscripts on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. The area to be mapped, totaling _____ square miles, is shown on the sketch map attached hereto as Exhibit "A."

Base sheets suitable for the preparation of cadastral maps shall be provided. These sheets consist of reproducible tracings of the topographic map sheets showing all information required under Section IV B 2, 3, 4, 5, 6, 7, and 9 hereof, except pavements, curbs, trails, fences, wooded areas, and other identifiable features.

B. Data to be Shown

The finished maps shall be drawn to a scale of one inch equals one hundred feet (1" = 100') and shall show correctly on each map face the following information:

1. Hypsography by contour lines having a vertical interval of two feet. All contours shall be drawn clear and sharp as continuous solid lines except through structures. Every fifth contour shall be accentuated and numbered. Elevations of saddles, kettles, summits, high points of all crests and low points of all sags in existing roadways, all existing road intersections, and all bridge decks at both ends of the bridge shall be shown as determined photogrammetrically, except where field elevations are available, to the nearest one-quarter contour interval. All contour lines and elevations shall be referred to National Geodetic Vertical Datum, 1929 Adjustment.
2. All planimetric details, such as pavements, curbs, trails, railways, power lines, buildings, fences, wooded areas, and other identifiable features on the photography, shall be shown in their correct positions and orientation within the tolerances of these specifications.
3. All hydrographic features, such as marshes, lakes, streams, watercourses, and drainage ditches, shall be shown in their correct positions and orientation within the tolerances of these specifications.
4. All section and quarter-section lines and U. S. Public Land Survey corners established in the field surveys shall be shown in their correct position and orientation, together with their exact grid lengths and bearings. The material of which the monuments marking said corners are made shall be indicated by symbol and legend, together with the State Plane Coordinates and bench mark elevations of the corners.
5. A north point based upon grid north.
6. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located.
7. A base map projection consisting of the intersection of grid lines on the Wisconsin State Plane Coordinate System. Grid line intersection tick marks shall be drawn at five (5) inch intervals conforming to the even 500 feet interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
8. Such lettering as may be secured from available maps of the area or as may be furnished by the _____ relative to the names of salient geographic features. The names of all state and county trunk highways, public streets, and major streams and lakes shall be shown on the maps.
9. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.

C. Digital Map File Organization and Specifications

The Engineer shall organize the digital map files in such a manner as to be able to create plotted digital topographic maps similar in appearance to the topographic maps historically prepared for the _____. This will require the preparation in digital form of a standard "map sheet" format, including appropriate title and legend information. The _____ shall furnish to the Engineer, as necessary, sample digital topographic map files as examples of the types of products to be prepared. These samples will illustrate the feature content, text size and placement, and the digital map file organization required for the delivered products. The samples may also provide the map border, legend, scale, and other map sheet elements needed by the Engineer for the completion of the digital topographic map files.

1. Map sheets plotted from the digital map files shall be approximately 36 inches by 36 inches in size when plotted at a scale of one inch equals two hundred feet (1" = 200'), and each sheet shall cover an entire U. S. Public Land Survey section. The digital topographic map data for each section shall overlap the adjacent sections by 100 feet ground distance beyond the section lines. The map title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. A north point based upon grid north shall be shown. A combination factor, sea level and scale, shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the required six-section control survey summary diagram within which the map sheet is located. A certificate shall be included in the title block stating that the map meets National Map Accuracy Standards.
2. The Engineer shall deliver the digital topographic map files in GenaMap proprietary mapping software format, version 6.1 or later. All digital arc/node and text files shall be delivered in binary form and shall conform to the GenaMap file structure. This requires that all arc/node or vector maps exist in a "ZF04" directory structure, and that all text maps exist in a "ZF10" directory structure. All other GenaMap compatible digital files prepared by the Engineer for map creation or display shall exist in suitable directories within the GenaMap directory structure.
3. The Engineer shall deliver the digital topographic map files on one of the following two types of media: 1) 4-millimeter Digital Data Storage (DDS) DAT magnetic tape, either 60 or 90 meters in length, and compatible with the _____ computer system; or 2) 8-millimeter Data Cartridge magnetic tape, 112 meters in length, and compatible with the _____ computer system. The digital topographic map files shall be placed on the magnetic tape in a sequential file format, using common UNIX operating system commands. The Engineer shall establish the correct format and procedures for the transfer and deliver of the digital information on magnetic tape in consultation with the _____.
4. The digital arc/node or vector map files shall be provided to the _____ in two separate, distinct formats. The first format, called the 'Graphic Primitive' format, shall represent the digital vector map data as fundamental, unsymbolized feature information. All point features shall be encoded as points at x,y locations rather than as markers or cells. All line features shall be encoded as solid, unsymbolized lines rather than as patterned lines. This file format will provide a portion of the map feature information needed to create an unsymbolized graphic map database. The naming convention for files in this format shall be of the form "GRPttrrss," where "ttrrss" are character designations for U. S. Public Land Survey township ("tt"), range ("rr"), and section ("ss"). For example, the file name of "GRP012233" indicates a graphic primitive arc/node map for Township 1 North, Range 22 East, Section 33.

The second format, called the 'Symbolized' format, shall be derived from the first format, and shall represent the digital vector map data as fully symbolized features. All point and line features shall be encoded in the file using the required symbols, cells, patterns, weights, and styles necessary such that the topographic and planimetric features plotted from these files would resemble in appearance the same features from hardcopy topographic maps traditionally prepared by the _____. The naming convention for files in this format

shall be of the form "SYMttrrs," similar to the naming convention of the first format. For example, the file name of "SYM012233" indicates a symbolized arc/node map for Township 1 North, Range 22 East, Section 33.

5. The digital arc/node or vector map files shall be organized in such a manner that data elements can be selectively retrieved, manipulated, and displayed, either singly or in combination with other data elements. The categories of data elements within the file structure shall be as listed in Table 1, attached hereto. The table is made up of columns as described below.

The first column, "Data Element Group/Elements," identifies all data elements that shall be individually retrievable within the digital map file structure, as well as the major data element group to which each element belongs.

The second and third columns, "Feature Type," indicate whether the elements will be categorized as point or line features in the Graphic Primitive (GRP) and the Symbolized (SYM) map files. Certain topographic map features may be shown as Point symbols in the GRP file and as Line features in the SYM file. For example, an individual tree would be depicted as a single point at an x,y location in the GRP file, with this point feature having the tag "TREE." The same individual tree would be depicted as a group of line segments or arcs in the shape of a tree in the SYM file, with each line segment or arc having the tag "TREE."

The fourth column, "GenaMap Tag," indicates the primary label or tag to be given to the features in the digital map files. Tags consist of typographic punctuation marks and upper-case letters.

6. All text shall be included in a single GenaMap text map, which can be utilized with both the Graphic Primitive and Symbolized arc/node maps. All text in this map file shall be assigned GenaMap Font number 12. Text is to be placed without a slant unless otherwise noted in Table 2, attached hereto, described below. Text is to be tagged according to the specifications noted in Table 2, attached hereto, described below. Decimal points or periods in text strings shall not be used as substitutes for point symbols on the maps. The naming convention for the text map shall be of the form "TttrrsT," where "ttrrs" are character designations for U. S. Public Land Survey township ("tt"), range ("rr"), and section ("ss"). For example, the file name of "T012233T" indicates a topographic text map for Township 1 North, Range 22 East, Section 33.

Text sizes for the features in the text map shall be as listed in Table 2, attached hereto. The table is made up of columns as described below.

The first column, "Data Element Group/Text Features," identifies all text which corresponds to the vector features in the major data element groups.

The second column, "Text Size," identifies the size for each text element. Text size is given in centimeters, and all text features have a height and width that are equal.

The third column, "GenaMap Tag," indicates the primary label or tag to be given to the text features in the digital map files. Tags consist of typographic punctuation marks and upper case letters.

7. Point, line, and area data symbolization and lettering styles and sizes shall be established by the Engineer in such a manner that any maps that may be plotted from the digital files will approach in appearance, insofar as is possible, maps historically prepared for the _____.
8. Contour lines, spot elevations, land/water contact lines, and similar types of mapped lines shall be digitally encoded in such a manner that their plotted appearance is virtually identical to that of traditional, drafted maps when plotted at the scale of one inch equals two hundred feet (1" = 200').

Contour lines shall be digitally encoded in the data structure of the digital topographic map files in a manner that parallels their method of compilation and use in traditional hardcopy topographic map production. That is, contour lines will not be topologically structured or topologically continuous in the digital topographic map files, but rather will exist as discontinuous, independent line segments, appropriately identified as set forth in Section IV.C.5., that, when plotted as appropriately symbolized lines, will be subject to interpretation by the map reader in the same manner that this interpretation occurs in the use of hardcopy topographic maps.

9. All continuous lines crossing map file boundaries shall have connectable points on the appropriate U. S. Public Land Survey section lines in the adjoining files. These points shall have identical x and y values. In addition, all continuous lines crossing map file boundaries shall be "broken" at the section lines. This means that all continuous lines that cross U. S. Public Land Survey section lines shall be composed of two or more line segments so that one segment will terminate on the section line and another continuing segment will begin at that identical x,y location on the section line.
10. All computer software used by the Engineer in the preparation and transfer of the digital map files shall be capable of maintaining the full mathematical precision of the map projection grid and all horizontal control stations, section corners, and quarter-section corners contained in the digital map files. This may require the use of computer software written in double precision.
11. The Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927, shall be utilized as the coordinate system for the encoding of all digital map data elements.

D. Preparation of Finished Topographic Maps

The Engineer shall utilize digital plotting equipment having a minimum resolution of 400 DPI and capable of preparing finished topographic maps that approach in their overall appearance finished topographic maps prepared for the _____ by traditional hand-drafting techniques. The files prepared by the Engineer shall provide for plotted map sheets 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey section. The title shall contain a graphic scale and the following information: scale, date, type of map, location by county and state, name of the _____, name of the Engineer, and appropriate project and sheet numbers. The finished topographic maps shall overlap the adjacent sections by 100 feet ground distance beyond the section lines.

The following procedures shall be employed in the development of the finished digital topographic map files and finished topographic maps:

1. The Engineer shall provide the vellum check plots of the topographic maps as specified by the _____.
2. The _____ shall conduct office editing and field checking of the topographic maps.
3. The _____ shall provide to the Engineer annotated paper prints of the topographic maps.
4. The Engineer shall revise the digital topographic map files to reflect the annotations shown on the topographic map prints.

5. Magnetic tapes of the corrected digital topographic map files together with the annotated prints shall be provided by the Engineer to the _____.
6. The digital topographic map files shall be checked by the _____ to determine compliance with the specifications.
7. Should the digital topographic map files be found by the _____ to meet the specifications, the _____ shall notify the Engineer to produce and deliver to the _____ the finished topographic maps on polyester film.
8. Should the digital topographic map files be found by the _____ to require further revisions to comply with the specifications, the _____ shall so notify the Engineer.
9. The Engineer shall then follow the procedures noted in paragraph number 4 and subsequent paragraphs to produce and deliver to the _____ the finished digital topographic map files and the finished topographic maps on polyester film.

E. Precision and Accuracy Standards

1. Both the digital map files and the finished topographic maps shall be prepared to meet National Map Accuracy Standards at the scale of one inch equals two hundred feet (1" = 200'), and a certificate to this effect shall appear on the face of each map sheet.
2. The map projection grid for the digital map files shall be constructed inside the computer memory through key entry procedures. This means that all Wisconsin State Plane Coordinate System grid interval lines and grid intersection points shall be encoded into the digital map files by means of precision keyboard entry techniques rather than by line digitization methods.
3. Each horizontal control station, section corner, and quarter-section corner contained in the digital map files shall be placed on the map projection grid through key entry of the adjusted coordinates computed for the point. The _____ shall furnish to the Engineer appropriate materials providing the x,y coordinate location of these features.
4. Ninety percent of all well-defined planimetric features shall be plotted so that their position in the digital map files and on the finished maps shall be accurate to within 1/30 of an inch of their true coordinate position and no feature shall be more than 1/20 of an inch from its true position.
5. The contours shall faithfully express the relief and topographic forms within the tolerances of these specifications. Ninety percent of the elevations determined from the solid-line contours of the map shall have an accuracy with respect to true elevation of one-half contour interval, based on a two-foot contour interval and no such elevations shall be in error by more than one contour interval.
6. All spot elevations shown on the maps, other than elevations of vertical control stations, shall be shown to the nearest 0.5 foot. Ninety percent of all spot elevations shown on the maps shall have an accuracy with respect to true elevation of one-fourth contour interval, based on a two-foot contour interval, and no such elevations shall be in error by more than one-half contour interval.
7. The completed topographic maps shall be field checked by the _____. The Engineer shall furnish instruments and assistance to the _____ for such field checking. The field measurements shall be compared against the map data, and any map sheets that do not conform to National Map Accuracy Standards and the requirements of these specifications shall be corrected by the Engineer to fully meet the specified accuracy.

V. ITEMS TO BE DELIVERED

Upon completion the Engineer shall deliver to the _____ the following items:

- A. Three sets of digital map files specified under Sections IV.C.4 and IV.C.6 herein containing digital topographic data of the project area as designated herein. The three sets of files consist of the Graphic Primitive (GRP) arc/node map, containing unsymbolized vector data as described in Section IV.C.4; the Symbolized (SYM) arc/node map, containing fully symbolized point and line features as described in Section IV.C.4; and the Text map, containing all text features as described in Section IV.C.6.
- B. One set of "reverse reading" digital plots on vellum of the topographic maps of the project area as designated herein suitable for conducting the required office editing and field checking.
- C. One reproducible tracing of the control summary diagram specified under Section III.D.1 herein.
- D. One set of reproducible tracings of the control station dossier sheets specified under Section III.D.2 herein.
- E. One set of contact print aerial photographs specified under Section II.J herein.
- F. One set of contact print aerial photographs with vertical and horizontal control identified thereon. These photos shall be printed as specified under Section II.H herein.
- G. The original field notes and computations as specified under Section III.D herein.
- H. One photo index as specified under Section II herein.
- I. The original aerial photograph negatives specified under Section II.K herein.
- J. One set of reproducible original plots on dimensionally stable polyester base material of the completed topographic maps of the project area as designated herein.

VI. DELIVERY DATES

- A. Photography
All photography shall be completed in the spring of _____. The contact prints and photo indices shall be delivered within 30 days after the completion of photography.
- B. Topographic Maps and Digital Map Files
All topographic maps and digital map files shall be delivered on or before _____.

C. Control Survey Data

All control survey data shall be delivered on or before _____.

VII. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all photogrammetric and control survey engineering services and all computer programming and computer operation services necessary for the delivery of the complete, finished photography, control surveys and monumentation, and maps and all other materials and items specified herein. This total contract price shall consist of the lump sum prices listed below for integral portions of the work:

A. Aerial photography of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
B. Location, relocation, and monumentation of _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
C. Vertical control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
D. Horizontal control surveys over _____ U. S. Public Land Survey corners as specified @ \$ _____ per corner:	\$ _____
E. Digital map file creation and topographic mapping of _____ square miles as specified @ \$ _____ per square mile:	\$ _____
Total	\$ _____

The foregoing unit prices are provided as a basis for computing any adjustment in the total cost of the contract that may have to be made due to any changes in the scope of the work ordered in writing by the _____ during the conduct of the project, and as a basis for computing work progress payments to the Engineer under the project.

It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Engineer must submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Table 1

TOPOGRAPHIC MAPPING ELEMENTS FOR GENAMAP ARC/NODE MAPS
1" = 200' SCALE

Data Element Group/Element	Feature Type ¹		GenaMap Tag
	GRP	SYM	
<u>Map Sheet Elements</u>			
Map Border	L	L	MAP.BORDER
Map Trim Lines	L	L	TRIM.LINE
zMap Logo	L	L	LOGO
Graphic Scale	L	L	BAR.SCALE
North Arrow	L	L	NORTH.ARROW
North Arrow Curve	L	L	NORTH.ARROW.CURVE
Map Legend Symbols	L	L	MAP.LEGEND.SYMBOL
Map Index Section Lines	L	L	INDEX.SECTION.LINE
Map Index County and Town Lines	L	L	INDEX.COUNTY.TOWNSHIP.LINE
Map Index City Boundary Lines	L	L	INDEX.CITY.BOUNDARY.LINE
Map Index Location Box	L	L	INDEX.LOCATION.BOX
<u>Geodetic and Geographic Reference Elements</u>			
NGS Triangulation Station Location	P	L	TRIANG.STATION
Traverse Station Location	P	L	TRAVERSE.STATION
Photo Center Location	P	L	PHOTO.CENTER
Bench Mark Location	P	L	BENCH.MARK
Wisconsin State Plane Coordinate Grid Intervals ²	P	L	GRID.TIC.OUT
Wisconsin State Plane Coordinate Grid Intersections ³	P	L	GRID.TIC.IN
U. S. Public Land Survey Corner	P	L	SECTION.CORNER
U. S. Public Land Survey Monuments	P	L	MONUMENT
U. S. Public Land Survey Section Line	L	L	SECTION.LINE
U. S. Public Land Survey Quarter-Section Line	L	L	QTR.SECTION.LINE
<u>Hydrographic Elements</u>			
Open Water Line ⁴	L	L	WATER.PONDED
Open Water Direction of Flow Arrow	P	L	WATER.FLOW
Single Width Water Line ⁵	L	L	WATER.NONPONDED
Marsh Boundary Line	L	L	MARSH.LINE
Marsh Symbol	P	L	MARSH.SYMBOL
<u>Planimetric Elements</u>			
Road Pavement/Curb Line	L	L	ROAD.PUBLIC
Road Median/Boulevard Line	L	L	ROAD.PUBLIC.MEDIAN
Unimproved Road Line	L	L	ROAD.UNIMPROVED
Road Shield or Symbol	P	L	ROAD.PUBLIC.SYMBOL
Driveway Line (paved)	L	L	DRIVEWAY.PAVED
Driveway (unpaved)	L	L	DRIVEWAY.UNPAVED
Parking (paved)	L	L	PARKING.PAVED
Parking (unpaved)	L	L	PARKING.UNPAVED
Trail Line	L	L	TRAIL
Fence Line	L	L	FENCE
Transmission Tower	L	L	TRANSMISSION.TOWER
Communications Tower	L	L	COMMUNICATIONS.TOWER
Utility Pole Location	P	L	POLE
Railway Track Centerline	L	L	RAILROAD.CENTERLINE
Railway (abandoned)	L	L	RAILROAD.ABANDONED

¹Indicates whether the feature is to be shown as a Point (P) symbol or a Line (L) symbol in the "Graphic Primitive" (GRP) and the "Symbolized" (SYM) digital map files.

²Grid intervals along the map sheet border of the area being mapped.

³Grid ties interior to and immediately adjacent to the U. S. Public Land Survey section and quarter-section lines of the area being mapped.

⁴Depicting open water boundaries (greater than 10' in width) for lakes, ponds, streams, watercourses, and drainage ditches.

⁵Depicting water bodies too narrow to show both edges (less than 10' in width) for streams, watercourses, and drainage ditches.

Table 1 (continued)

Data Element Group/Element	Feature Type ⁶		GenaMap Tag
	GRP	SYM	
Planimetric Elements (continued)			
Building Roof/Foundation Outline	L	L	STRUCTURE
Ruins Foundation Outline	L	L	RUIN
Dam Line	L	L	DAM
Pier Line	L	L	PIER
Dock Wall Line	L	L	DOCK.WALL
Culvert (small)	P	L	CULVERT.SMALL
Culvert Line (large)	L	L	CULVERT.LARGE
Bridge Deck Line	L	L	BRIDGE.DECK
Bridge Wing/Retaining Wall Line	L	L	BRIDGE.WING
Aviation Runway/Taxiway Line (paved)		L	RUNWAY.PAVED
Aviation Runway/Taxiway Line (unpaved)	L	L	RUNWAY.UNPAVED
Cemetery	L	L	CEMETERY
Paved Slab	L	L	PAVED.SLAB
Open Storage, Pile, U/C	L	L	OPEN_STORAGE/PILE
Pipeline	L	L	PIPELINE
Overhead Structure	L	L	OVERHEAD.STRUCTURE
Pool	L	L	POOL
Tank, Silo	L	L	TANK/SILO
Sign	P,L	L	SIGN
Substation Structure	L	L	SUBSTATION
Wall	L	L	WALL
Tree Location	P	L	TREE
Wooded Area Boundary Line	L	L	TREE.LINE
Park/Recreation Area Line	L	L	PARK/RECREATION.LINE
Other Planimetric Features	P,L	L	OTHER.FEATURE
Hypsometric Elements			
Accentuated Contour Elevation Line	L	L	CONTOUR.INDEX
Accentuated Contour Depression Line	L	L	DEPRESSION.INDEX
Accentuated Approx. Contour Elevation Line	L	L	CONTOUR.INDEX.APPROX
Accentuated Approx. Contour Depression Line	L	L	DEPRESSION.INDEX.APPROX
Unaccentuated Contour Elevation Line	L	L	CONTOUR.INTERMEDIATE
Unaccentuated Contour Depression Line	L	L	DEPRESSION.INTERMEDIATE
Unaccentuated Approx. Contour Elevation Line	L	L	CONTOUR.INTERMEDIATE.APPROX
Unaccentuated Approx. Contour Depression Line	L	L	DEPRESSION.INTERMEDIATE.APPROX
Spot Elevation Location	P	L	SPOT.ELEVATION

⁶Indicates whether the feature is to be shown as a Point (P) symbol or a Line (L) symbol in the "Graphic Primitive" (GRP) and the "Symbolized" (SYM) digital map files.

Table 2

TOPOGRAPHIC MAPPING TEXT FOR GENAMAP TEXT MAPS
1" = 200' SCALE

Data Element Group/Text Feature	Text Size ¹	GenaMap Tag
<u>Map Sheet Elements</u>		
Map Title	.40, .60	MAPSHEET.TXT
Map Legend Box Text	.26, .40	MAPSHEET.TXT
Graphic Scale Text	.20	MAPSHEET.TXT
North Arrow Text	.20	MAPSHEET.TXT
Map Legend Symbol Text	.20, .22	MAPSHEET.TXT
Map Index Text	.06, .10	MAPSHEET.TXT
<u>Geodetic and Geographic Reference Elements</u>		
NGS Triangulation Station Text	.20	TRIANG.STATION.TXT
Traverse Station Text	.20	TRAVERSE.STATION.TXT
Photo Center Text	.20	PHOTO.CENTER.TXT
Bench Mark Text	.20	BENCH.MARK.TXT
Wisconsin State Plane Coordinate Grid Text	.20	GRID.TIC.OUT.TXT
U. S. Public Land Survey Corner Coordinates	.20	SECTION.CORNER.TXT
U. S. Public Land Survey Monument Coordinates	.20	MONUMENT.TXT
U. S. Public Land Survey Section Bearing/Length	.20	SECTION.LINE.TXT
U. S. Public Land Survey Quarter-Section Bearing/Length	.20	QTR.SECTION.LINE.TXT
<u>Hydrographic Elements</u>		
Open Water Name Text	.25*	WATER.PONDED.TXT
Single Width Water Name Text	.25*	WATER.NONPONDED.TXT
Marsh Name Text	.25*	MARSH.TXT
<u>Planimetric Elements</u>		
Road Name Text	.22	ROAD.PUBLIC.TXT
Unimproved Road Name Text	.22	ROAD.UNIMPROVED.TXT
Driveway & Parking Text	.22	DRIVEWAY.PARKING.TXT
Trail Text	.22	TRAIL.TXT
Railway Name Text	.22	RAILROAD.CENTERLINE.TXT
Building Name Text	.22	STRUCTURE.TXT
Ruins Foundation Name Text	.22	RUIN.TXT
Dam Name Text	.22	DAM.TXT
Pier Name Text	.22	PIER.TXT
Dock Wall Name Text	.22	DOCK.WALL.TXT
Aviation Runway/Taxiway Name Text	.22	RUNWAY.TXT
Cemetery Text	.22	CEMETERY.TXT
Paved Slab Text	.22	PAVED.SLAB.TXT
Open Storage, Pile, U/C Text	.22	OPEN_STORAGE/PILE.TXT
Pipeline Text	.22	PIPELINE.TXT
Overhead Structure Text	.22	OVERHEAD.STRUCTURE.TXT
Pool Text	.22	POOL.TXT
Tank, Silo Text	.22	TANK/SILO.TXT
Sign Text	.22	SIGN.TXT
Substation Text	.22	SUBSTATION.TXT
Tree Text	.22	TREE.TXT
Wall Text	.22	WALL.TXT
Park/Recreation Area Text	.22	PARK/RECREATION.TXT
Other Planimetric Feature Text	.22	OTHER.FEATURE.TXT
<u>Hypsometric Elements</u>		
Accentuated Contour Elevation Number	.22*	CONTOUR.INDEX.TXT
Accentuated Contour Depression Number	.22*	DEPRESSION.INDEX.TXT
Accentuated Approx. Contour Elevation Value	.22*	CONTOUR.INDEX.APPROX.TXT
Accentuated Approx. Contour Depression Value	.22*	DEPRESSION.INDEX.APPROX.TXT
Spot Elevation Value	.22	SPOT.ELEVATION.TXT
Water Surface Elevation Value	.22	SPOT.ELEVATION.WATER.TXT
U. S. Public Land Survey Corner Elevation	.20	SECTION.CORNER.ELEVATION.TXT

¹Text size is centimeters, text height and text width are equal. GenaMap font number 12 is to be used for all text. All text shall be placed without a slant, with the exception of the Hydrographic Element text and Hypsometric Element text indicated by "*" which is to be placed with a slant of -20.0 degrees.

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APPENDICES

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Appendix B

DETAILED SPECIFICATIONS FOR CADASTRAL MAPPING

Appendix B-1

DETAILED SPECIFICATIONS FOR ONE INCH EQUALS 100 FEET SCALE TRADITIONAL CADASTRAL MAPPING

I. GENERAL

These specifications set forth the requirements of _____ for cadastral mapping services. The Consultant shall furnish all labor, materials, and equipment necessary to properly complete the work specified herein.

II. CADASTRAL MAPS

A. General

The _____ shall furnish to the Consultant _____ predrafted base map sheets in the form of reproducible copies having a matte finish on both sides prepared on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. Each sheet shall measure 36 inches by 36 inches overall and shall cover one U. S. Public Land Survey quarter section at a scale of one inch equals one hundred feet (1" = 100').

B. Predrafted Data

The following data shall be shown on the predrafted base map sheets by the _____ prior to delivery to the Consultant:

1. All section and quarter-section lines and corners together with their grid and ground level lengths and grid bearings, all in their correct position and orientation. The section and quarter-section lines and the type of monument marking the section and quarter-section corners shall be indicated by appropriate symbols and a legend.
2. A north point based upon grid north shall be shown on its correct orientation on each base map sheet.
3. A combination scale and sea level reduction factor shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
4. A basic map projection, consisting of the intersections of grid lines on the Wisconsin State Plane Coordinate System. The grid line intersection tick marks shall be shown on the base map sheets at five (5)-inch intervals conforming to the even 500-foot interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
5. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.
6. Selected topographic features useful to the plotting or construction of real property boundary lines from legal descriptions, such as the threads of major streams and watercourses, lake shore lines, railways, and principal buildings.

C. Precision and Accuracy Standards—Predrafted Data

The base map sheets as provided to the Consultant by the _____ shall meet the following standards of precision and accuracy:

1. Each grid tick shall be plotted within 1/100 of an inch of the true state plane coordinate values.
2. Each U. S. Public Land Survey section and quarter section corner shall be plotted within 1/100 of an inch of the true position as expressed by the state plane coordinate values for the corner.
3. Ninety percent of all well-defined topographic features, such as the threads of major streams and watercourses, lake shore lines, railways, and principal buildings, existing prior to the date of the aerial photography used in preparing the _____ topographic maps, shall generally be plotted to within 1/30 of an inch of their true positions, and no such point shall be more than 1/20 of an inch from its true position.

D. Additional Data to be Furnished by _____

The _____ shall furnish to the Consultant, at no cost to the Consultant, the following additional data for use in preparation of the preliminary cadastral maps from the predrafted base map sheets:

1. Copies of all recorded subdivision plats and certified survey maps showing real property boundaries within the area for which cadastral maps are to be prepared.
2. Copies of plats of surveys showing all principal buildings constructed since the date of the aerial photography used in preparing the _____ topographic maps.
3. Copies of legal descriptions and, where available, plats of all public utility easements contained in the official records of the _____.
4. Copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications contained in the official records of the _____.

E. Construction of Cadastral Maps

General: Upon delivery of the predrafted base map sheets from the _____, the Consultant shall prepare preliminary cadastral maps for delivery to the _____. The preparation of these preliminary cadastral maps shall include the following work:

1. The Consultant shall plot in pencil on the predrafted base map sheets all of the following real property boundary lines and related information, all in their correct position and orientation, utilizing differentiating line symbols approved by the _____ for the area to be mapped:
 - a. All public street, road, and pedestrian right-of-way boundary lines, alley lines, and right-of-way centerlines, all in their correct position and orientation, together with associated text consisting of street and road names and right-of-way widths or half-widths; all existing and abandoned railway right-of-way boundary lines and centerlines, together with associated text consisting of railway names and right-of-way widths or half-widths; and all cul-de-sac radii, together with associated text consisting of radius values in feet.
 - b. All real property boundary lines in their correct position and orientation, consisting of: platted land subdivision lot boundary lines, certified survey map parcel boundary lines, and unplatted land division boundary lines; original or historical property boundary lines; property division lines showing splits and recombinations of splits of lots, parcels, or vacated streets and alleys; property lines extending into rights-of-way; property division or "tie" lines extending into rights-of-way; property lines imposed by the division of parcels by section lines of the U. S. Public Land Survey System; meander or survey reference lines; together with associated text comprised of all real property boundary line dimensions and annotations.
 - c. All real property parcel identification numbers, or unique tax key numbers, obtained from the _____ County parcel numbering system; as well as all notes and annotations indicating gaps and overlaps in legal descriptions.
 - d. All platted land boundary lines, consisting of: land subdivision boundary lines; certified survey map boundary lines; condominium boundary lines; together with associated text comprised of land subdivision names, lot and block numbers, certified survey map numbers and parcel letters or numbers, and condominium names and other associated dimensions and text.
 - e. All major cross-country public and private utility easement boundary lines, together with associated text of name or purpose of the easement, dimensions, and annotations.
 - f. All civil division boundary lines, consisting of divisions between village, city, and town municipalities, together with associated text containing the names of these entities.
 - g. All vinculum marks or "tie" marks (hooks) indicating common ownership of adjacent or connected properties.
 - h. All text-related or miscellaneous lines necessary to support text placement, consisting of the following: tick marks or points of tangency to delimit real property parcel dimensions along parcel lines; arrows or pointers to assist placement of real property parcel dimensions; arrows or pointers to assist placement of names and parcel identification numbers; and arrows or pointers to assist placement of notes and annotations.

It is recognized that the recorded dimensions and orientation of real property boundaries to be plotted on the base map sheets may not always agree with the horizontal control survey data shown on those sheets, since most property descriptions were written using field survey data obtained prior to the relocation of section and one-quarter-section corners and completion of the horizontal survey control network tied to the Wisconsin State Plane Coordinate System. Further, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and generally adhered to in other property boundary surveys is 1 part in 3,000 as compared to the third-order, class I survey accuracy of 1 part in 10,000 for the horizontal control surveys. As a result, overlapping or separated property boundary descriptions may be expected to exist. The property boundary line maps are to record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlaps or gaps shall be shown as mapped lines. Overlaps or gaps of less than 2.5 feet will be evident only from an examination of the recorded property line dimensions.

2. After the lines and features plotted in pencil as specified in Section E above have been checked by the _____, the Consultant shall ink all of those lines and features and shall correctly letter in India ink on the sheets the following information in a neat and orderly manner:
 - a. For all recorded subdivision plats and certified survey maps:
 - (1) Subdivision name or certified survey map number.
 - (2) Block and lot numbers.
 - (3) Street names.
 - (4) Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.
 - (5) Recorded lot dimensions to the highest degree of accuracy permitted by the data source.
 - (6) Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.
 - (7) _____ Tax Assessment key numbers.
 - b. For all properties other than those contained in a recorded subdivision plat or certified survey map:
 - (1) Street names.
 - (2) Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.
 - (3) Recorded property dimensions to the highest degree of accuracy permitted by the data source.
 - (4) Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.

(5) _____ Tax Assessment key numbers.

F. Precision and Accuracy Standards for the Preliminary Cadastral Map

1. Each real property boundary line shall be graphically constructed in its correct location and orientation on the predrafted map sheets in a manner which parallels the location of these lines on the surface of the earth following land surveying practice in the State of Wisconsin, and all real property boundary lines shall be plotted within 1/40 of an inch of their true position. The construction and plotting of the real property boundary lines shall be based upon and include the assembly of all authoritative information such as title documents, subdivision plats, certified survey maps, and private and public survey records that may be useful in determining the actual location of the real property boundaries, as well as proper analysis of this information to arrive at the best location of the property boundary lines. Proper performance in this respect depends largely upon a thorough knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason must be accomplished under the direction of a registered land surveyor.

Where recorded subdivision plats, certified survey maps, and plats of survey properly tied to the Wisconsin State Plane Coordinate System as that system has been made available for use in land surveys through the control survey network established within Southeastern Wisconsin by the Southeastern Wisconsin Regional Planning Commission; where the bearings shown on the plats and maps are properly referenced to grid north of the State Plane Coordinate System; and where the boundaries of the public rights-of-way and parcels shown on the plats and maps form closed geometric figures, the real property lines may be constructed through the computation and plating of coordinate positions for the ends of the property lines concerned, using the bearings and distances shown on the plats and maps.

2. Any overlap or gaps between adjoining property boundary lines as indicated by the construction and plotting of the real property boundary lines in accordance with Section F 1 above shall be noted by the Consultant on the preliminary cadastral maps.

III. FINAL CADASTRAL MAP DELIVERY

- A. The Consultant shall deliver the completed preliminary cadastral maps to the _____ together with the data used in the map compilation. Real property boundary line and related information data shall be current to the date of delivery of the completed preliminary cadastral maps.
- B. The _____ shall then examine and check the completed cadastral maps for conformance with the provisions of these specifications.
- C. The Consultant shall then perform such additional corrective work as may be required to secure complete and accurate finished cadastral maps.

IV. DELIVERY DATES

- A. Predrafted Base Map Sheets
The _____ shall deliver the predrafted base map sheets as specified in Section II B herein, together with all information specified in Section II D herein, to the Consultant within _____ days of the execution date of the contract.
- B. Finished Cadastral Maps
The Consultant shall deliver the finished cadastral maps as specified in Section II F herein, together with all related documents, to the _____, _____ days after the _____ delivers all predrafted base map sheets to the Consultant.

V. BASIS OF PAYMENT

- A. The Contract price of the work, the lump sum of _____ (\$) shall include all the labor, materials, and equipment necessary to properly complete the preliminary cadastral maps and related services for the _____ U. S. Public Land Survey quarter sections as specified herein.
- B. It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Consultant may submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Appendix B-2

DETAILED SPECIFICATIONS FOR ONE INCH EQUALS 200 FEET SCALE TRADITIONAL CADASTRAL MAPPING

I. GENERAL

These specifications set forth the requirements of _____ for cadastral mapping services. The Consultant shall furnish all labor, materials, and equipment necessary to properly complete the work specified herein.

II. CADASTRAL MAPS

A. General

The _____ shall furnish to the Consultant _____ predrafted base map sheets in the form of reproducible copies having a matte finish on both sides prepared on dimensionally stable polyester base material having a minimum thickness of 0.007 inch. Each sheet shall measure 36 inches by 36 inches overall and shall cover one U. S. Public Land Survey section at a scale of one inch equals two hundred feet (1" = 200').

B. Predrafted Data

The following data shall be shown on the predrafted base map sheets by the _____ prior to delivery to the Consultant:

1. All section and quarter-section lines and corners together with their grid and ground level lengths and grid bearings, all in their correct position and orientation. The section and quarter-section lines and the type of monument marking the section and quarter-section corners shall be indicated by appropriate symbols and a legend.
2. A north point based upon grid north shall be shown on its correct orientation on each base map sheet.
3. A combination scale and sea level reduction factor shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
4. A basic map projection, consisting of the intersections of grid lines on the Wisconsin State Plane Coordinate System. The grid line intersection tick marks shall be shown on the base map sheets at five (5)-inch intervals conforming to the even 1,000-foot interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.
5. Map borders and trim lines, and a title block, with the latter containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____. An explanatory legend shall be provided depicting symbols used on the map, together with associated text.
6. Selected topographic features useful to the plotting or construction of real property boundary lines from legal descriptions, such as the threads of major streams and watercourses, lake shore lines, railways, and principal buildings.

C. Precision and Accuracy Standards—Predrafted Data

The base map sheets as provided to the Consultant by the _____ shall meet the following standards of precision and accuracy:

1. Each grid tick shall be plotted within 1/100 of an inch of the true state plane coordinate values.
2. Each U. S. Public Land Survey section and quarter section corner shall be plotted within 1/100 of an inch of the true position as expressed by the state plane coordinate values for the corner.
3. Ninety percent of all well-defined topographic features, such as the threads of major streams and watercourses, lake shore lines, railways, and principal buildings, existing prior to the date of the aerial photography used in preparing the _____ topographic maps, shall generally be plotted to within 1/30 of an inch of their true positions, and no such point shall be more than 1/20 of an inch from its true position.

D. Additional Data to be Furnished by _____

The _____ shall furnish to the Consultant, at no cost to the Consultant, the following additional data for use in preparation of the preliminary cadastral maps from the predrafted base map sheets:

1. Copies of all recorded subdivision plats and certified survey maps showing real property boundaries within the area for which cadastral maps are to be prepared.
2. Copies of plats of surveys showing all principal buildings constructed since the date of the aerial photography used in preparing the _____ topographic maps.
3. Copies of legal descriptions and, where available, plats of all public utility easements contained in the official records of the _____.
4. Copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications contained in the official records of the _____.

E. Construction of Cadastral Maps

General: Upon delivery of the predrafted base map sheets from the _____, the Consultant shall prepare preliminary cadastral maps for delivery to the _____. The preparation of these preliminary cadastral maps shall include the following work:

1. The Consultant shall plot in pencil on the predrafted base map sheets all of the following real property boundary lines and related information, all in their correct position and orientation, utilizing differentiating line symbols approved by the _____ for the area to be mapped:

- a. All public street, road, and pedestrian right-of-way boundary lines, alley lines, and right-of-way centerlines, all in their correct position and orientation, together with associated text consisting of street and road names and right-of-way widths or half-widths; all existing and abandoned railway right-of-way boundary lines and centerlines, together with associated text consisting of railway names and right-of-way widths or half-widths; and all cul-de-sac radii, together with associated text consisting of radius values in feet.
- b. All real property boundary lines in their correct position and orientation, consisting of: platted land subdivision lot boundary lines, certified survey map parcel boundary lines, and unplatted land division boundary lines; original or historical property boundary lines; property division lines showing splits and recombinations of splits of lots, parcels, or vacated streets and alleys; property lines extending into rights-of-way; property division or "tie" lines extending into rights-of-way; property lines imposed by the division of parcels by section lines of the U. S. Public Land Survey System; meander or survey reference lines; together with associated text comprised of all real property boundary line dimensions and annotations.
- c. All real property parcel identification numbers, or unique tax key numbers, obtained from the _____ County parcel numbering system; as well as all notes and annotations indicating gaps and overlaps in legal descriptions.
- d. All platted land boundary lines, consisting of: land subdivision boundary lines; certified survey map boundary lines; condominium boundary lines; together with associated text comprised of land subdivision names, lot and block numbers, certified survey map numbers and parcel letters or numbers, and condominium names and other associated dimensions and text.
- e. All major cross-country public and private utility easement boundary lines, together with associated text of name or purpose of the easement, dimensions, and annotations.
- f. All civil division boundary lines, consisting of divisions between village, city, and town municipalities, together with associated text containing the names of these entities.
- g. All vinculum marks or "tie" marks (hooks) indicating common ownership of adjacent or connected properties.
- h. All text-related or miscellaneous lines necessary to support text placement, consisting of the following: tick marks or points of tangency to delimit real property parcel dimensions along parcel lines; arrows or pointers to assist placement of real property parcel dimensions; arrows or pointers to assist placement of names and parcel identification numbers; and arrows or pointers to assist placement of notes and annotations.

It is recognized that the recorded dimensions and orientation of real property boundaries to be plotted on the base map sheets may not always agree with the horizontal control survey data shown on those sheets, since most property descriptions were written using field survey data obtained prior to the relocation of section and one-quarter-section corners and completion of the horizontal survey control network tied to the Wisconsin State Plane Coordinate System. Further, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and generally adhered to in other property boundary surveys is 1 part in 3,000 as compared to the third-order, class I survey accuracy of 1 part in 10,000 for the horizontal control surveys. As a result, overlapping or separated property boundary descriptions may be expected to exist. The property boundary line maps are to record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlaps or gaps shall be shown as mapped lines. Overlaps or gaps of less than 2.5 feet will be evident only from an examination of the recorded property line dimensions.

2. After the lines and features plotted in pencil as specified in Section E above have been checked by the _____, the Consultant shall ink all of those lines and features and shall correctly letter in India ink on the sheets the following information in a neat and orderly manner:
 - a. For all recorded subdivision plats and certified survey maps:
 - (1) Subdivision name or certified survey map number.
 - (2) Block and lot numbers.
 - (3) Street names.
 - (4) Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.
 - (5) Recorded lot dimensions to the highest degree of accuracy permitted by the data source.
 - (6) Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.
 - (7) _____ Tax Assessment key numbers.
 - b. For all properties other than those contained in a recorded subdivision plat or certified survey map:
 - (1) Street names.
 - (2) Street, alley, and other public way right-of-way widths to the highest degree of accuracy permitted by the data source.
 - (3) Recorded property dimensions to the highest degree of accuracy permitted by the data source.
 - (4) Easement right-of-way widths to the highest degree of accuracy permitted by the data source together with the purpose of the easement.
 - (5) _____ Tax Assessment key numbers.

F. Precision and Accuracy Standards for the Preliminary Cadastral Map

1. Each real property boundary line shall be graphically constructed in its correct location and orientation on the predrafted map sheets in a manner which parallels the location of these lines on the surface of the earth following land surveying practice in the State of Wisconsin, and all real property boundary lines shall be plotted within 1/40 of an inch of their true position. The construction and

plotting of the real property boundary lines shall be based upon and include the assembly of all authoritative information such as title documents, subdivision plats, certified survey maps, and private and public survey records that may be useful in determining the actual location of the real property boundaries, as well as proper analysis of this information to arrive at the best location of the property boundary lines. Proper performance in this respect depends largely upon a thorough knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason must be accomplished under the direction of a registered land surveyor.

Where recorded subdivision plats, certified survey maps, and plats of survey properly tied to the Wisconsin State Plane Coordinate System as that system has been made available for use in land surveys through the control survey network established within Southeastern Wisconsin by the Southeastern Wisconsin Regional Planning Commission; where the bearings shown on the plats and maps are properly referenced to grid north of the State Plane Coordinate System; and where the boundaries of the public rights-of-way and parcels shown on the plats and maps form closed geometric figures, the real property lines may be constructed through the computation and platting of coordinate positions for the ends of the property lines concerned, using the bearings and distances shown on the plats and maps.

2. Any overlap or gaps between adjoining property boundary lines as indicated by the construction and plotting of the real property boundary lines in accordance with Section F 1 above shall be noted by the Consultant on the preliminary cadastral maps.

III. FINAL CADASTRAL MAP DELIVERY

- A. The Consultant shall deliver the completed preliminary cadastral maps to the _____ together with the data used in the map compilation. Real property boundary line and related information data shall be current to the date of delivery of the completed preliminary cadastral maps.
- B. The _____ shall then examine and check the completed cadastral maps for conformance with the provisions of these specifications.
- C. The Consultant shall then perform such additional corrective work as may be required to secure complete and accurate finished cadastral maps.

IV. DELIVERY DATES

- A. Predrafted Base Map Sheets
The _____ shall deliver the predrafted base map sheets as specified in Section II B herein, together with all information specified in Section II D herein, to the Consultant within ____ days of the execution date of the contract.
- B. Finished Cadastral Maps
The Consultant shall deliver the finished cadastral maps as specified in Section II F herein, together with all related documents, to the _____, ____ days after the _____ delivers all predrafted base map sheets to the Consultant.

V. BASIS OF PAYMENT

- A. The Contract price of the work, the lump sum of _____ (\$) _____ shall include all the labor, materials, and equipment necessary to properly complete the preliminary cadastral maps and related services for the _____ U. S. Public Land Survey quarter sections as specified herein.
- B. It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amounts stipulated above for all the service required as specified herein. The Consultant may submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Appendix B-3

DETAILED SPECIFICATIONS FOR ONE INCH EQUALS 100 FEET SCALE DIGITAL CADASTRAL MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for digital and hardcopy cadastral map preparation. The Consultant shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. CADASTRAL MAPS

A. General

The Consultant shall prepare cadastral maps in the form of digital cadastral map files and finished cadastral maps in hardcopy form. For the purpose of interpreting these standards within the context of the digital cadastral map files, the "publication scale" of these digital maps shall be one inch equals one hundred feet (1" = 100'). The Consultant shall also provide finished cadastral maps plotted to a scale of one inch equals one hundred feet (1" = 100'). These finished cadastral maps shall be prepared in the form of ink tracings, electrostatic images, or ink-jet printed images of the digital cadastral map files on dimensionally stable and reproducible polyester base material. The project area to be mapped consists of _____ U. S. Public Land Survey System quarter sections in Township _____ North, Range _____ East, in _____ County, totaling approximately _____ square miles. The project area contains approximately _____ cadastral parcels.

B. Material to be Furnished by the _____

The _____ shall furnish to the Consultant, at no cost to the Consultant, the following material for use in preparation of the digital cadastral map files and finished cadastral maps:

1. Copies of the most recent Control Survey Summary Diagrams detailing the system of horizontal survey control for the project area. This material will be used to establish correct U. S. Public Land Survey System monument and corner locations and Wisconsin State Plane Coordinate System northing and easting values, and also to establish correct grid and ground distances and bearings along section and quarter-section lines within the digital cadastral map files for the project area.
2. Copies of all recorded subdivision plats, certified survey maps, plats of survey, and, where available, private and public survey records that may be useful in determining the actual location of the real property boundaries within the project area.
3. Copies of legal descriptions, and, where available, plats of all major cross-country public utility easements contained in the official records of _____ County within the project area.
4. Copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications contained in the official records of _____ County within the project area.
5. One copy of the current Assessment Roll for each civil division within the project area.
6. Photostatic reproductions of the legal descriptions contained in the most recently recorded deed transactions for all real property boundaries in the project area not included within recorded subdivision plats or certified survey maps within the project area for those real property descriptions where the abbreviated legal description contained in the current Assessment Roll is judged to be incomplete or in some other way deficient.
7. Copies of current legal descriptions of the boundaries of incorporated civil divisions within the project area.

In the event that certain materials are deficient, or in the event that additional legal descriptions contained in recorded deed transactions are needed, the Consultant shall notify the _____, and the _____ shall furnish the additional materials to the Consultant, at no cost to the Consultant.

C. Data to be Shown on the Cadastral Maps

Both the digital cadastral map files and the finished cadastral maps to be prepared by the Consultant shall show correctly on each map face the following information:

1. All map sheet elements. If requested, the _____ shall provide to the Consultant a digital map file in GenaMap binary format containing the map sheet elements to be used as a template for creation of the digital cadastral map files. The _____ shall also provide to the Consultant, if necessary, a plotted hardcopy version of this digital map file. The map sheet elements to be shown consist of the following:
 - a. A map border and map trim lines.
 - b. A title block containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, section and quarter section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____.
 - c. An explanatory legend, depicting symbols used on the map, together with associated text.
 - d. A north point or arrow based upon grid north.
 - e. A combination scale and sea level reduction factor for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The combination scale and sea level reduction factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
 - f. A basic map projection, consisting of the intersections of grid lines on the Wisconsin State Plane Coordinate System. The grid line intersection tick marks shall be shown on the base map sheets at five (5)-inch intervals conforming to the even 500-foot interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.

2. All U. S. Public Land Survey System section and quarter-section lines, together with their grid and ground level lengths and grid bearings, all in their correct position and orientation; all U. S. Public Land Survey System monumented and unmonumented section and quarter-section corners, together with their Wisconsin State Plane Coordinate System northing and easting values; and related text consisting of adjoining quarter-section numbers.
3. All public street, road, and pedestrian right-of-way boundary lines, alley lines, and right-of-way centerlines, all in their correct position and orientation, together with associated text consisting of street and road names and right-of-way widths or half-widths; all existing and abandoned railway right-of-way boundary lines and centerlines, together with associated text consisting of railway names and right-of-way widths or half-widths; and all cul-de-sac radii, together with associated text consisting of radius values in feet.
4. All real property boundary lines in their correct position and orientation, consisting of: platted land subdivision lot boundary lines, certified survey map parcel boundary lines, and unplatted land division boundary lines; original or historical property boundary lines; property division lines showing splits and recombinations of splits of lots, parcels, or vacated streets and alleys; property lines extending into rights-of-way; property division or "tie" lines extending into rights-of-way; property lines imposed by the division of parcels by section lines of the U. S. Public Land Survey System; meander or survey reference lines; together with associated text comprised of all real property boundary line dimensions and annotations.
5. All real property parcel identification numbers, or unique tax key numbers, obtained from the _____ County parcel numbering system; as well as all notes and annotations indicating gaps and overlaps in legal descriptions.
6. All platted land boundary lines, consisting of: land subdivision boundary lines; certified survey map boundary lines; condominium boundary lines; together with associated text comprised of land subdivision names, lot and block numbers, certified survey map numbers and parcel letters or numbers, and condominium names and other associated dimensions and text.
7. All major cross-country public and private utility easement boundary lines, together with associated text of name or purpose of the easement, dimensions, and annotations.
8. All civil division boundary lines, consisting of divisions between village, city, and town municipalities, together with associated text containing the names of these entities.
9. All vinculum marks or "tie" marks (hooks) indicating common ownership of adjacent or connected properties.
10. All text-related or miscellaneous lines necessary to support text placement, consisting of the following: tick marks or points of tangency to delimit real property parcel dimensions along parcel lines; arrows or pointers to assist placement of real property parcel dimensions; arrows or pointers to assist placement of names and parcel identification numbers; and arrows or pointers to assist placement of notes and annotations.

It is recognized that the recorded dimensions and orientation of real property boundaries to be shown in the digital cadastral map files and finished cadastral maps may not always agree with the horizontal control survey data shown on those sheets, since most property descriptions were written using field survey data obtained prior to the relocation of section and one-quarter-section corners and completion of the horizontal survey control network tied to the Wisconsin State Plane Coordinate System. Further, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and generally adhered to in other property boundary surveys is 1 part in 3,000 as compared to the third order, class I survey accuracy of 1 part in 10,000 for the horizontal control surveys. As a result, overlapping or separated property boundary descriptions may be expected to exist. The digital cadastral map files and finished cadastral maps are to record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlaps or gaps shall be shown as mapped lines. Overlaps or gaps of less than 2.5 feet will be evident only from an examination of the recorded property line dimensions.

D. Digital Map File Organization and Specifications

The Consultant shall organize the digital cadastral map files in such a manner as to provide plotted cadastral maps similar in appearance to cadastral maps prepared by the _____. Among other things, this will require the preparation in digital form of a standard "map sheet" format, including appropriate title and legend information. If requested, the _____ shall furnish to the Consultant sample digital cadastral map files and a sample finished cadastral map as examples of the types of products that are to be prepared. These samples will also help to illustrate the feature content, text size and placement, and the digital map file organization required for the delivered products.

1. The digital map sheets shall be 36 inches by 36 inches in size when plotted at a scale of one inch equals one hundred feet (1" = 100'), and each sheet shall cover an entire U. S. Public Land Survey System quarter section. The title block shall contain the following information: graphic scale and text, date, type of map, location by county and state, name of the _____, name of the Consultant, and appropriate project and sheet numbers, if applicable. A north point based upon grid north shall be shown. A combination scale and sea level reduction factor shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
2. The Consultant shall deliver the digital cadastral map files in GenaMap proprietary mapping software format, version 6.1 or later. All digital arc/node and text files shall be delivered in binary form and shall conform to the GenaMap file structure. This requires that all arc/node or vector maps exist in a "ZF04" directory structure, and that all text maps exist in a "ZF10" directory structure. All other GenaMap compatible digital files prepared by the Consultant for map creation or display shall exist in suitable directories within the GenaMap directory structure.
3. The Consultant shall deliver the digital cadastral map files on one of the following three types of media: 1) 4-millimeter Digital Data Storage (DDS) magnetic tape, either 60 or 90 meters in length, and compatible with the _____ computer system; 2) 8-millimeter Data Cartridge magnetic tape, 112 meters in length, and compatible with the _____ computer system; or 3) CD-ROM disk, written to ISO 9660 Level II specifications. The digital cadastral map files shall be placed on the media in a sequential file format, using common UNIX computer operating system commands. The Consultant shall establish the correct format and procedures for the transfer and delivery of the digital information on magnetic tape or CD-ROM disk in consultation with the _____.
4. The digital cadastral map files shall be organized and conform to the following standards for GenaMap arc/node and text maps:
 - a. Arc/node, or vector, map files shall consist of twelve (12) separate map files as identified in Table 1, attached hereto. The separate arc/node map files provide a systematic and logical organization of map features, and insure that data elements can be selectively retrieved, manipulated, and displayed, either singly or in combination with other data elements. The five columns in the table are described as follows:

The first column in Table 1, "Map Prefix," identifies a two-letter mnemonic that describes each of the twelve arc/node maps. The file naming convention to be followed for arc/node maps is of the form "PPttrrssq," where "PP" is the two-letter, upper-case map prefix, and "ttrrssq" are character designations for U. S. Public Land Survey System township ("tt"), range ("rr"), section ("ss"), and one-quarter section ("q", numbered counter-clockwise beginning with the number 1 [one] in the northeast quarter). For example, an arc/node map with the name "PL0122331" indicates a Parcel Line map for Township 1 North, Range 22 East, Section 33, Northeast quarter.

The second column, "Layer Name," identifies the full name associated with the two-character map prefix. It is intended to describe the general group of features included in each of the twelve arc/node maps.

The third column, "Feature Type," indicates the type of graphic primitive to be digitally encoded for each of the enumerated features. All features in the digital files will be explicitly defined as either points, lines, or areas.

The fourth column, "Feature Tag," indicates the GenaMap tag to be assigned to the enumerated features. All features will be labelled with the appropriate tag specified in this column. The one exception to this requirement is the tag for real property area features in the Parcel Area map. These features will be tagged with the unique _____ County tax key identification number assigned to each property.

The fifth column, "Description," further identifies the individual features that are to be tagged and included in each arc/node map.

The Consultant may, in consultation with the _____, suggest changes or modifications to any element of these specifications for arc/node maps. If such modifications are approved by the _____, a new table and set of specifications will be issued to describe the revised standards for arc/node map files.

- b. Text map files shall consist of twelve (12) separate map files as identified in Table 2, attached hereto. This table describes the items to be included in each text map and specifies the font attributes for GenaMap font number 12 which is to be used exclusively in all text maps. The six columns in the table are described as follows:

The first column in Table 2, "Map Prefix," identifies a two-letter mnemonic that describes each of the twelve text maps. The file naming convention to be followed for text maps is similar to that for arc/node maps, and is of the form "PPttrrssqT," where "PP" is the two-letter, upper-case map prefix, "ttrrssq" are character designations for U. S. Public Land Survey System township ("tt"), range ("rr"), section ("ss"), and one-quarter section ("q", numbered counter-clockwise beginning with the number 1 [one] in the northeast quarter), and "T" is simply upper-case letter T to indicate that the digital map file is a text map. For example, a text map with the name "PD0122331T" indicates a Parcel Dimension text map for Township 1 North, Range 22 East, Section 33, Northeast quarter.

The second column, "Text Layer Name," identifies the full name associated with the two-character map prefix. It is intended to describe the general group of text features included in each of the twelve text maps.

The third column, "Text Description," indicates the text items that are to be included in each text map.

The fourth column, "Text Tag," indicates the GenaMap tag to be assigned to the text features. All text will be labelled with the appropriate tag specified in this column.

The fifth column, "Width & Height," indicates the font width and height, in centimeters, for the feature text.

The sixth column, "Slant," identifies the text slant, in degrees, for the feature text.

The Consultant may, in consultation with the _____, suggest changes or modifications to any element of these specifications for text maps. If such modifications are approved by the _____, a new table and set of specifications will be issued to describe the revised standards for text map files.

5. The digital cadastral map files are to be encoded as simple unsymbolized point, line, and area graphic primitives. Feature symbology, such as colors, line weights, and line patterns, shall not be assigned or encoded into features in the digital files. Any symbology that may be required for such activities as quality control and creation of check plots will be accomplished by use of a standard GenaMap "Bundle Table" symbology database. The _____ shall furnish a digital file of this symbology database to the Consultant if requested.
6. The Consultant shall use proper methods and procedures to digitally encode the vector data such that the data will create topologically correct vector map files. Among other things, this will require that the Consultant use procedures to "snap" line segments together to ensure that the vector map files do not contain gaps or overshoots between line segments, and that all line segments are properly connected and continuous where applicable. Procedures should also be used to ensure that there are no duplicate, coincident, or overlapping line segments in any vector map files.
7. The extent of the area to be mapped for each file shall be the section and quarter-section lines that form the boundary of each U. S. Public Land Survey System quarter section within the project area. This requires that all right-of-way lines, real property boundary lines, and other cadastral lines that ordinarily cross section boundary lines be terminated at these boundary lines. For the purposes of "edge matching" such cadastral lines, all continuous lines crossing map file boundaries shall have connectable points on the appropriate U. S. Public Land Survey section and quarter-section lines in the adjoining files. These points shall have identical x and y values.
8. If applicable, the _____ shall provide copies to the Consultant of previously prepared digital cadastral map files, in GenaMap format, for _____ U. S. Public Land Survey quarter sections that are immediately adjacent to the exterior of the project area to be mapped. The Consultant shall utilize these digital cadastral map files for the purpose of "edge matching" such features as right-of-way boundary lines, real property boundary lines, land subdivision and certified survey map boundary lines, and other cadastral lines as necessary to insure proper alignment of boundary lines across section and quarter-section lines in adjacent maps.
9. All computer software used by the Consultant in the preparation and transfer of the digital cadastral map files shall be capable of maintaining the full mathematical precision of the horizontal control survey information required for this contract. This may require the use of computer software written in double precision.
10. The Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927, shall be utilized as the coordinate system for the encoding of all digital map data elements.

E. Preparation of Finished Cadastral Maps

The Consultant shall utilize digital plotting equipment having a minimum resolution of 400 DPI and capable of preparing check plots and finished maps that approach in their overall appearance finished cadastral maps prepared by the _____. All plotting of the check plots and finished maps shall be to a high standard of workmanship.

All check plots submitted for edit purposes and all finished cadastral maps shall be plotted directly from the digital cadastral map files in GenaMap format. The check plots and finished maps shall display all text features in the correct font and size according to the specifications given in Table 2 attached hereto. Text features in the digital cadastral map files shall be properly placed in relationship to adjacent vector and text features, such that text will not overstrike or overplot adjacent vector and text features on the hardcopy check plots and finished cadastral maps.

The plotted map sheets shall be 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey System quarter section. The map title shall contain a graphic scale and the following information: scale, date of mapping, type of map, location by county and state, name of the _____, name of the Consultant, and appropriate project and sheet numbers, if applicable.

The following procedures shall be employed in the development of the finished digital cadastral map files and finished cadastral maps:

1. The Consultant shall provide vellum or paper check plots of the digital cadastral map files for each U. S. Public Land Survey Section to the _____. The check plots to be provided consist of a series of six individual plots as described in Table 3, attached hereto. The four columns in the table are described as follows:

The first column in Table 3, "Plot," identifies the number or name of the check plot in the series of six check plots that are to be produced for each U. S. Public Land Survey quarter section.

The second column, "Maps," indicates the digital cadastral map files that are to be plotted, either wholly or in part, for each check plot.

The third column, "Features to Plot," identifies the arc/node features and text to be displayed on each check plot. The exception to this is "Checkplot 3," where real property parcels and other area features are to be labelled as well as plotted in order to verify the integrity and accuracy of the polygons in the "PA" digital cadastral map file.

The fourth column, "Symbology," is intended as a guide to the display of information on each check plot. Each check plot is intended to allow inspection of related sets of vector and text maps by means of differentiating symbology, with most check plots also displaying ancillary vector and text maps in background symbology. Symbolization of features and text shall be achieved through the use of color, line style, line pattern, or any other type of representation agreed upon by the Consultant and the _____.

The series of six checkplots is intended to furnish a systematic, graphic, analog representation of the digital cadastral map files, and as such shall provide a means to verify the completeness, accuracy, and integrity of the digitally encoded cadastral data. The Consultant and the _____ shall collaborate on the content and the symbology of the six cadastral map check plots in order to facilitate the editing and review of the plots and the digital cadastral map files.

In addition to the six check plots, the Consultant shall also provide to the _____ all land records and other materials used by the Consultant in the preparation of the digital cadastral map files for each U. S. Public Land Survey quarter-section.

2. The _____ shall conduct office editing and review of the cadastral map check plots utilizing the land records provided by the Consultant.
3. The _____ shall annotate the cadastral map check plots, if necessary, to indicate corrections or additions to be made to the digital cadastral map files, and return the annotated check plots and, if necessary, the attendant land records, to the Consultant.
4. The Consultant shall revise the digital cadastral map files to reflect the annotations and corrections shown on the cadastral map check plots.
5. Magnetic tapes of the corrected digital cadastral map files, in the GenaMap digital format as specified in Section II.D.2 above and the media format as specified in Section II.D.3 above, together with the original set of six annotated cadastral map check plots and one copy of the finished cadastral map plot on high-quality paper media, shall be provided by the Consultant to the _____.
6. The _____ shall inspect the digital cadastral map files, annotated cadastral map check plots, and finished cadastral map plot to determine compliance with the specifications.
7. Should the digital cadastral map files and finished cadastral map plot be found by the _____ to meet the specifications, the _____ shall notify the Consultant that said materials are accepted in full by the _____. The Consultant shall then produce and deliver to the _____ the finished cadastral map plot on dimensionally stable and reproducible polyester base material for the accepted quarter-sections. The Consultant shall also return all attendant land records utilized in the preparation of the digital cadastral map files and finished hardcopy maps to the _____.
8. Should the digital cadastral map files and finished cadastral map plot be found by the _____ to require further revisions to comply with the specifications, the _____ shall so notify the Consultant, and the _____ shall return any digital cadastral map files or plots to the Consultant for correction as may be necessary.
9. The Consultant shall then follow the procedures noted in Section II.E.4 and subsequent paragraphs to produce and deliver to the _____ the finished digital cadastral map files and the finished cadastral map plot on high-quality paper media.

F. Precision and Accuracy Standards

1. The map projection grid for the digital cadastral map files shall be constructed inside the computer memory through key entry procedures. Digital plotting equipment utilized by the Consultant shall be capable of plotting each grid line or tick on the finished map sheets within 1/100 of an inch of the true grid values.

2. Each section corner and quarter-section corner contained in the digital map files shall be plotted on the map projection grid through key entry of the adjusted coordinates computed for the point. Digital plotting equipment utilized by the Consultant shall be capable of plotting each section corner and quarter-section corner on the finished map sheets within 1/100 of an inch of the true position as expressed by the adjusted coordinates computed for the point.
3. Each real property boundary line shall be graphically constructed in its correct location and orientation on the predrafted map sheets in a manner which parallels the location of these lines on the surface of the earth following land surveying practice in the State of Wisconsin, and all real property boundary lines shall be plotted within 1/40 of an inch of their true position. Except as provided below, the property boundary lines will be constructed on hard copy work sheets and then board digitized. The construction and plotting of the real property boundary lines shall be based upon and include the assembly of all authoritative information such as title documents, subdivision plats, certified survey maps, and private and public survey records that may be useful in determining the actual location of the real property boundaries, as well as proper analysis of this information to arrive at the best location of the property boundary lines. Proper performance in this respect depends largely upon a thorough knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason must be accomplished under the direction of a registered land surveyor.
4. Any overlaps or gaps between adjoining property boundary lines as indicated by the construction and plotting of the real property boundary lines in accordance with Section II.F.3 above shall be noted by the Consultant on the digital cadastral map files and finished cadastral maps.
5. Ninety percent of all well-defined planimetric features shall be plotted so that their position in the digital cadastral map files and on the finished cadastral maps shall be accurate to within 1/30 of an inch of their true coordinate position, and no point shall be more than 1/20 of an inch from its true position.
6. The completed finished cadastral maps shall be office checked by the _____. Recorded real property parcel dimensions and right-of-way dimensions shall be compared against the map data, and any finished cadastral maps and digital cadastral map files that do not conform to the requirements of these specifications shall be corrected by the Consultant to fully meet the specified accuracy.

III. ITEMS TO BE DELIVERED

Upon completion the Consultant shall deliver to the _____ the following items:

- A. One set of digital cadastral map files, in the GenaMap format and media format as specified under Section II.D.2 and Section II.D.3 above, containing cadastral maps of the project area as designated herein.
- B. One set of original plots on dimensionally stable and reproducible polyester base material of the finished cadastral maps of the project area as designated herein.

IV. DELIVERY DATE

All digital cadastral map files and finished cadastral maps shall be delivered to the _____ on or before _____.

V. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all computer programming and computer operation services necessary for the delivery of the completed digital cadastral map files and finished cadastral maps specified herein.

It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amount stipulated above for all the service required as specified herein. The Consultant shall submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Table 1

SPECIFICATIONS FOR GENAMAP CADASTRAL ARC/NODE MAPS
1" = 100' SCALE

Map Prefix	Layer Name	Feature Type	Feature Tag	Description
CG	Cadastral Geometry	Point	MONUMENT.PT	USPLSS monument location
		Point	OTHER.PT	Other point location
		Line	SEC.LINE	USPLSS section line
		Line	QSEC.LINE	USPLSS quarter-section line
RW	Right of Way	Line	ROW	Street and road right-of-way line
		Line	RR.ROW	Railroad right-of-way line
		Line	ROW/RR.ROW	Common street and road and railroad right-of-way line
		Line	ROW.CENTER.LINE	Right-of-way centerline
		Line	RR.CENTER.LINE	Railroad centerline
		Line	RADIUS	Cul-de-sac radius
PL	Parcel Line	Line	PARCEL.LINE	Property boundary line
		Line	ORIGINAL.PARCEL.LINE	Historical property boundary line
		Line	EXTENDED.PARCEL.LINE	Property boundary line extending into right-of-way
		Line	PLSS.LINE	Public Land Survey System line
		Line	TIE.LINE	Property division line
		Line	EXTENDED.TIE.LINE	Property division line extending into right-of-way
		Line	MEANDER.LINE	Survey reference line
PA	Parcel Area	Line	PROPERTY.LINE	All edges
		Area	(parcel ID number)	Unique tax key ID number
		Area	GAP	Small gap between properties
		Area	OVERLAP	Overlapping property area
		Area	ROAD.RESERVATION	Undedicated right-of-way area of CSM
EA	Easement	Line	EASEMENT.LINE	Easement boundary line
SD	Subdivision	Line	SD.LINE	Subdivision boundary line
CS	Certified Survey Map	Line	CSM.LINE	Certified survey map boundary line
CO	Condominium	Line	CO.LINE	Condominium boundary line
CD	Civil Division	Line	CD.LINE	Civil division boundary line
TM	Tie Mark	Line	TIE	"Hook" connecting properties
TR	Text Related	Line	DA	Dimension arrow
		Line	IA	Identification arrow
		Line	PT	Point of tangency tic mark
		Line	NOTE	Note or annotation arrow
MS	Map Sheet	Line	MAP.BORDER	Map border line
		Line	TRIM.LINE	Map trim line
		Line	BAR.SCALE	Map bar scale
		Line	NORTH.ARROW	Map north arrow
		Line	NORTH.ARROW.CURVE	Arc along north arrow
		Line	MAP.LEGEND.SYMBOL	Map legend symbol
		Line	MAP.LEGEND.SEC.LINE	Map legend symbolized line
		Line	MAP.LEGEND.QSEC.LINE	Map legend symbolized line
		Line	MAP.LEGEND.CD.LINE	Map legend symbolized line
		Line	MAP.LEGEND.SD.LINE	Map legend symbolized line
		Line	LOGO	Map logo or seal
		Line	INDEX.LOCATION.BOX	Map index locator
		Line	INDEX.SECTION.LINE	Map index section line
		Line	INDEX.COUNTY.TOWNSHIP.LINE	Map index county and township boundary line
		Line	INDEX.CITY.BOUNDARY.LINE	Map index civil division boundary line
		Line	GRID.TIC.IN	Interior SPCS grid tic
		Line	GRID.TIC.OUT	Exterior SPCS grid interval

Table 2

SPECIFICATIONS FOR GENAMAP CADASTRAL TEXT MAPS
1" = 100' SCALE

Map Prefix	Text Layer Name	Text Description	Text Tag	Width & Height	Slant
CG_T	Cadastral Geometry	SPCS Northings and Eastings	COORDS	.18	0
		Section and quarter-section line bearings	BEARNG	.18	0
		Section and quarter-section line grid distances	GRDIST	.18	0
		Section and quarter-section line ground distances	GRDIST	.18	-20
		Adjoining quarter-section numbers	QTRNUM	.35	0
RW_T	Right of Way	Street and road names	STRNAM	.22	0
		Railway names	RWYNAM	.22	0
		Right-of-way widths	ROWDIM	.18	0
		Cul-de-sac radius values	CDSRAD	.18	0
PD_T	Parcel Dimension	Property dimensions	PRPDIM	.16, .14 or .12	0
PL_T	Parcel ID Number	Parcel tax key numbers	TAXPIN	.24	0
SD_T	Subdivision	Subdivision names	SUBNAM	.35	0
		Block numbers	BLKNUM	.30 or .28	0
		Lot numbers & outlot names	LOTNUM	.25	0
		Block number circle (upper-case letter "O")	BLKCIR	.75W x .55H	0
CS_T	Certified Survey Map	CSM names or numbers	CSMNAM	.20	0
		CSM parcel letters or numbers	CSMLOT	.20	0
		Road reservation dimensions	RESDIM	.18	0
CO_T	Condominium	Condominium names	CONNAM	.35	0
		Phase or stage numbers	PHANUM	.30	0
CD_T	Civil Division	Civil division names	CIVNAM	.18	0
		Adjoining county names	ADJNAM	.22	0
TM_T	Tie Mark	Tie mark text "Z" hooks		.20	0
EA_T	Easement	Easement names and dimensions		.16	0
NO_T	Note	Notes and annotations		.16	0
MS_T	Map Sheet	Map title			
		Map legend text			
		Miscellaneous map sheet text			

NOTE: All text is Font 12.

Table 3

**SPECIFICATIONS FOR CADASTRAL CHECK PLOTS
1" = 100' SCALE**

Plot	Maps	Features to Plot	Symbology
Checkplot 1	CG, RW	All features	Vary according to feature
	CG_T, RW_T	All text	Vary to distinguish text
Checkplot 2	CG, RW; CG_T, RW_T	All features and text	Background symbology
	PL, TM	All features	Vary according to feature
	TR	PT and DA only	Vary according to feature
	PD_T, TM_T	All text	Vary to distinguish text
Checkplot 3	CG, RW, PL, TM, TR; CG_T, RW_T, PD_T, TM_T	All features and text	Background symbology
	PA	Plot: PROPERTY.LINE Label: GAP, OVERLAP, ROAD.RESERVATION, N.T. Label: Parcel ID Tags	Vary according to feature and tag to be labelled
Checkplot 4	CG, RW, PL, TM; CG_T, RW_T, PD_T, TM_T	All features and text	Background symbology
	TR	PT and DA only	
	SD, CS, CO	All features	Vary according to feature
	TR	IA only	Vary according to feature
	SD_T, CS_T, CO_T	All text	Vary to distinguish text
Checkplot 5	CG, RW, PL, TM; CG_T, RW_T, PD_T, TM_T, SD_T, CS_T, CO_T	All features and text	Background symbology
	TR	PT and DA only	
	CD, EA	All features	Vary according to feature
	TR	IA and NOTE only	Vary according to feature
	CD_T, EA_T, PI_T, NO_T	All text	Vary to distinguish text
Final Checkplot	All vector and text maps, including MS and MS_T	All features and text	Appropriate symbology for finished hardcopy map

APPENDICES

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Appendix B-4

DETAILED SPECIFICATIONS FOR ONE INCH EQUALS 200 FEET SCALE DIGITAL CADASTRAL MAPPING

I. GENERAL

These specifications set forth the requirements of the _____ for digital and hardcopy cadastral map preparation. The Consultant shall furnish all labor, materials, and equipment necessary to complete properly the work specified herein.

II. CADASTRAL MAPS

A. General

The Consultant shall prepare cadastral maps in the form of digital cadastral map files and finished cadastral maps in hardcopy form. For the purpose of interpreting these standards within the context of the digital cadastral map files, the "publication scale" of these digital maps shall be one inch equals two hundred feet (1" = 200'). The Consultant shall also provide finished cadastral maps plotted to a scale of one inch equals two hundred feet (1" = 200'). These finished cadastral maps shall be prepared in the form of ink tracings, electrostatic images, or ink-jet printed images of the digital cadastral map files on dimensionally stable and reproducible polyester base material. The project area to be mapped consists of all _____ U. S. Public Land Survey System Sections in Township _____ North, Range _____ East in _____ County, totaling approximately _____ square miles. The project area contains approximately _____ cadastral parcels.

B. Material to be Furnished by the _____

The _____ shall furnish to the Consultant, at no cost to the Consultant, the following material for use in preparation of the digital cadastral map files and finished cadastral maps:

1. Copies of the most recent Control Survey Summary Diagrams detailing the system of horizontal survey control for the project area. This material will be used to establish correct U. S. Public Land Survey System monument and corner locations and Wisconsin State Plane Coordinate System northing and easting values, and also to establish correct grid and ground distances and bearings along section and quarter-section lines within the digital cadastral map files for the project area.
2. Copies of all recorded subdivision plats, certified survey maps, plats of survey, and, where available, private and public survey records that may be useful in determining the actual location of the real property boundaries within the project area.
3. Copies of legal descriptions, and, where available, plats of all major cross-country public utility easements contained in the official records of _____ County within the project area.
4. Copies of legal descriptions and, where available, plats of all street right-of-way openings, reservations, or dedications contained in the official records of _____ County within the project area.
5. One copy of the current Assessment Roll for each civil division within the project area.
6. Photostatic reproductions of the legal descriptions contained in the most recently recorded deed transactions for all real property boundaries in the project area not included within recorded subdivision plats or certified survey maps within the project area for those real property descriptions where the abbreviated legal description contained in the current Assessment Roll is judged to be incomplete or in some other way deficient.
7. Copies of current legal descriptions of the boundaries of incorporated civil divisions within the project area.

In the event that certain materials are deficient, or in the event that additional legal descriptions contained in recorded deed transactions are needed, the Consultant shall notify the _____, and the _____ shall furnish the additional materials to the Consultant, at no cost to the Consultant.

C. Data to be Shown on the Cadastral Maps

Both the digital cadastral map files and the finished cadastral maps to be prepared by the Consultant shall show correctly on each map face the following information:

1. All map sheet elements. If requested, the _____ shall provide to the Consultant a digital map file in GenaMap binary format containing the map sheet elements to be used as a template for creation of the digital cadastral map files. The _____ shall also provide to the Consultant, if necessary, a plotted hardcopy version of this digital map file. The map sheet elements to be shown consist of the following:
 - a. A map border and map trim lines.
 - b. A title block containing a graphic scale, together with associated text, and the following information: type of map; location by U. S. Public Land Survey township, range, and section, county, and state; the name of the Engineer preparing the map; date of mapping; appropriate sheet numbers; and the name and seal of _____.
 - c. An explanatory legend, depicting symbols used on the map, together with associated text.
 - d. A north point or arrow based upon grid north.
 - e. A combination scale and sea level reduction factor for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The combination scale and sea level reduction factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
 - f. A basic map projection, consisting of the intersections of grid lines on the Wisconsin State Plane Coordinate System. The grid line intersection tick marks shall be shown on the base map sheets at five (5)-inch intervals conforming to the even 1,000-foot interval coordinate values east and north of the grid origins. The corresponding State Plane Coordinate values shall be shown only along the margins of the map sheets.

2. All U. S. Public Land Survey System section and quarter-section lines, together with their grid and ground level lengths and grid bearings, all in their correct position and orientation; all U. S. Public Land Survey System monumented and unmonumented section and quarter-section corners, together with their Wisconsin State Plane Coordinate System northing and easting values; and related text consisting of adjoining quarter-section numbers.
3. All public street, road, and pedestrian right-of-way boundary lines, alley lines, and right-of-way centerlines, all in their correct position and orientation, together with associated text consisting of street and road names and right-of-way widths or half-widths; all existing and abandoned railway right-of-way boundary lines and centerlines, together with associated text consisting of railway names and right-of-way widths or half-widths; and all cul-de-sac radii, together with associated text consisting of radius values in feet.
4. All real property boundary lines in their correct position and orientation, consisting of: platted land subdivision lot boundary lines, certified survey map parcel boundary lines, and unplatted land division boundary lines; original or historical property boundary lines; property division lines showing splits and recombinations of splits of lots, parcels, or vacated streets and alleys; property lines extending into rights-of-way; property division or "tie" lines extending into rights-of-way; property lines imposed by the division of parcels by section lines of the U. S. Public Land Survey System; meander or survey reference lines; together with associated text comprised of all real property boundary line dimensions and annotations.
5. All real property parcel identification numbers, or unique tax key numbers, obtained from the _____ County parcel numbering system; as well as all notes and annotations indicating gaps and overlaps in legal descriptions.
6. All platted land boundary lines, consisting of: land subdivision boundary lines; certified survey map boundary lines; condominium boundary lines; together with associated text comprised of land subdivision names, lot and block numbers, certified survey map numbers and parcel letters or numbers, and condominium names and other associated dimensions and text.
7. All major cross-country public and private utility easement boundary lines, together with associated text of name or purpose of the easement, dimensions, and annotations.
8. All civil division boundary lines, consisting of divisions between village, city, and town municipalities, together with associated text containing the names of these entities.
9. All vinculum marks or "tie" marks (hooks) indicating common ownership of adjacent or connected properties.
10. All text-related or miscellaneous lines necessary to support text placement, consisting of the following: tick marks or points of tangency to delimit real property parcel dimensions along parcel lines; arrows or pointers to assist placement of real property parcel dimensions; arrows or pointers to assist placement of names and parcel identification numbers; and arrows or pointers to assist placement of notes and annotations.

It is recognized that the recorded dimensions and orientation of real property boundaries to be shown in the digital cadastral map files and finished cadastral maps may not always agree with the horizontal control survey data shown on those sheets, since most property descriptions were written using field survey data obtained prior to the relocation of section and one-quarter-section corners and completion of the horizontal survey control network tied to the Wisconsin State Plane Coordinate System. Further, the required survey accuracy for property boundary descriptions for land subdivisions as defined in Chapter 236 of the Wisconsin Statutes and generally adhered to in other property boundary surveys is 1 part in 3,000 as compared to the third order, class I survey accuracy of 1 part in 10,000 for the horizontal control surveys. As a result, overlapping or separated property boundary descriptions may be expected to exist. The digital cadastral map files and finished cadastral maps are to record all dimensions as contained in the official records of the county Register of Deeds, and wherever an overlap or gap of 2.5 feet or more exists, such overlaps or gaps shall be shown as mapped lines. Overlaps or gaps of less than 2.5 feet will be evident only from an examination of the recorded property line dimensions.

D. Digital Map File Organization and Specifications

The Consultant shall organize the digital cadastral map files in such a manner as to provide plotted cadastral maps similar in appearance to cadastral maps prepared by the _____. Among other things, this will require the preparation in digital form of a standard "map sheet" format, including appropriate title and legend information. If requested, the _____ shall furnish to the Consultant sample digital cadastral map files and a sample finished cadastral map as examples of the types of products that are to be prepared. These samples will also help to illustrate the feature content, text size and placement, and the digital map file organization required for the delivered products.

1. The digital map sheets shall be 36 inches by 36 inches in size when plotted at a scale of one inch equals two hundred feet (1" = 200'), and each sheet shall cover an entire U. S. Public Land Survey System section. The title block shall contain the following information: graphic scale and text, date, type of map, location by county and state, name of the _____, name of the Consultant, and appropriate project and sheet numbers, if applicable. A north point based upon grid north shall be shown. A combination scale and sea level reduction factor shall be given on each sheet for the reduction of measured ground lengths to corresponding grid lengths on the Wisconsin State Plane Coordinate System. The factor shall represent the value for the area covered by the SEWRPC-prepared six-section control survey summary diagram within which the map sheet is located.
2. The Consultant shall deliver the digital cadastral map files in GenaMap proprietary mapping software format, version 6.1 or later. All digital arc/node and text files shall be delivered in binary form and shall conform to the GenaMap file structure. This requires that all arc/node or vector maps exist in a "ZF04" directory structure, and that all text maps exist in a "ZF10" directory structure. All other GenaMap compatible digital files prepared by the Consultant for map creation or display shall exist in suitable directories within the GenaMap directory structure.
3. The Consultant shall deliver the digital cadastral map files on one of the following three types of media: 1) 4-millimeter Digital Data Storage (DDS) magnetic tape, either 60 or 90 meters in length, and compatible with the _____ computer system; 2) 8-millimeter Data Cartridge magnetic tape, 112 meters in length, and compatible with the _____ computer system; or 3) CD-ROM disk, written to ISO 9660 Level II applications. The digital cadastral map files shall be placed on the media in a sequential file format, using common UNIX computer operating system commands. The Consultant shall establish the correct format and procedures for the transfer and delivery of the digital information on magnetic tape or CD-ROM disk in consultation with the _____.
4. The digital cadastral map files shall be organized and conform to the following standards for GenaMap arc/node and text maps:
 - a. Arc/node, or vector, map files shall consist of twelve (12) separate map files as identified in Table 1, attached hereto. The separate arc/node map files provide a systematic and logical organization of map features, and insure that data elements

can be selectively retrieved, manipulated, and displayed, either singly or in combination with other data elements. The five columns in the table are described as follows:

The first column in Table 1, "Map Prefix," identifies a two-letter mnemonic that describes each of the twelve arc/node maps. The file naming convention to be followed for arc/node maps is of the form "PPttrrss," where "PP" is the two-letter, upper-case map prefix, and "ttrrss" are character designations for U. S. Public Land Survey System township ("tt"), range ("rr"), and section ("ss"). For example, an arc/node map with the name "PL012233" indicates a Parcel Line map for Township 1 North, Range 22 East, Section 33.

The second column, "Layer Name," identifies the full name associated with the two-character map prefix. It is intended to describe the general group of features included in each of the twelve arc/node maps.

The third column, "Feature Type," indicates the type of graphic primitive to be digitally encoded for each of the enumerated features. All features in the digital files will be explicitly defined as either points, lines, or areas.

The fourth column, "Feature Tag," indicates the GenaMap tag to be assigned to the enumerated features. All features will be labeled with the appropriate tag specified in this column. The one exception to this requirement is the tag for real property area features in the Parcel Area map. These features will be tagged with the unique _____ County tax key identification number assigned to each property.

The fifth column, "Description," further identifies the individual features that are to be tagged and included in each arc/node map.

The Consultant may, in consultation with the _____, suggest changes or modifications to any element of these specifications for arc/node maps. If such modifications are approved by the _____, a new table and set of specifications will be issued to describe the revised standards for arc/node map files.

- b. Text map files shall consist of twelve (12) separate map files as identified in Table 2, attached hereto. This table describes the items to be included in each text map and specifies the font attributes for GenaMap font number 12 which is to be used exclusively in all text maps. The six columns in the table are described as follows:

The first column in Table 2, "Map Prefix," identifies a two-letter mnemonic that describes each of the twelve text maps. The file naming convention to be followed for text maps is similar to that for arc/node maps, and is of the form "PPttrrssT," where "PP" is the two-letter, upper-case map prefix, "ttrrss" are character designations for U. S. Public Land Survey System township ("tt"), range ("rr"), and section ("ss"), and "T" is simply upper-case letter T to indicate that the digital map file is a text map. For example, a text map with the name "PD012233T" indicates a Parcel Dimension text map for Township 1 North, Range 22 East, Section 33.

The second column, "Text Layer Name," identifies the full name associated with the two-character map prefix. It is intended to describe the general group of text features included in each of the twelve text maps.

The third column, "Text Description," indicates the text items that are to be included in each text map.

The fourth column, "Text Tag," indicates the GenaMap tag to be assigned to the text features. All text will be labelled with the appropriate tag specified in this column.

The fifth column, "Width & Height," indicates the font width and height, in centimeters, for the feature text.

The sixth column, "Slant," identifies the text slant, in degrees, for the feature text.

The Consultant may, in consultation with the _____, suggest changes or modifications to any element of these specifications for text maps. If such modifications are approved by the _____, a new table and set of specifications will be issued to describe the revised standards for text map files.

5. The digital cadastral map files are to be encoded as simple unsymbolized point, line, and area graphic primitives. Feature symbology, such as colors, line weights, and line patterns, shall not be assigned or encoded into features in the digital files. Any symbology that may be required for such activities as quality control and creation of check plots will be accomplished by use of a standard GenaMap "Bundle Table" symbology database. The _____ shall furnish a digital file of this symbology database to the Consultant if requested.
6. The Consultant shall use proper methods and procedures to digitally encode the vector data such that the data will create topologically correct vector map files. Among other things, this will require that the Consultant use procedures to "snap" line segments together to ensure that the vector map files do not contain gaps or overshoots between line segments, and that all line segments are properly connected and continuous where applicable. Procedures should also be used to ensure that there are no duplicate, coincident, or overlapping line segments in any vector map files.
7. The extent of the area to be mapped for each file shall be the section lines that form the boundary of each U. S. Public Land Survey System Section within the project area. This requires that all right-of-way lines, real property boundary lines, and other cadastral lines that ordinarily cross section boundary lines be terminated at these boundary lines. For the purposes of "edge matching" such cadastral lines, all continuous lines crossing map file boundaries shall have connectable points on the appropriate U. S. Public Land Survey Section lines in the adjoining files. These points shall have identical x and y values.
8. If applicable, the _____ shall provide copies to the Consultant of previously prepared digital cadastral map files, in GenaMap format, for U. S. Public Land Survey Sections that are immediately adjacent to the exterior of the project area to be mapped. The Consultant shall utilize these digital cadastral map files for the purpose of "edge matching" such features as right-of-way boundary lines, real property boundary lines, land subdivision and certified survey map boundary lines, and other cadastral lines as necessary to insure proper alignment of boundary lines across section lines in adjacent maps.
9. All computer software used by the Consultant in the preparation and transfer of the digital cadastral map files shall be capable of maintaining the full mathematical precision of the horizontal control survey information required for this contract. This may require the use of computer software written in double precision.
10. The Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927, shall be utilized as the coordinate system for the encoding of all digital map data elements.

E. Preparation of Finished Cadastral Maps

The Consultant shall utilize digital plotting equipment having a minimum resolution of 400 DPI and capable of preparing check plots and finished maps that approach in their overall appearance cadastral maps prepared by the _____. All plotting of the check plots and finished maps shall be to a high standard of workmanship.

All check plots submitted for edit purposes and all finished cadastral maps shall be plotted directly from the digital cadastral map files in GenaMap format. The check plots and finished maps shall display all text features in the correct font and size according to the specifications given in Table 2 attached hereto. Text features in the digital cadastral map files shall be properly placed in relationship to adjacent vector and text features, such that text will not overstrike or overplot adjacent vector and text features on the hardcopy check plots and finished cadastral maps.

The plotted map sheets shall be 36 inches by 36 inches in size, and each sheet shall cover an entire U. S. Public Land Survey System Section. The map title shall contain a graphic scale and the following information: scale, date of mapping, type of map, location by county and state, name of the _____, name of the Consultant, and appropriate project and sheet numbers, if applicable.

The following procedures shall be employed in the development of the finished digital cadastral map files and finished cadastral maps:

1. The Consultant shall provide vellum or paper check plots of the digital cadastral map files for each U. S. Public Land Survey Section to the _____. The check plots to be provided consist of a series of six individual plots as described in Table 3, attached hereto. The four columns in the table are described as follows:

The first column in Table 3, "Plot," identifies the number or name of the check plot in the series of six check plots that are to be produced for each U. S. Public Land Survey Section.

The second column, "Maps," indicates the digital cadastral map files that are to be plotted, either wholly or in part, for each check plot.

The third column, "Features to Plot," identifies the arc/node features and text to be displayed on each check plot. The exception to this is "Checkplot 3," where real property parcels and other area features are to be labelled as well as plotted in order to verify the integrity and accuracy of the polygons in the "PA" digital cadastral map file.

The fourth column, "Symbology," is intended as a guide to the display of information on each check plot. Each check plot is intended to allow inspection of related sets of vector and text maps by means of differentiating symbology, with most check plots also displaying ancillary vector and text maps in background symbology. Symbolization of features and text shall be achieved through the use of color, line style, line pattern, or any other type of representation agreed upon by the Consultant and the _____.

The series of six checkplots is intended to furnish a systematic, graphic, analog representation of the digital cadastral map files, and as such shall provide a means to verify the completeness, accuracy, and integrity of the digitally encoded cadastral data. The Consultant and the _____ shall collaborate on the content and the symbology of the six cadastral map check plots in order to facilitate the editing and review of the plots and the digital cadastral map files.

In addition to the six check plots, the Consultant shall also provide to the _____ all land records and other materials used by the Consultant in the preparation of the digital cadastral map files for each U. S. Public Land Survey section.

2. The _____ shall conduct office editing and review of the cadastral map check plots utilizing the land records provided by the Consultant.
3. The _____ shall annotate the cadastral map check plots, if necessary, to indicate corrections or additions to be made to the digital cadastral map files, and return the annotated check plots to the Consultant.
4. The Consultant shall revise the digital cadastral map files to reflect the annotations and corrections shown on the cadastral map check plots.
5. Magnetic tapes of the corrected digital cadastral map files, in the GenaMap digital format as specified in Section II.D.2 above and the media format as specified in Section II.D.3 above, together with the original set of six annotated cadastral map check plots and one copy of the finished cadastral map plot on high-quality paper media, shall be provided by the Consultant to the _____.
6. The _____ shall inspect the digital cadastral map files, annotated cadastral map check plots, and finished cadastral map plot to determine compliance with the specifications.
7. Should the digital cadastral map files and finished cadastral map plot be found by the _____ to meet the specifications, the _____ shall notify the Consultant that said materials are accepted in full by the _____. The Consultant shall then produce and deliver to the _____ the finished cadastral map plot on dimensionally stable and reproducible polyester base material for the accepted sections. The Consultant shall also return all attendant land records utilized in the preparation of the digital cadastral map files and finished hardcopy maps to the _____.
8. Should the digital cadastral map files and finished cadastral map plot be found by the _____ to require further revisions to comply with the specifications, the _____ shall so notify the Consultant, and the _____ shall return any digital cadastral map files or plots to the Consultant for correction as may be necessary.
9. The Consultant shall then follow the procedures noted in Section II.E.4 and subsequent paragraphs to produce and deliver to the _____ the finished digital cadastral map files and the finished cadastral map plot on high-quality paper media.

F. Precision and Accuracy Standards

1. The map projection grid for the digital cadastral map files shall be constructed inside the computer memory through key entry procedures. Digital plotting equipment utilized by the Consultant shall be capable of plotting each grid line or tick on the finished map sheets within 1/100 of an inch of the true grid values.
2. Each section corner and quarter-section corner contained in the digital map files shall be plotted on the map projection grid through key entry of the adjusted coordinates computed for the point. Digital plotting equipment utilized by the Consultant shall be capable of plotting each section corner and quarter-section corner on the finished map sheets within 1/100 of an inch of the true position as expressed by the adjusted coordinates computed for the point.
3. Each real property boundary line shall be graphically constructed in its correct location and orientation on the predrafted map sheets in a manner which parallels the location of these lines on the surface of the earth following land surveying practice in the State of Wisconsin, and all real property boundary lines shall be plotted within 1/40 of an inch of their true position. Except as provided below, the property boundary lines will be constructed on hard copy work sheets and then board digitized. The construction and plotting of the real property boundary lines shall be based upon and include the assembly of all authoritative information such as title documents, subdivision plats, certified survey maps, and private and public survey records that may be useful in determining the actual location of the real property boundaries, as well as proper analysis of this information to arrive at the best location of the property boundary lines. Proper performance in this respect depends largely upon a thorough knowledge of local survey customs, conditions, and laws of boundaries and titles, and for this reason must be accomplished under the direction of a registered land surveyor.
4. Any overlaps or gaps between adjoining property boundary lines as indicated by the construction and plotting of the real property boundary lines in accordance with Section II.F.3 above shall be noted by the Consultant on the digital cadastral map files and finished cadastral maps.
5. Ninety percent of all well-defined planimetric features shall be plotted so that their position in the digital cadastral map files and on the finished cadastral maps shall be accurate to within 1/30 of an inch of their true coordinate position, and no point shall be more than 1/20 of an inch from its true position.
6. The completed finished cadastral maps shall be office checked by the _____. Recorded real property parcel dimensions and right-of-way dimensions shall be compared against the map data, and any finished cadastral maps and digital cadastral map files that do not conform to the requirements of these specifications shall be corrected by the Consultant to fully meet the specified accuracy.

III. ITEMS TO BE DELIVERED

Upon completion the Consultant shall deliver to the _____ the following items:

- A. One set of digital cadastral map files, in the GenaMap format and media format as specified under Section II.D.2 and Section II.D.3 above, containing cadastral maps of the project area as designated herein.
- B. One set of original plots on dimensionally stable and reproducible polyester base material of the finished cadastral maps of the project area as designated herein.

IV. DELIVERY DATE

All digital cadastral map files and finished cadastral maps shall be delivered to the _____ on or before _____.

V. BASIS OF PAYMENT

The contract price of the work, the lump sum of \$ _____, shall include all computer programming and computer operation services necessary for the delivery of the completed digital cadastral map files and finished cadastral maps specified herein.

It is expressly understood and agreed that in no event will the total compensation and reimbursement to be paid exceed the amount stipulated above for all the service required as specified herein. The Consultant shall submit invoices to the _____ during the progress of the work for partial payment on account for work completed and accepted to date. Such invoices shall not be submitted more often than every 30 days. The amount shown on such invoices shall be estimated on the basis of contract prices and the quantity of work completed and accepted by the _____. Such invoices will be checked by the _____ and payment made in an amount not to exceed 90 percent of such amount thereof as has been found by the _____ to reasonably represent the value of partially completed work, less any amounts previously paid on account. Payment of the 10 percent withheld during progress of the work shall be made upon final approval of the work by the _____.

Table 1
SPECIFICATIONS FOR GENAMAP CADASTRAL ARC/NODE MAPS
1" = 200' SCALE

Map Prefix	Layer Name	Feature Type	Feature Tag	Description
CG	Cadastral Geometry	Point	MONUMENT.PT	USPLSS monument location
		Point	OTHER.PT	Other point location
		Line	SEC.LINE	USPLSS section line
		Line	QSEC.LINE	USPLSS quarter-section line
RW	Right of Way	Line	ROW	Street and road right-of-way line
		Line	RR.ROW	Railroad right-of-way line
		Line	ROW/RR.ROW	Common street and road and railroad right-of-way line
		Line	ROW.CENTER.LINE	Right-of-way centerline
		Line	RADIUS	Cul-de-sac radius
PL	Parcel Line	Line	PARCEL.LINE	Property boundary line
		Line	ORIGINAL.PARCEL.LINE	Historical property boundary line
		Line	EXTENDED.PARCEL.LINE	Property boundary line extending into right-of-way
		Line	PLSS.LINE	Public Land Survey System line
		Line	TIE.LINE	Property division line
		Line	EXTENDED.TIE.LINE	Property division line extending into right-of-way
		Line	MEANDER.LINE	Survey reference line
PA	Parcel Area	Line	PROPERTY.LINE	All edges
		Area	(parcel ID number)	Unique tax key ID number
		Area	GAP	Small gap between properties
		Area	OVERLAP	Overlapping property area
		Area	ROAD.RESERVATION	Undedicated area of CSM
EA	Easement	Line	EASEMENT.LINE	Easement boundary line
SD	Subdivision	Line	SD.LINE	Subdivision boundary line
CS	Certified Survey Map	Line	CSM.LINE	Certified survey map boundary line
CO	Condominium	Line	CO.LINE	Condominium boundary line
CD	Civil Division	Line	CD.LINE	Civil division boundary line
TM	Tie Mark	Line	TIE	"Hook" connecting properties
TR	Text Related	Line	DA	Dimension arrow
		Line	IA	Identification arrow
		Line	PT	Point of tangency tic mark
		Line	NOTE	Note or annotation arrow
MS	Map Sheet	Line	MAP.BORDER	Map border line
		Line	TRIM.LINE	Map trim line
		Line	BAR.SCALE	Map bar scale
		Line	NORTH.ARROW	Map north arrow
		Line	NORTH.ARROW.CURVE	Arc along north arrow
		Line	LOGO	Map logo or seal
		Line	MAP.LEGEND.SYMBOL	Map legend symbol
		Line	MAP.LEGEND.SEC.LINE	Map legend symbolized line
		Line	MAP.LEGEND.QSEC.LINE	Map legend symbolized line
		Line	MAP.LEGEND.CD.LINE	Map legend symbolized line
		Line	MAP.LEGEND.SD.LINE	Map legend symbolized line
		Line	INDEX.LOCATION.BOX	Map index locator
		Line	INDEX.SECTION.LINE	Map index section line
		Line	INDEX.COUNTY.TOWNSHIP.LINE	Map index county and township boundary line
		Line	INDEX.CITY.BOUNDARY.LINE	Map index civil division boundary line
		Line	GRID.TIC.IN	Interior SPCS grid tic
		Line	GRID.TIC.OUT	Exterior SPCS grid interval

Table 2
SPECIFICATIONS FOR GENAMAP CADASTRAL TEXT MAPS
1" = 200' SCALE

Map Prefix	Text Layer Name	Text Description	Text Tag	Width & Height	Slant
CG_T	Cadastral Geometry	SPCS Northings and Eastings	COORDS	.18	0
		Section and quarter-section line bearings	BEARNG	.18	0
		Section and quarter-section line grid distances	GRDIST	.18	0
		Section and quarter-section line ground distances	GRDIST	.18	-20
		Adjoining quarter-section numbers	QTRNUM	.30	0
RW_T	Right of Way	Street and road names	STRNAM	.22	0
		Railway names	RWYNAM	.22	0
		Right-of-way widths	ROWDIM	.12	0
		Cul-de-sac radius values	CDSRAD	.12	0
PD_T	Parcel Dimension	Property dimensions	PRPDIM	.12 or .10	0
PI_T	Parcel ID Number	Parcel tax key numbers	TAXPIN	.12 or 10	0
SD_T	Subdivision	Subdivision names	SUBNAM	.30	0
		Block numbers	BLKNUM	.20 or .18	0
		Lot numbers & outlot names	LOTNUM	.12	0
		Block number circle (lower-case letter "o")	BLKCIR	.65W x .60H	0
CS_T	Certified Survey Map	CSM names or numbers	CSMNAM	.20	0
		CSM parcel letters or numbers	CSMLOT	.20	0
		Road reservation dimensions	RESDIM	.12	0
CO_T	Condominium	Condominium names	CONNAM	.20	0
		Phase or stage numbers	PHANUM	.15	0
CD_T	Civil Division	Civil division names	CIVNAM	.20	0
		Adjoining county names	ADJNAM	.16	0
TM_T	Tie Mark	Tie mark text "Z" hooks		.20	0
EA_T	Easement	Easement names and dimensions		.12	0
NO_T	Note	Notes and annotations		.16	0
MS_T	Map Sheet	Map title			
		Map legend text			
		Miscellaneous map sheet text			

Note: All text is Font 12.

Table 3
SPECIFICATIONS FOR CADASTRAL CHECK PLOTS
1" = 200' SCALE

Plot	Maps	Features to Plot	Symbology
Checkplot 1	CG, RW	All features	Vary according to feature
	CG_T, RW_T	All text	Vary to distinguish text
Checkplot 2	CG, RW; CG_T, RW_T	All features and text	Background symbology
	PL, TM	All features	Vary according to feature
	TR	PT and DA only	Vary according to feature
	PD_T, TM_T	All text	Vary to distinguish text
Checkplot 3	CG, RW, PL, TM, TR; CG_T, RW_T, PD_T, TM_T	All features and text	Background symbology
	PA	Plot: PROPERTY.LINE Label: GAP, OVERLAP, ROAD.RESERVATION, N.T. Label: Parcel ID Tags	Vary according to feature and tag to be labelled
Checkplot 4	CG, RW, PL, TM; CG_T, RW_T, PD_T, TM_T	All features and text	Background symbology
	TR	PT and DA only	
	SD, CS, CO	All features	Vary according to feature
	TR	IA only	Vary according to feature
	SD_T, CS_T, CO_T	All text	Vary to distinguish text
Checkplot 5	CG, RW, PL, TM; CG_T, RW_T, PD_T, TM_T, SD_T, CS_T, CO_T	All features and text	Background symbology
	TR	PT and DA only	
	CD, EA	All features	Vary according to feature
	TR	IA and NOTE only	Vary according to feature
	CD_T, EA_T, PL_T, NO_T	All text	Vary to distinguish text
Final Checkplot	All vector and text maps, including MS and MS_T	All features and text	Appropriate symbology for finished hardcopy map

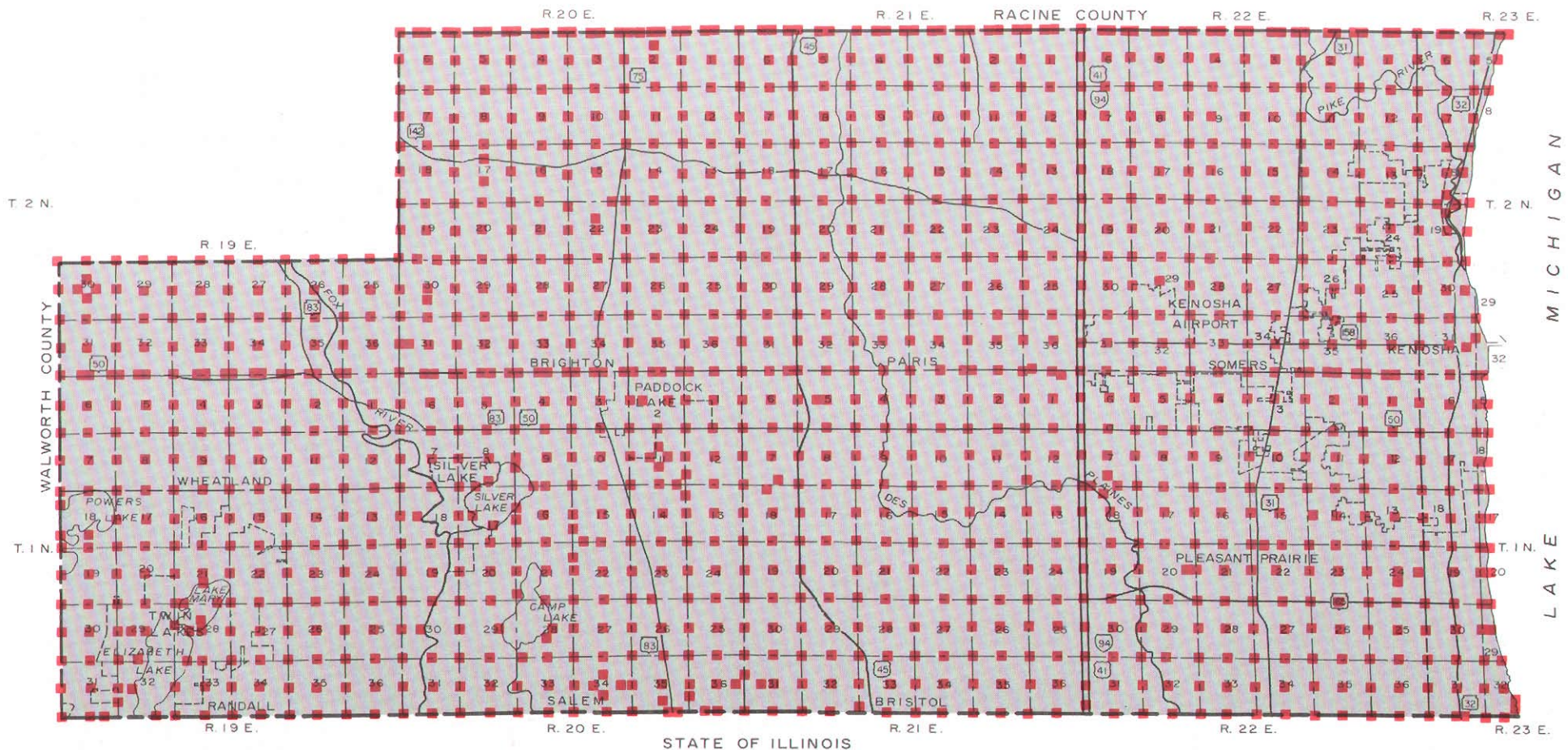
APPENDICES

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CONTROL SURVEY SUMMARY DIAGRAM INDEX FOR THE REGION

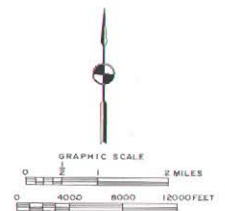


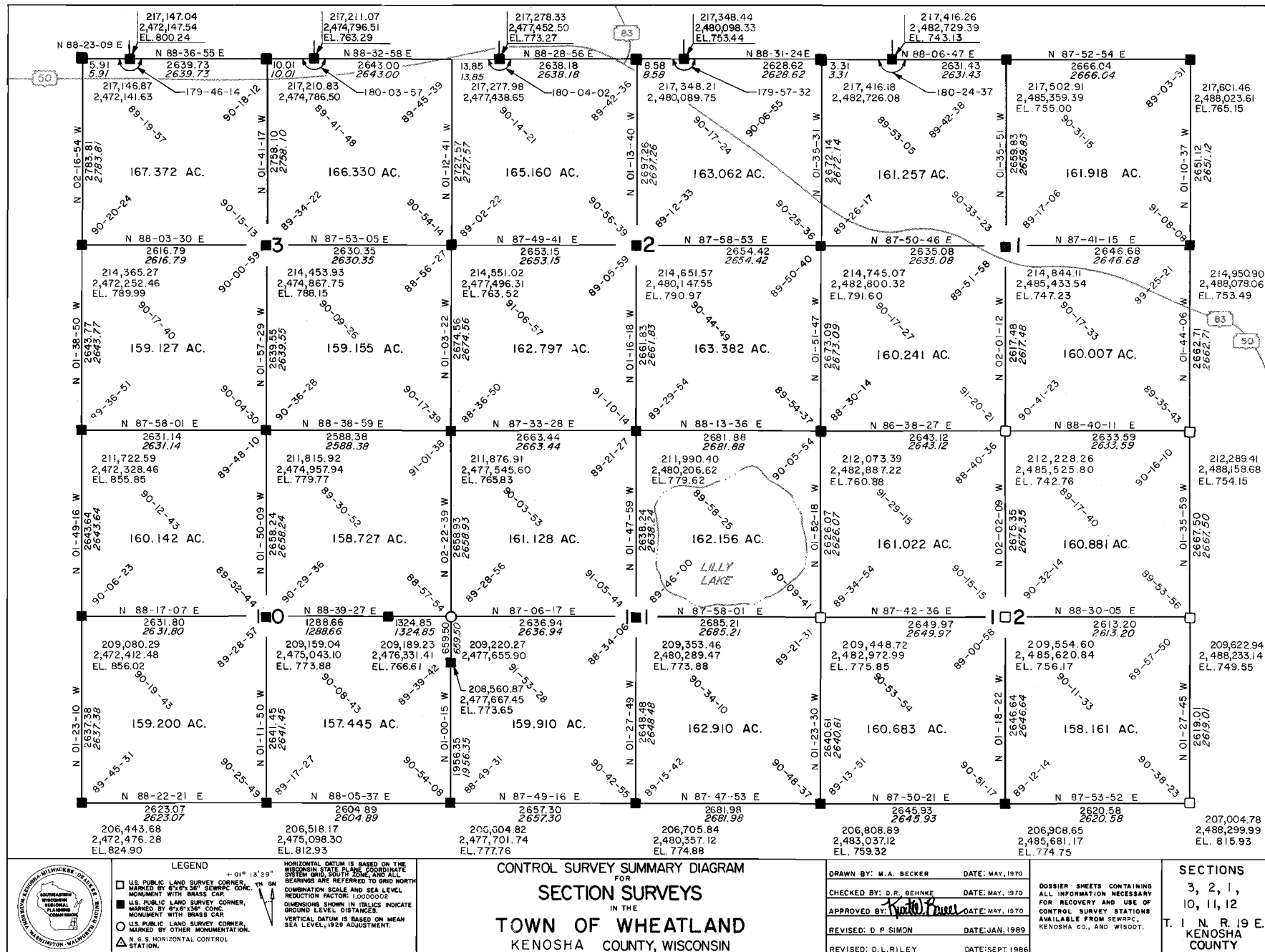
**STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE RELOCATION, MONUMENTATION,
AND COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS IN KENOSHA COUNTY: SEPTEMBER 1996**

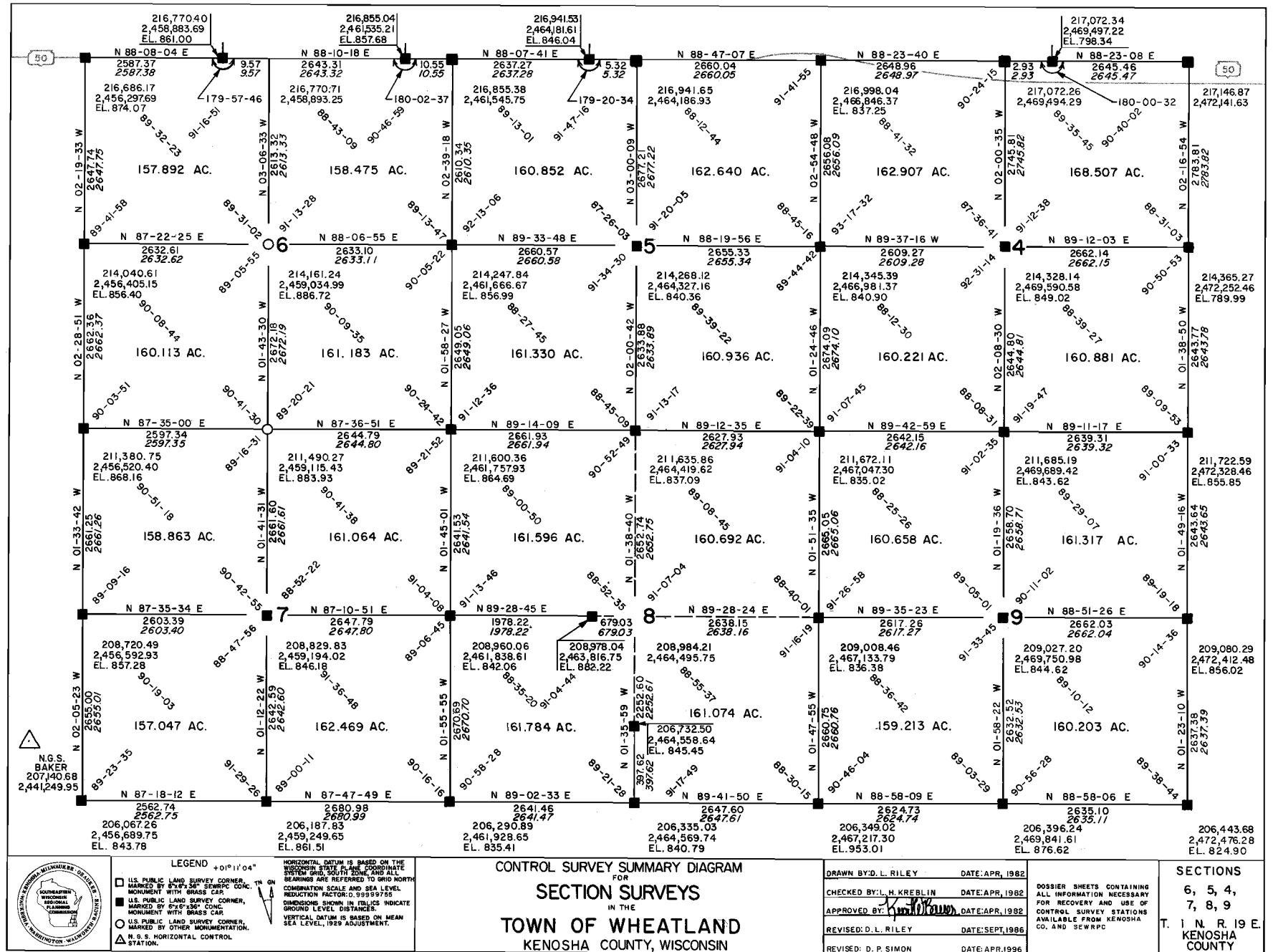


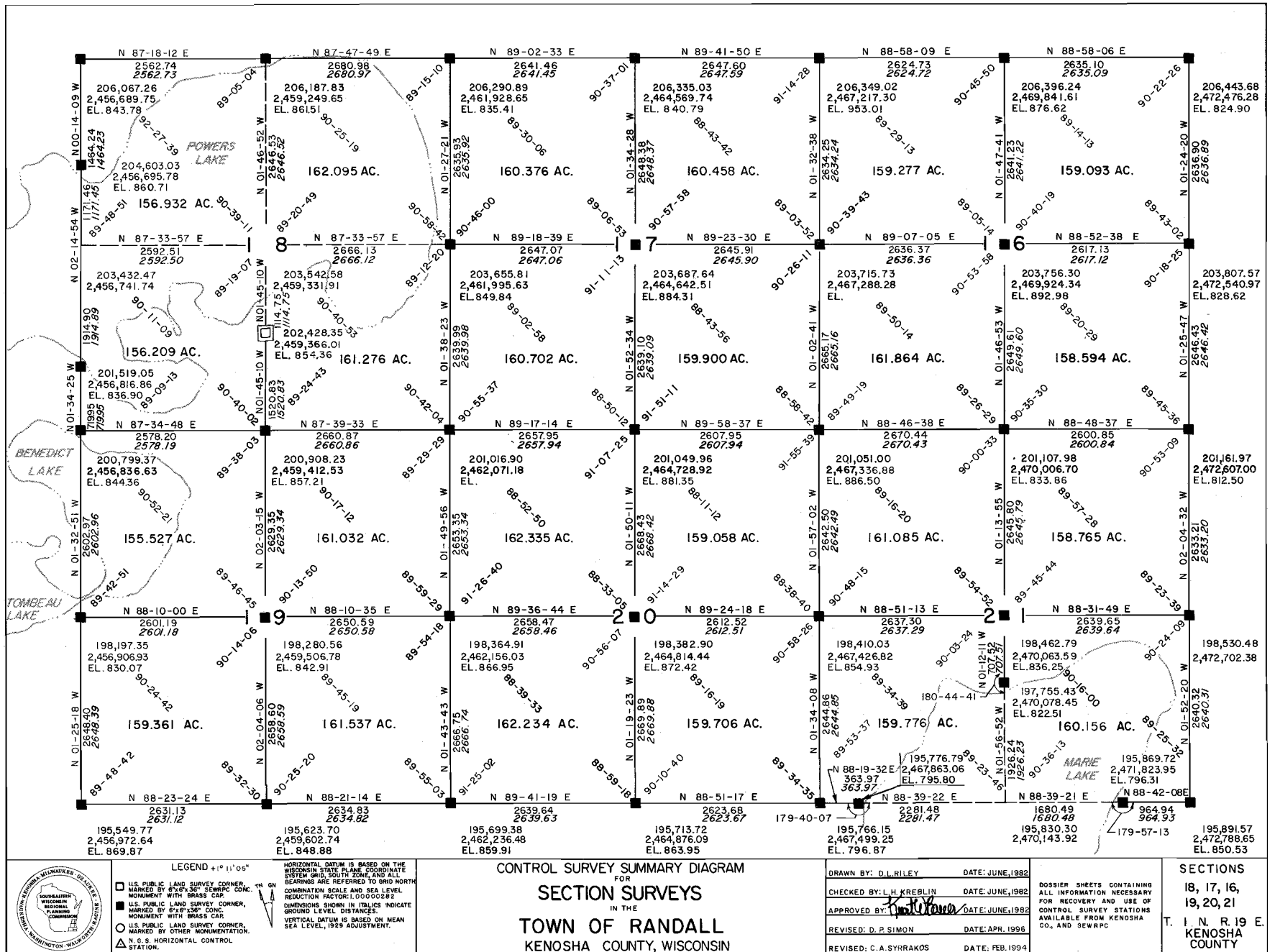
LEGEND

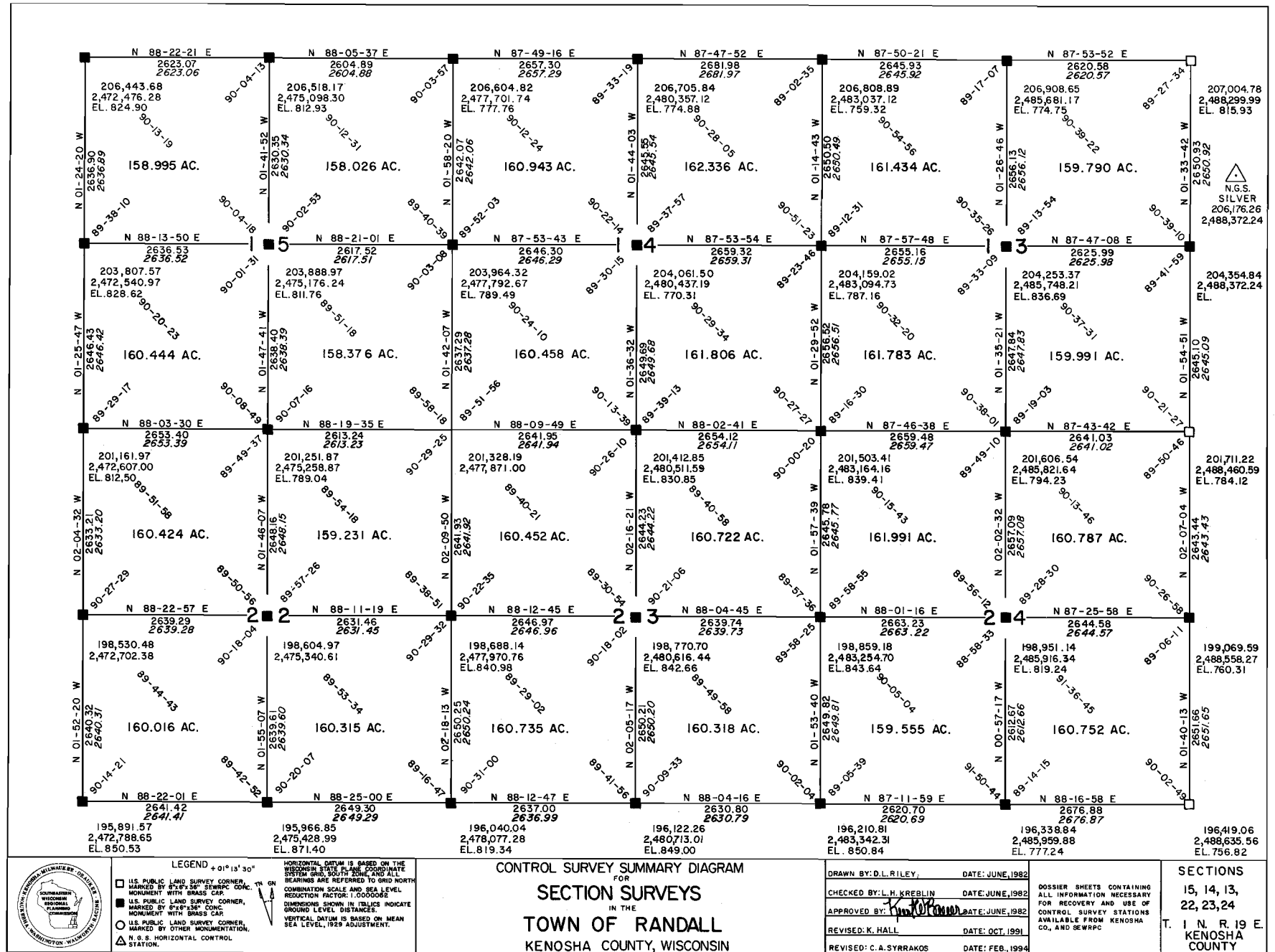
- LARGE-SCALE TOPOGRAPHIC MAPPING COMPLETED
- U. S. PUBLIC LAND SURVEY CORNERS WHICH HAVE BEEN RELOCATED, MONUMENTED, AND COORDINATED

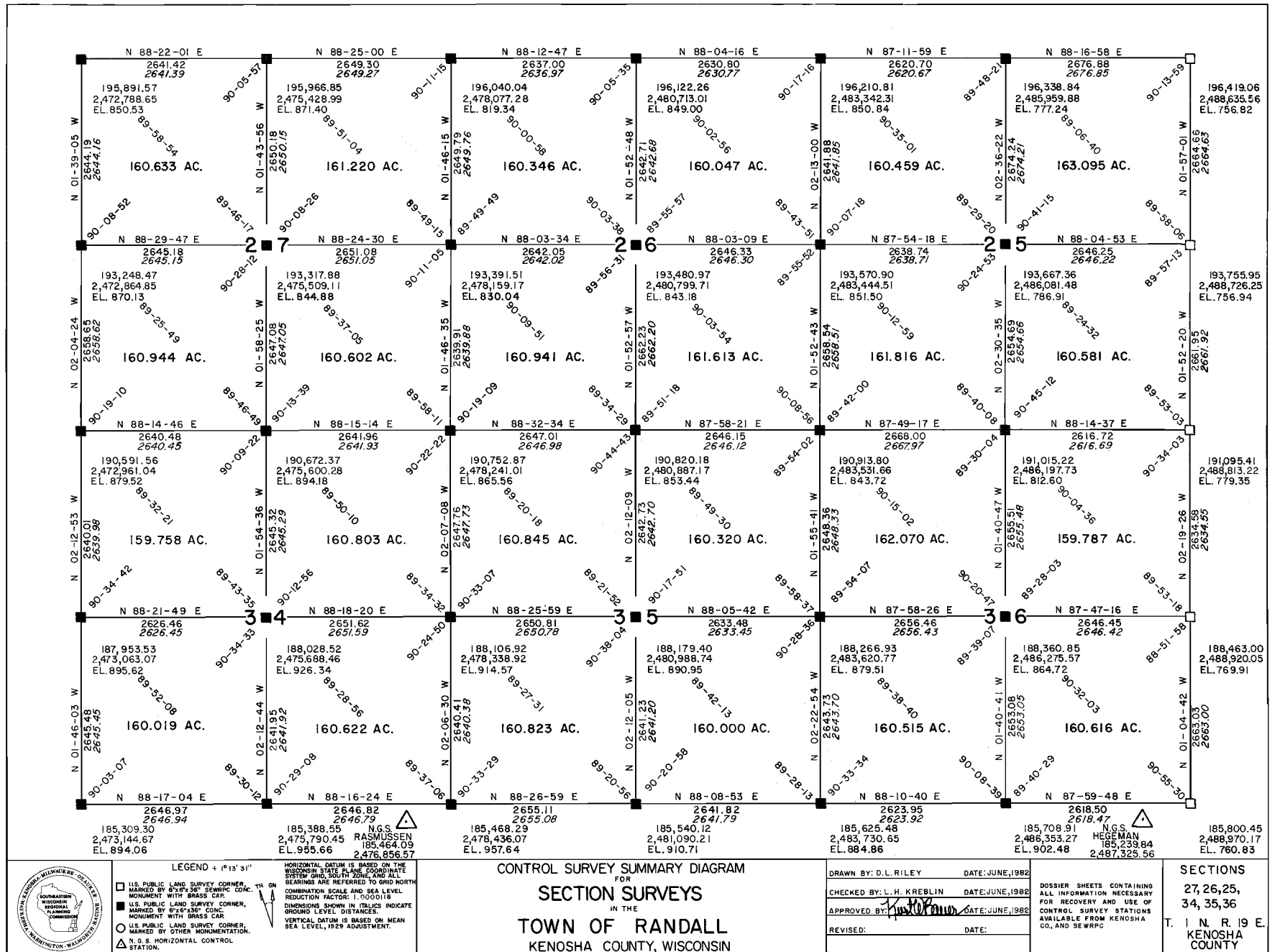


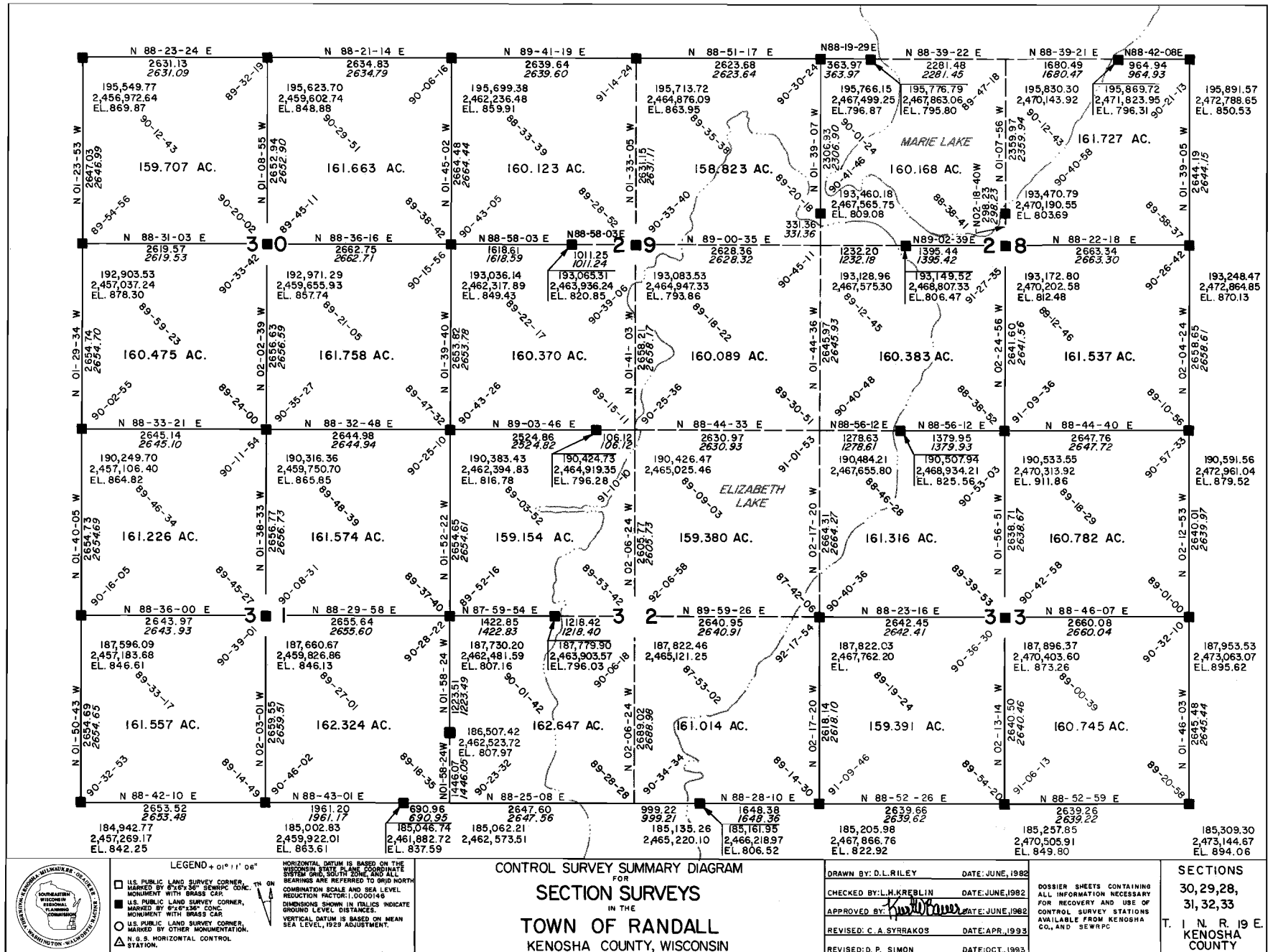


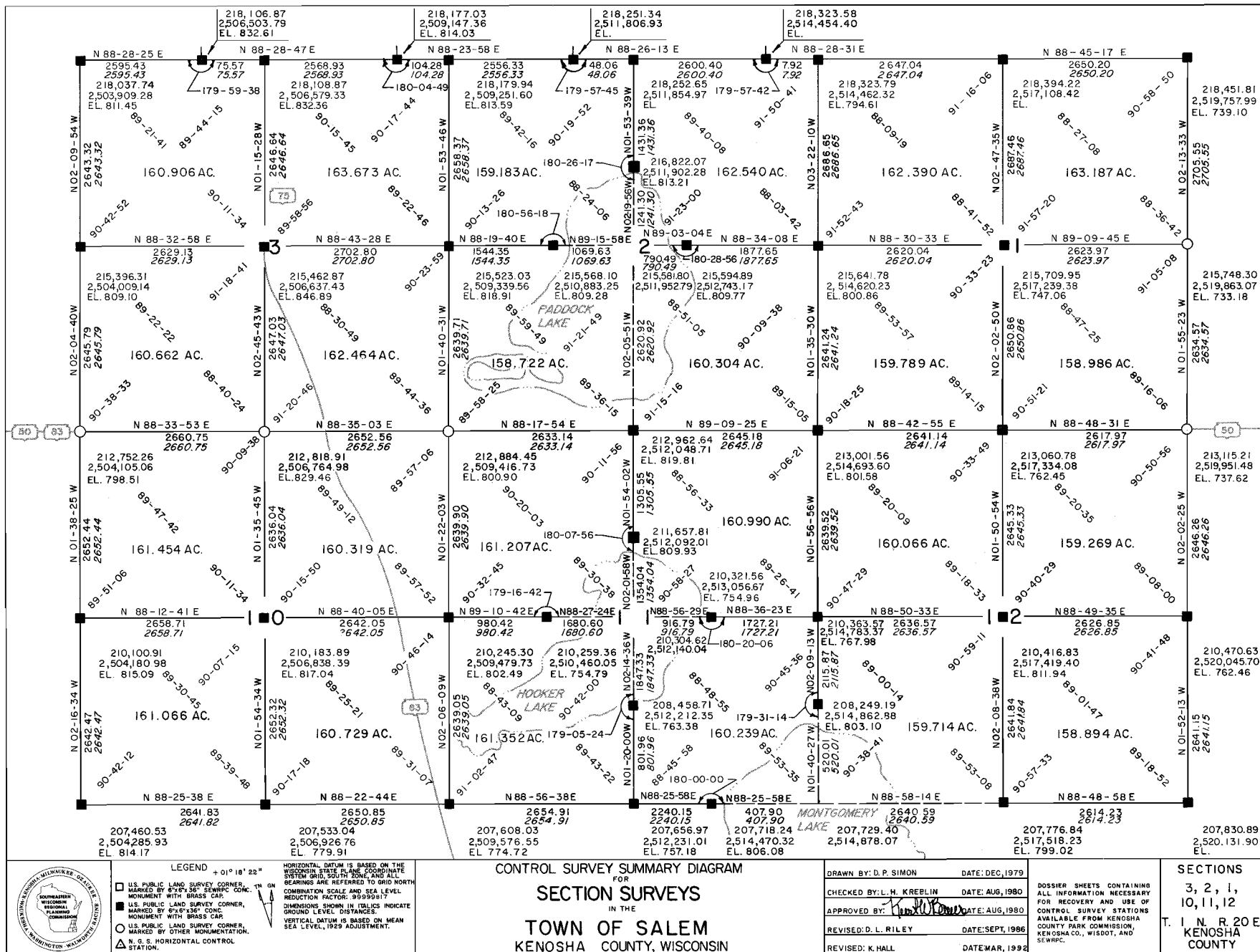


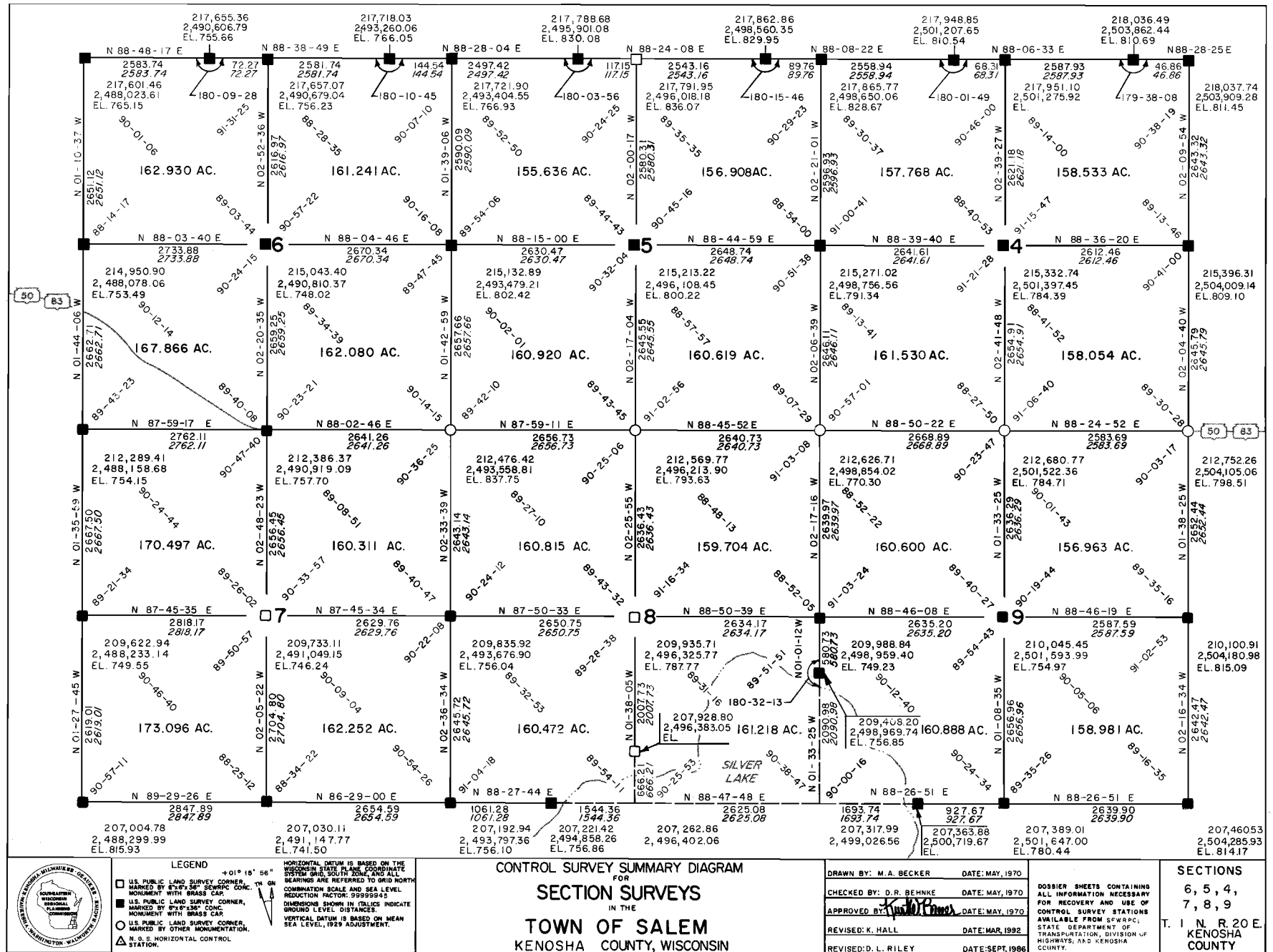


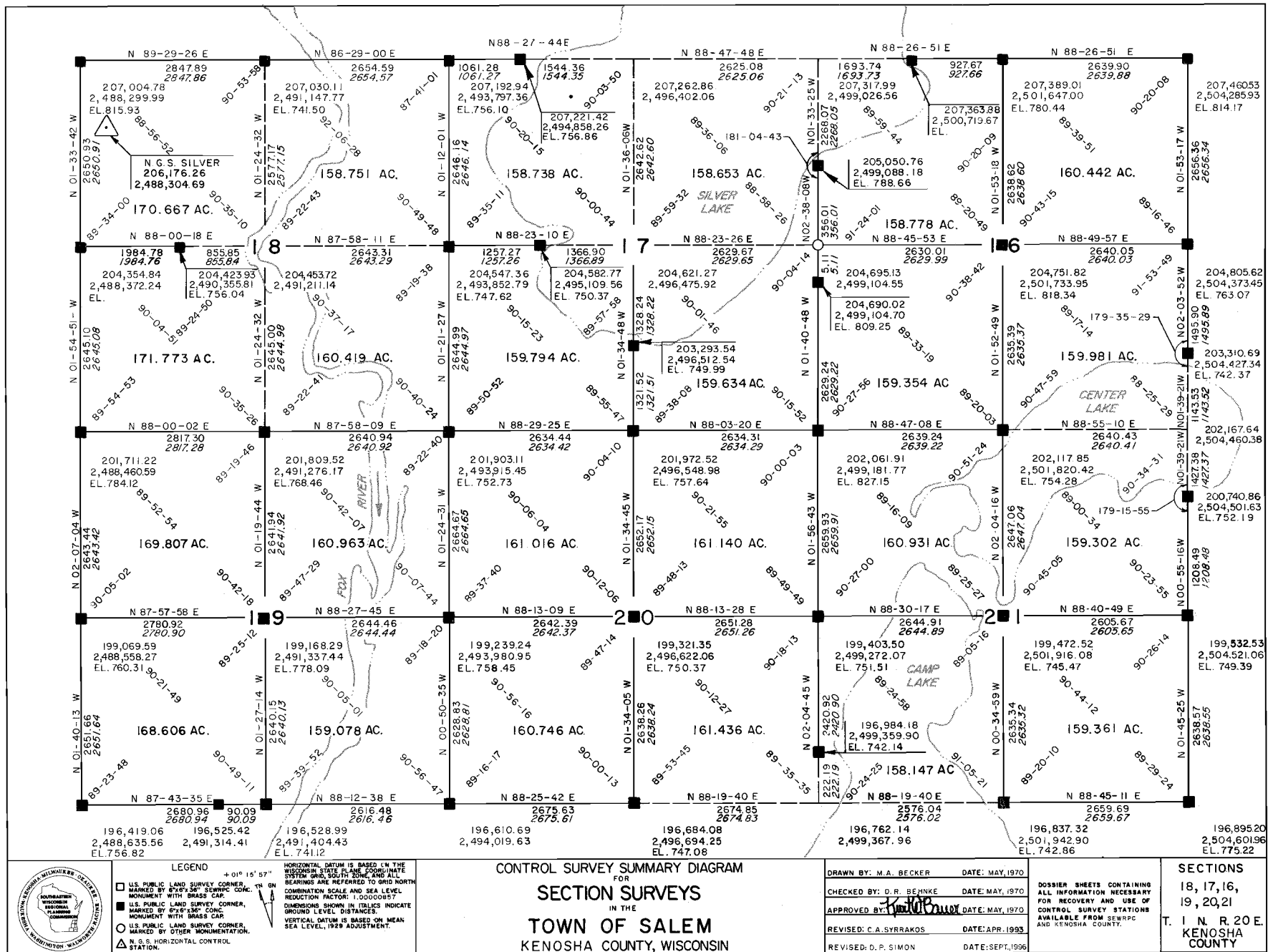


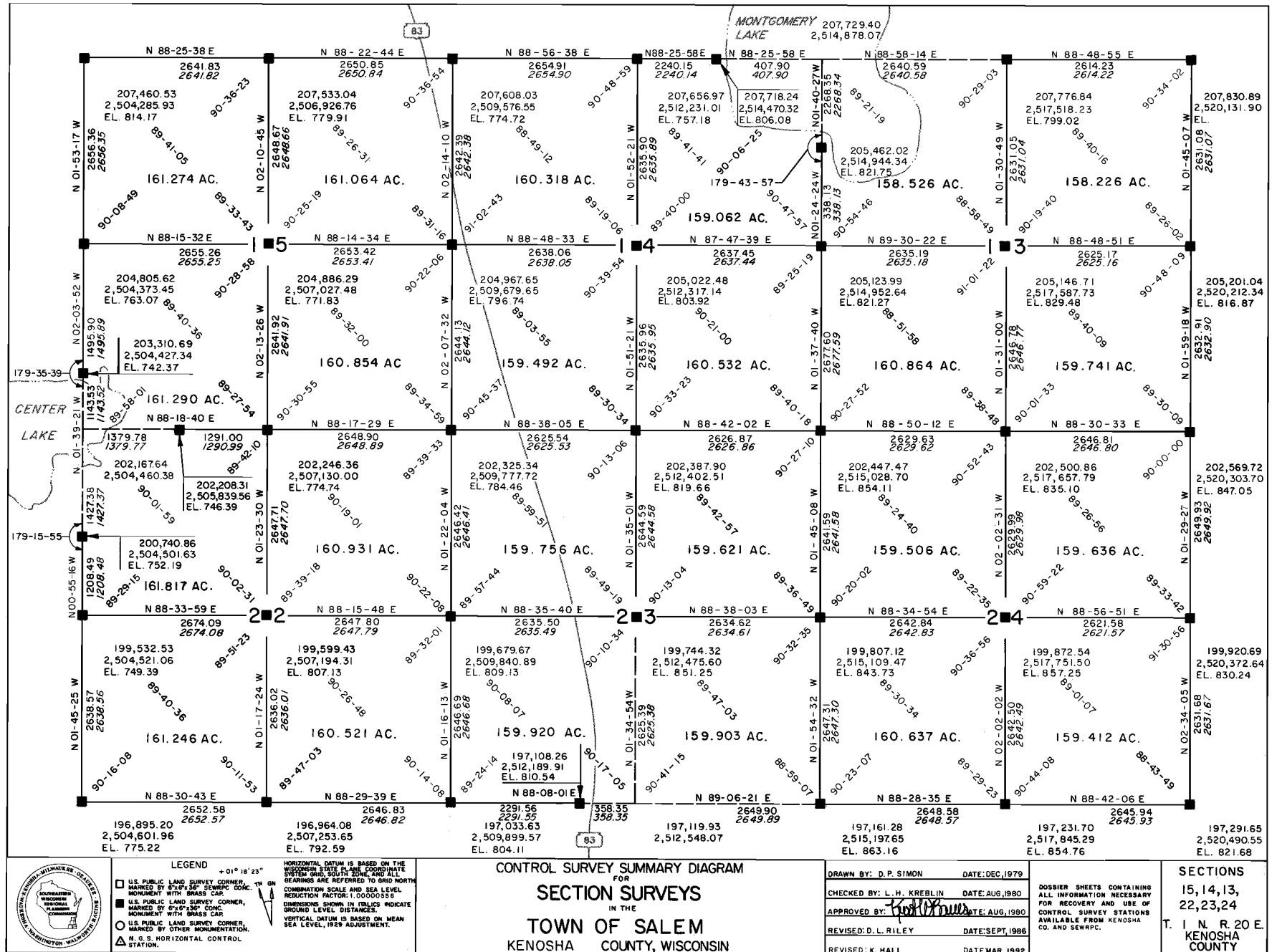


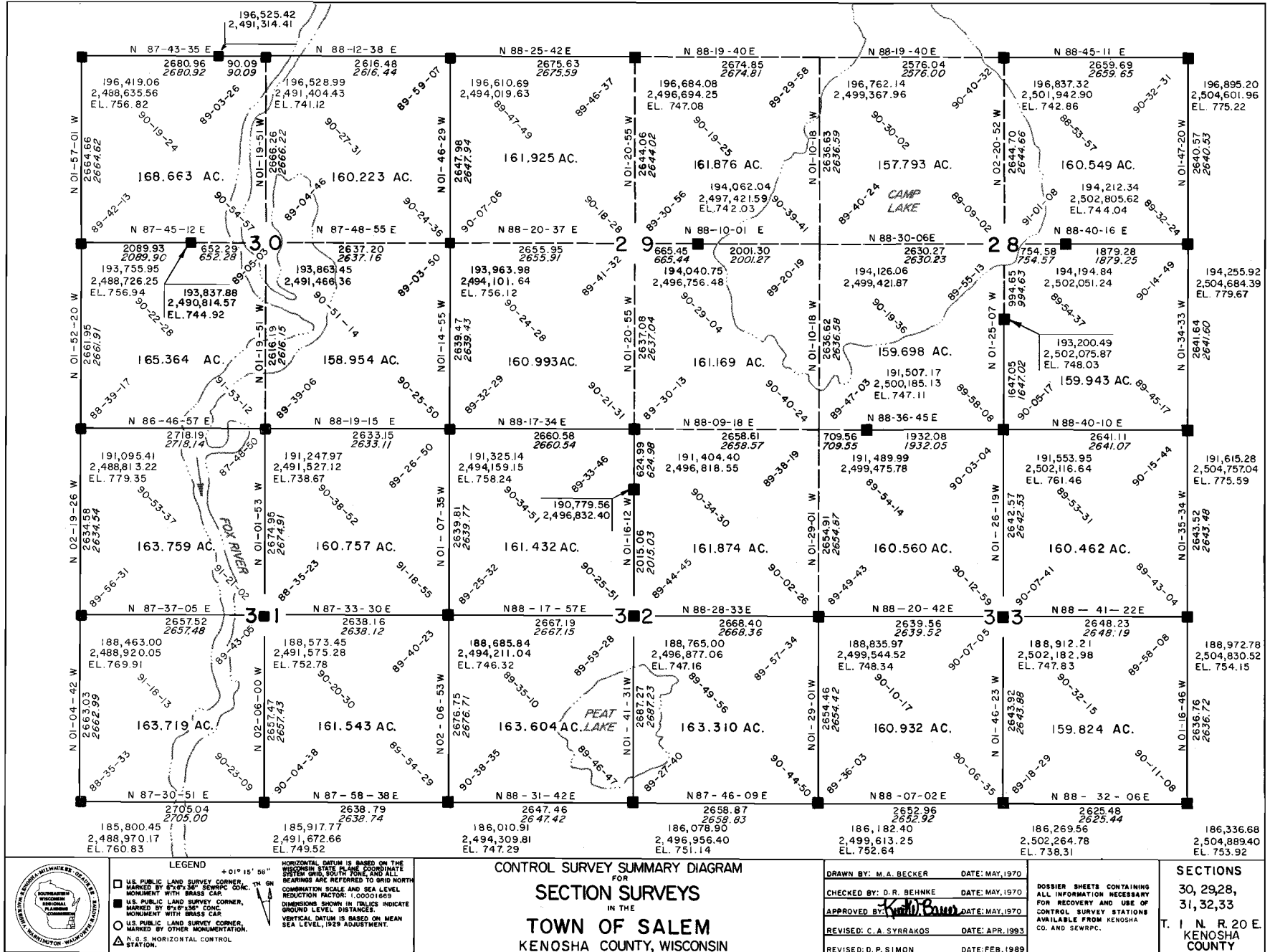


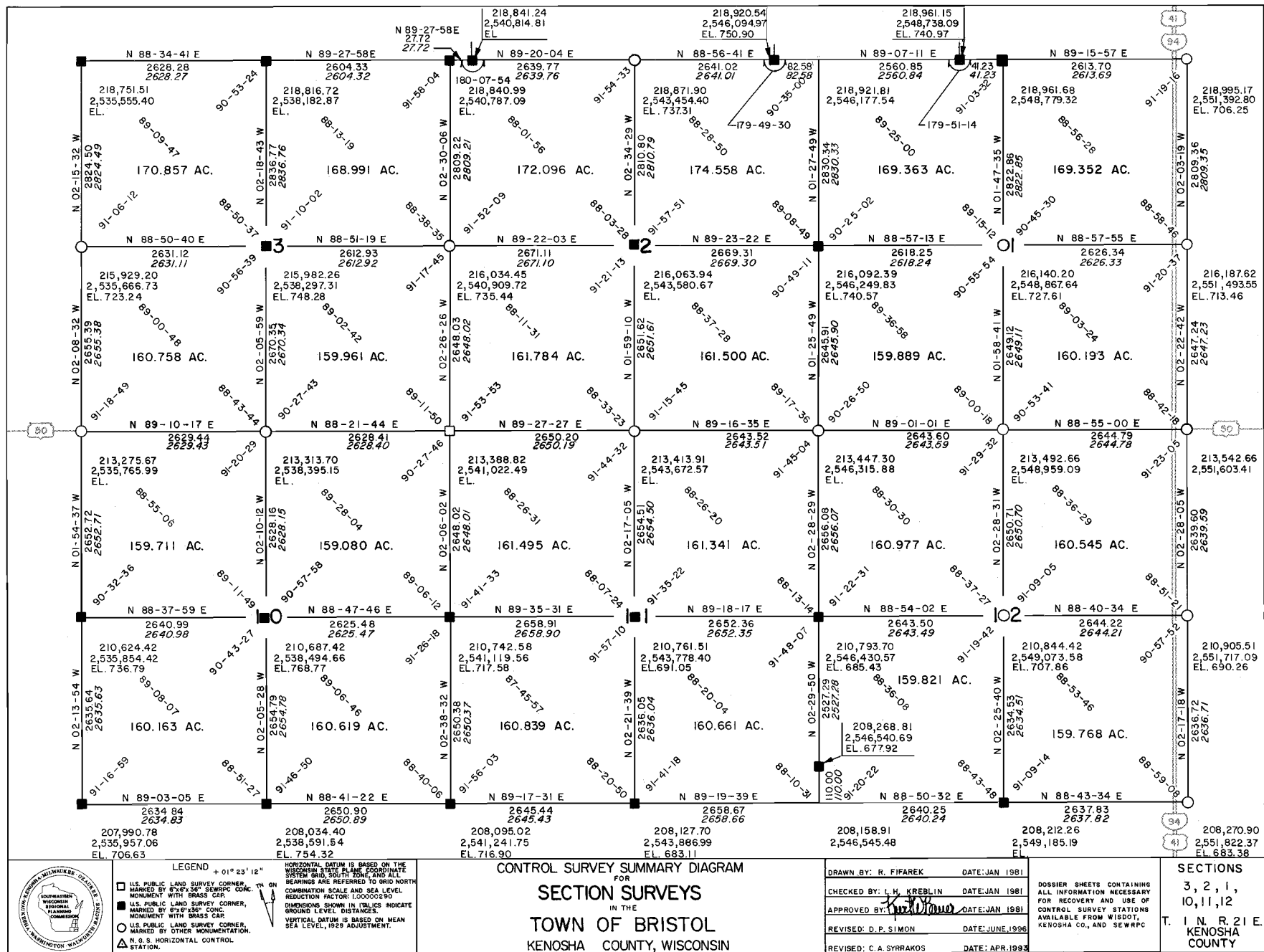


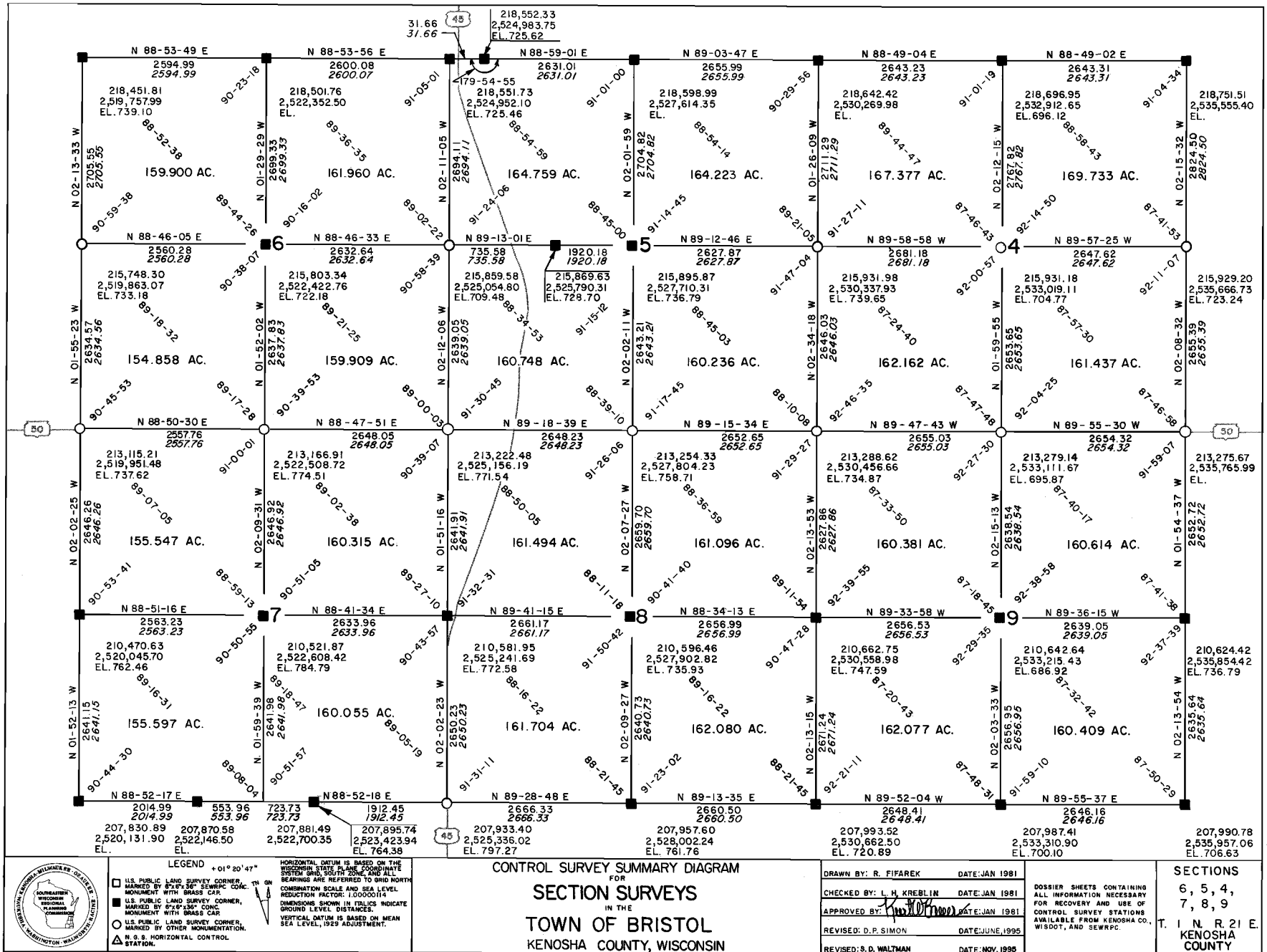


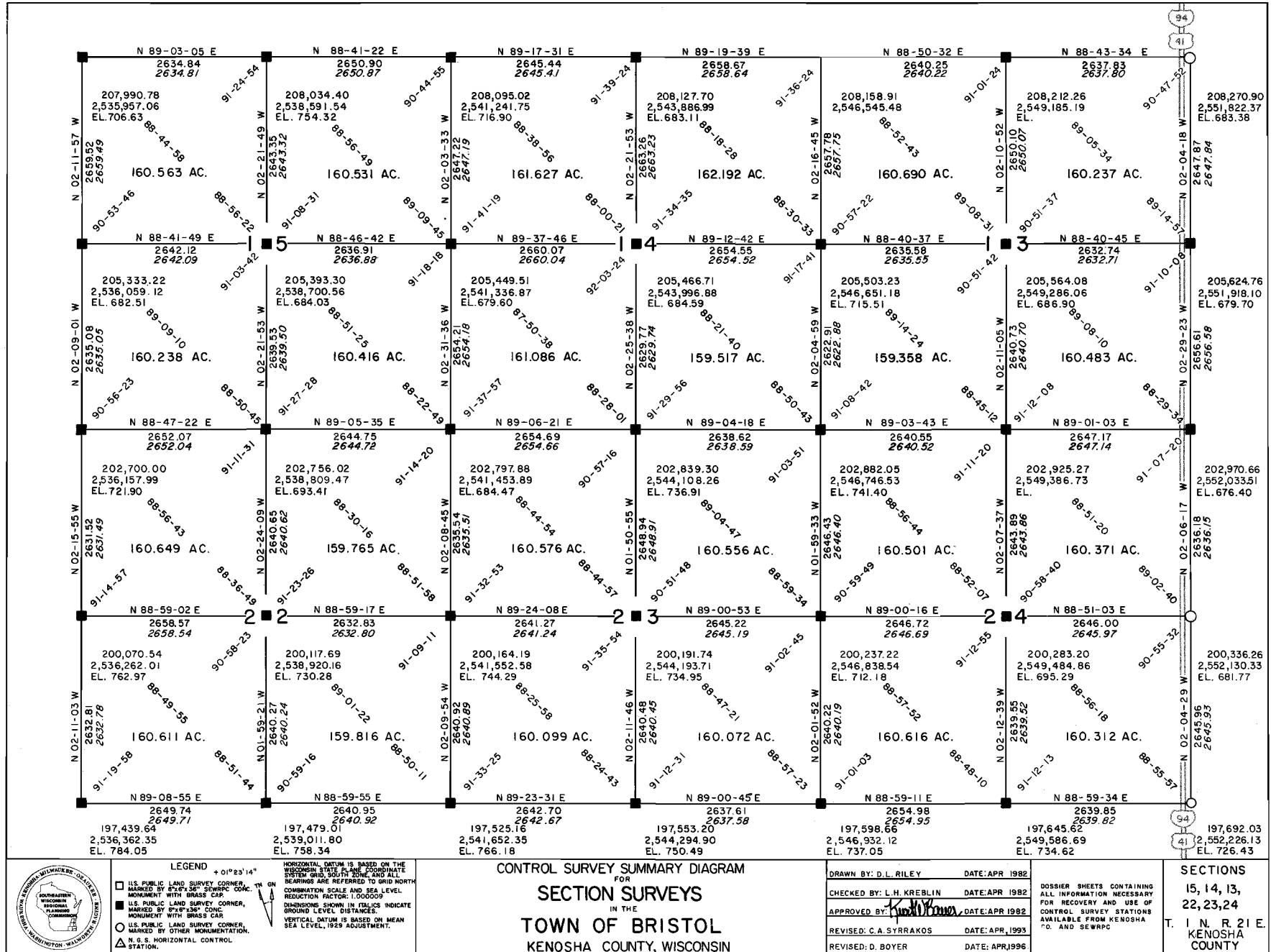


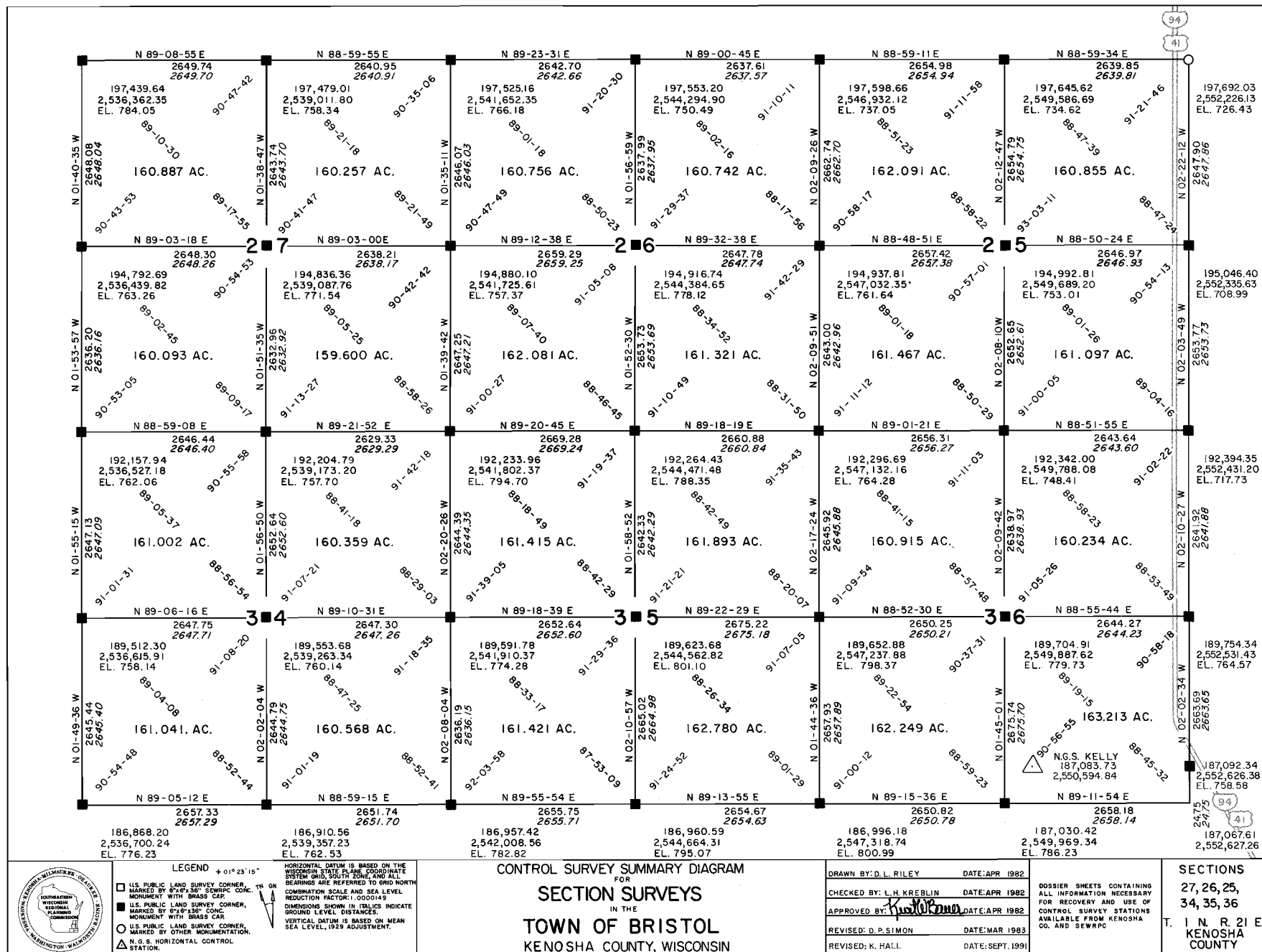


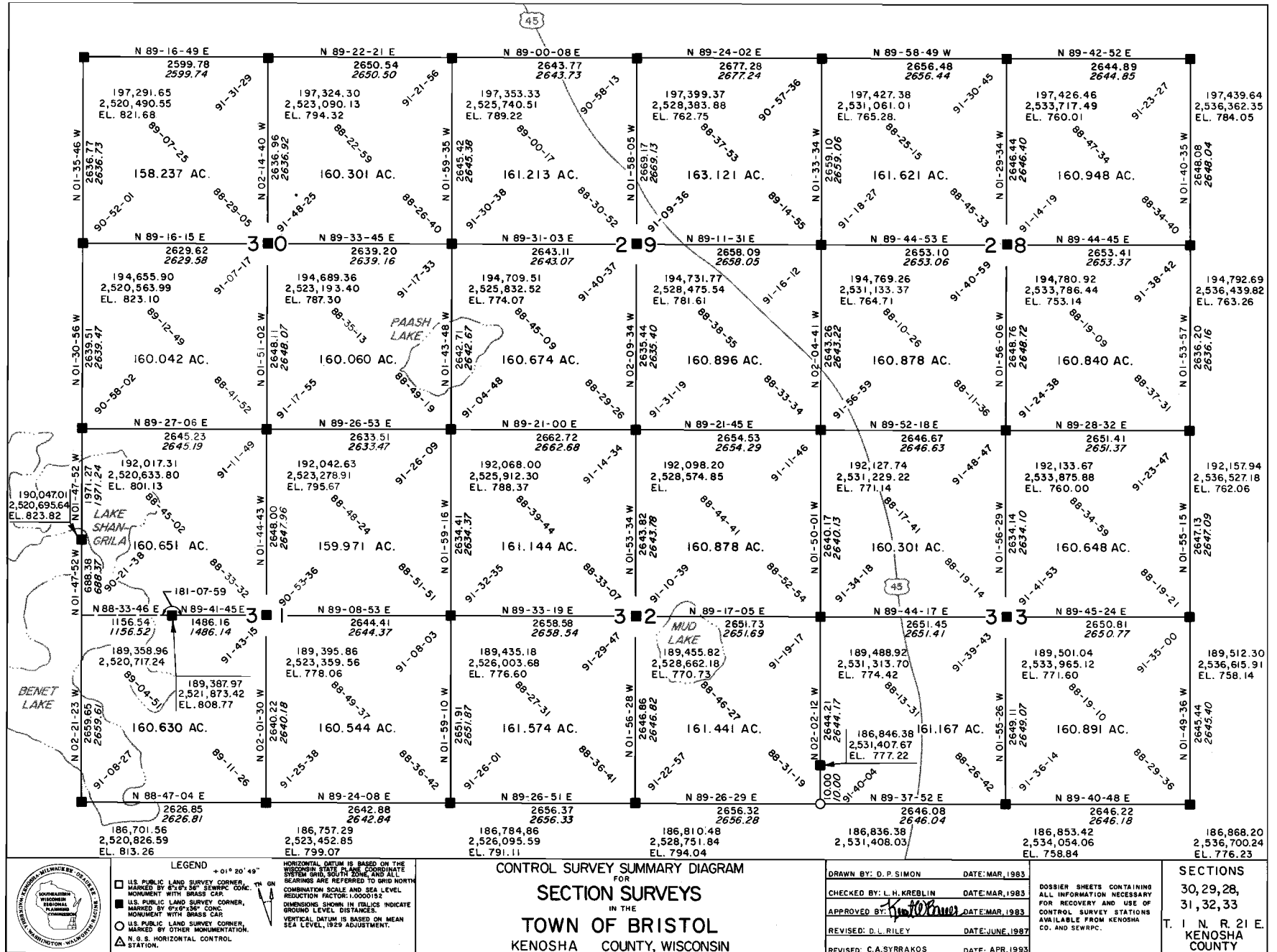


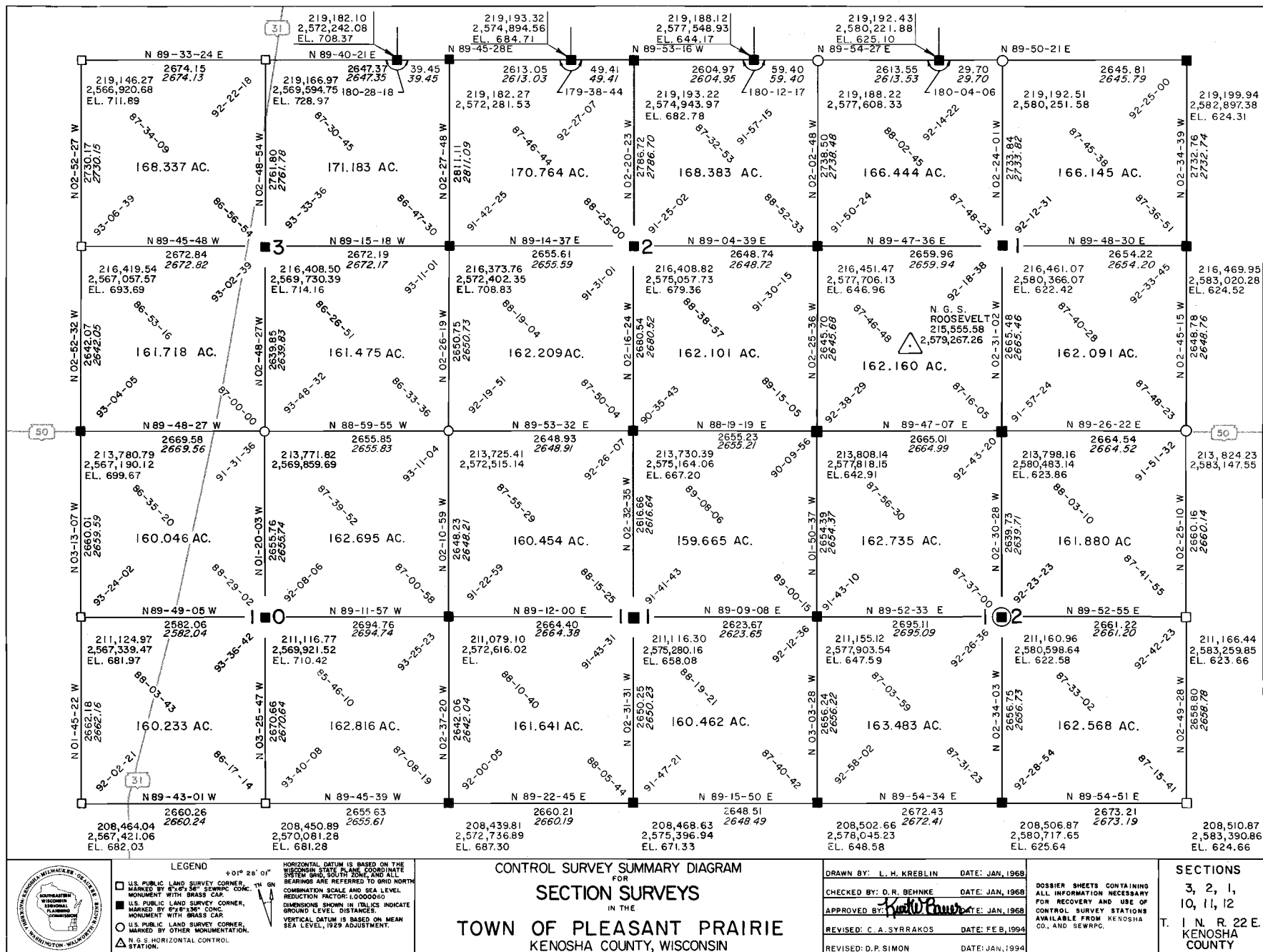


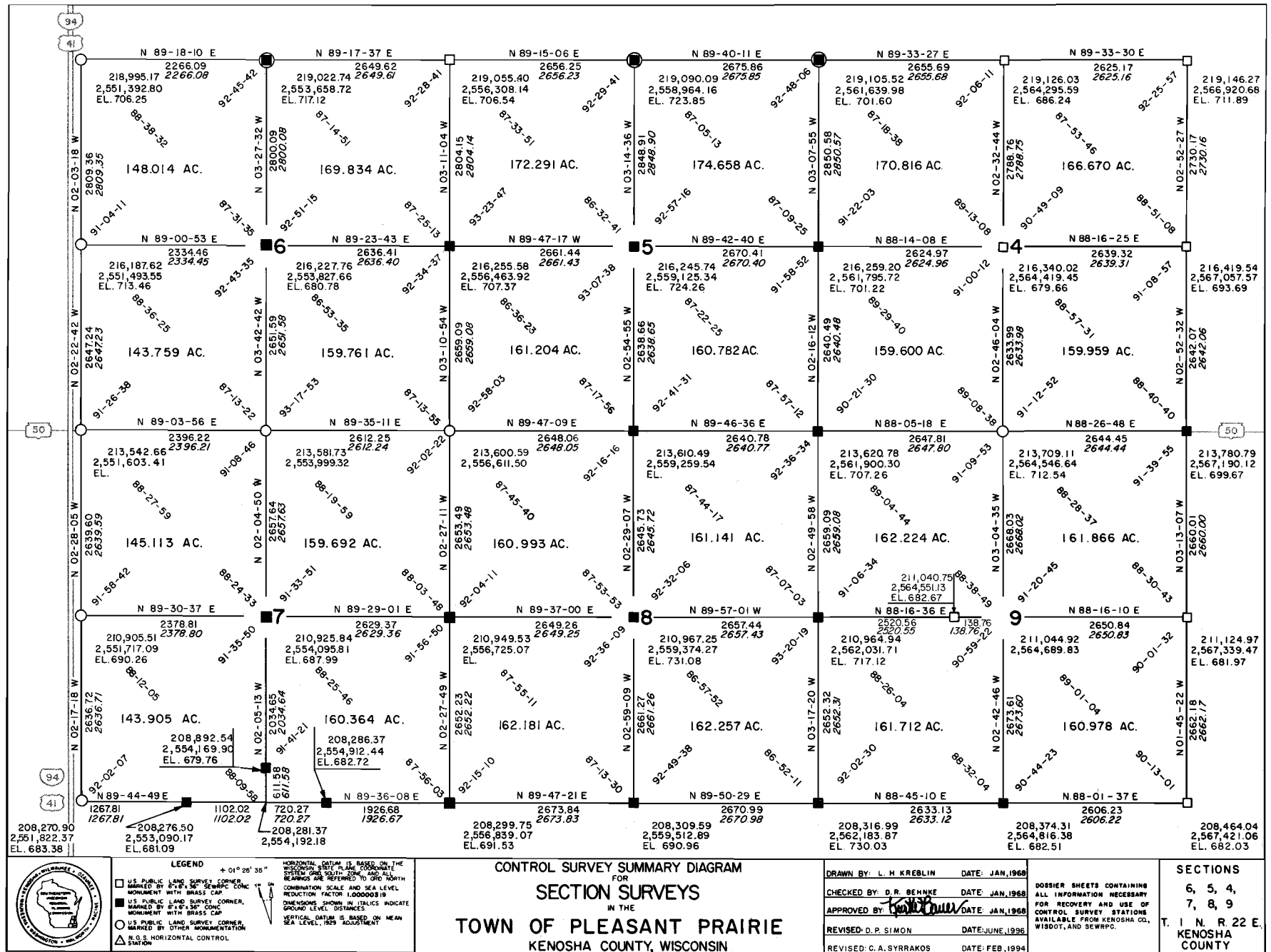


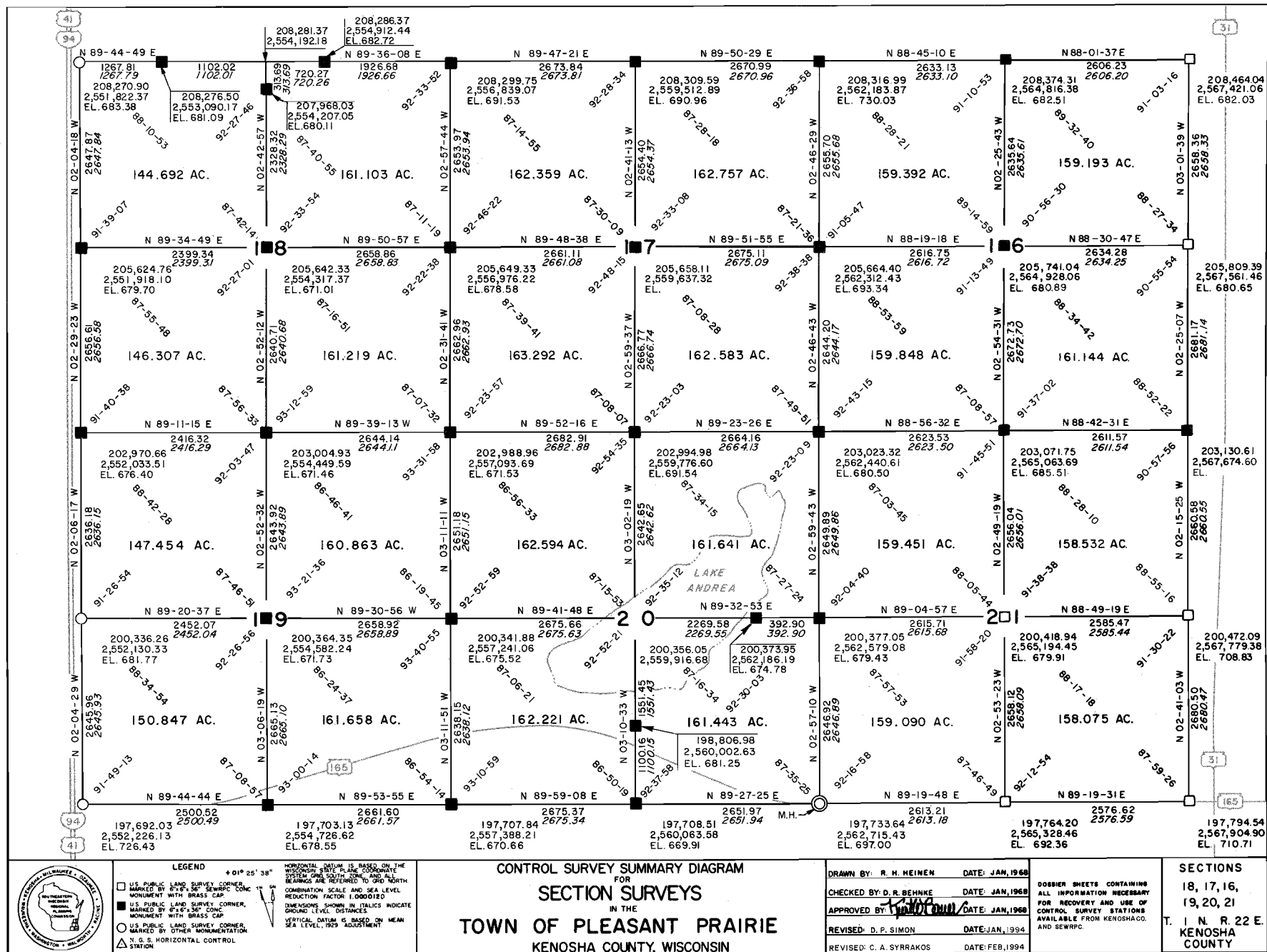


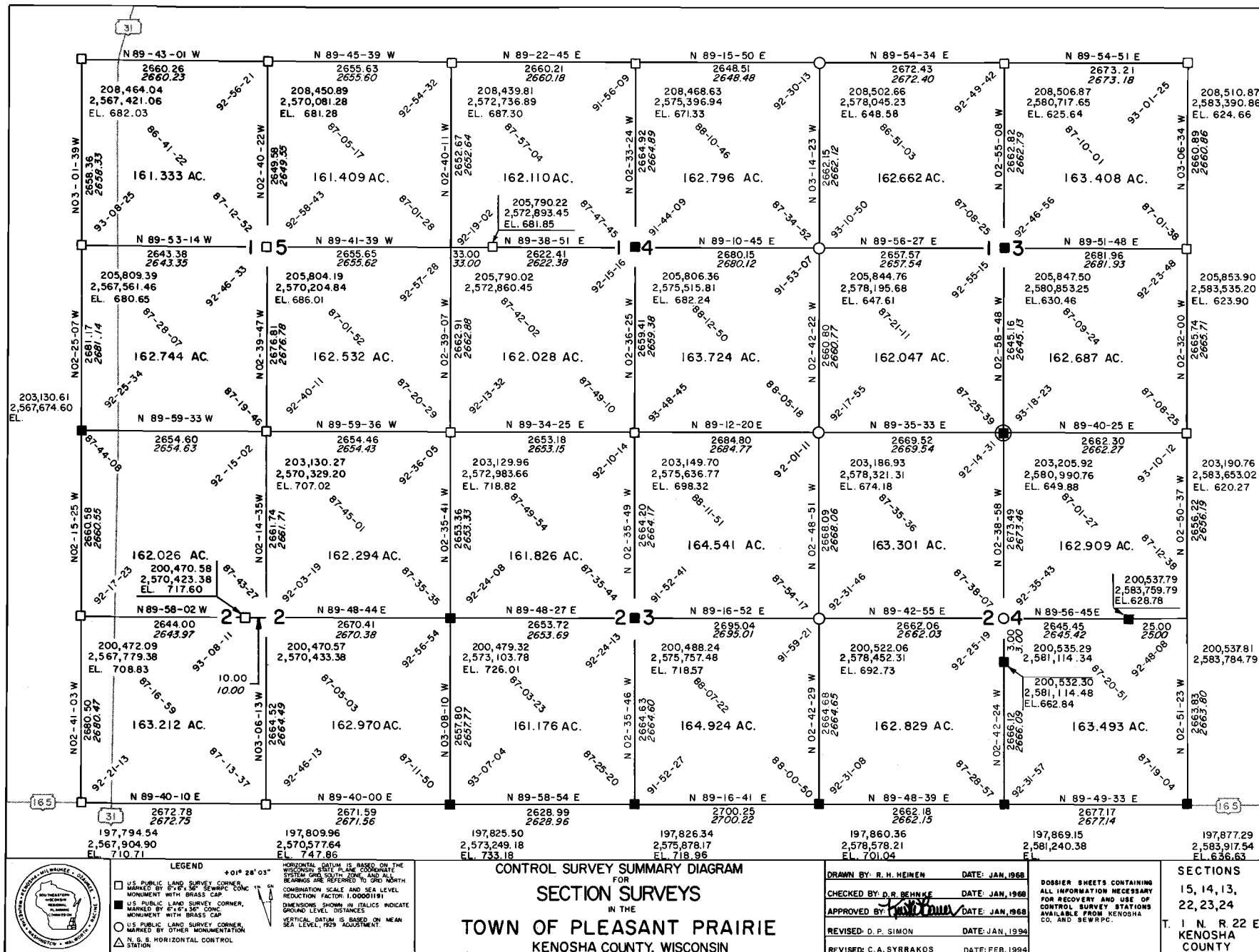


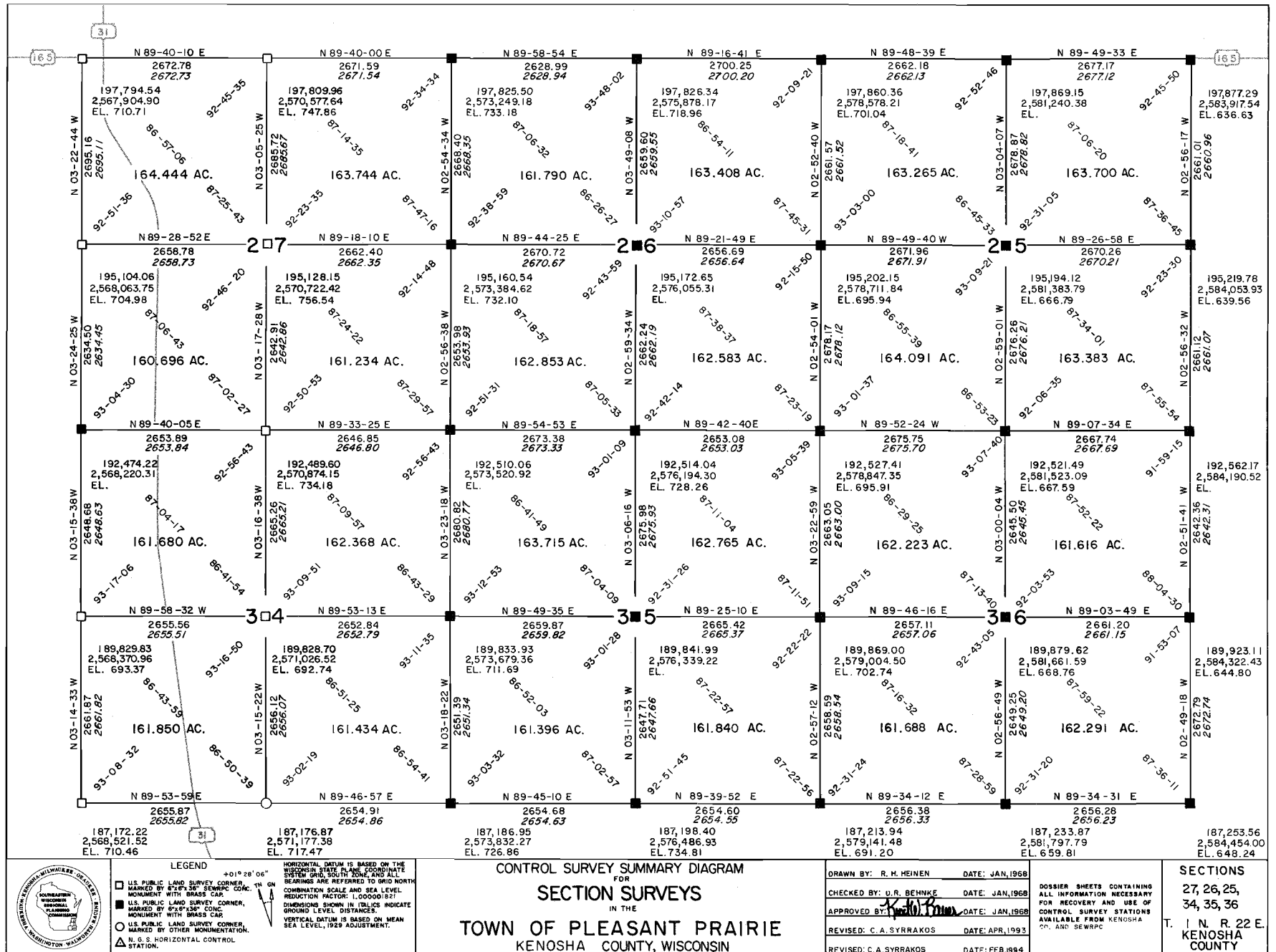


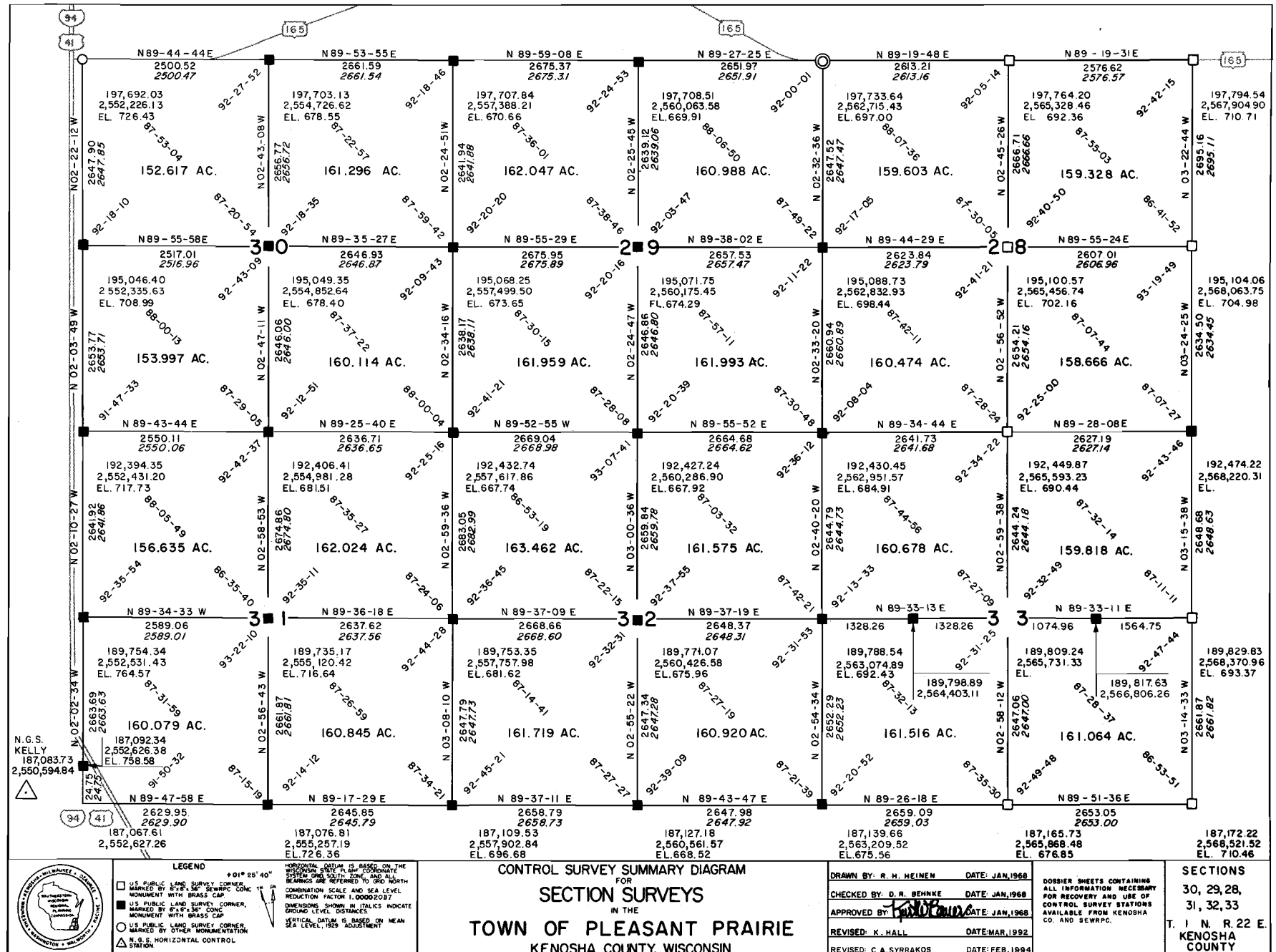


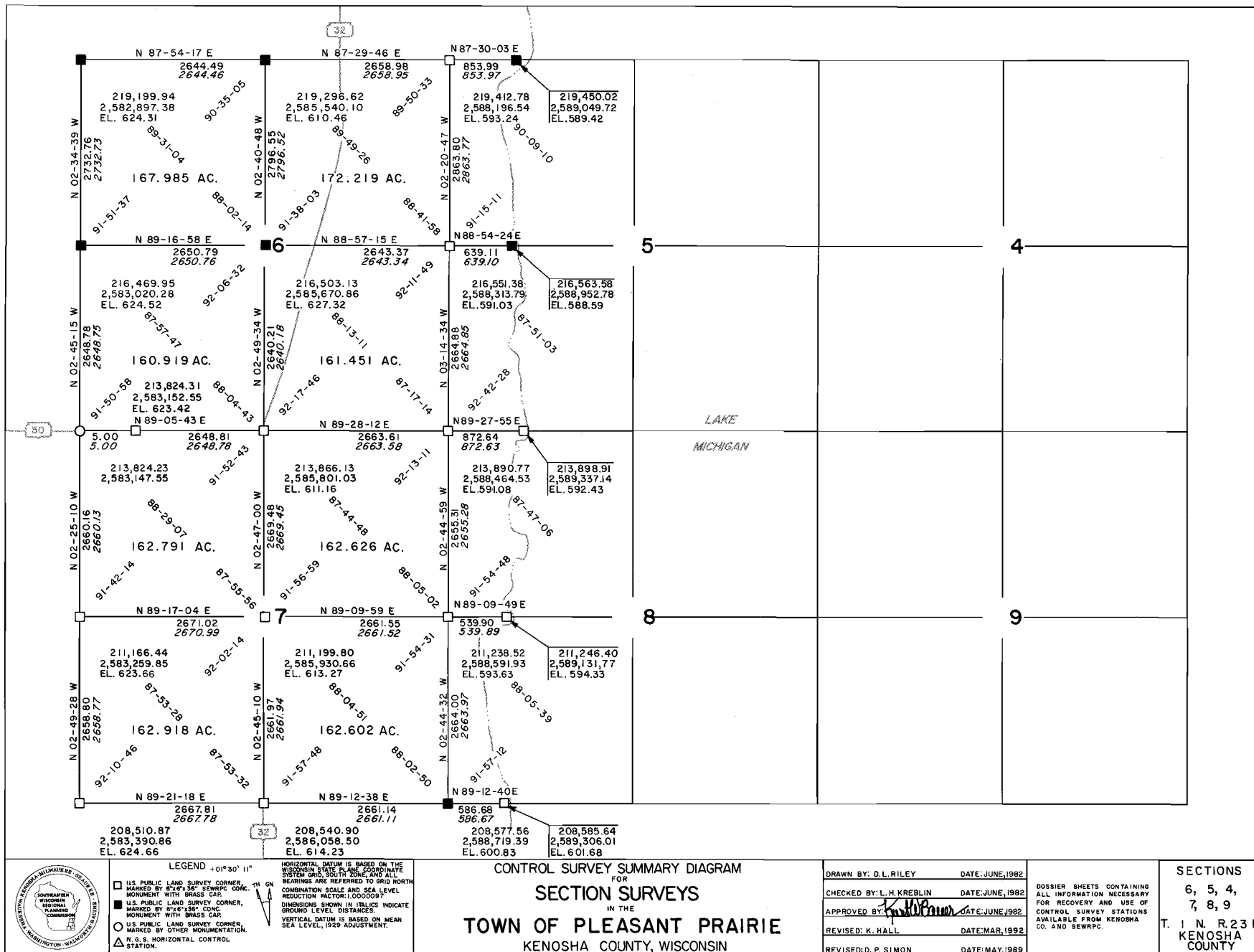


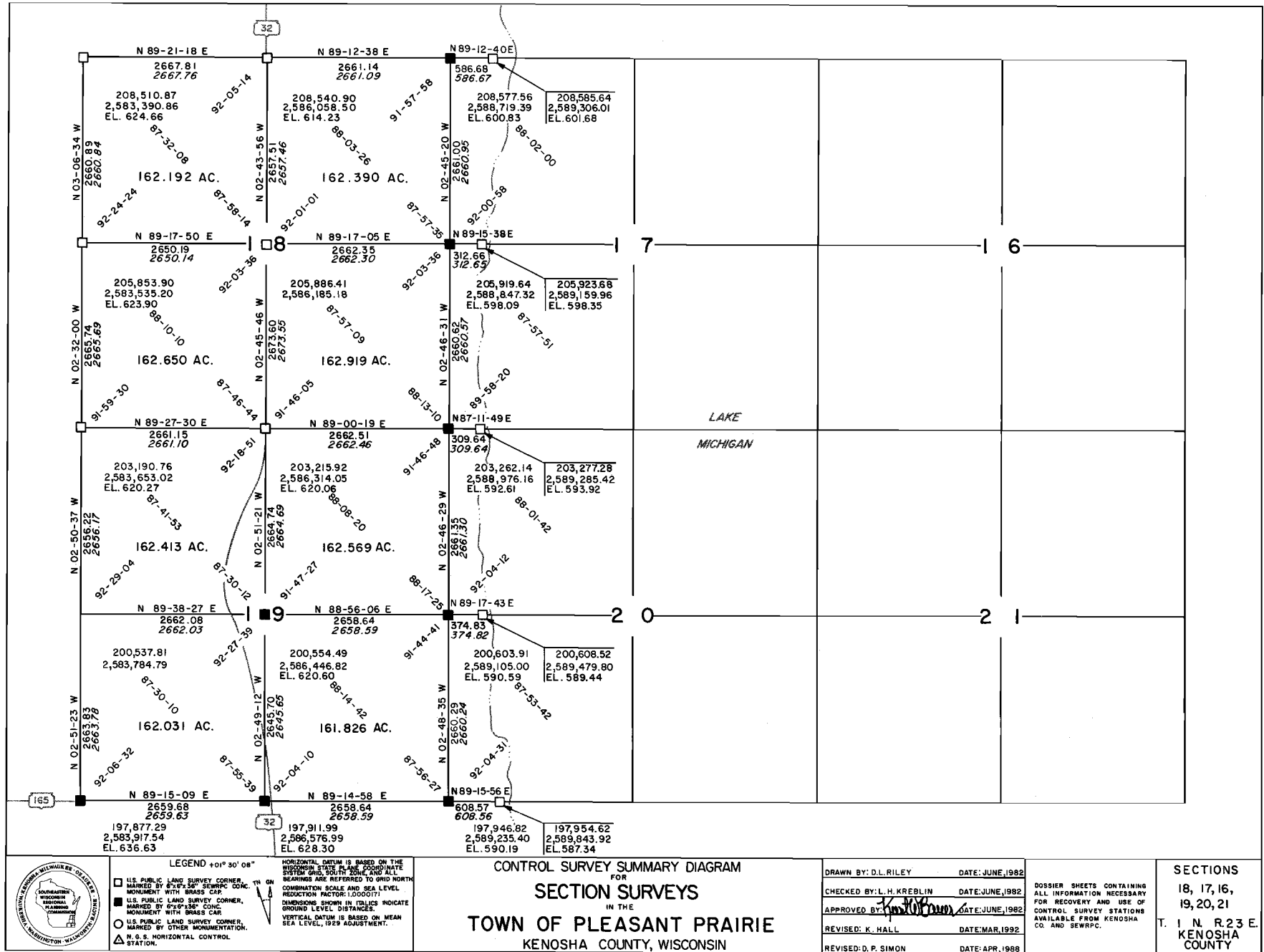


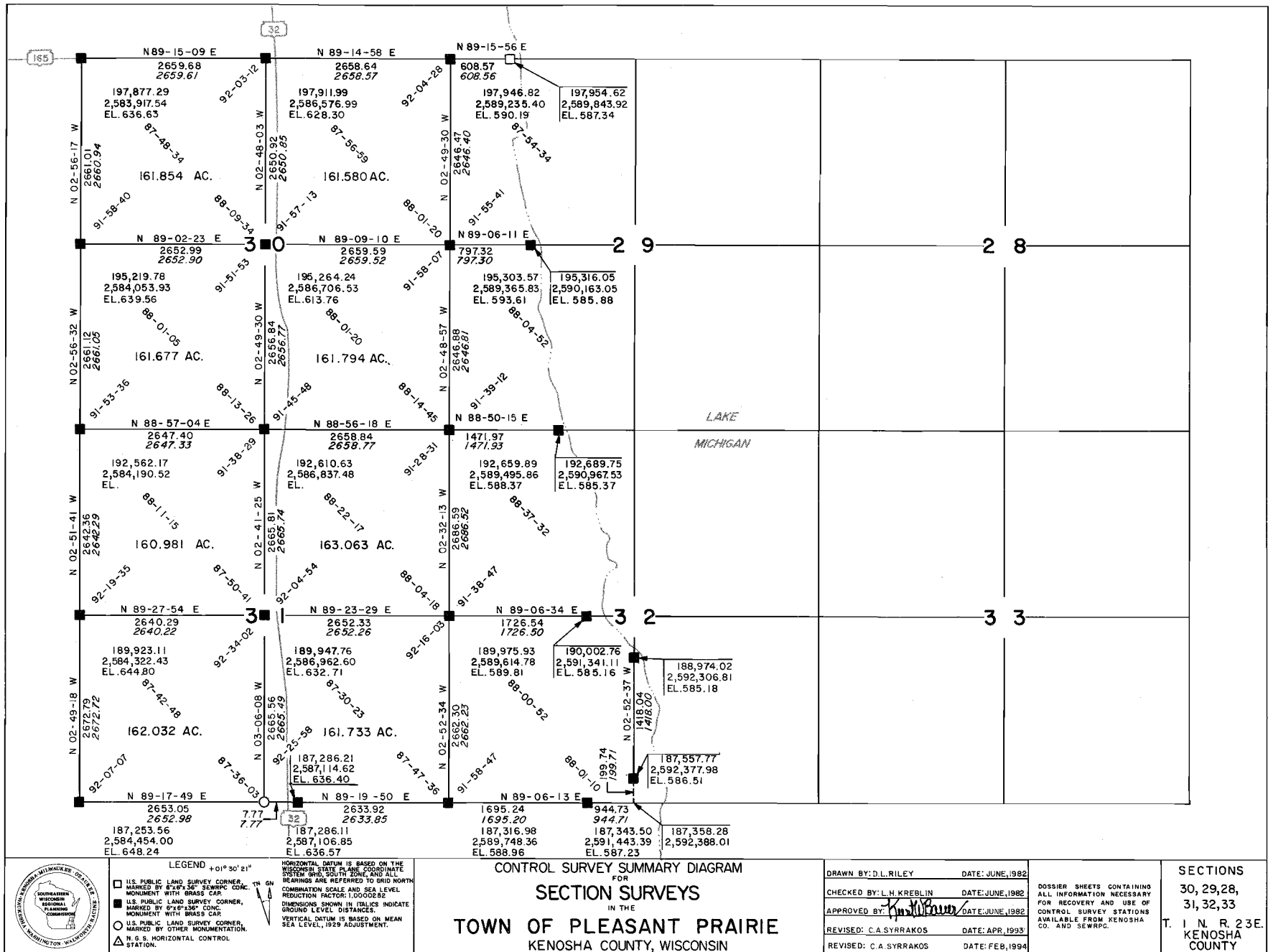


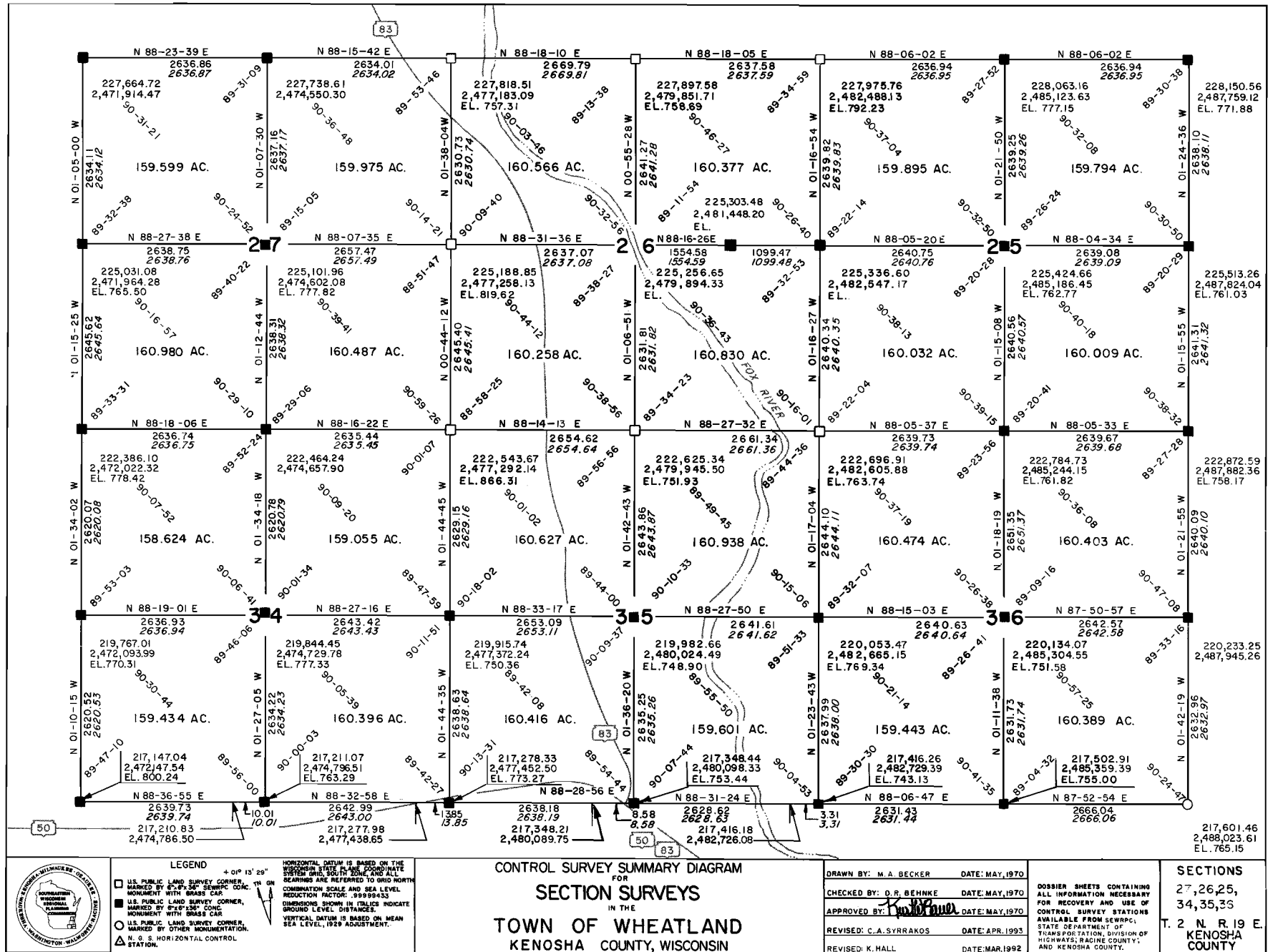


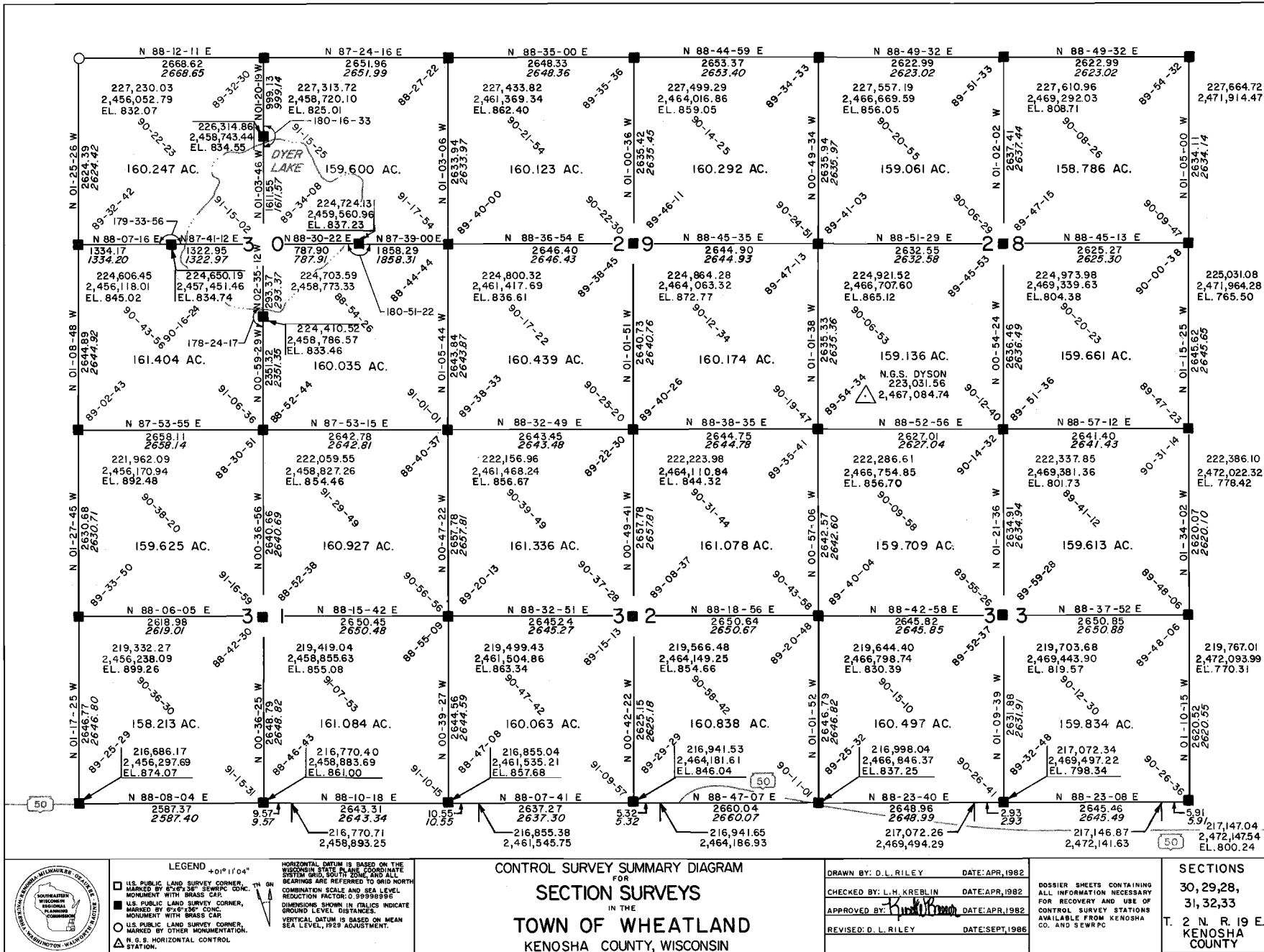


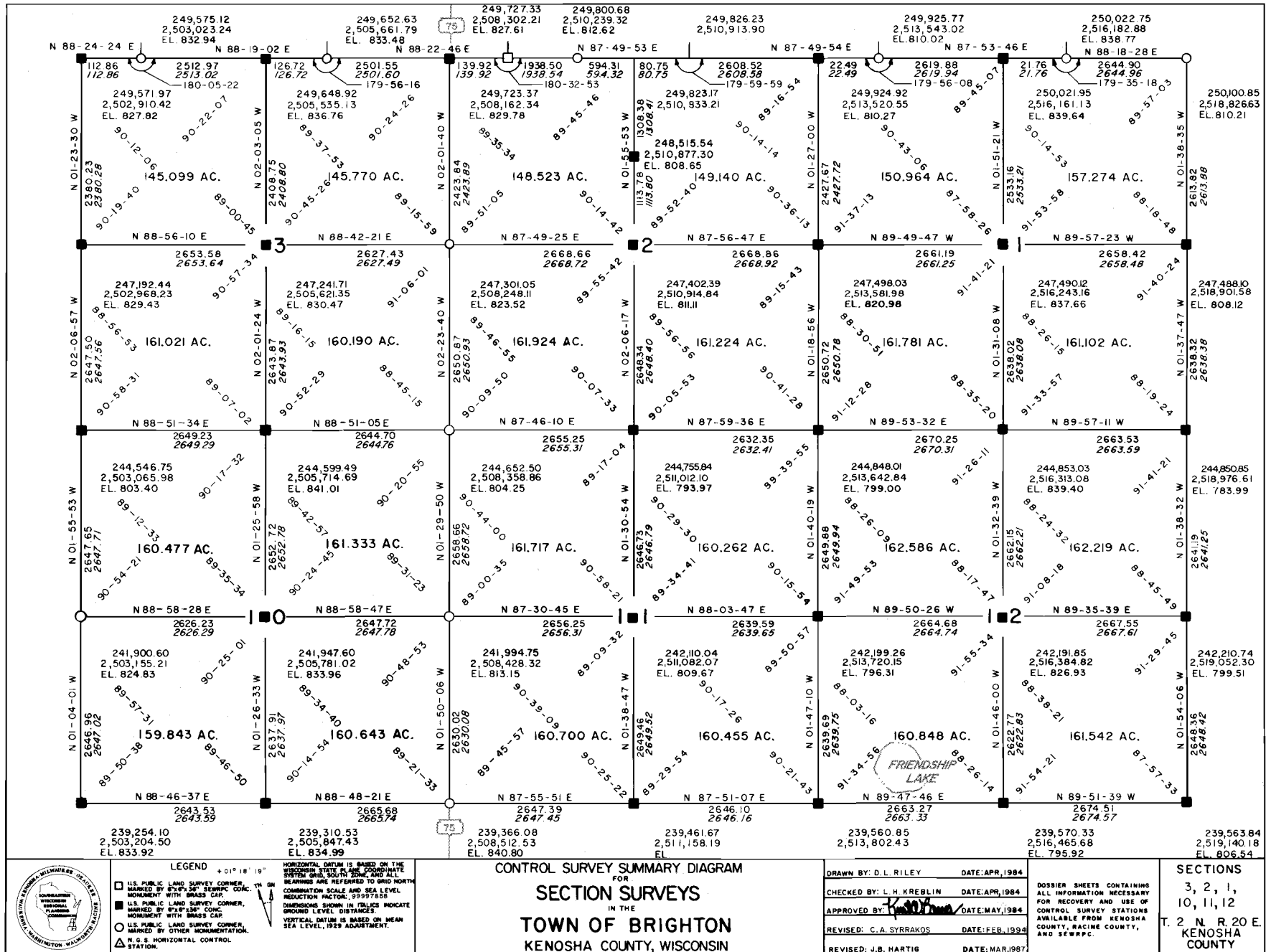


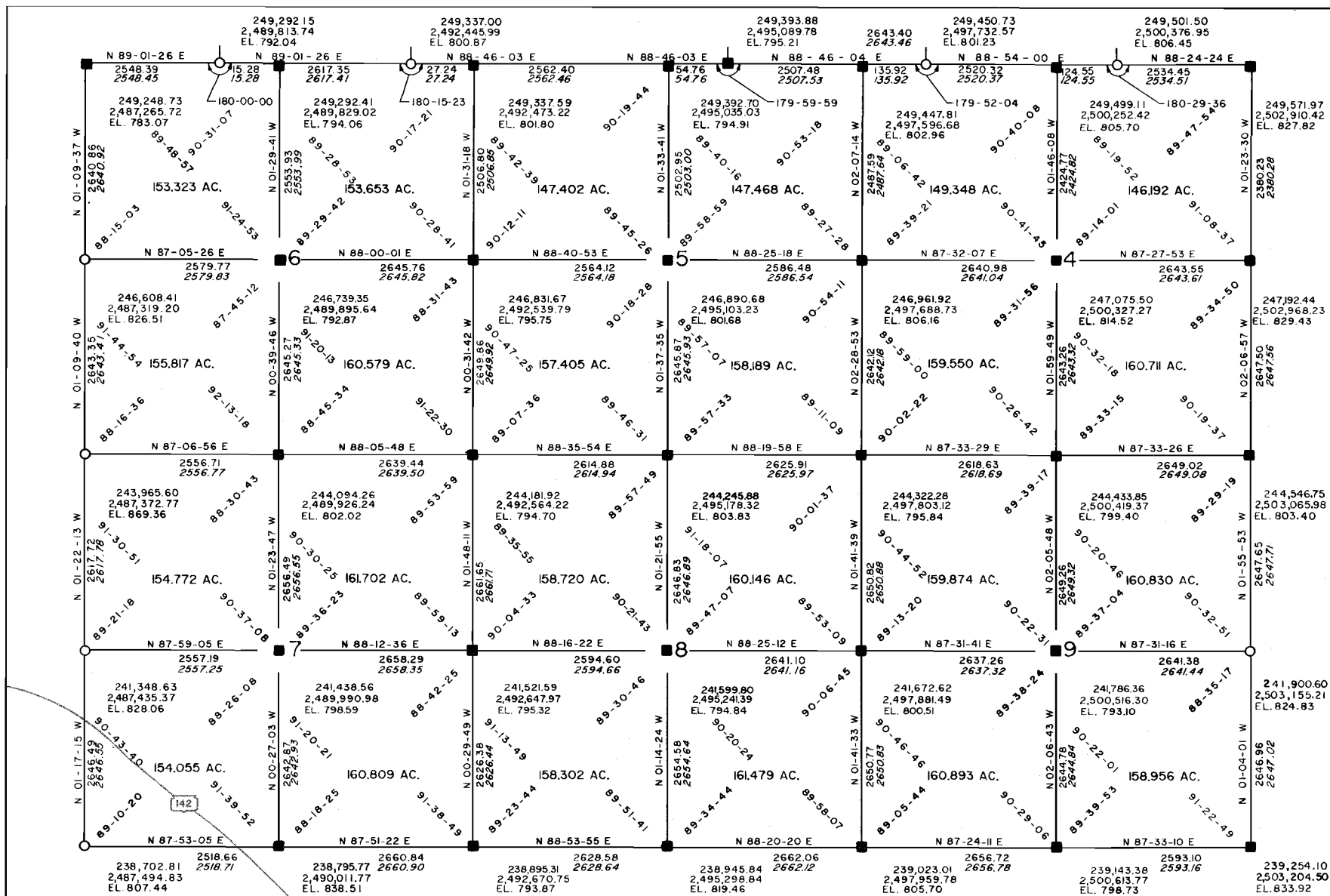


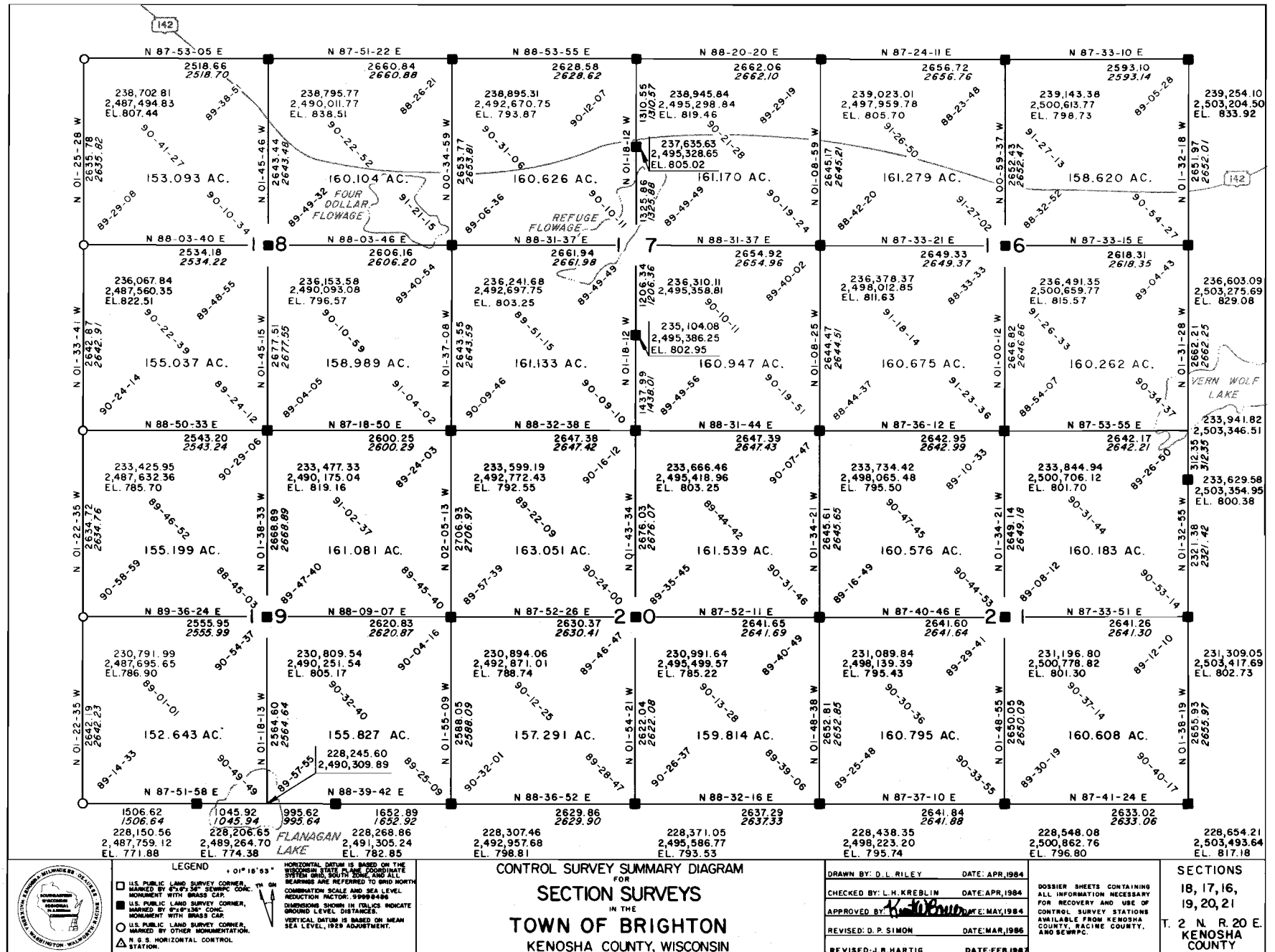


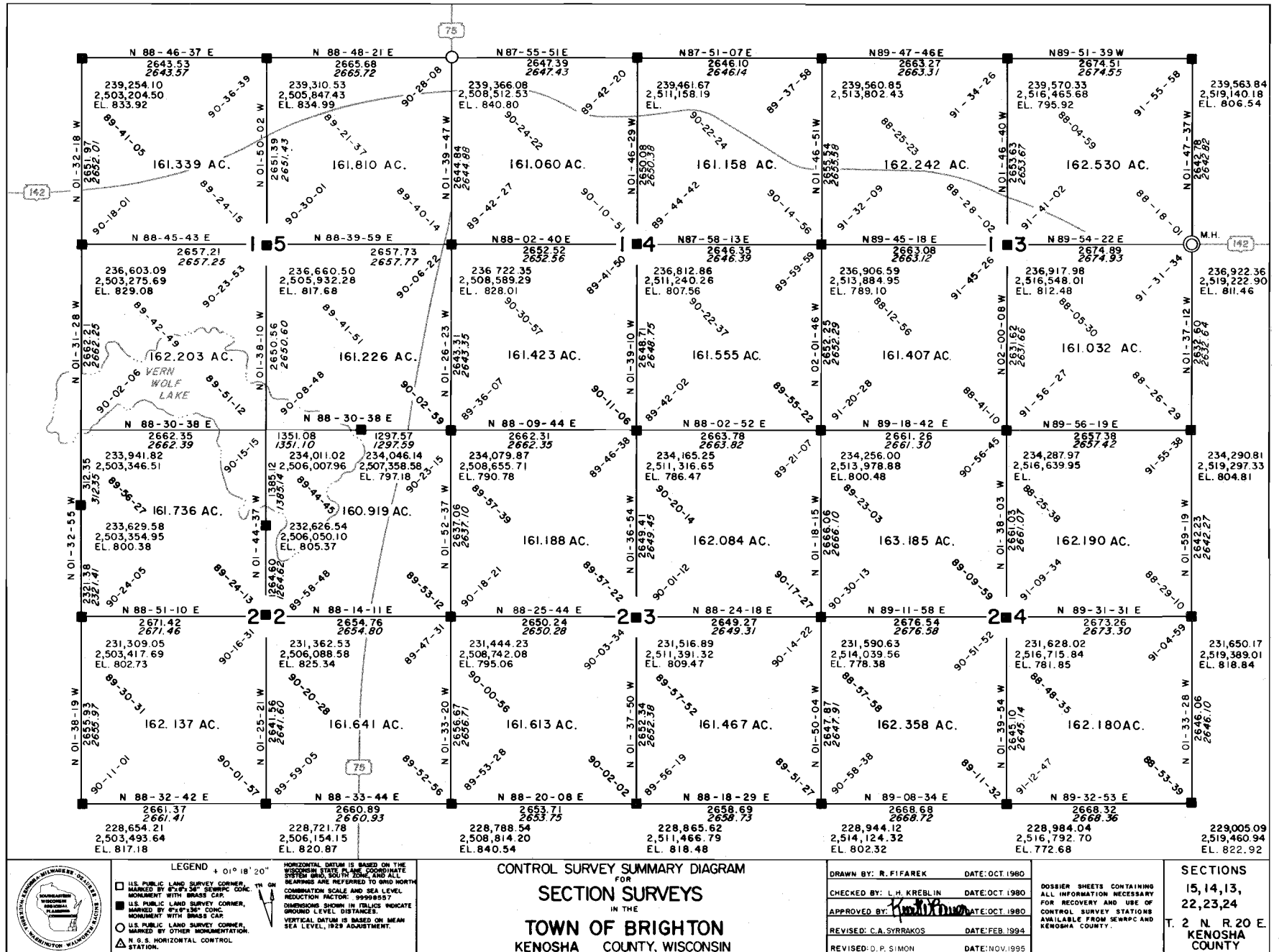


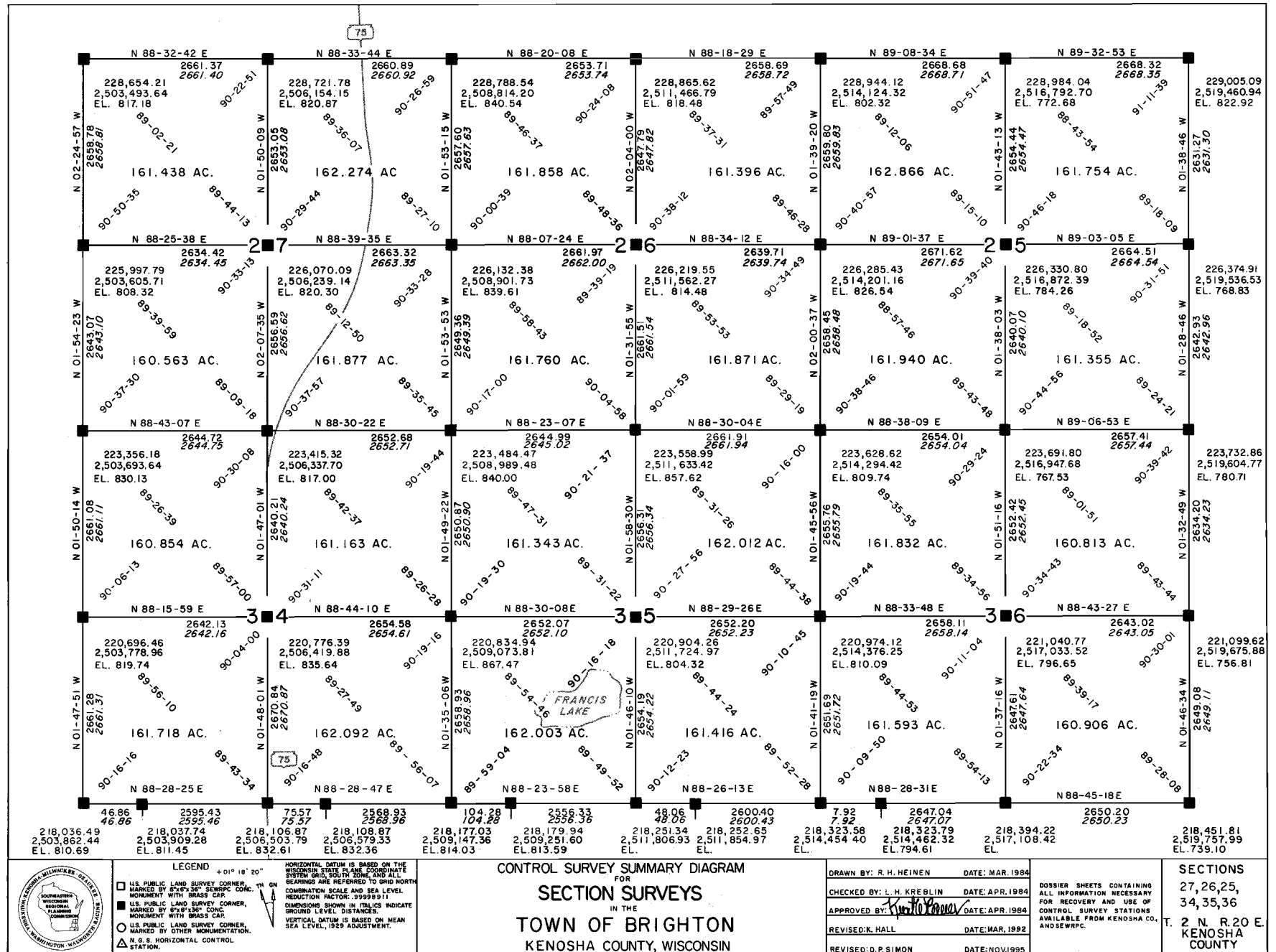


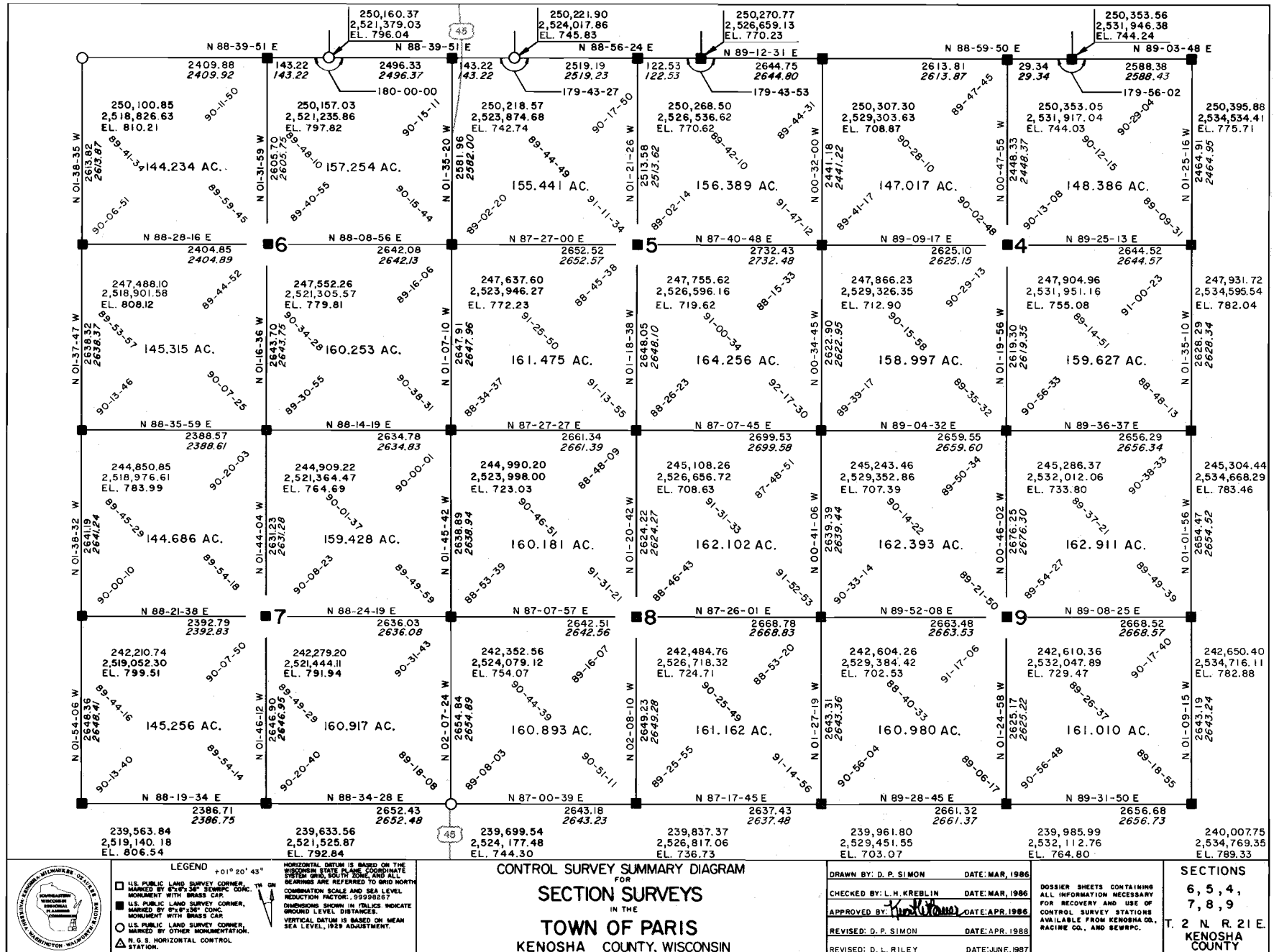


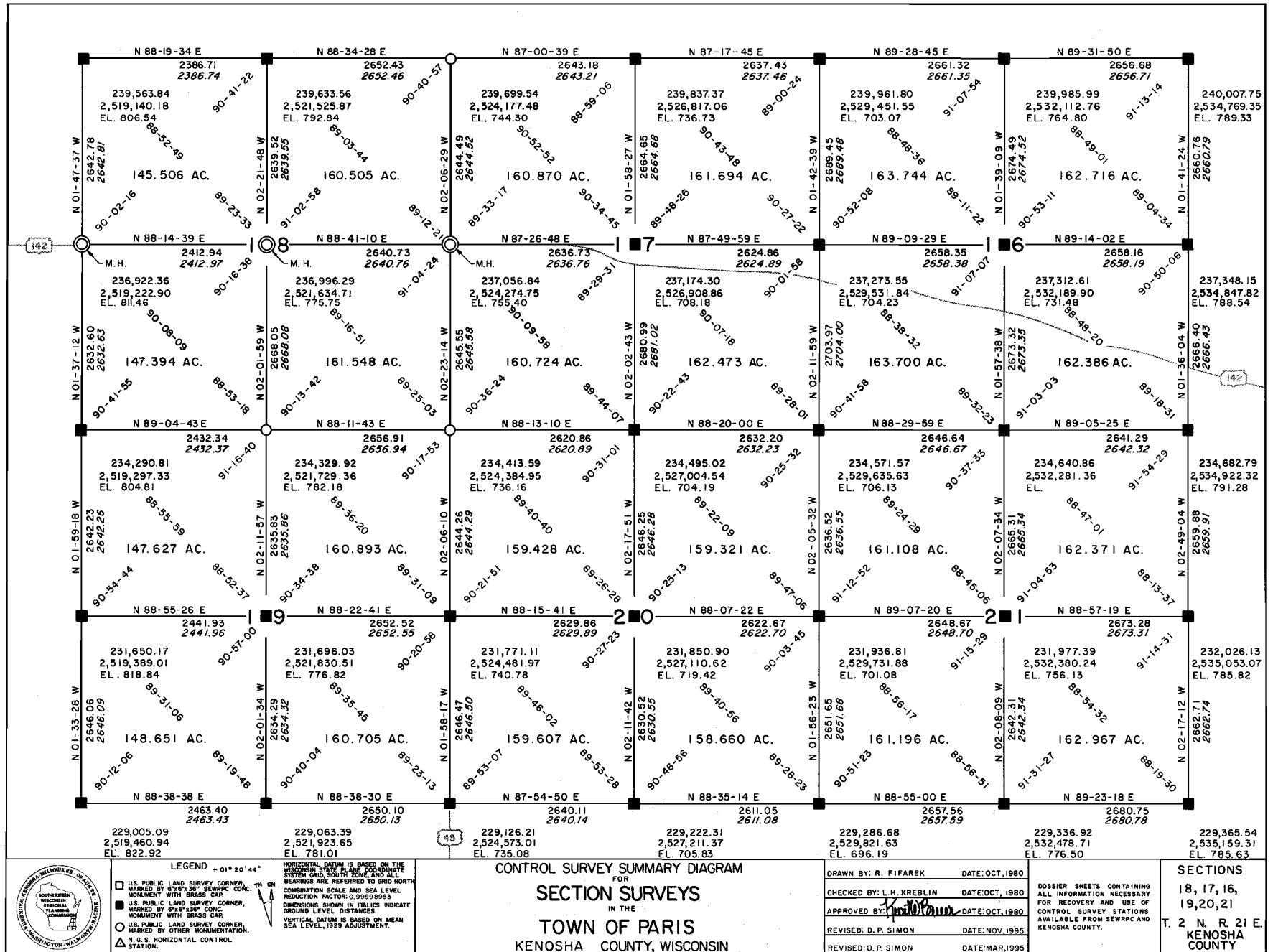


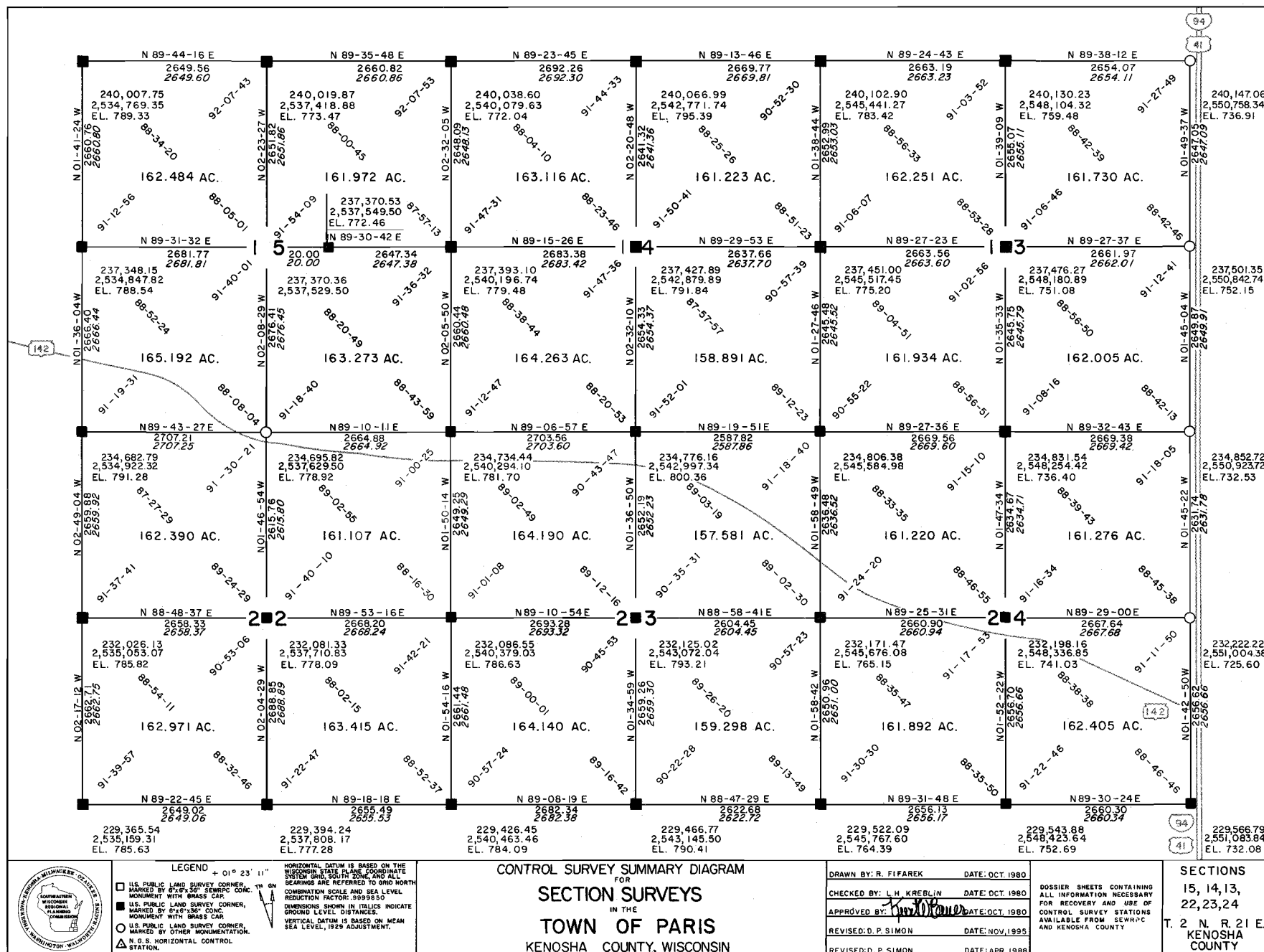


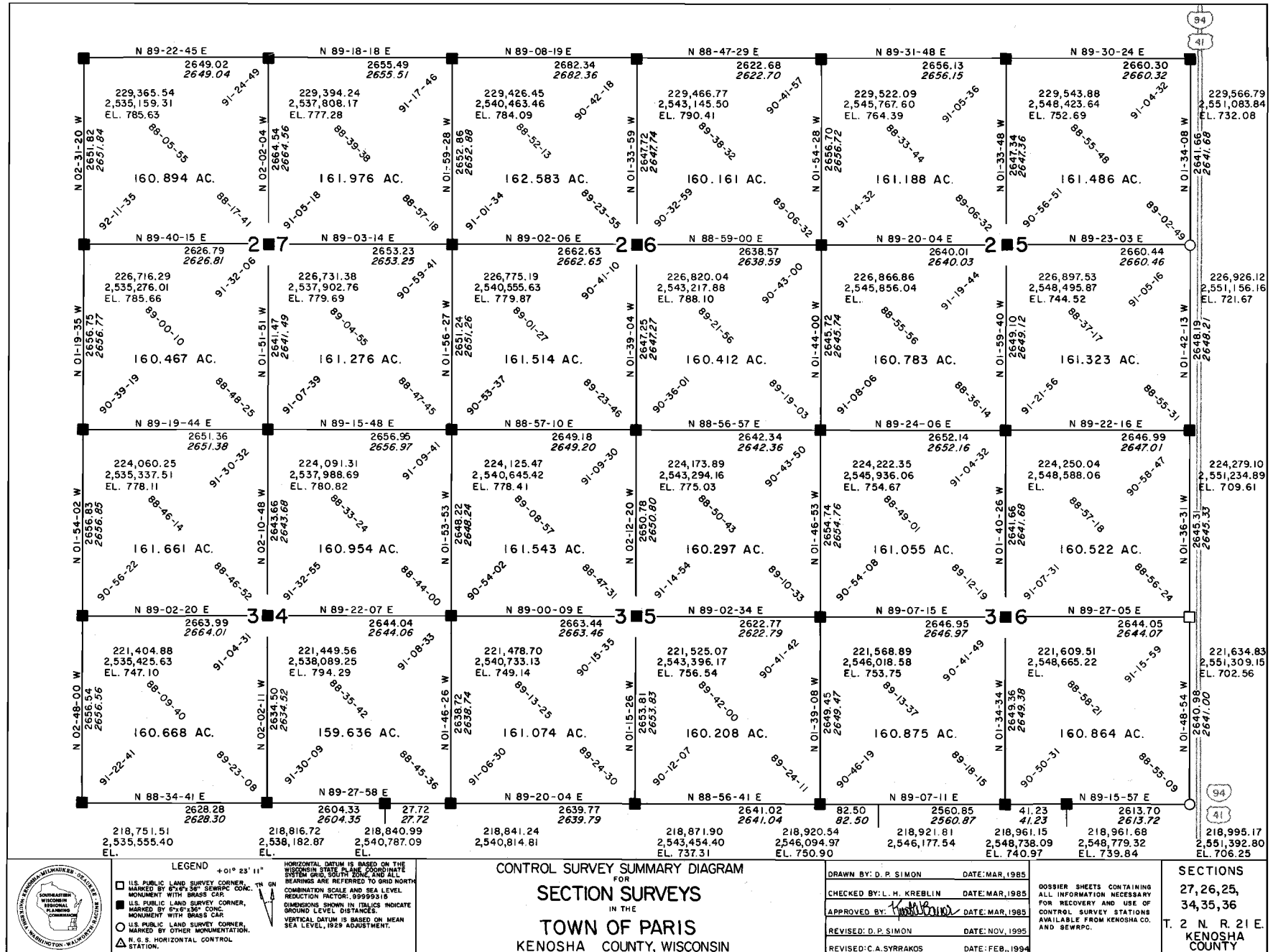


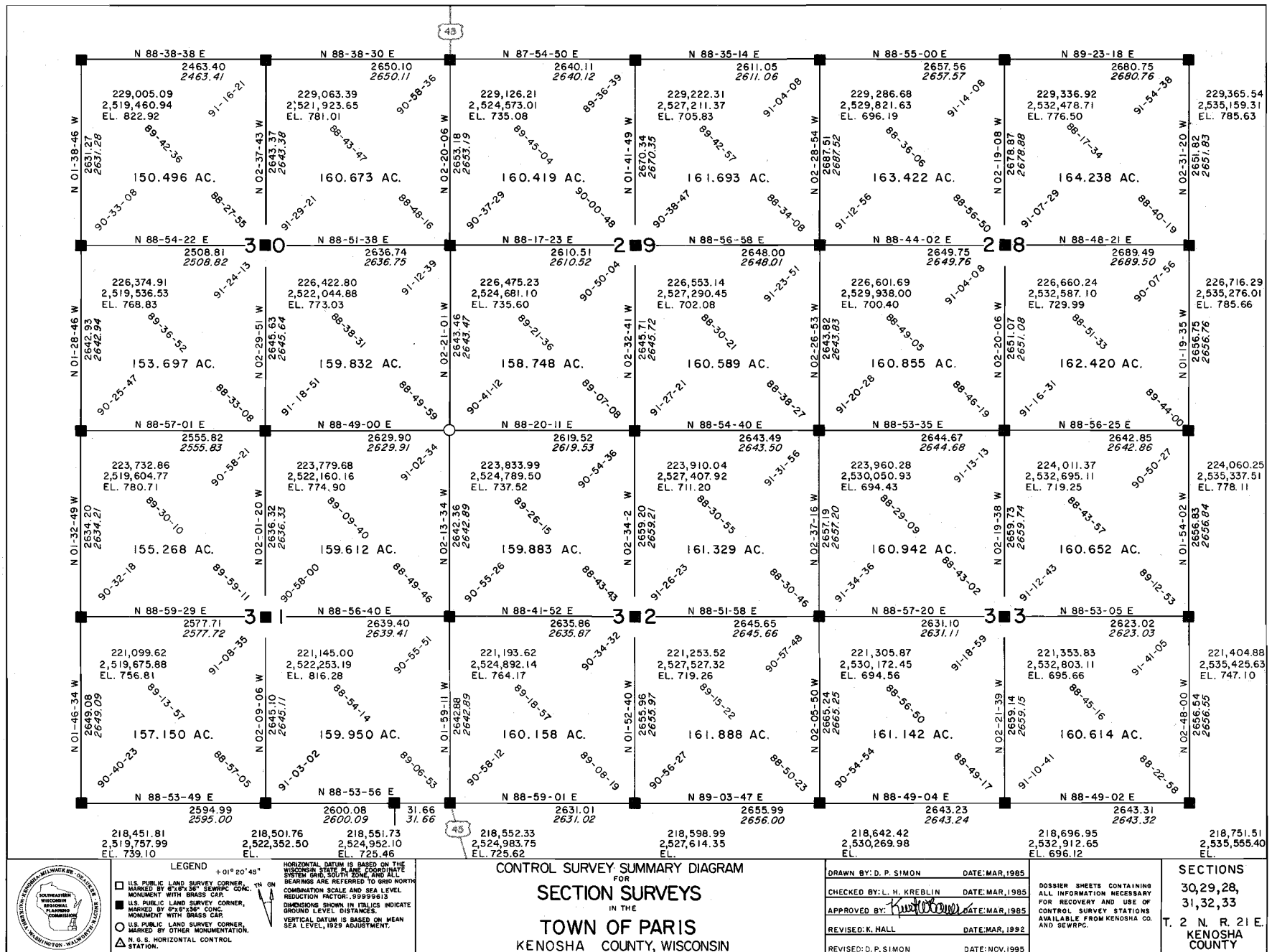


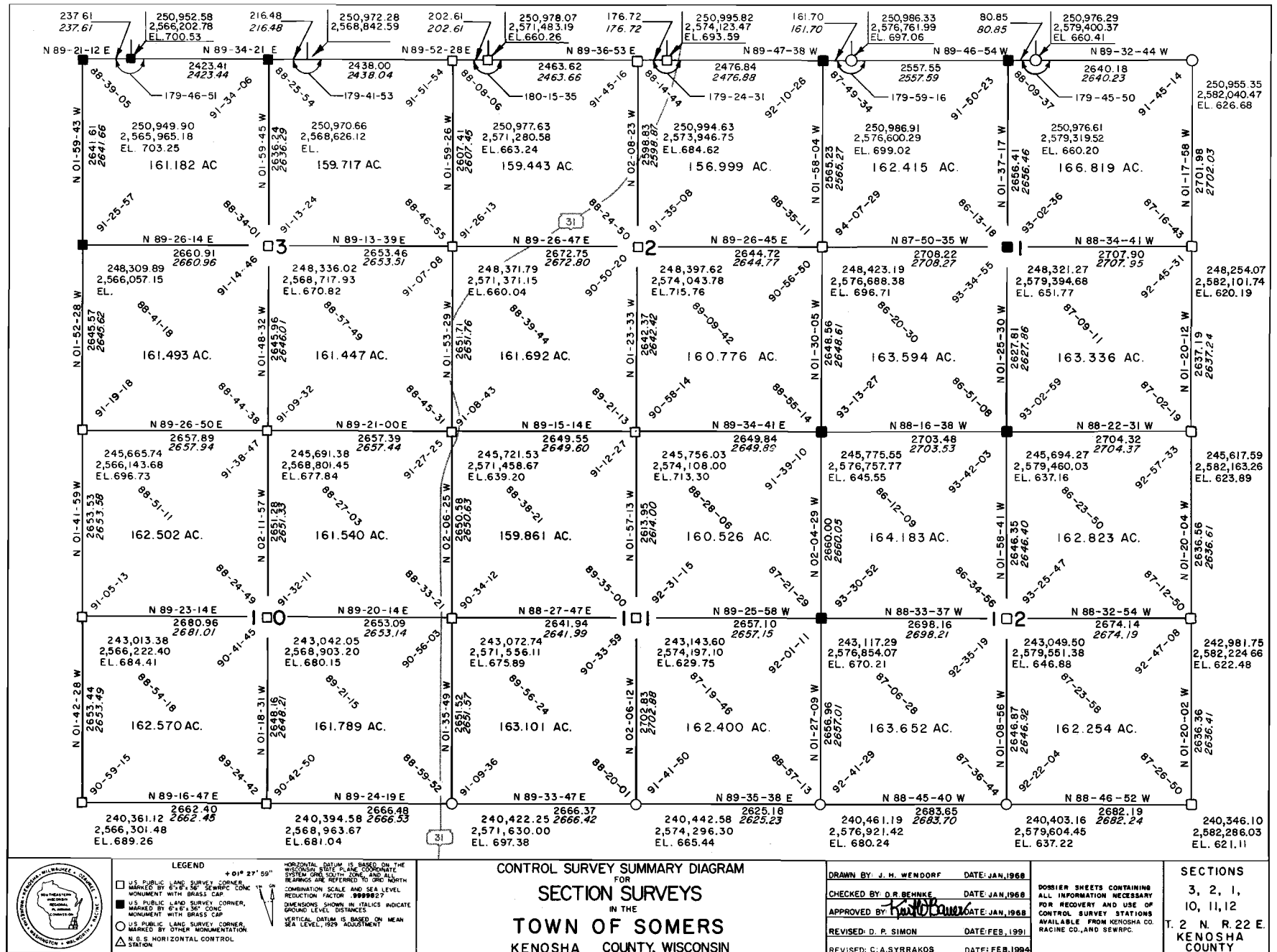


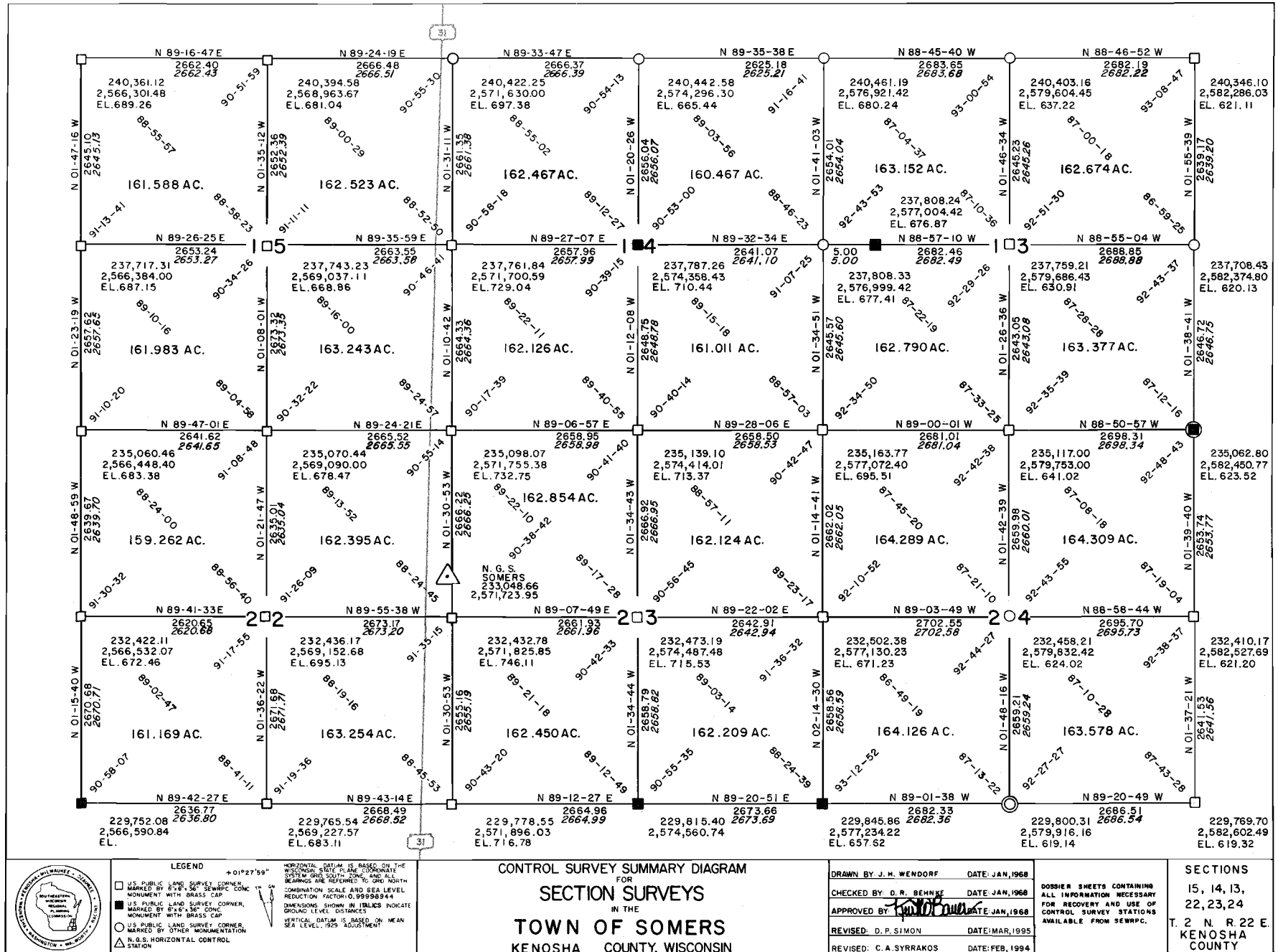


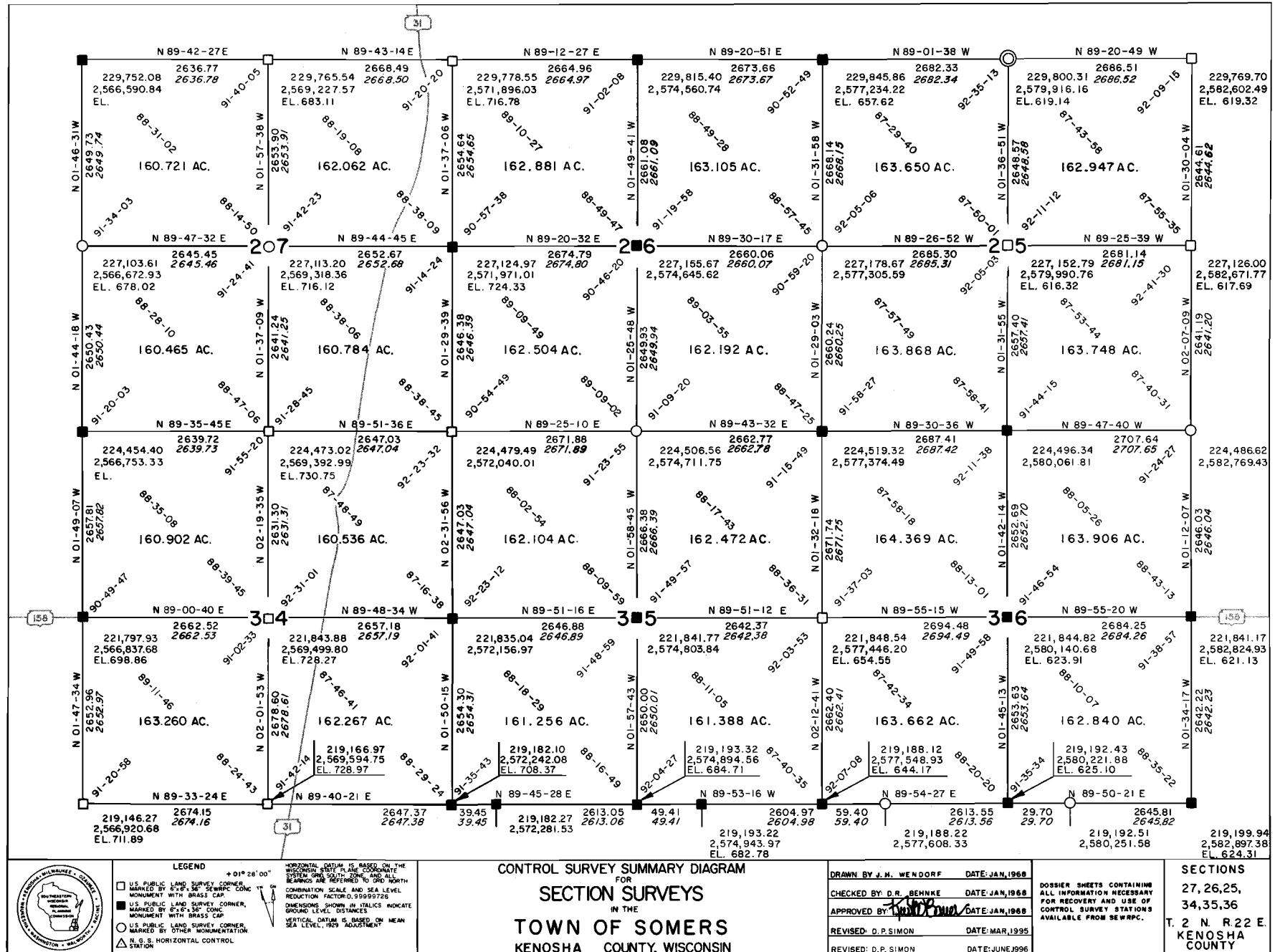


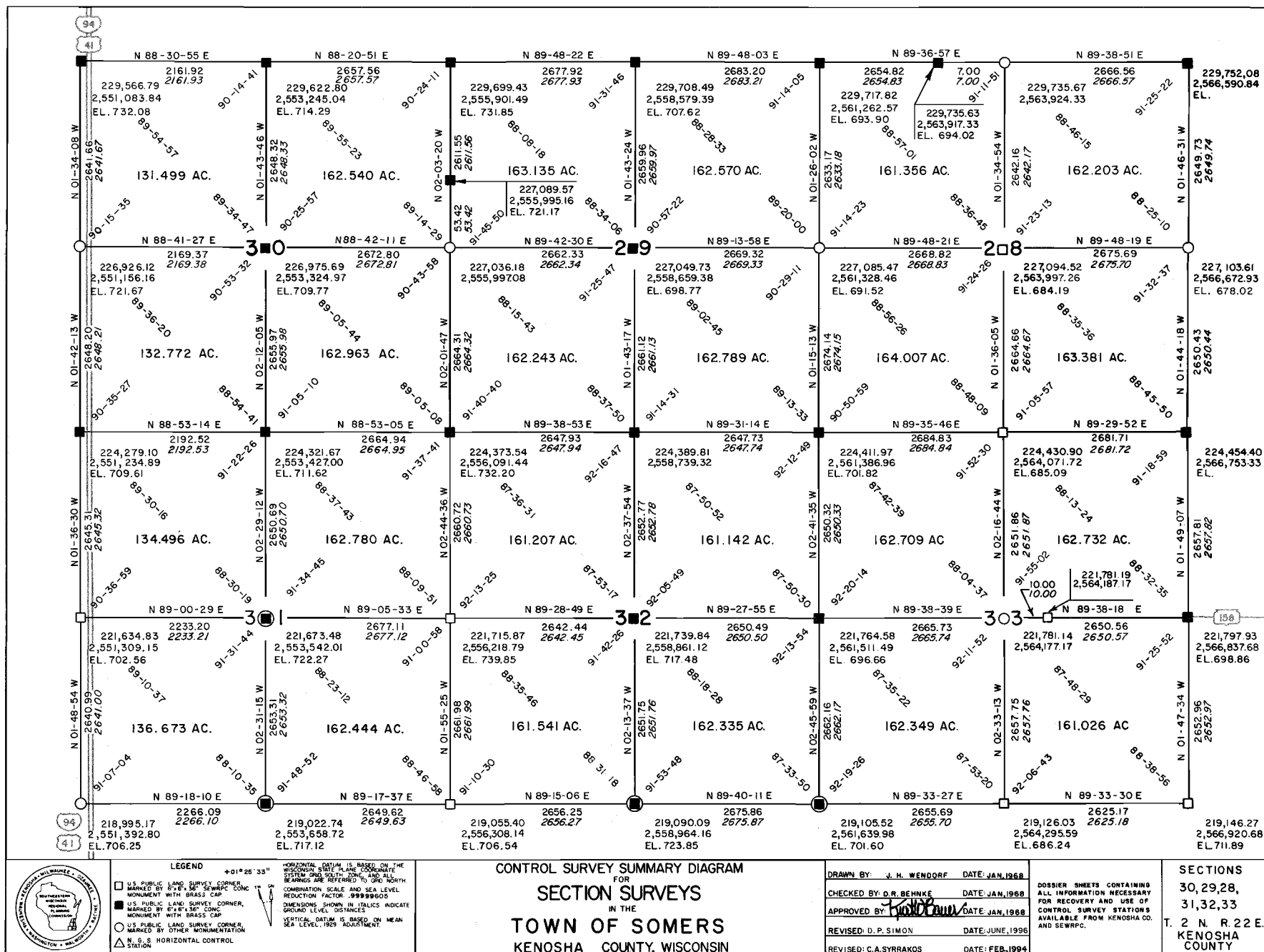


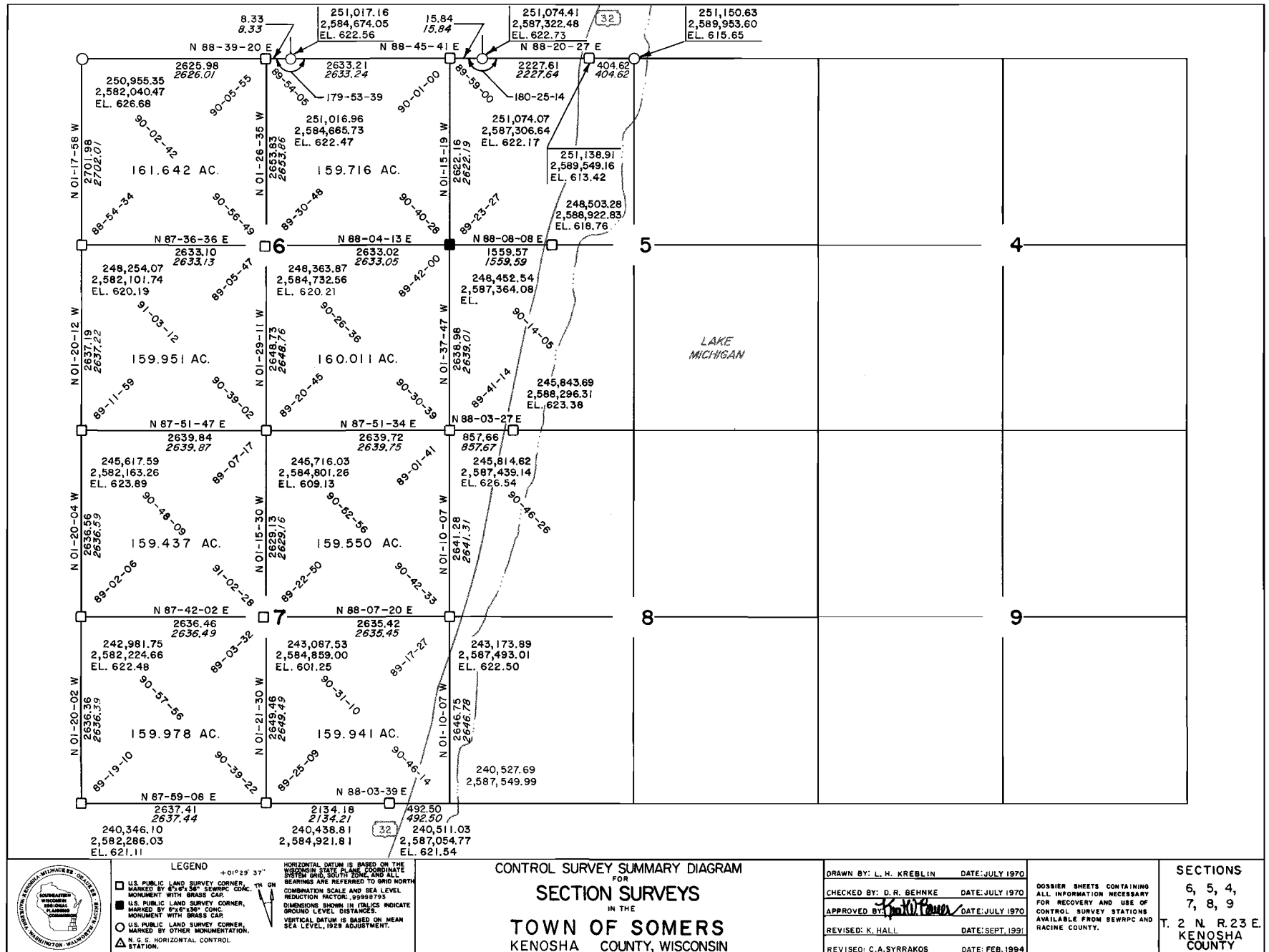












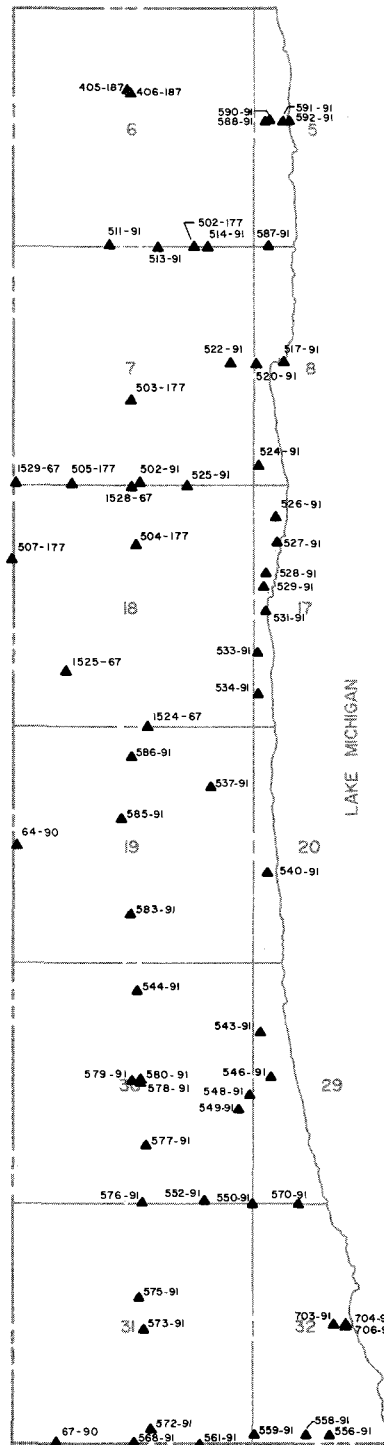
This map displays a grid of numbered locations (1-36) across the Pacific Ocean region, from 10°N to 10°S and 150°E to 150°W. Each location is marked with a triangle and associated alphanumeric codes, likely representing specific data points or coordinates. The map includes latitude and longitude markings along the edges and a scale bar at the bottom.

Key locations and their associated codes include:

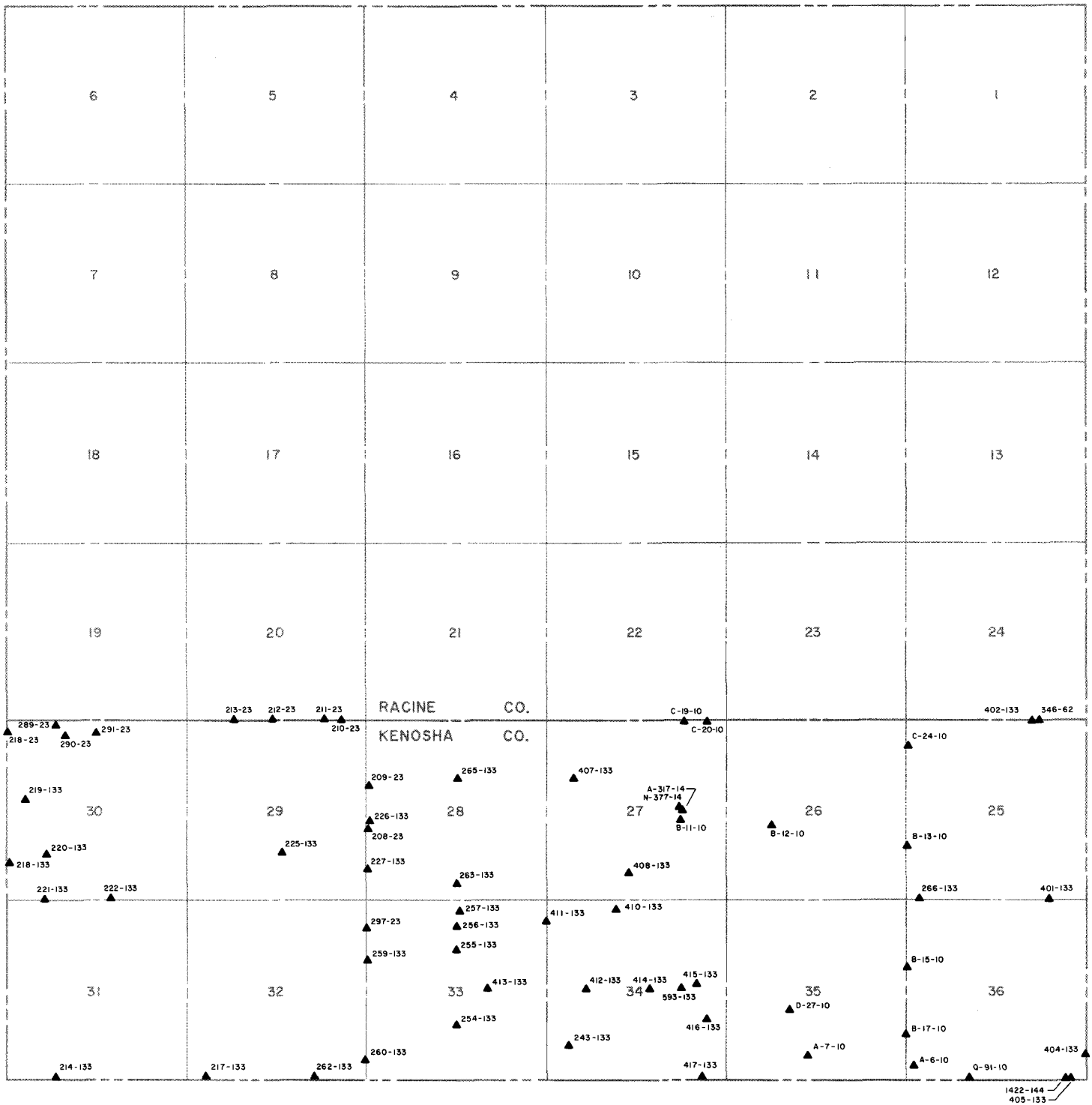
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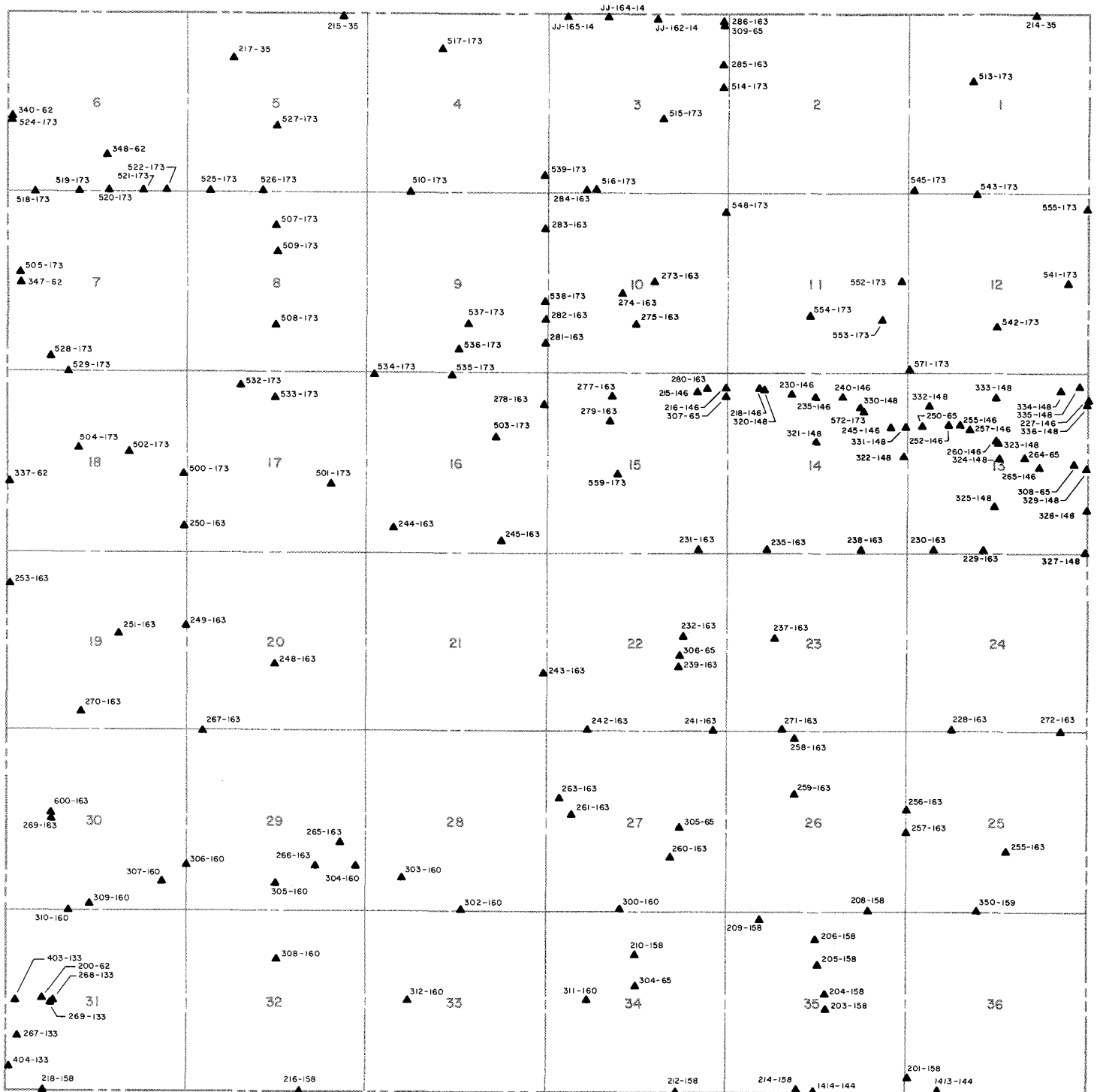
TRAVERSE DIAGRAM, TOWNSHIP 1 NORTH, RANGE 23 EAST
KENOSHA COUNTY



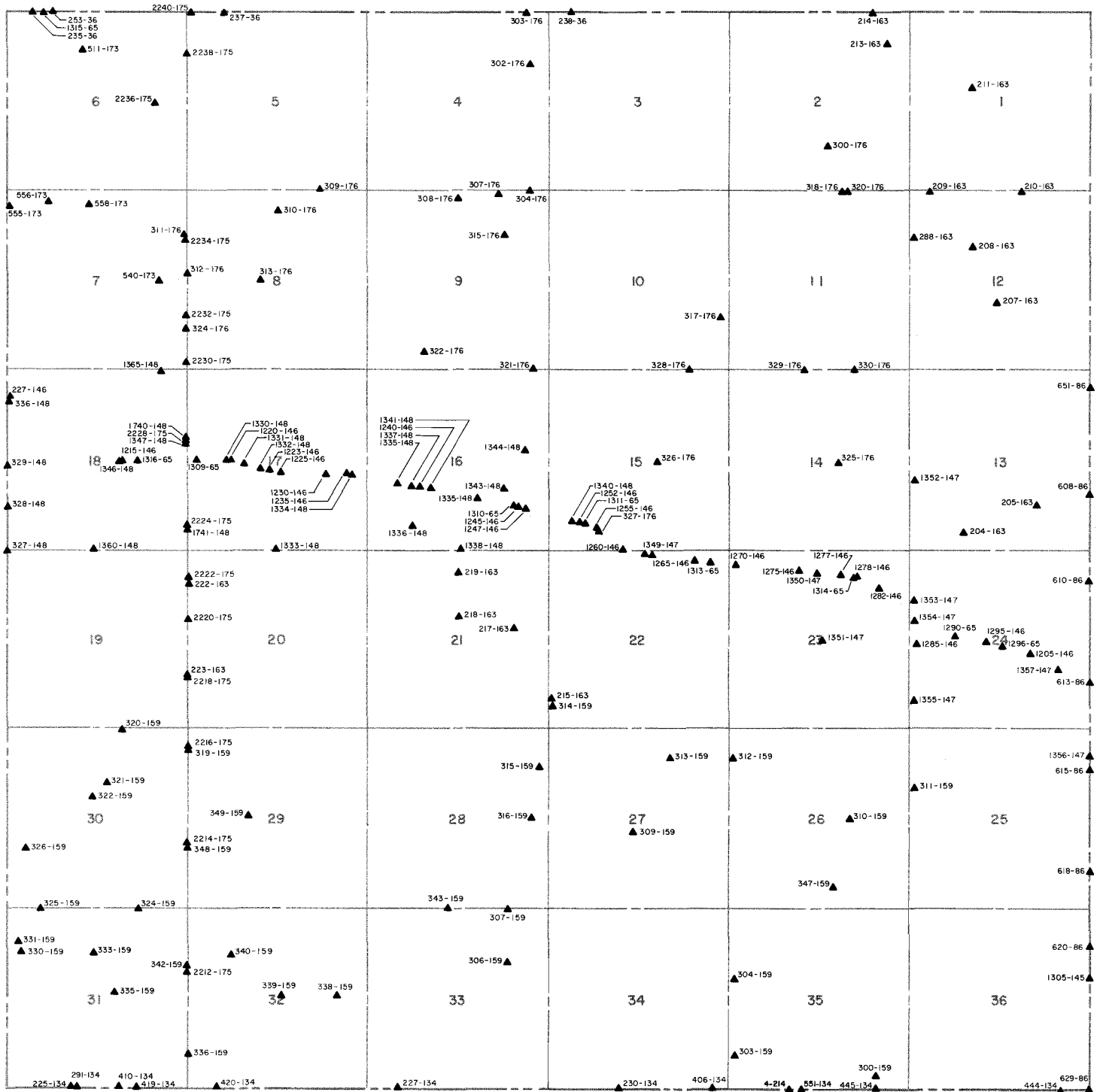
TRAVERSE DIAGRAM, TOWNSHIP 2 NORTH, RANGE 19 EAST KENOSHA COUNTY



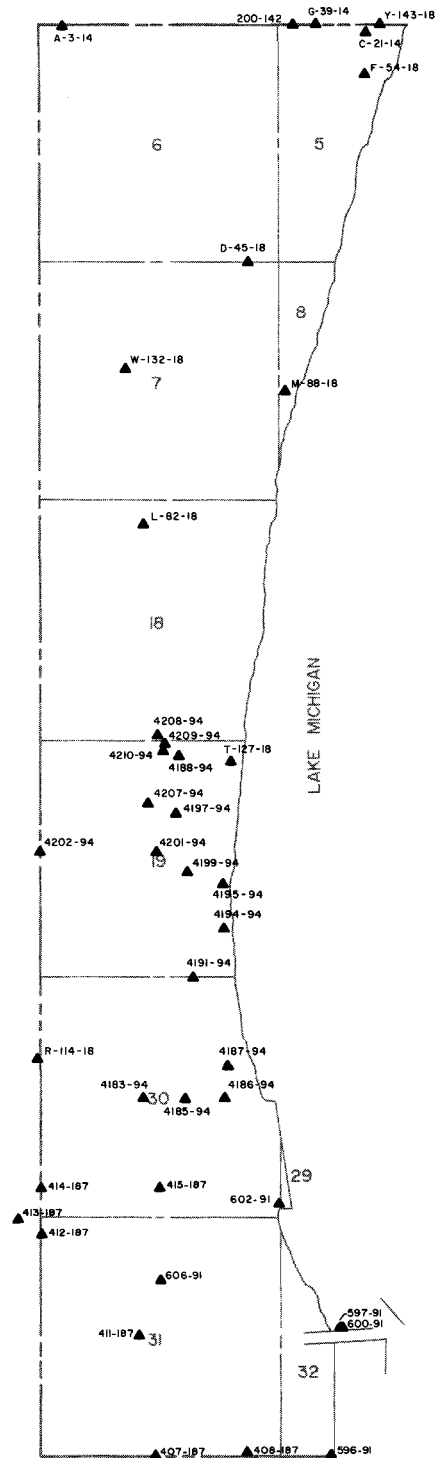
TRAVERSE DIAGRAM, TOWNSHIP 2 NORTH, RANGE 20 EAST KENOSHA COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 2 NORTH, RANGE 21 EAST KENOSHA COUNTY

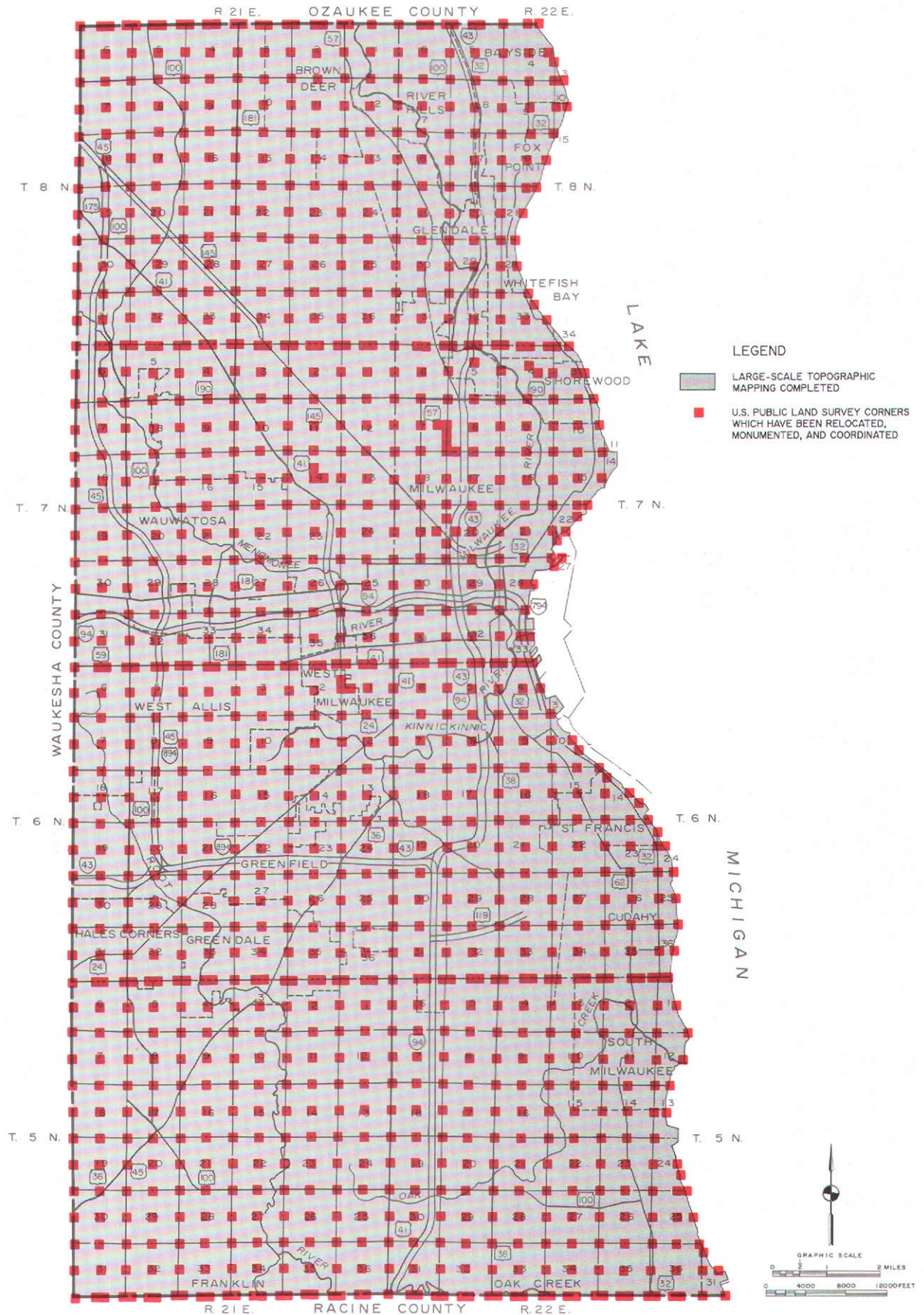


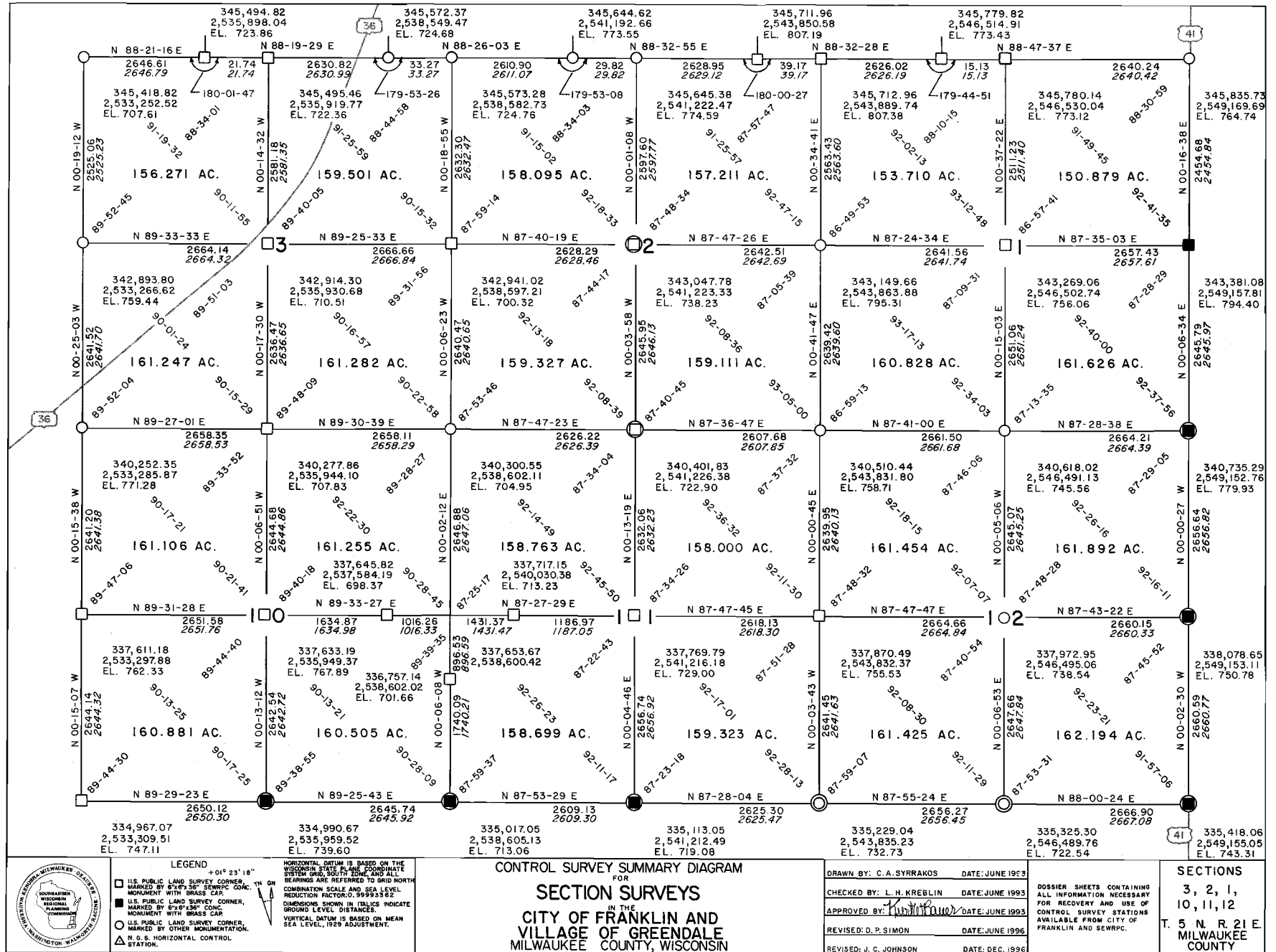
TRAVERSE DIAGRAM, TOWNSHIP 2 NORTH, RANGE 23 EAST KENOSHA COUNTY

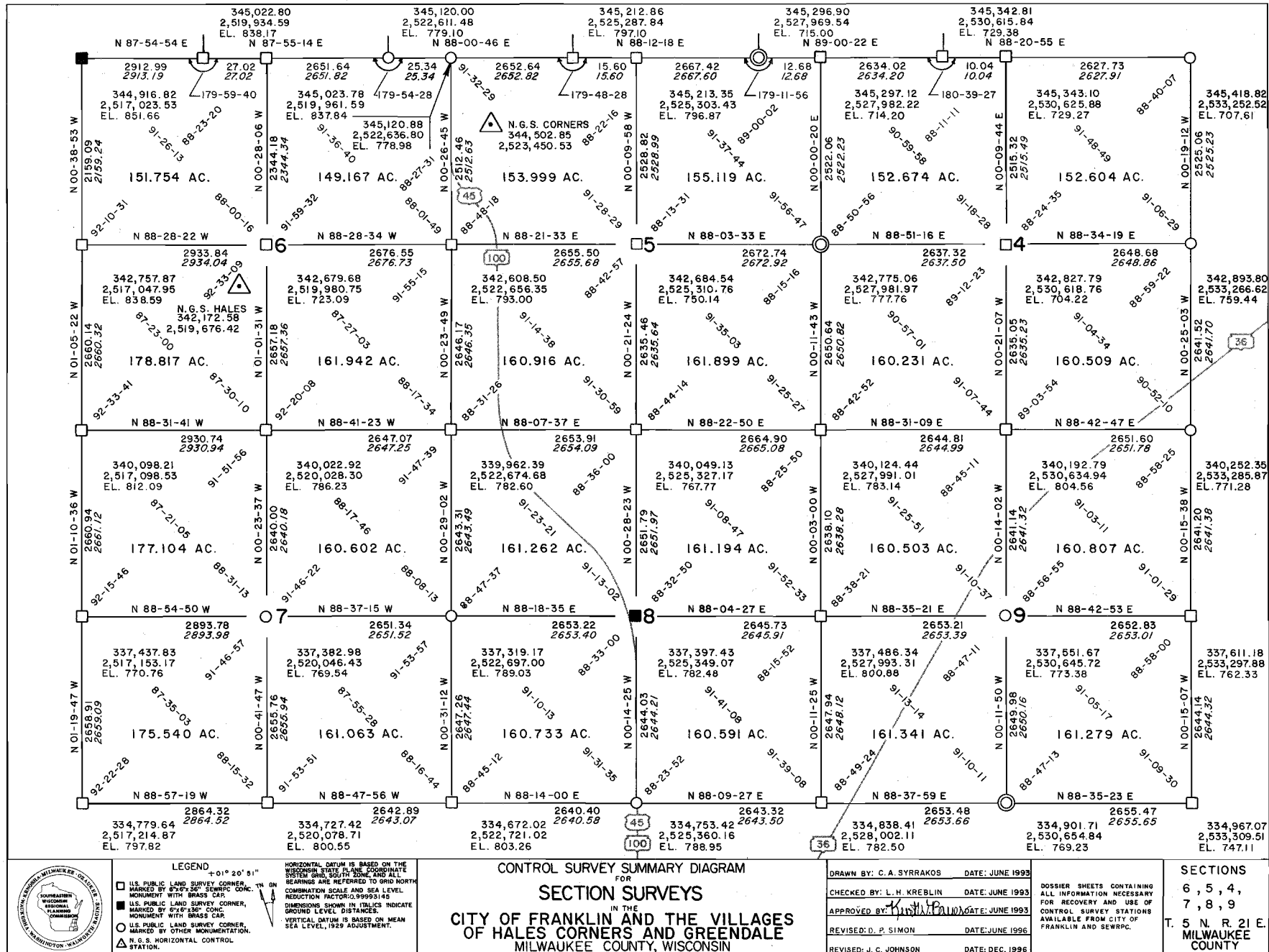


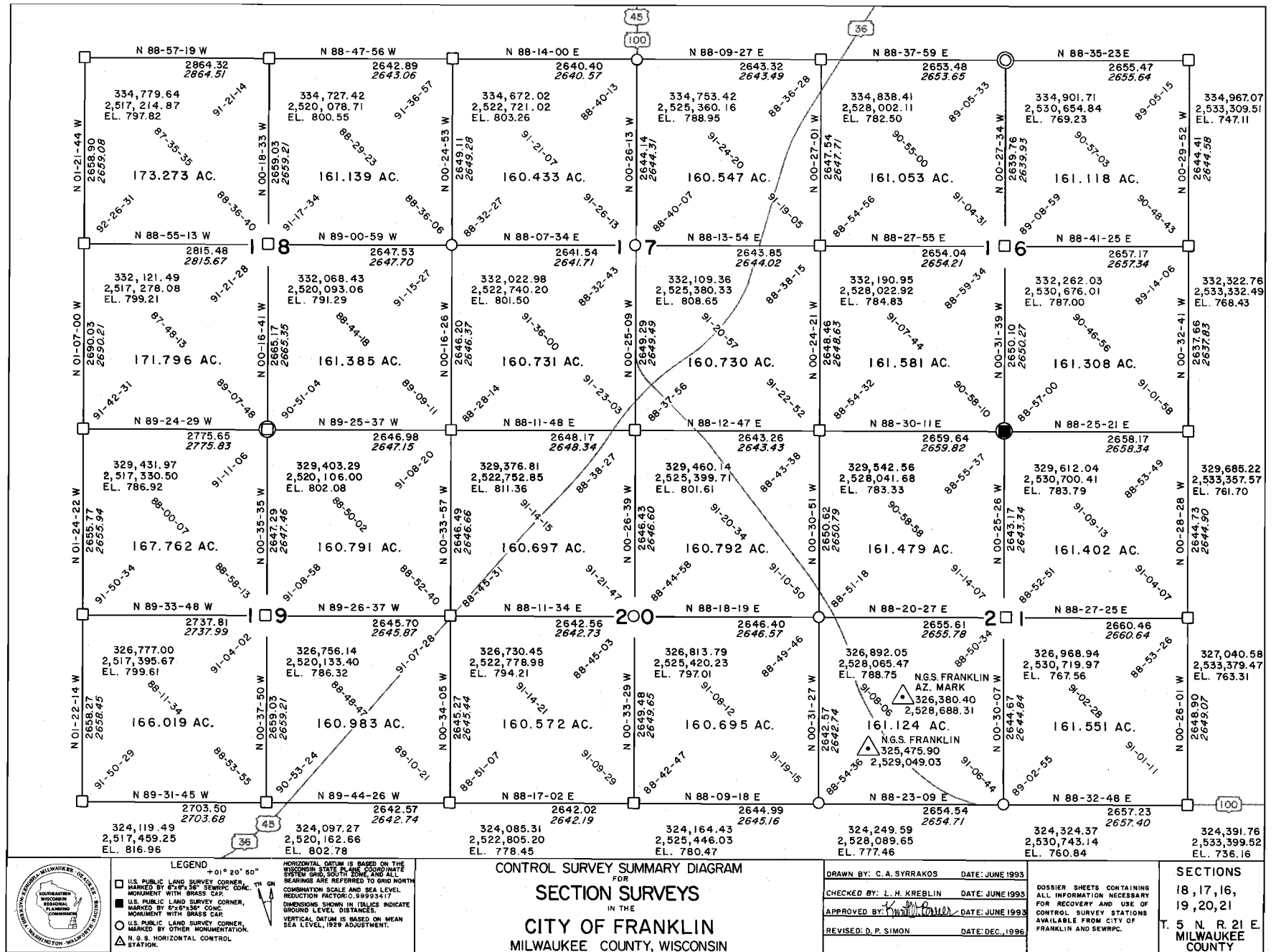
Map C-2

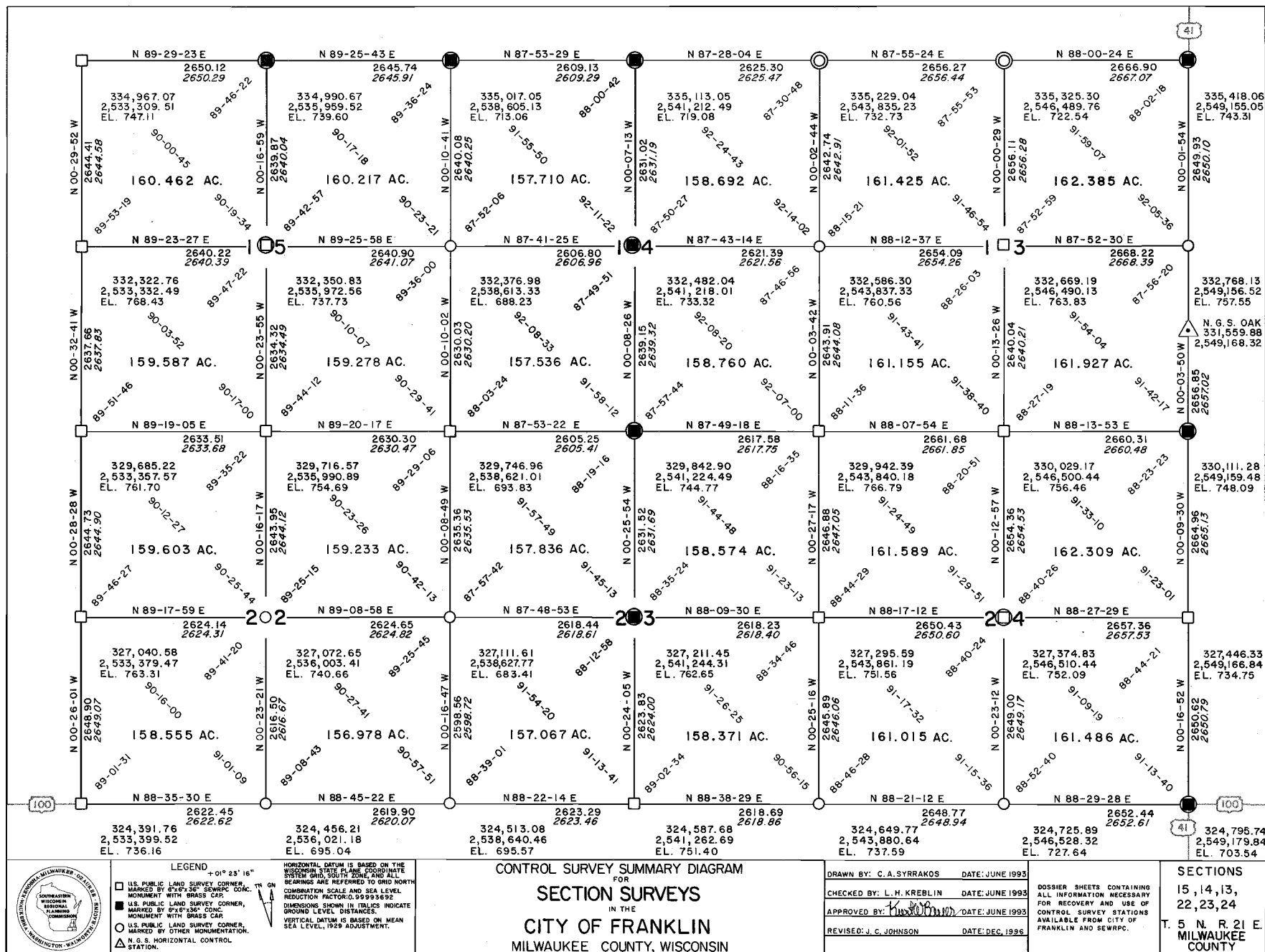
**STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE
RELOCATION, MONUMENTATION, AND COORDINATION OF U. S. PUBLIC
LAND SURVEY CORNERS IN MILWAUKEE COUNTY: SEPTEMBER 1996**

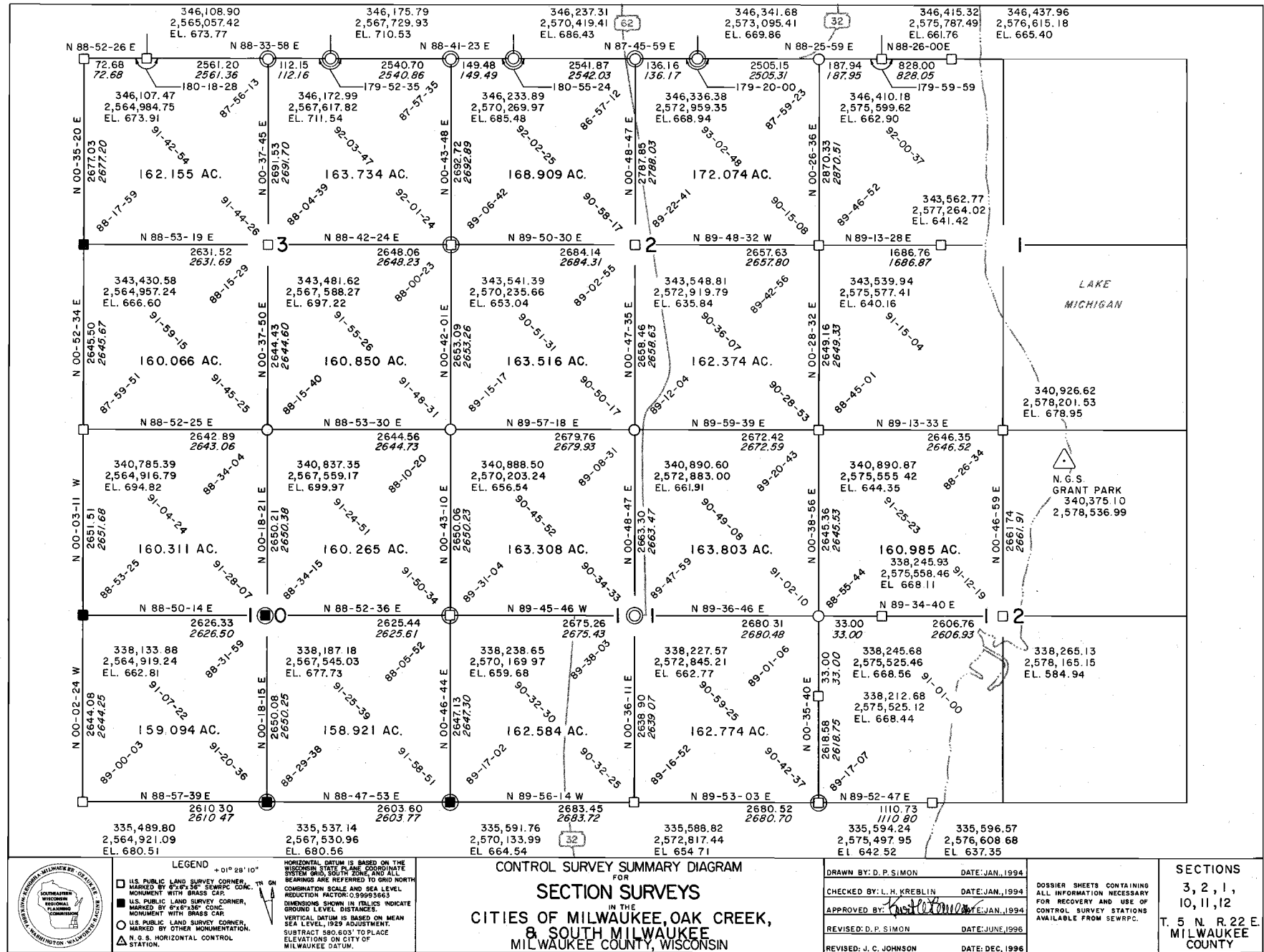


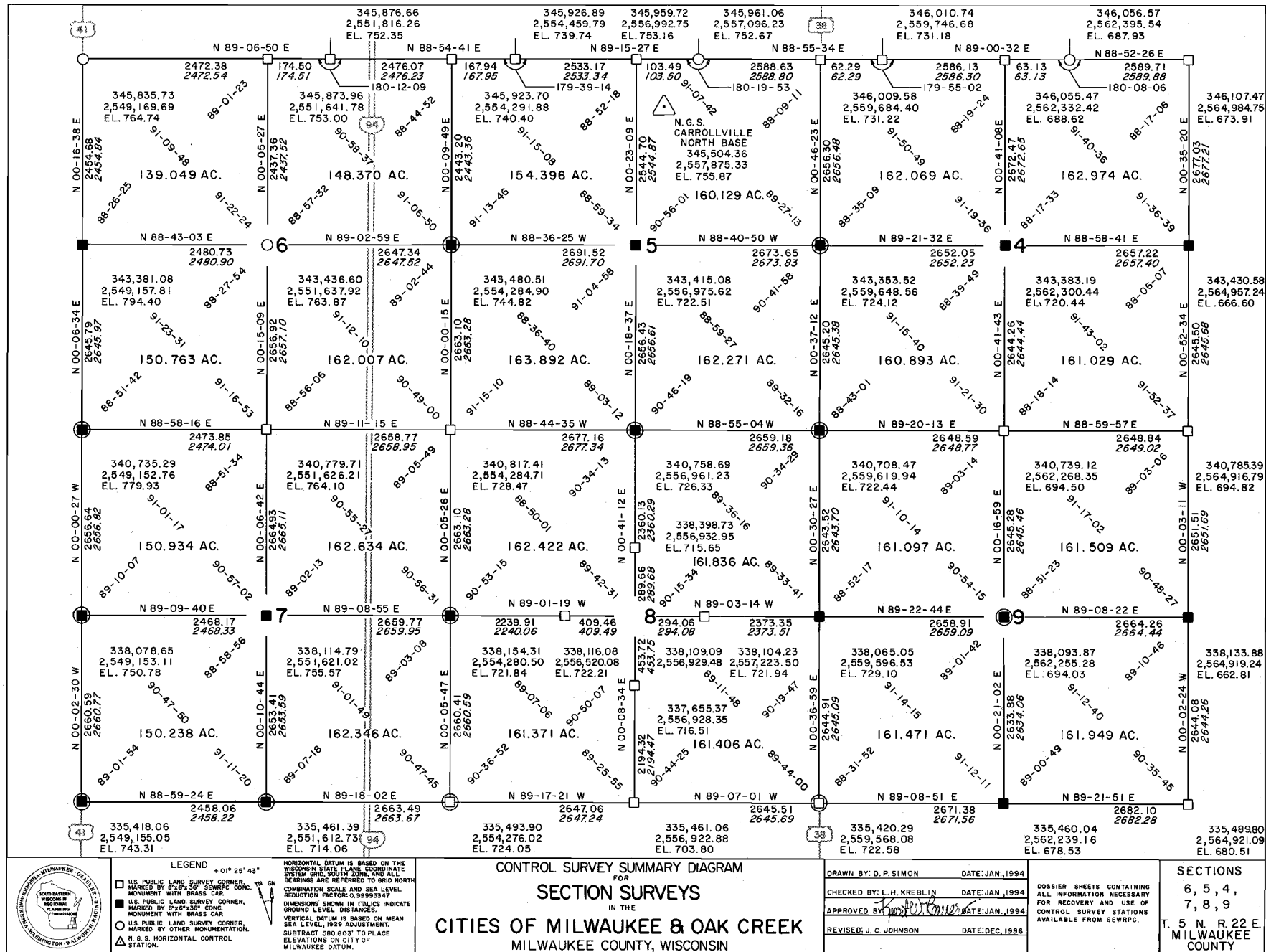


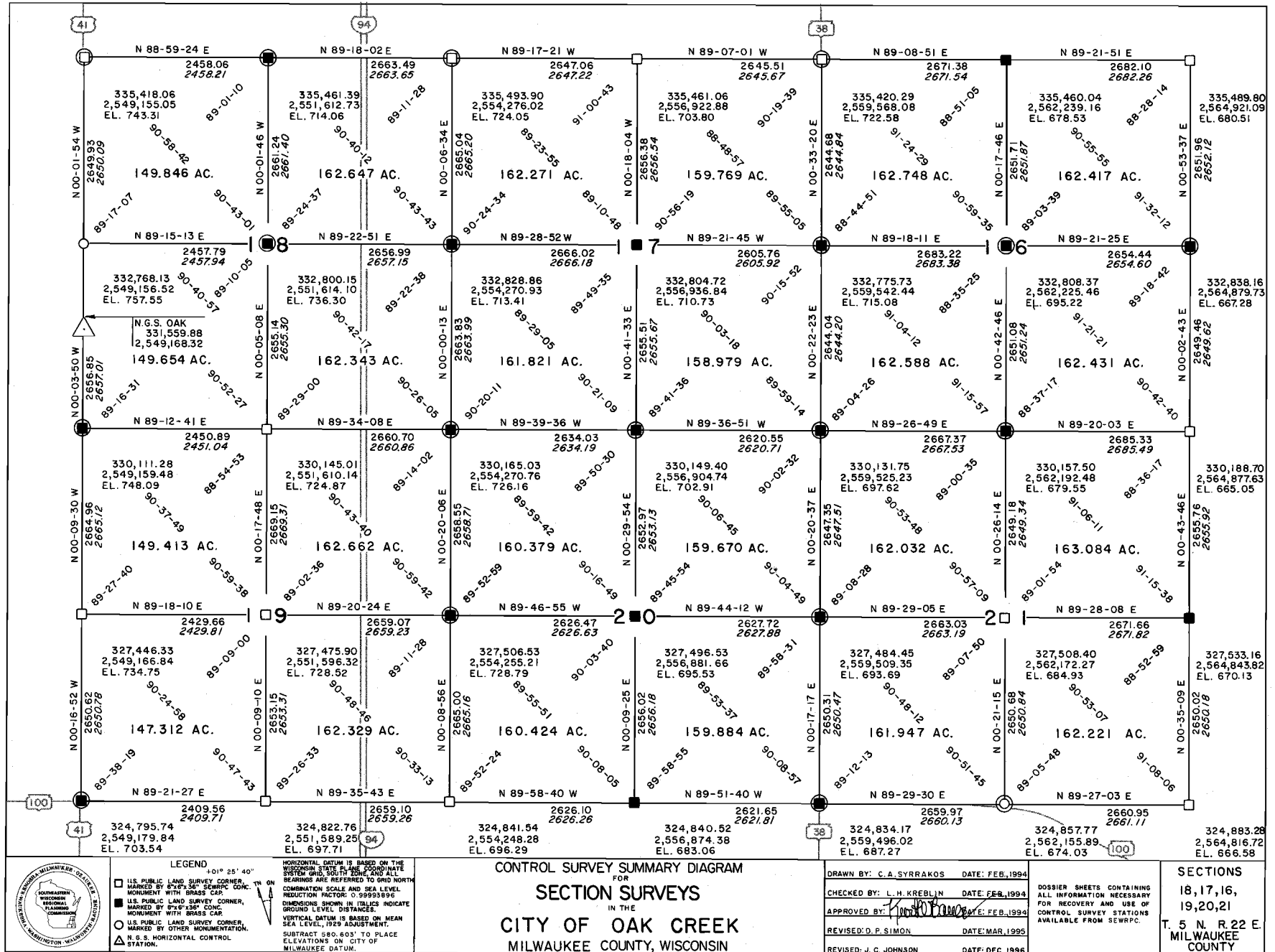


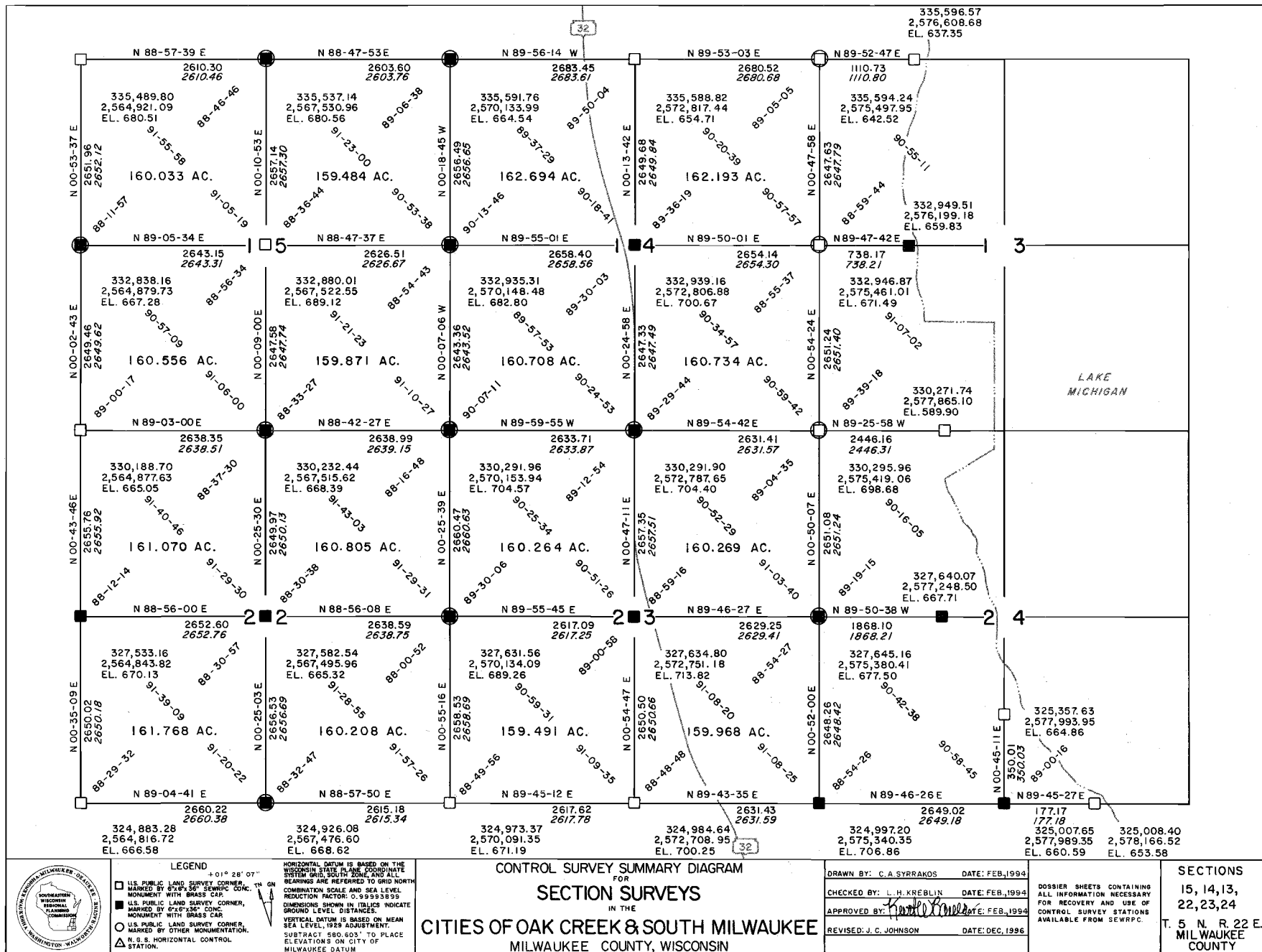


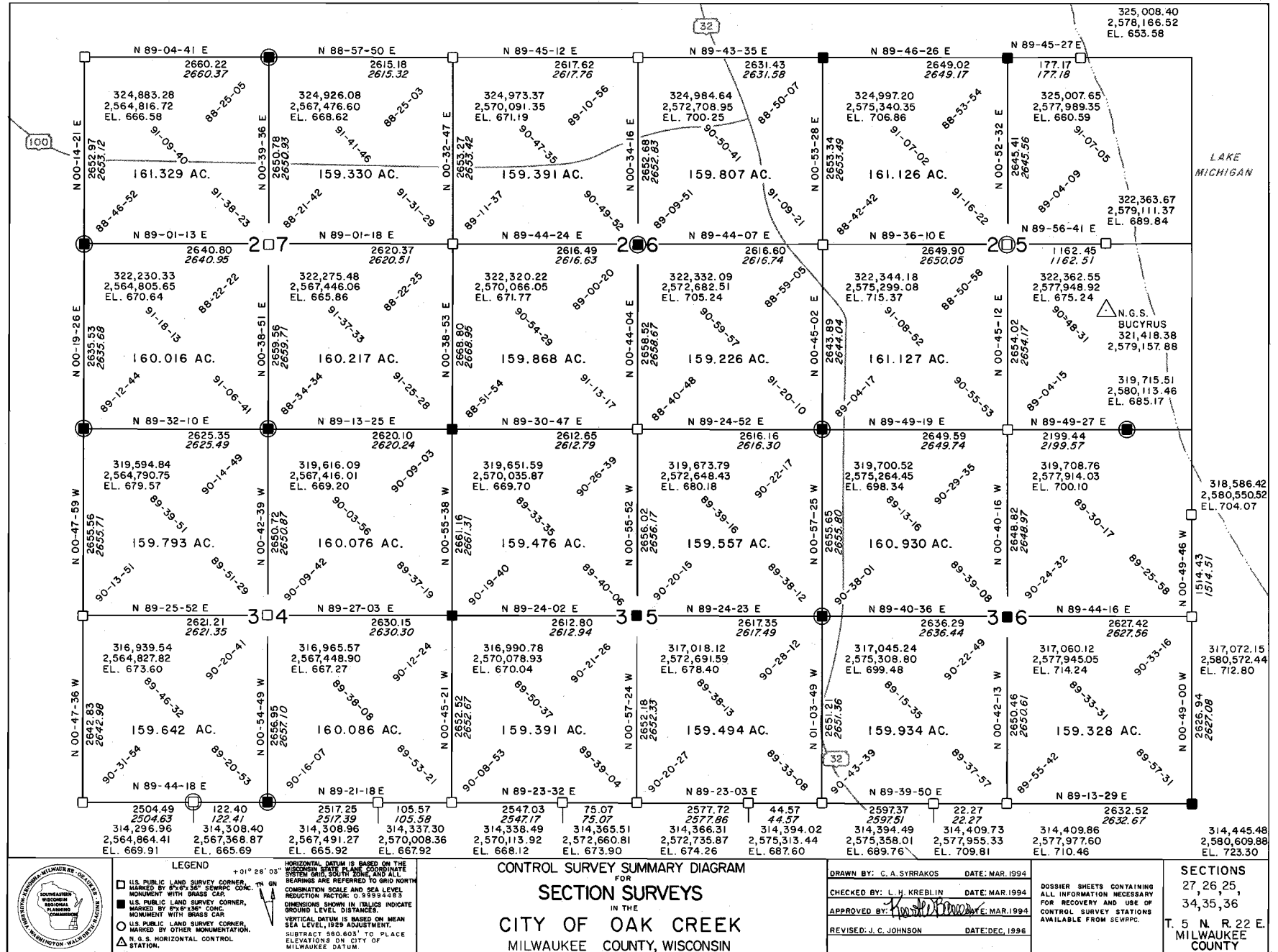


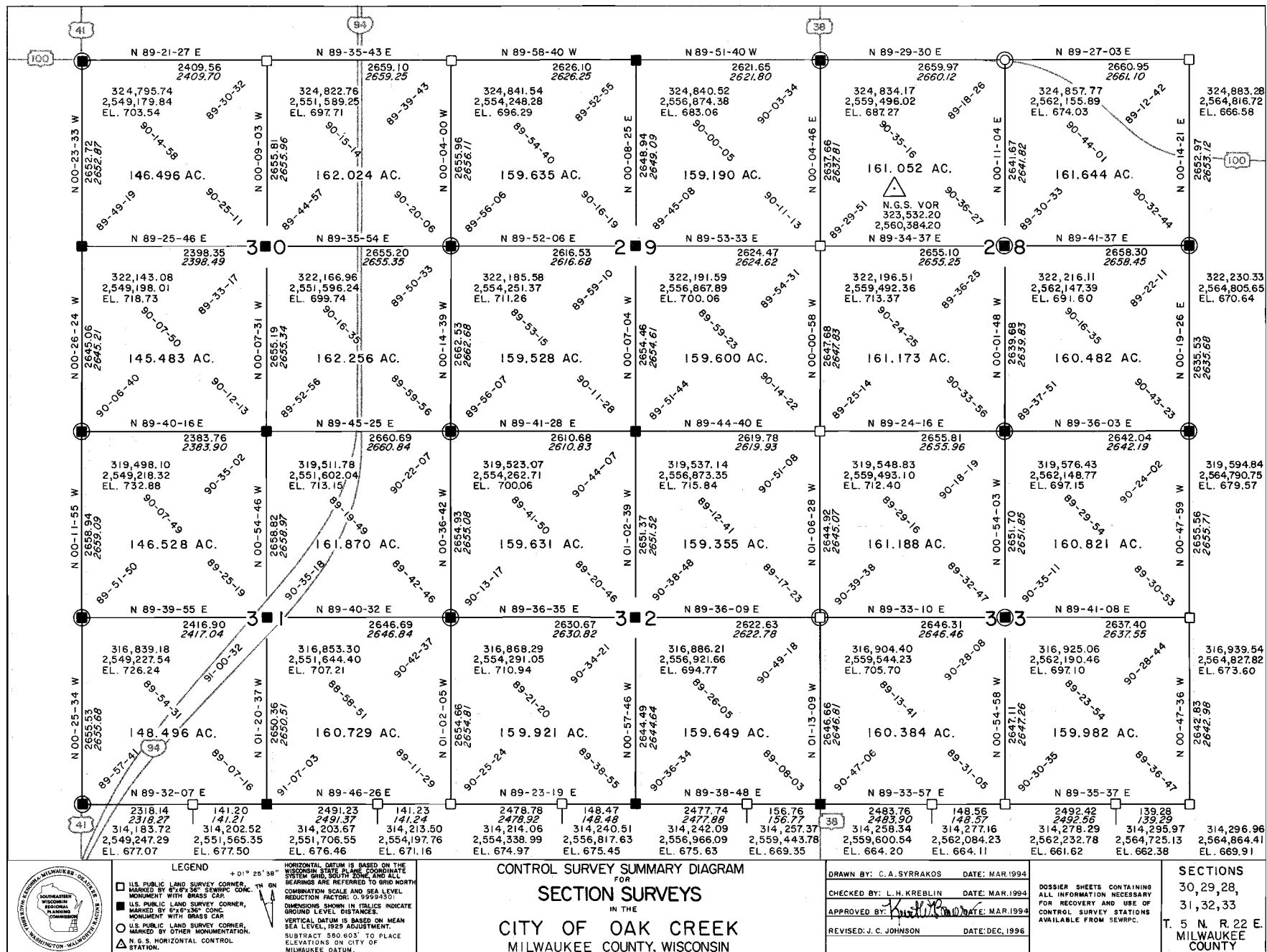


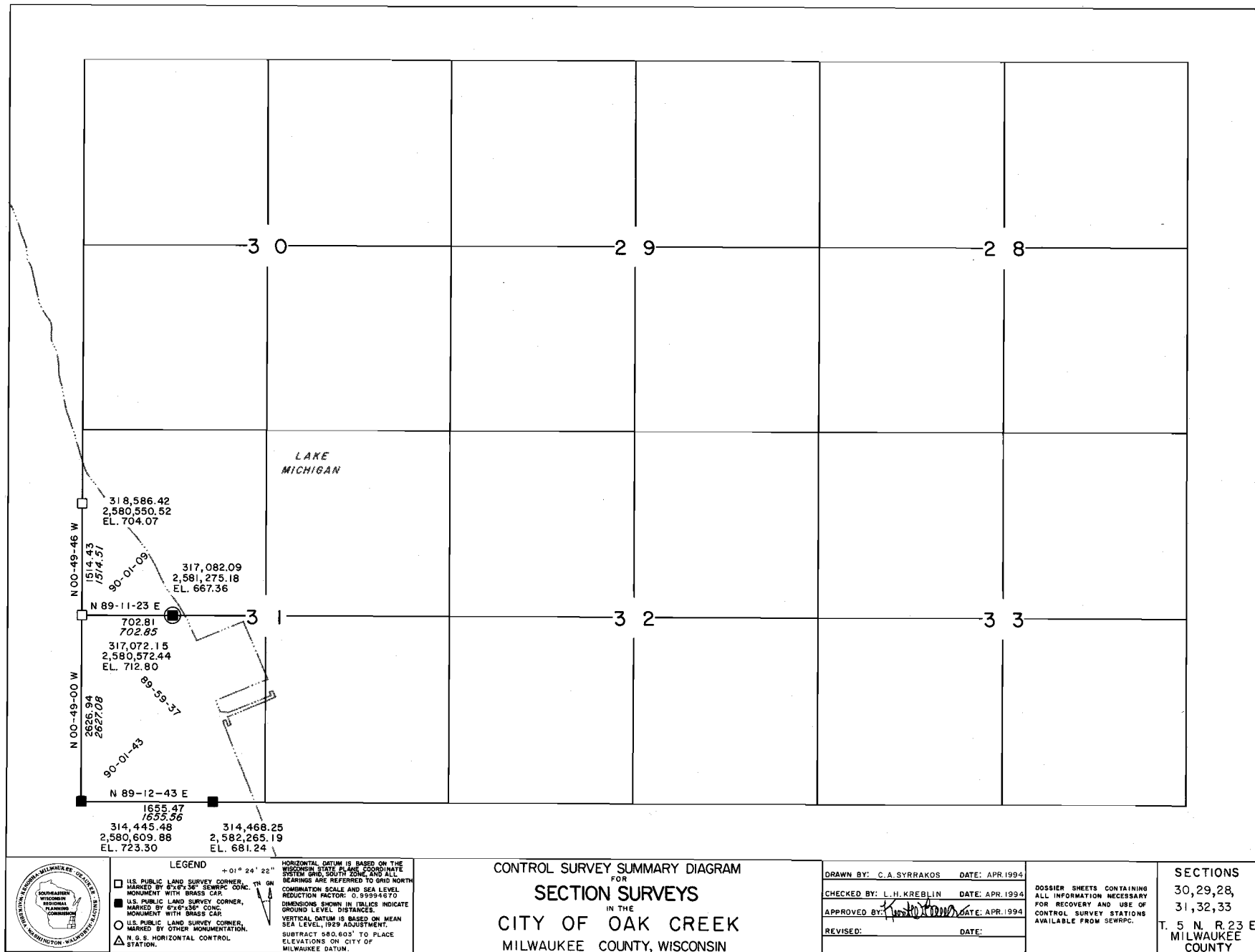


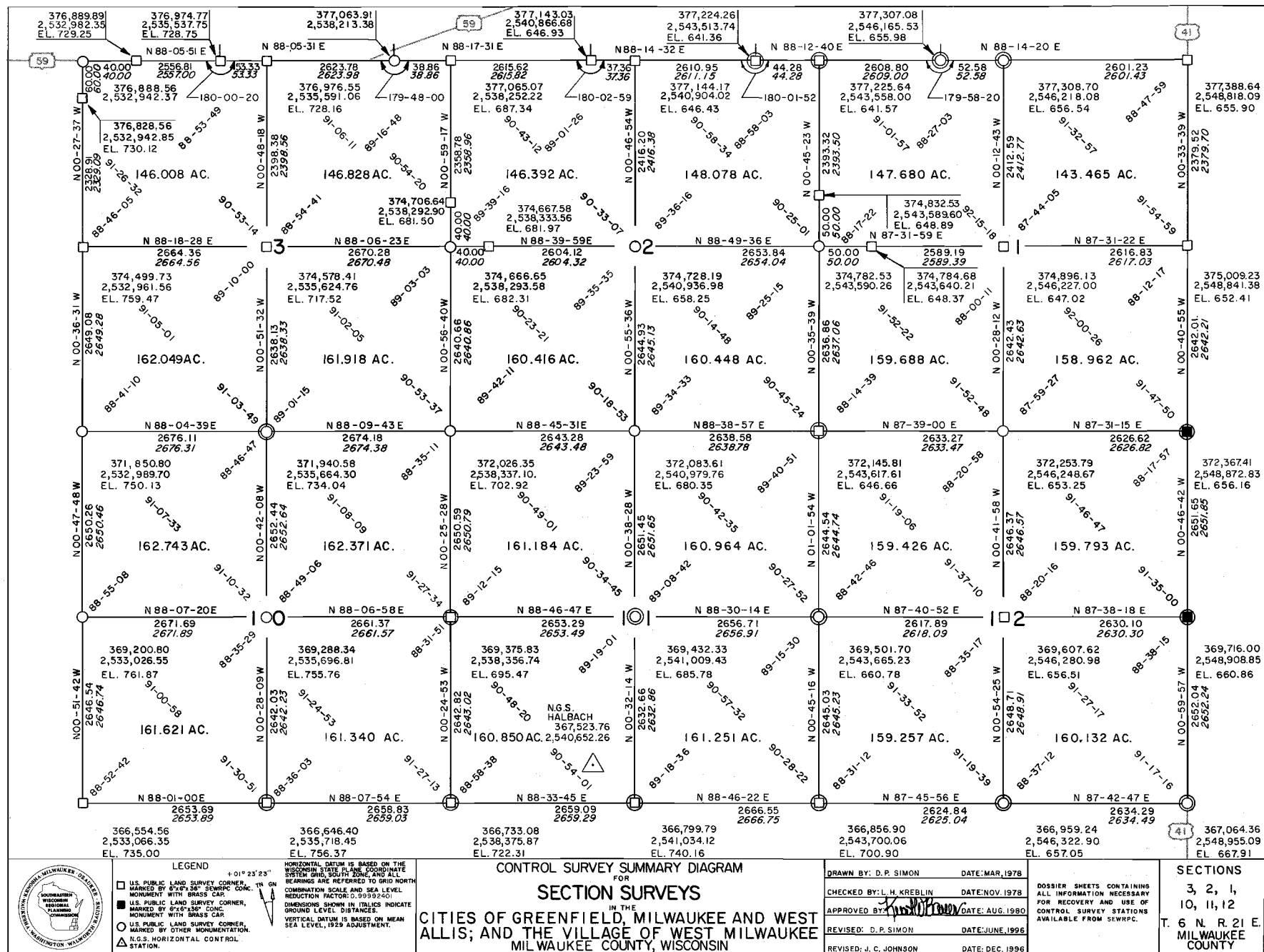


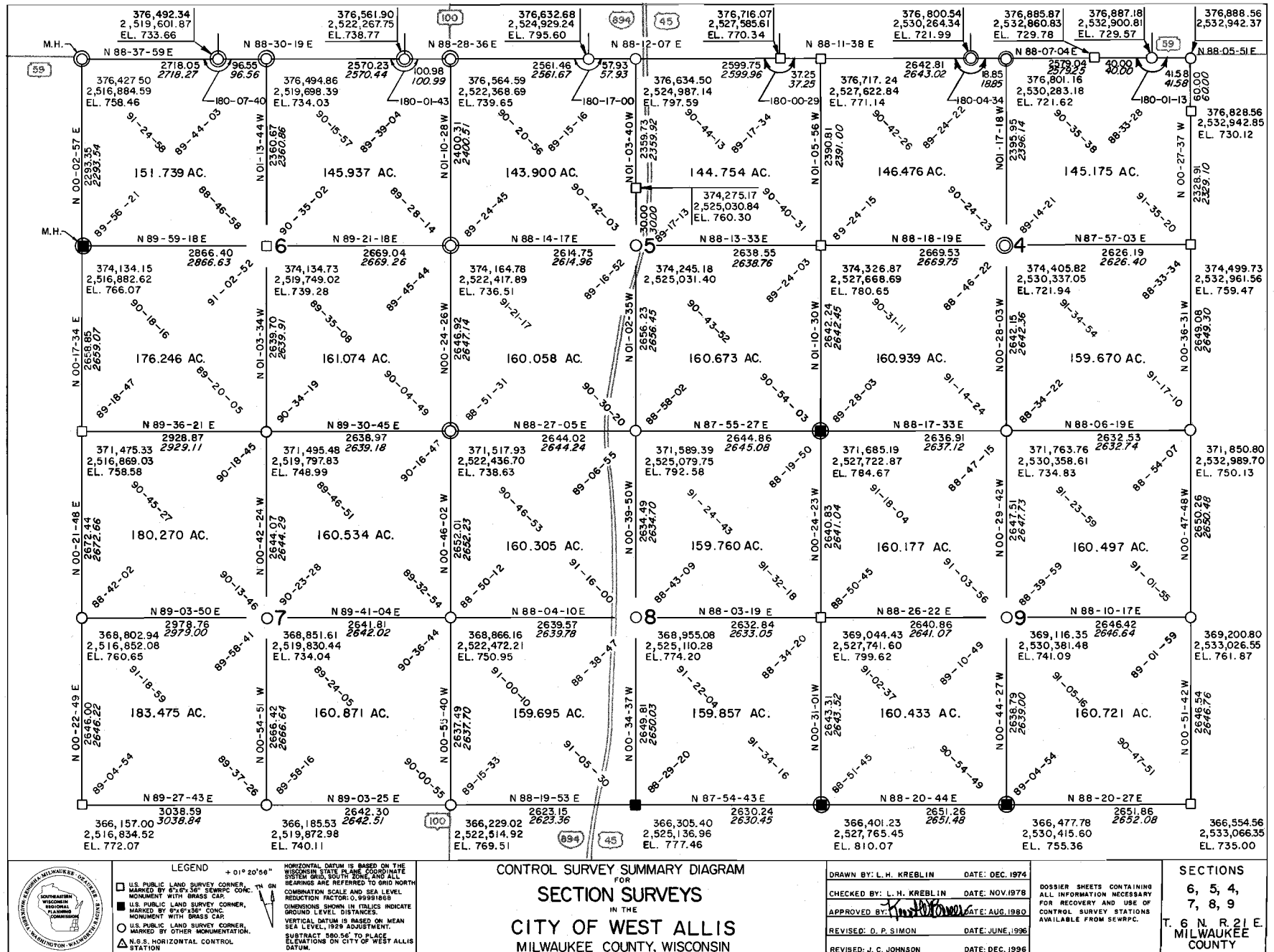


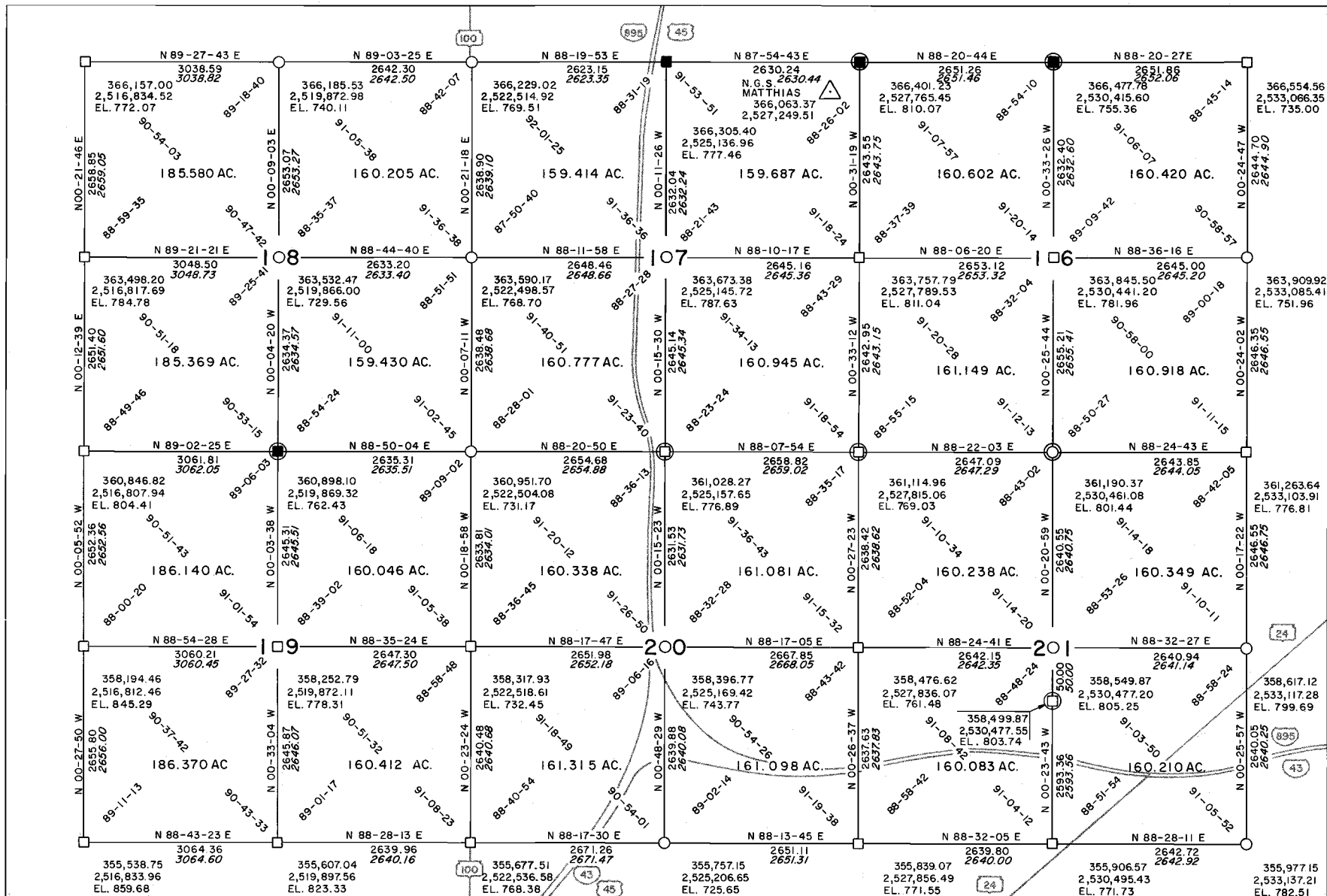












LEGEND

□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 36" SEMI-PC CONC. MONUMENT WITH BRASS CAP.

■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 36" CONC. MONUMENT WITH BRASS CAP.

○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.

△ STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99982306.

DIVISIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM

SECTION SURVEYS

IN THE

CITIES OF GREENFIELD, MILWAUKEE, AND WEST ALLIS

MILWAUKEE COUNTY, WISCONSIN

DRAWN BY: L. H. KREBLIN	DATE: DEC. 1974
CHECKED BY: L. H. KREBLIN	DATE: JAN. 1975
APPROVED BY: <i>[Signature]</i>	DATE: AUG. 1980
REVISED: D. P. SIMON	DATE: APR. 1995
REVISED: D. P. SIMON	DATE: JUNE, 1996

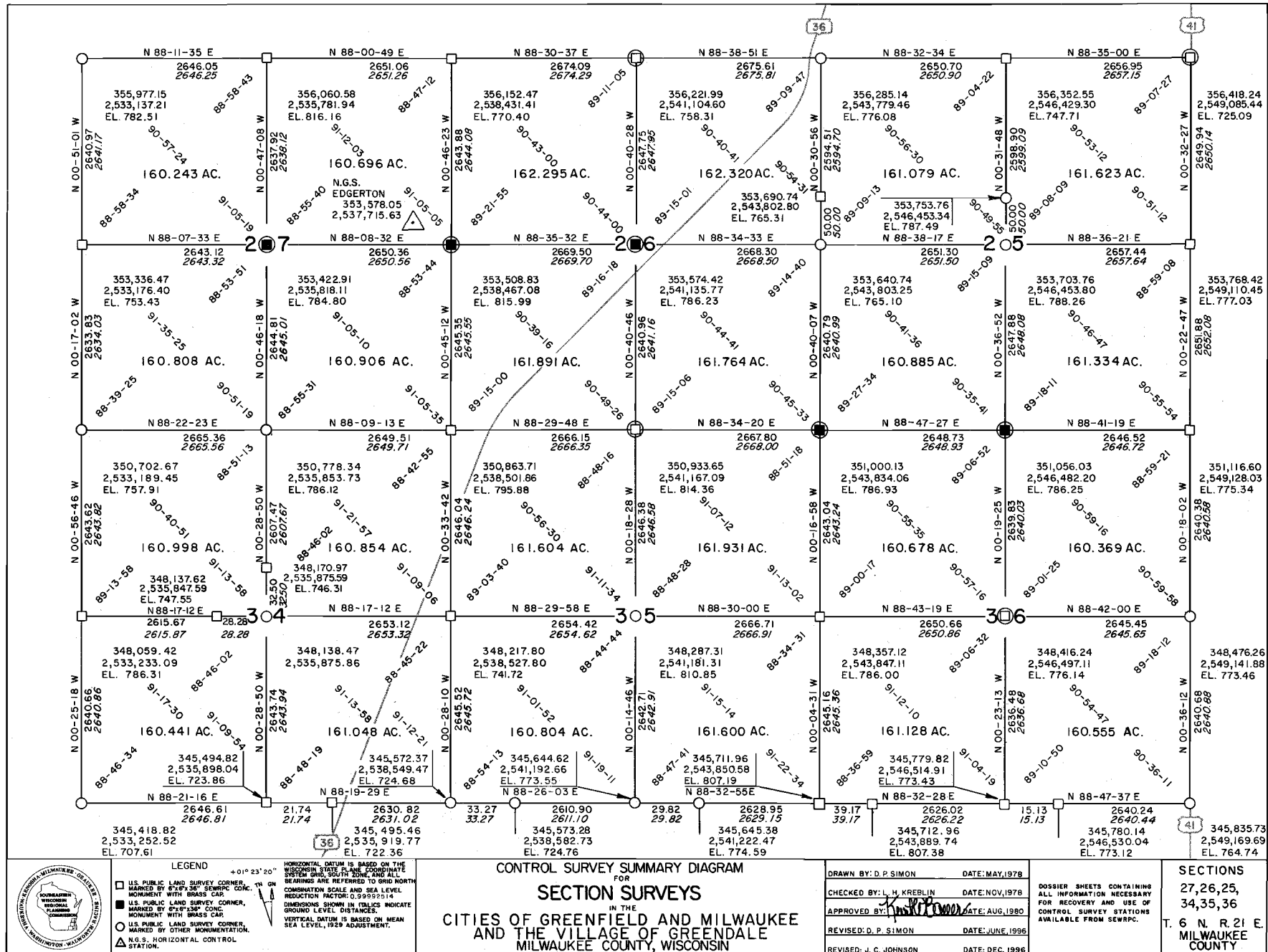
SECTIONS

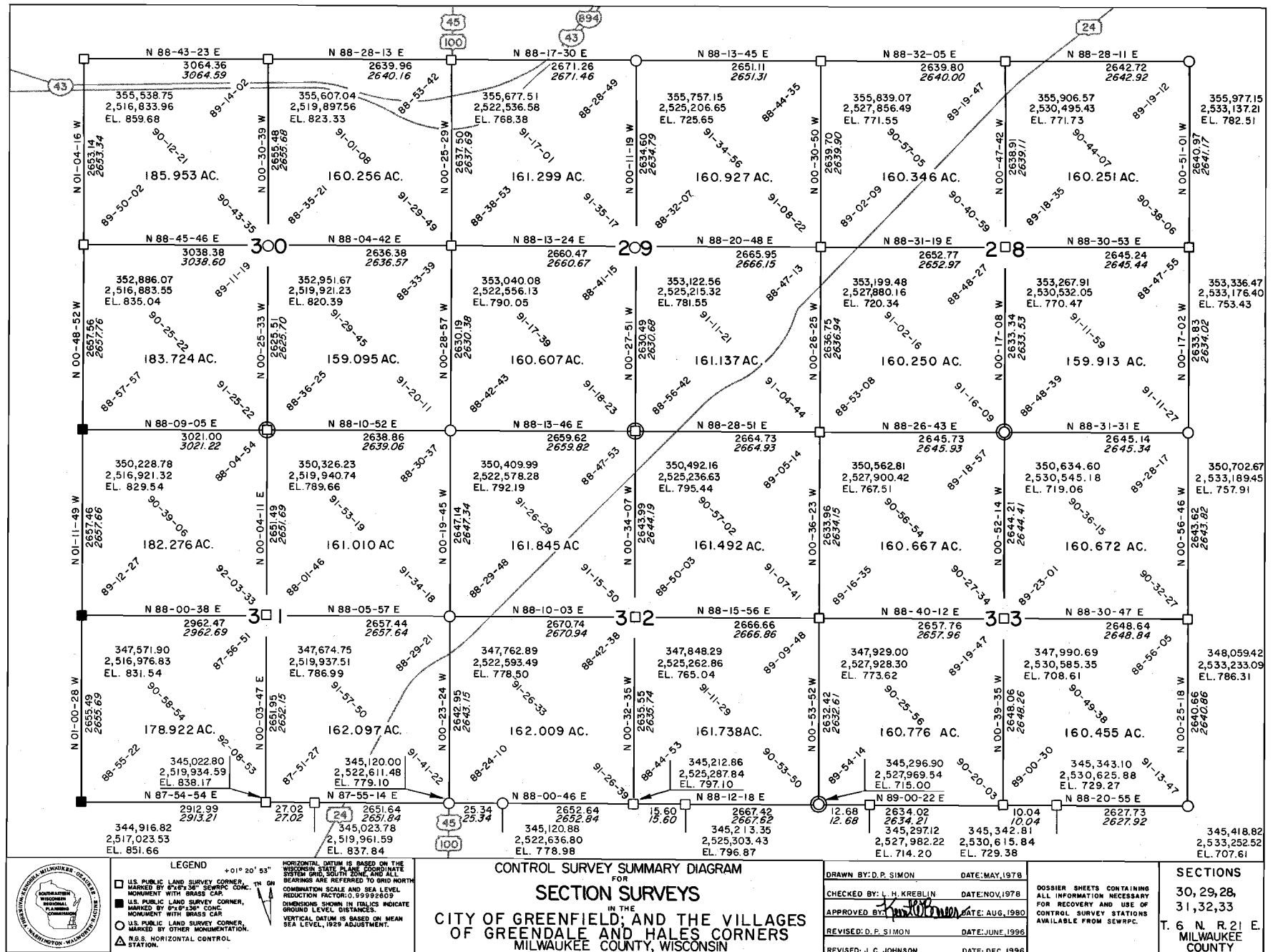
18, 17, 16,
19, 20, 21

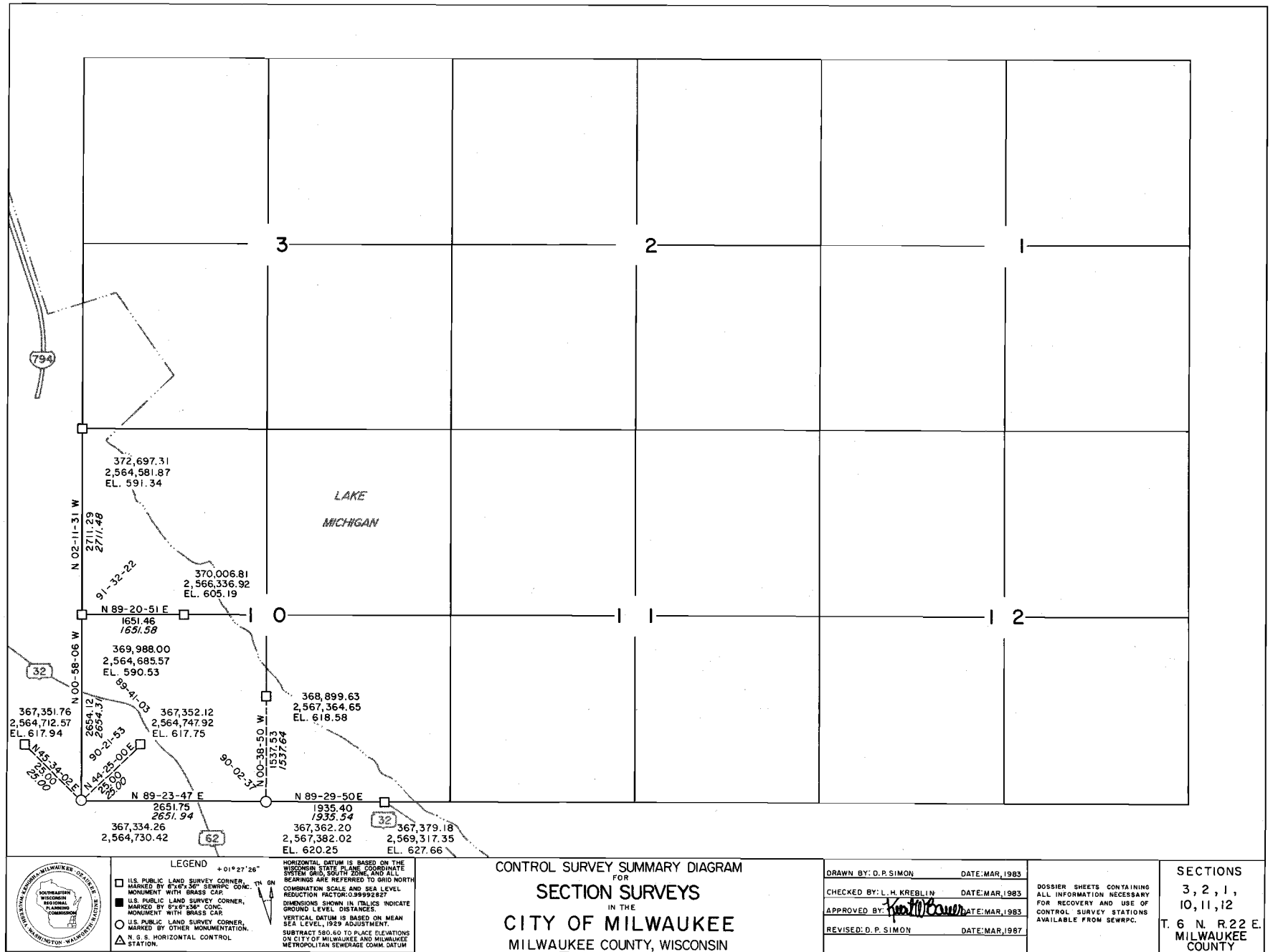
T. 6 N. R. 21 E.

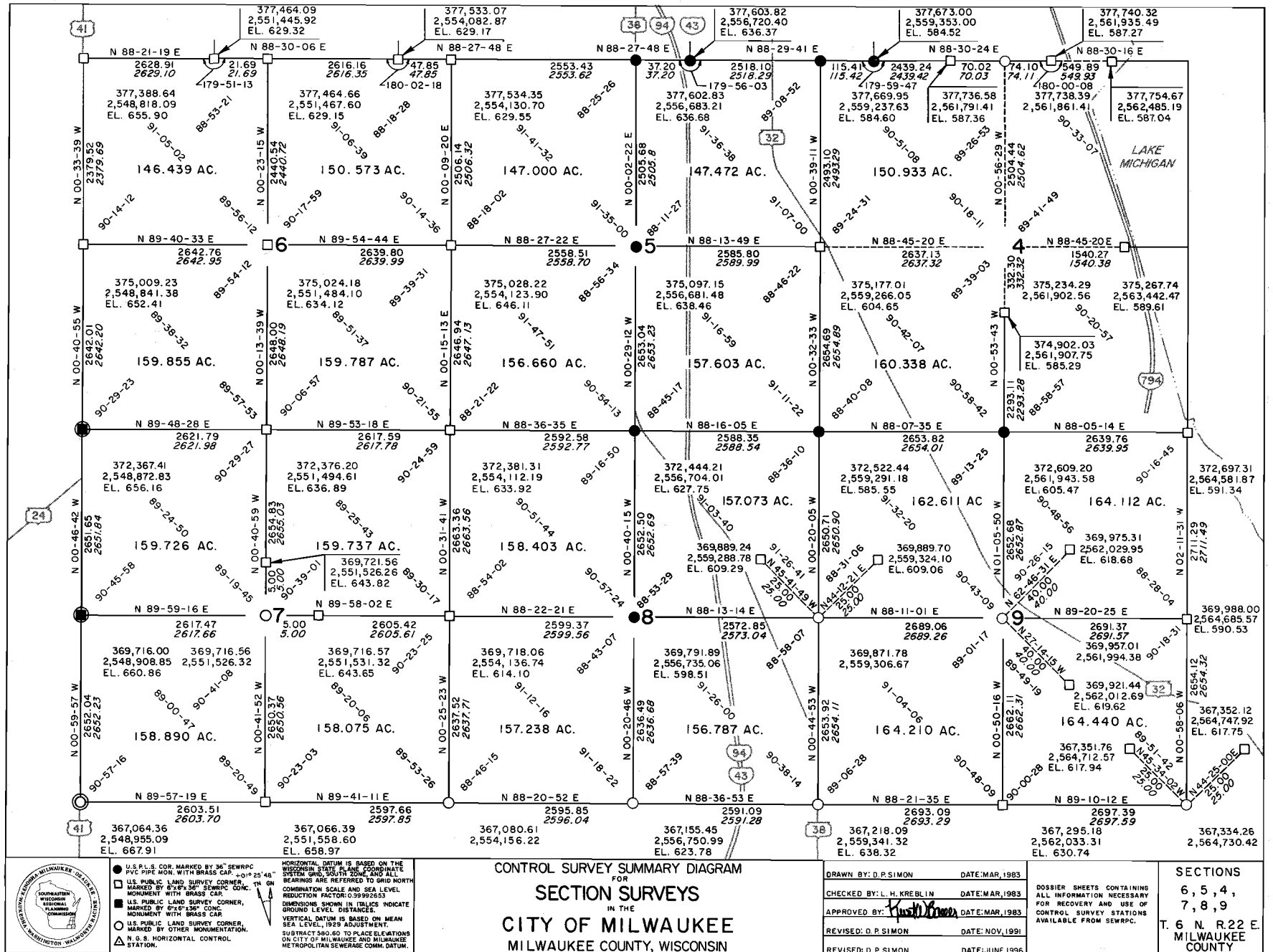
MILWAUKEE COUNTY

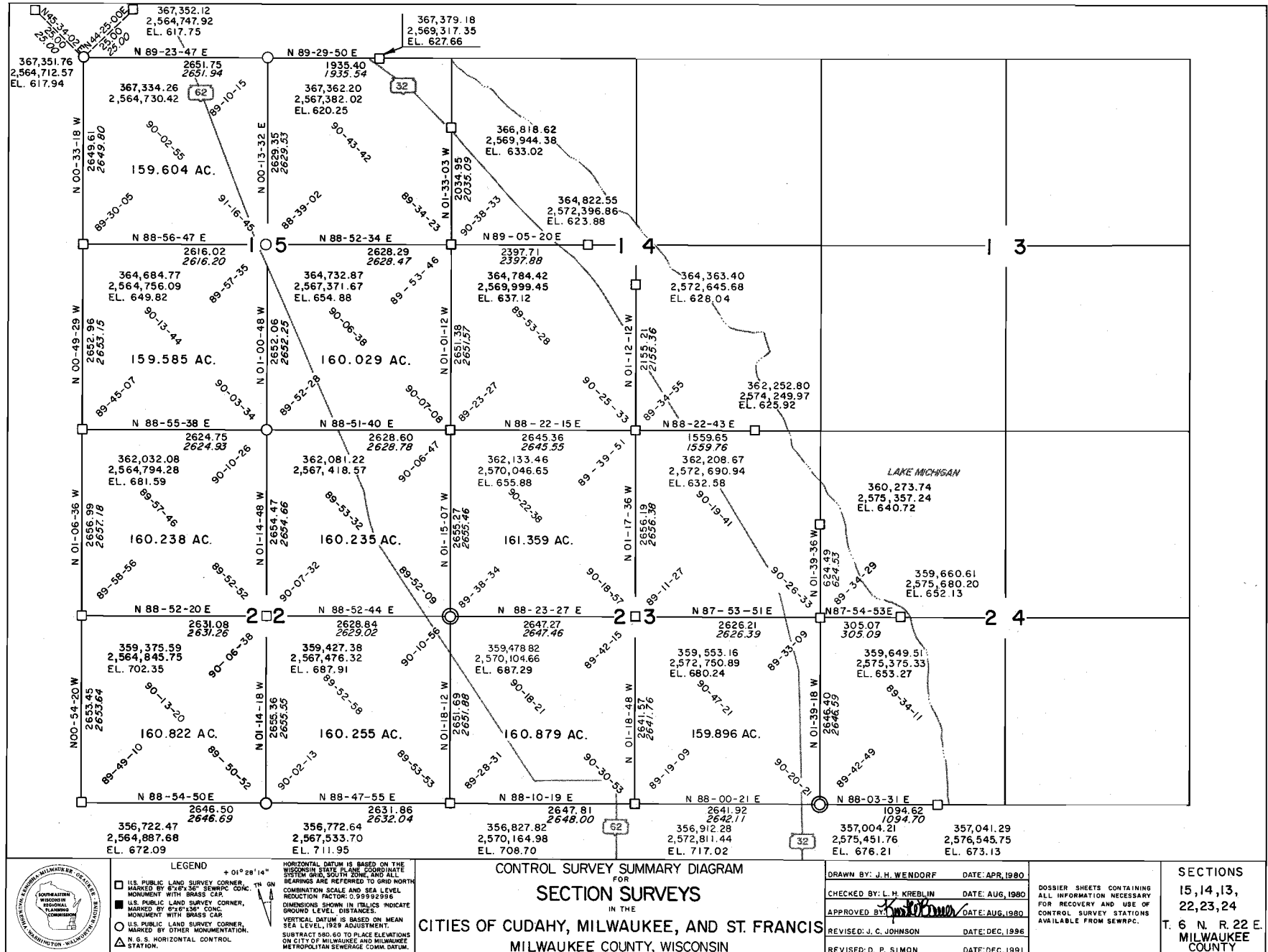
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM SEWRPC.

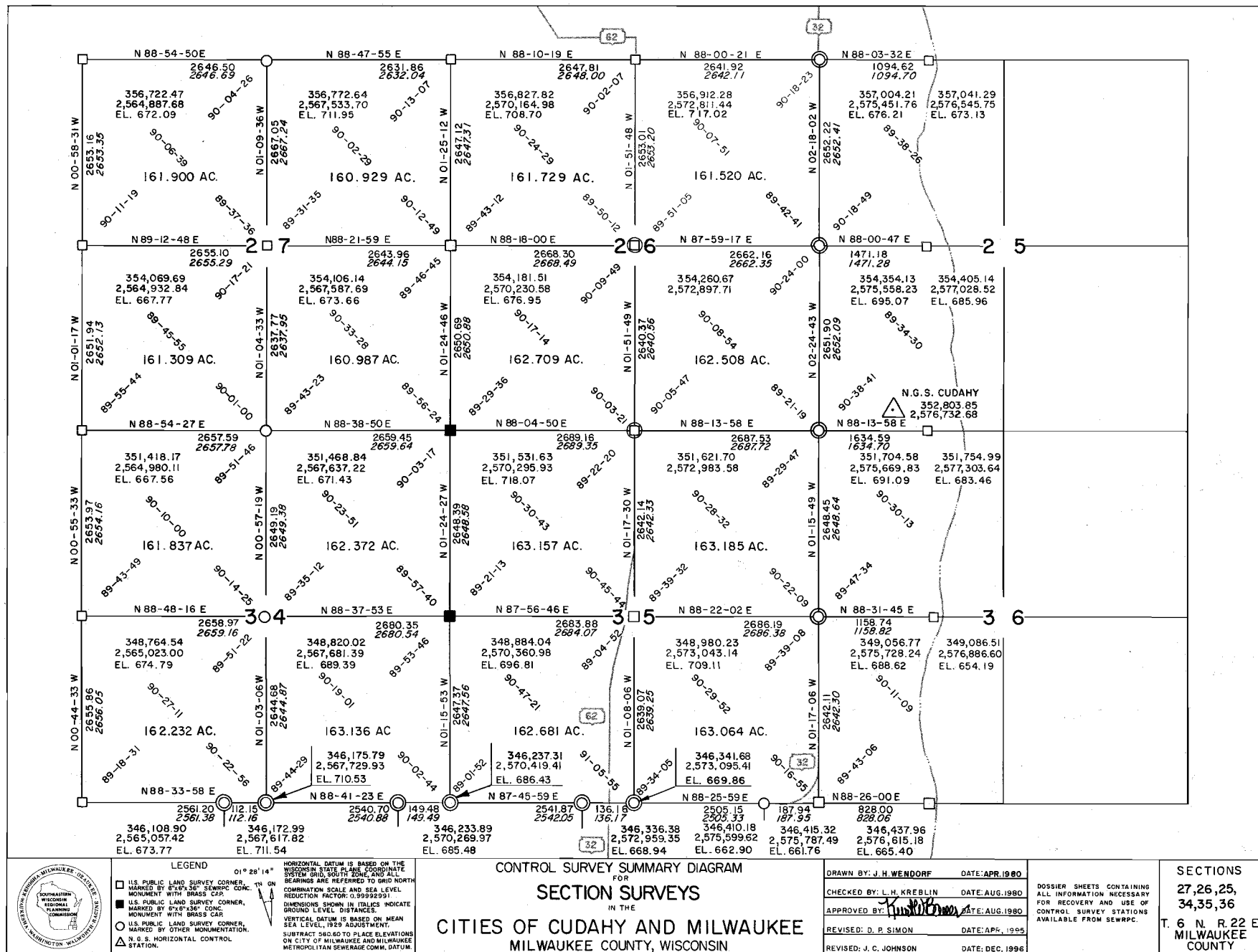


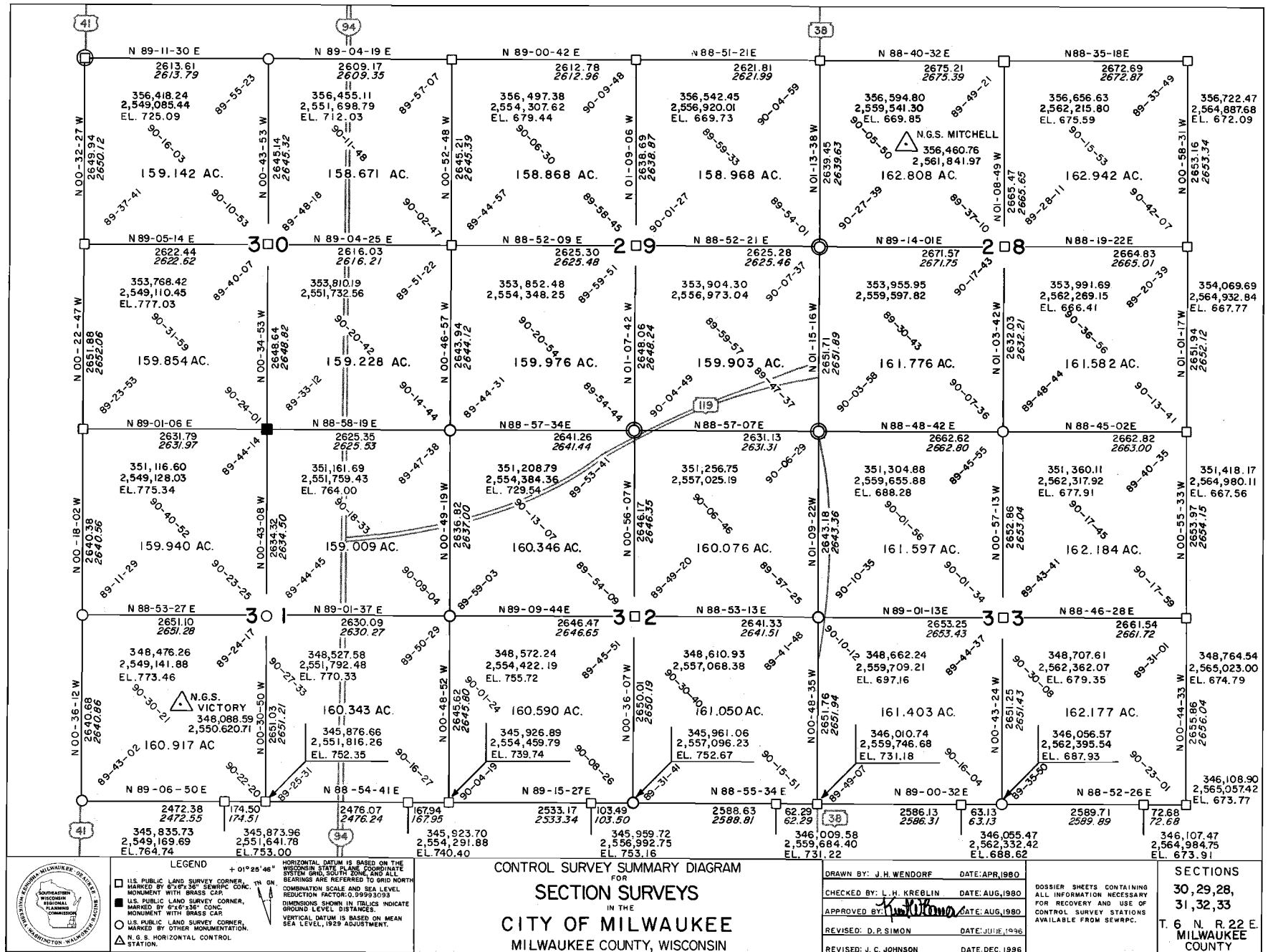


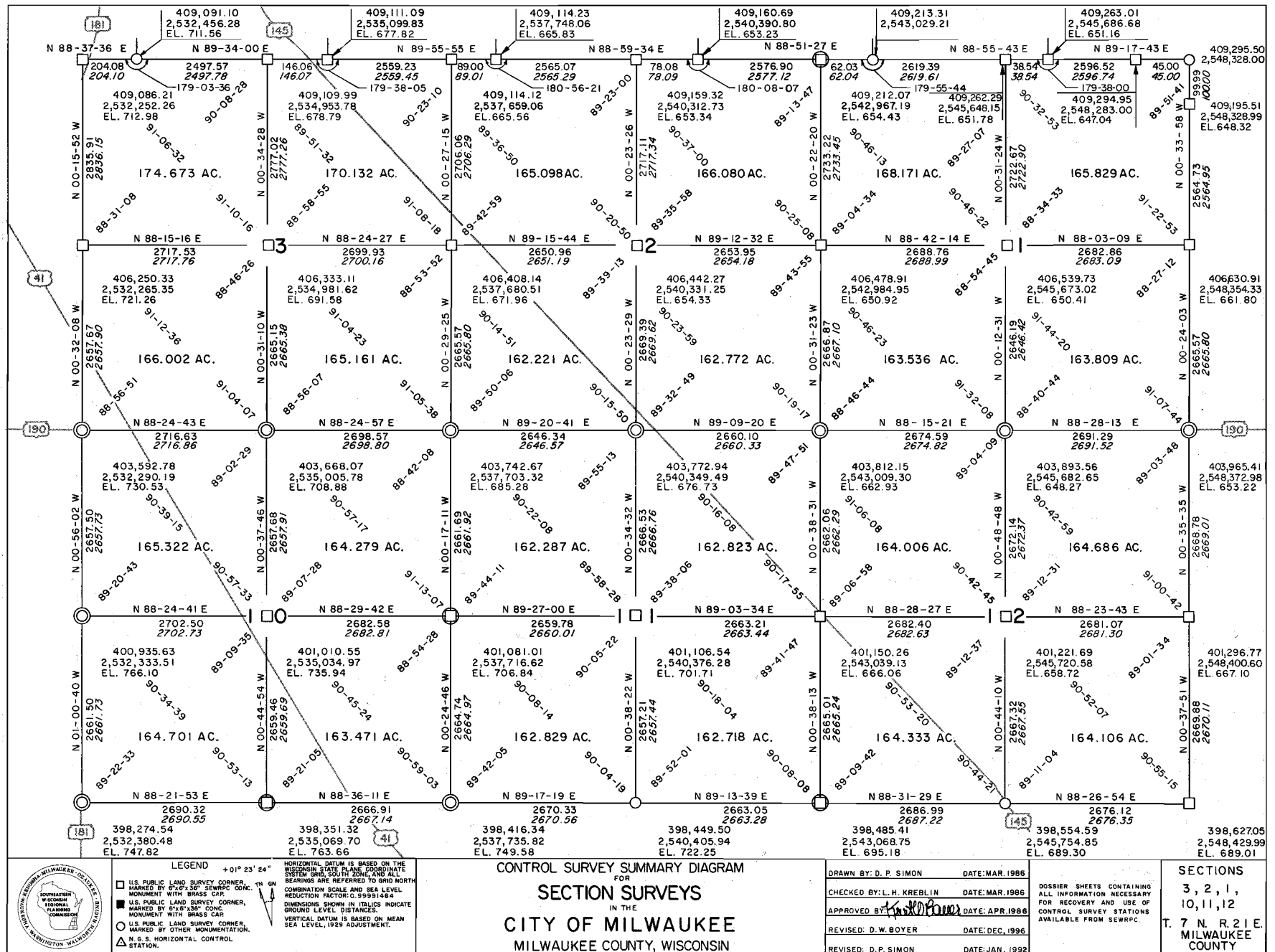


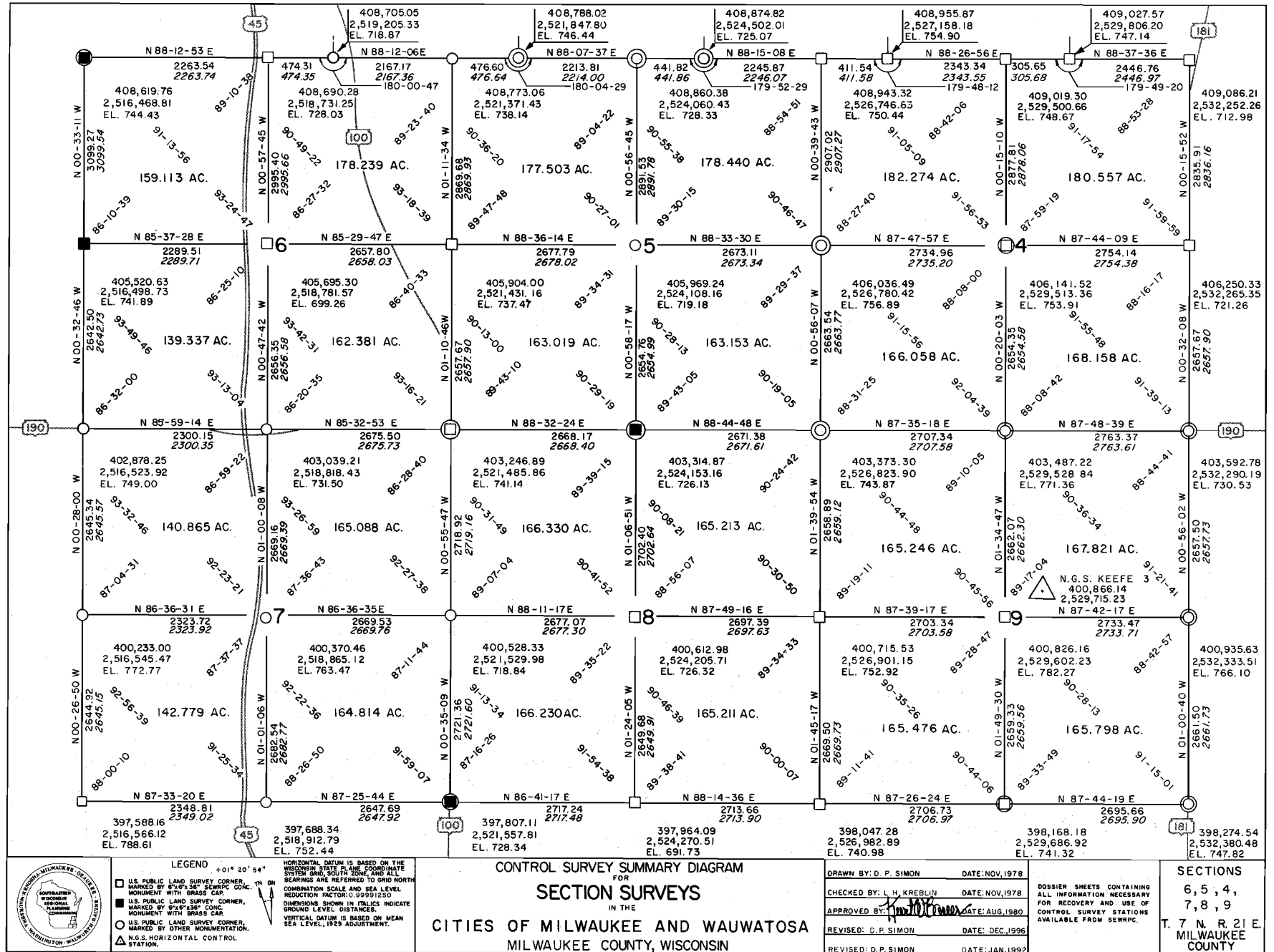


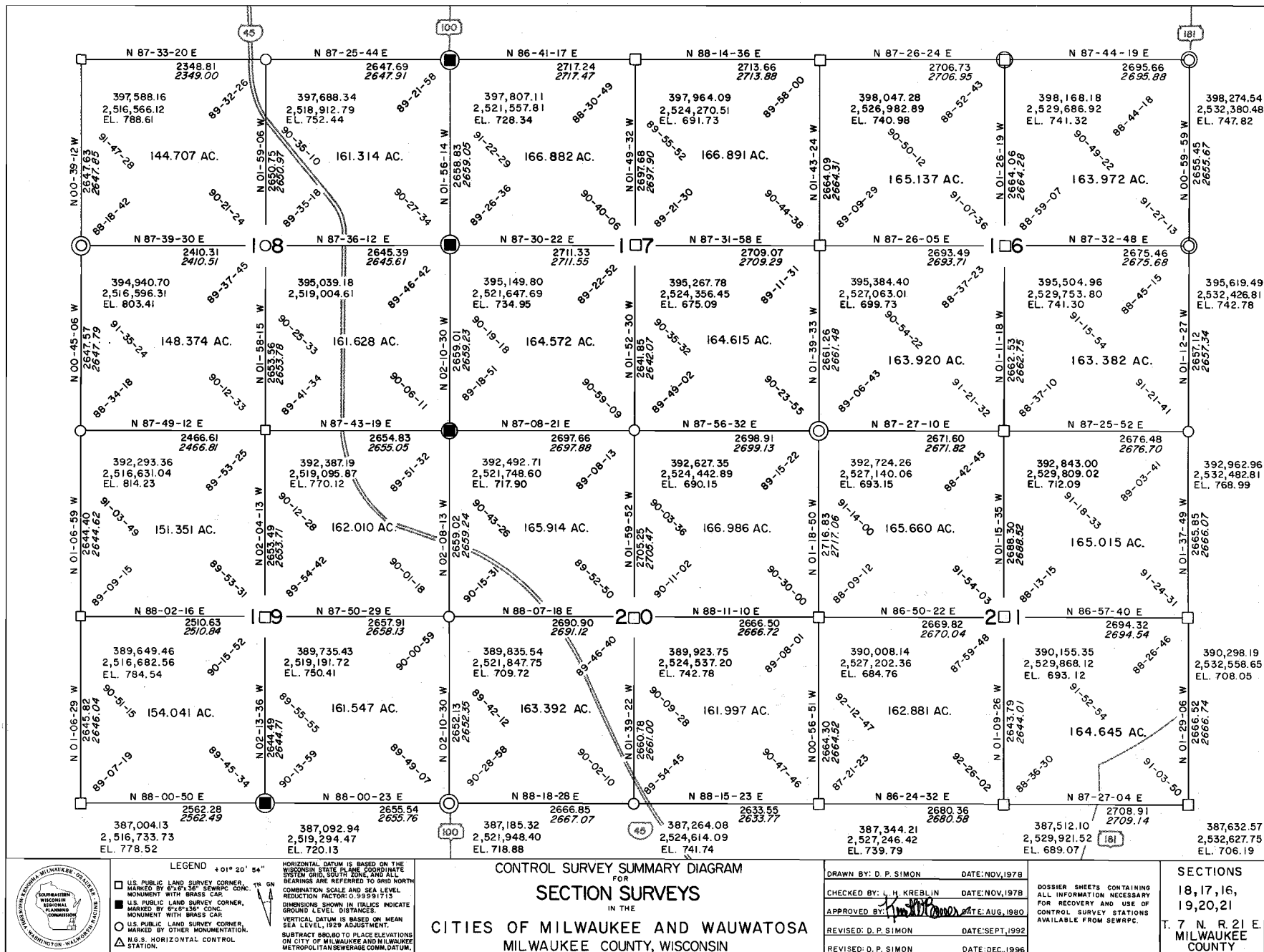


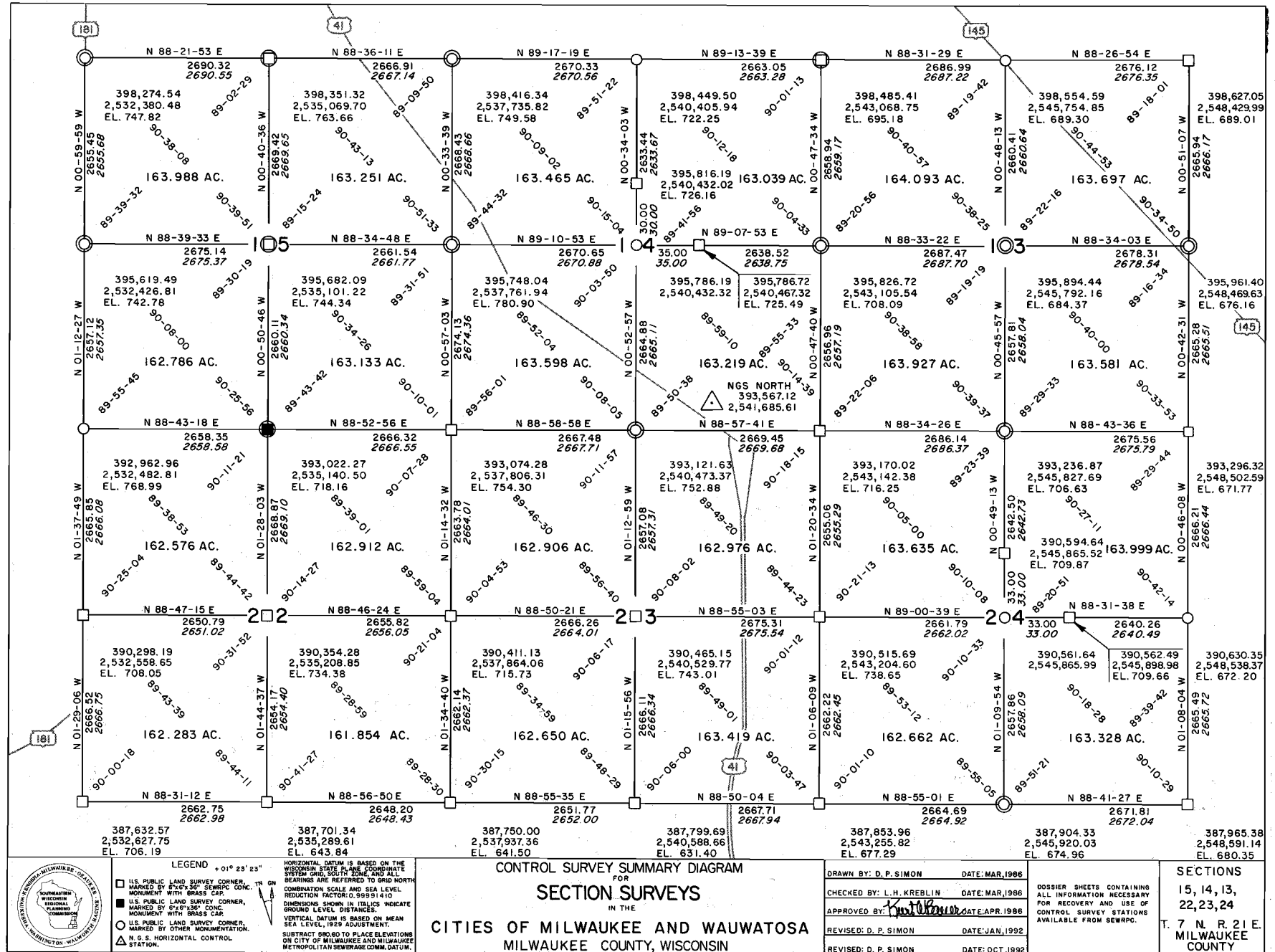


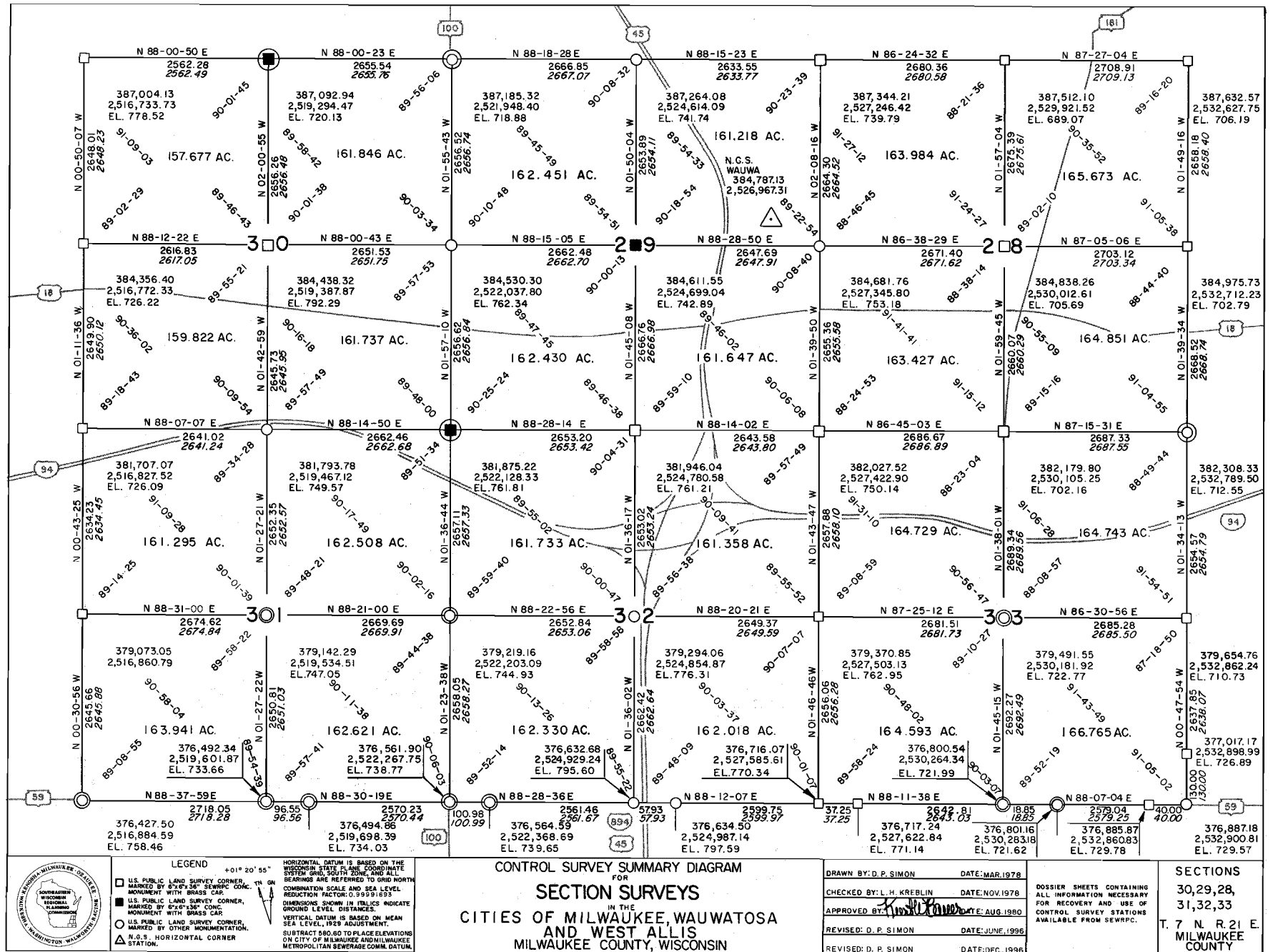


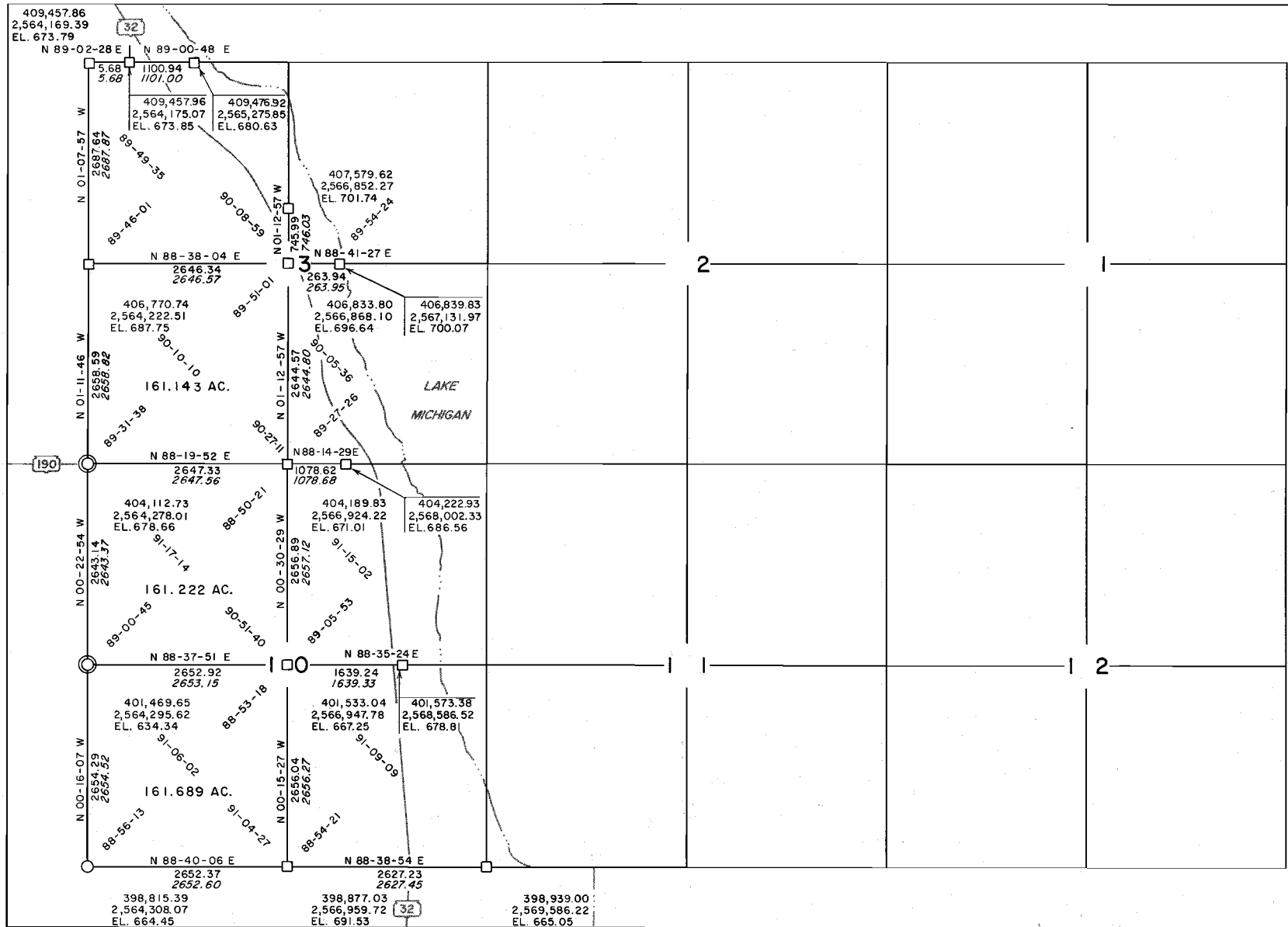












LEGEND

- U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"x6"x36" CONCRETE MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"x6"x36" CONCRETE MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER MARKED BY OTHER MONUMENTATION
- △ N. & S. HORIZONTAL CONTROL STATION



HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, 1983, WITH THE 1983 REDUCTION FACTOR: 0.9999443

DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

SUBTRACT 980.60 TO PLACE ELEVATIONS ON CITY OF MILWAUKEE AND MILWAUKEE METROPOLITAN SEWERAGE COMM. DATUM.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE CITY OF MILWAUKEE; AND VILLAGES OF SHOREWOOD AND WHITEFISH BAY MILWAUKEE COUNTY, WISCONSIN

DRAWN BY: D. P. SIMON DATE: JAN, 1985

CHECKED BY: L. H. KREBLIN DATE: JAN, 1985

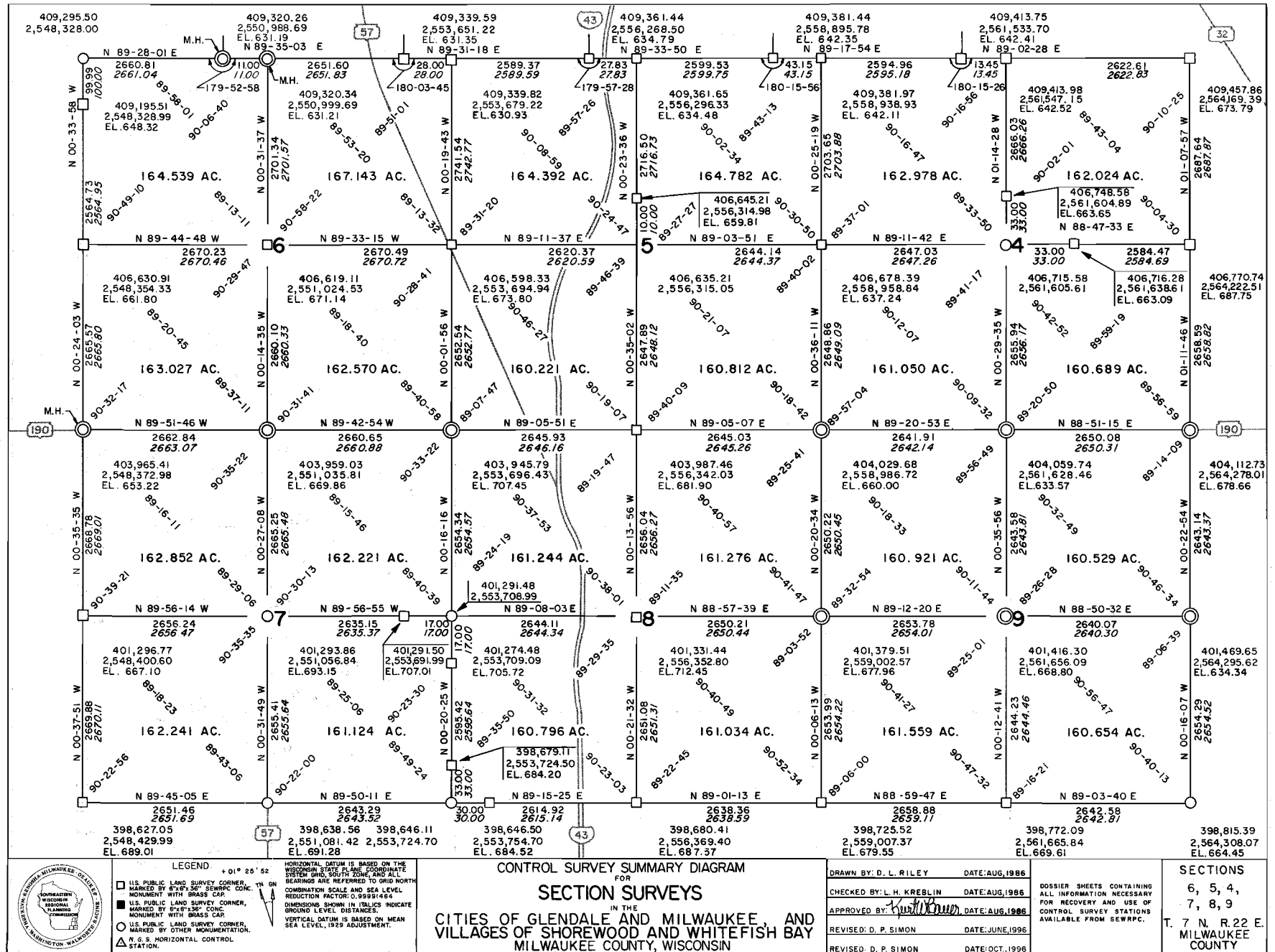
APPROVED BY: *[Signature]* DATE: JAN, 1985

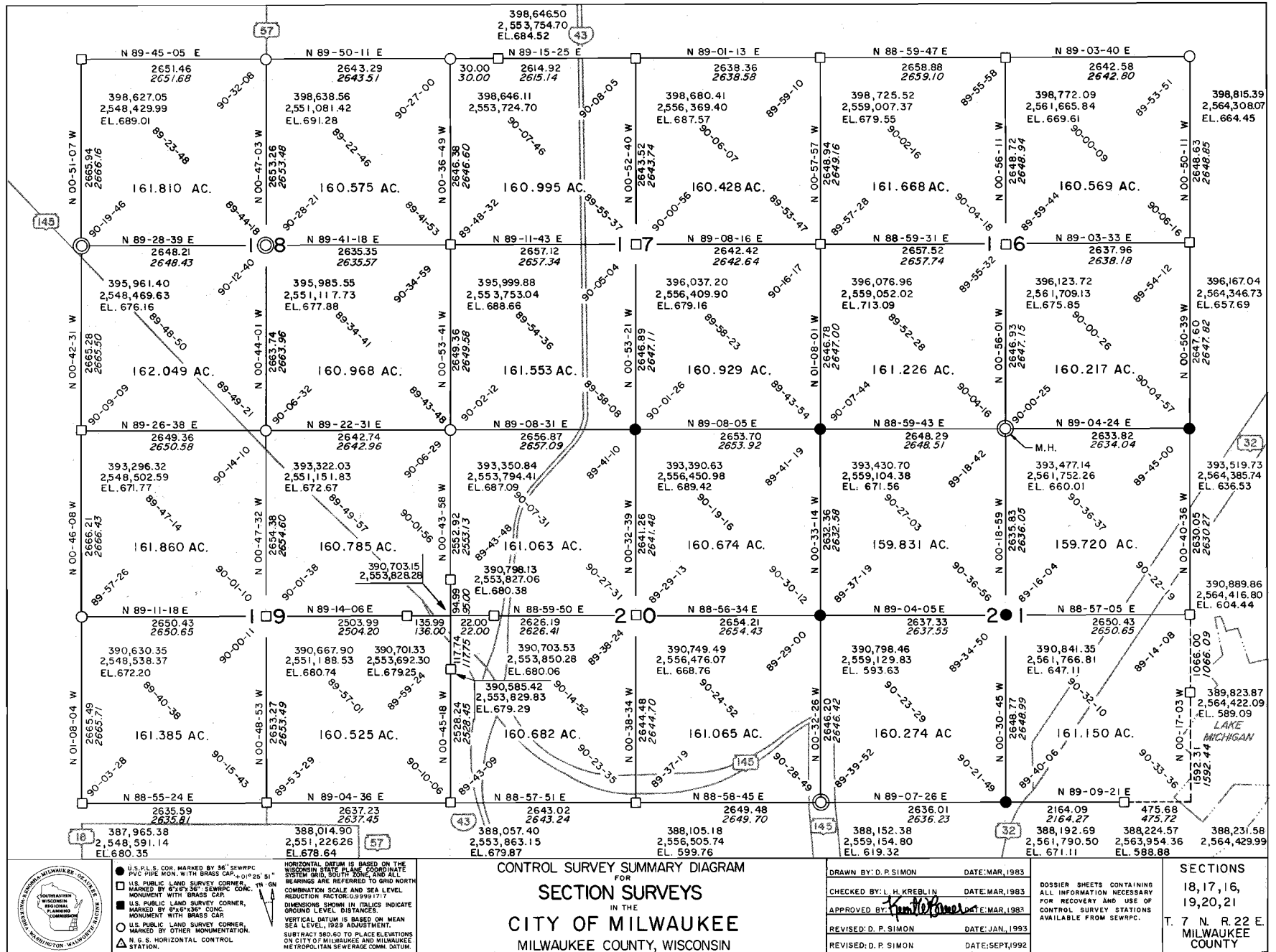
REVISED: D. P. SIMON DATE: JUNE 1996

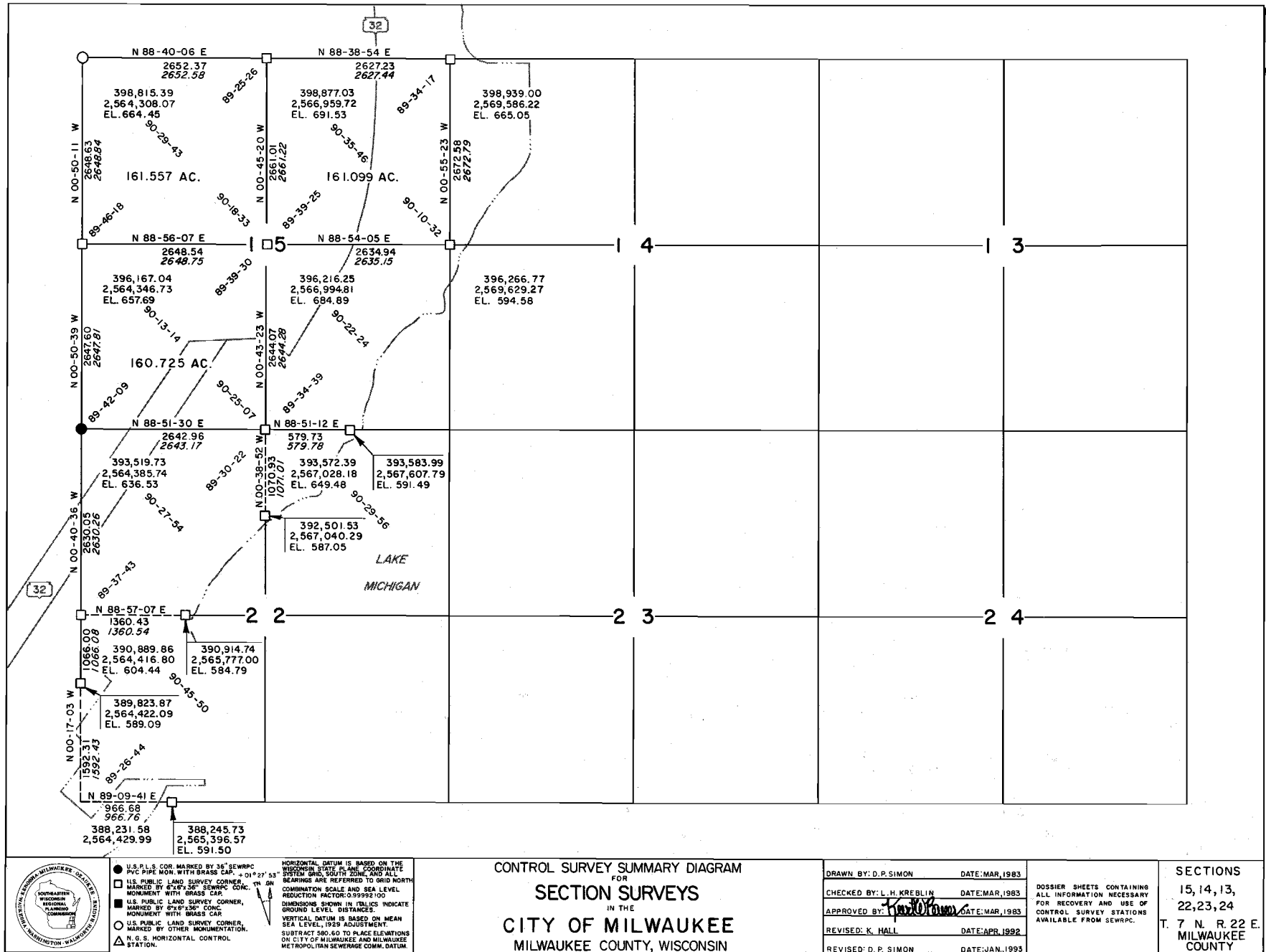
REVISED: L. A. SAKALE DATE: DEC 1996

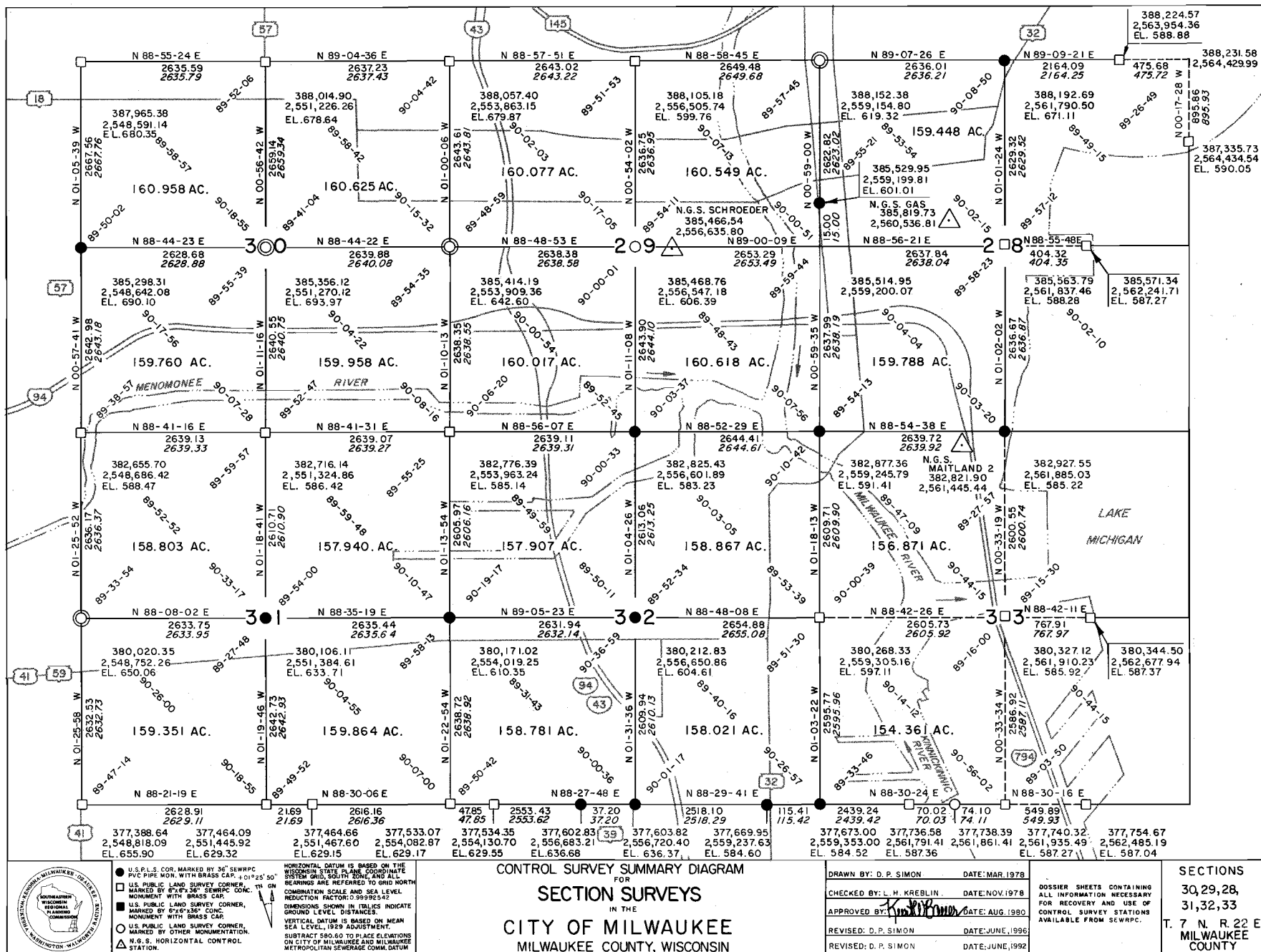
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM SEWRPC.

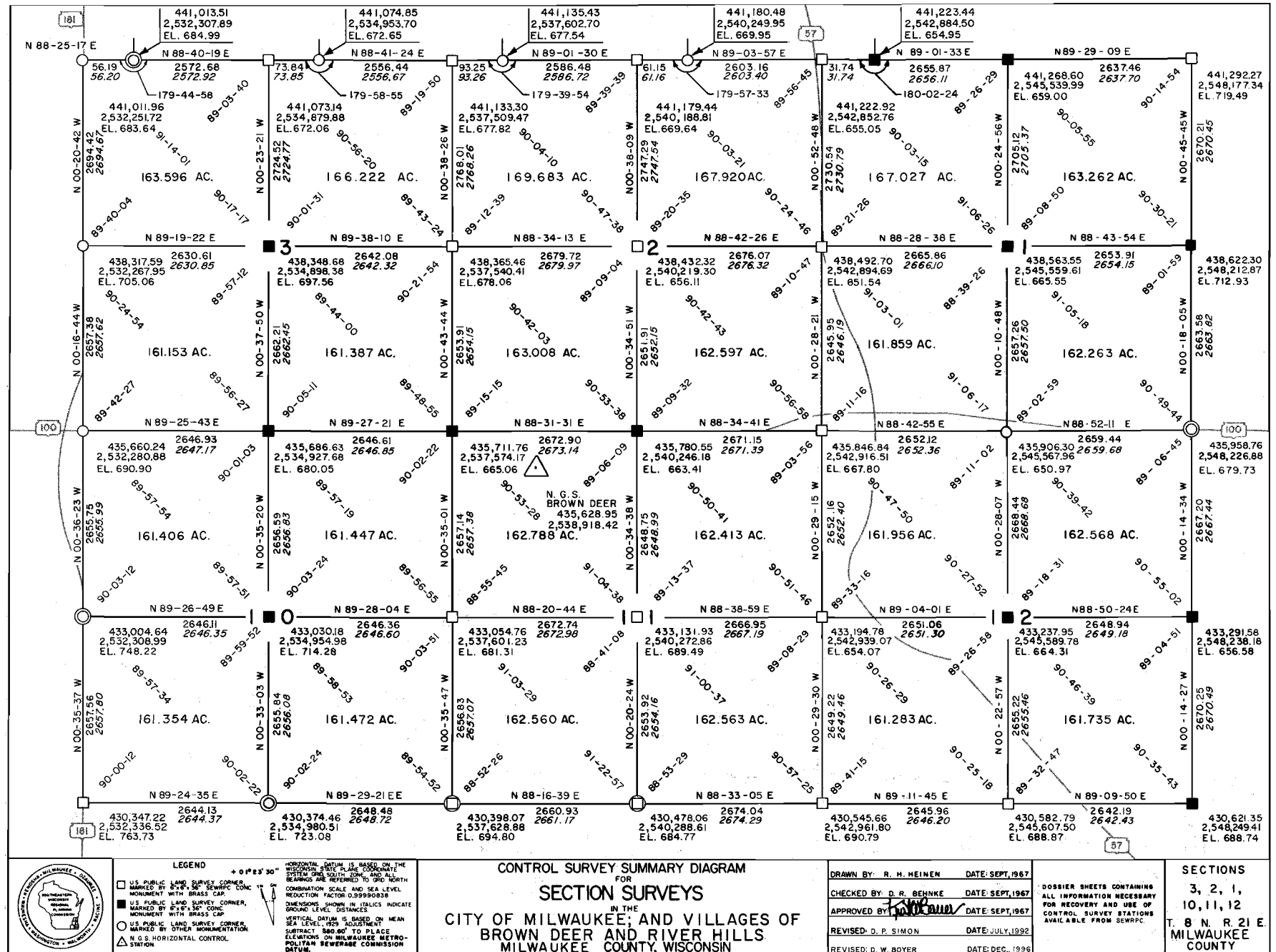
SECTIONS 3, 2, 1, 10, 11, 12 T. 7 N. R. 22 E. MILWAUKEE COUNTY

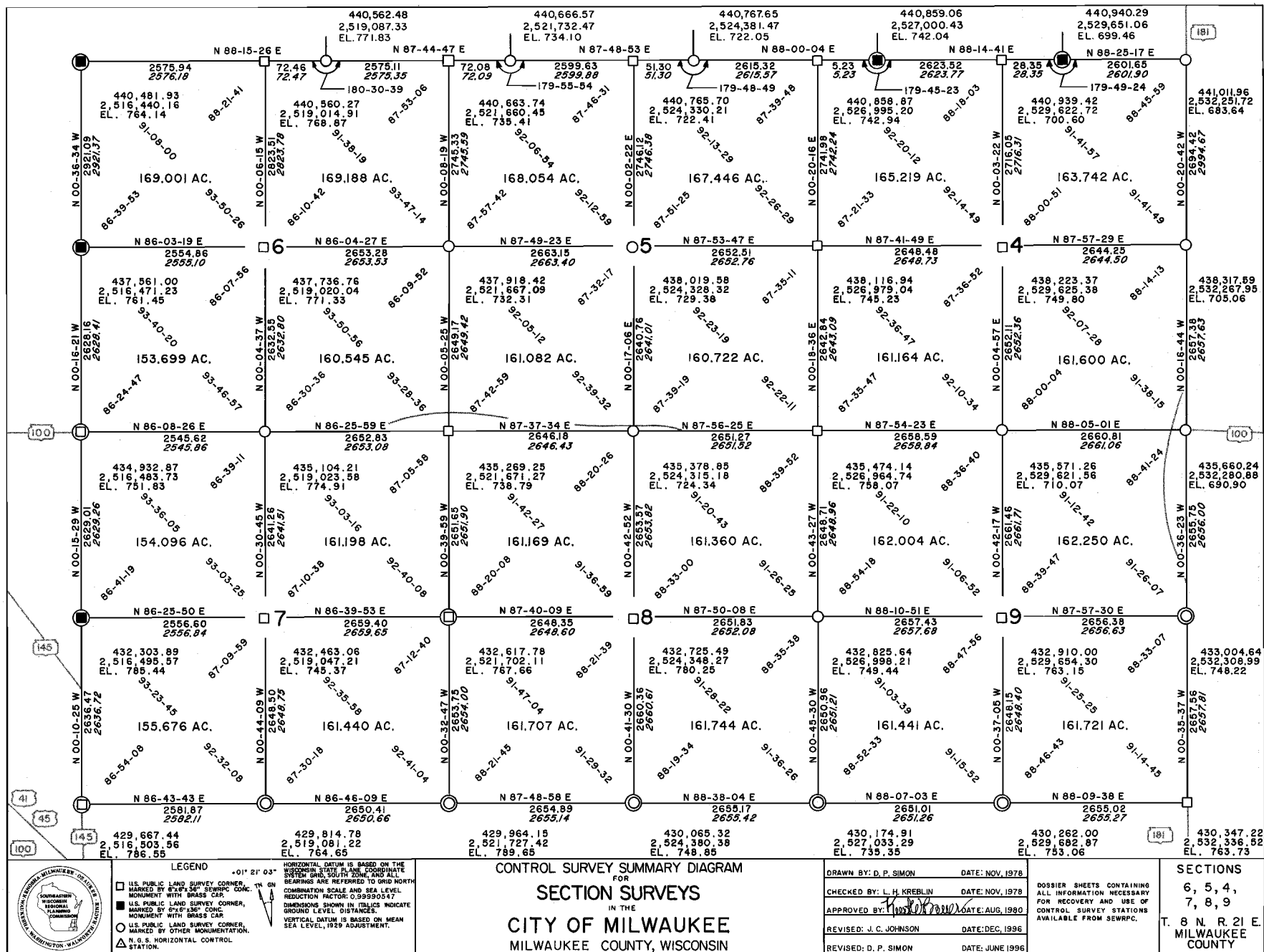


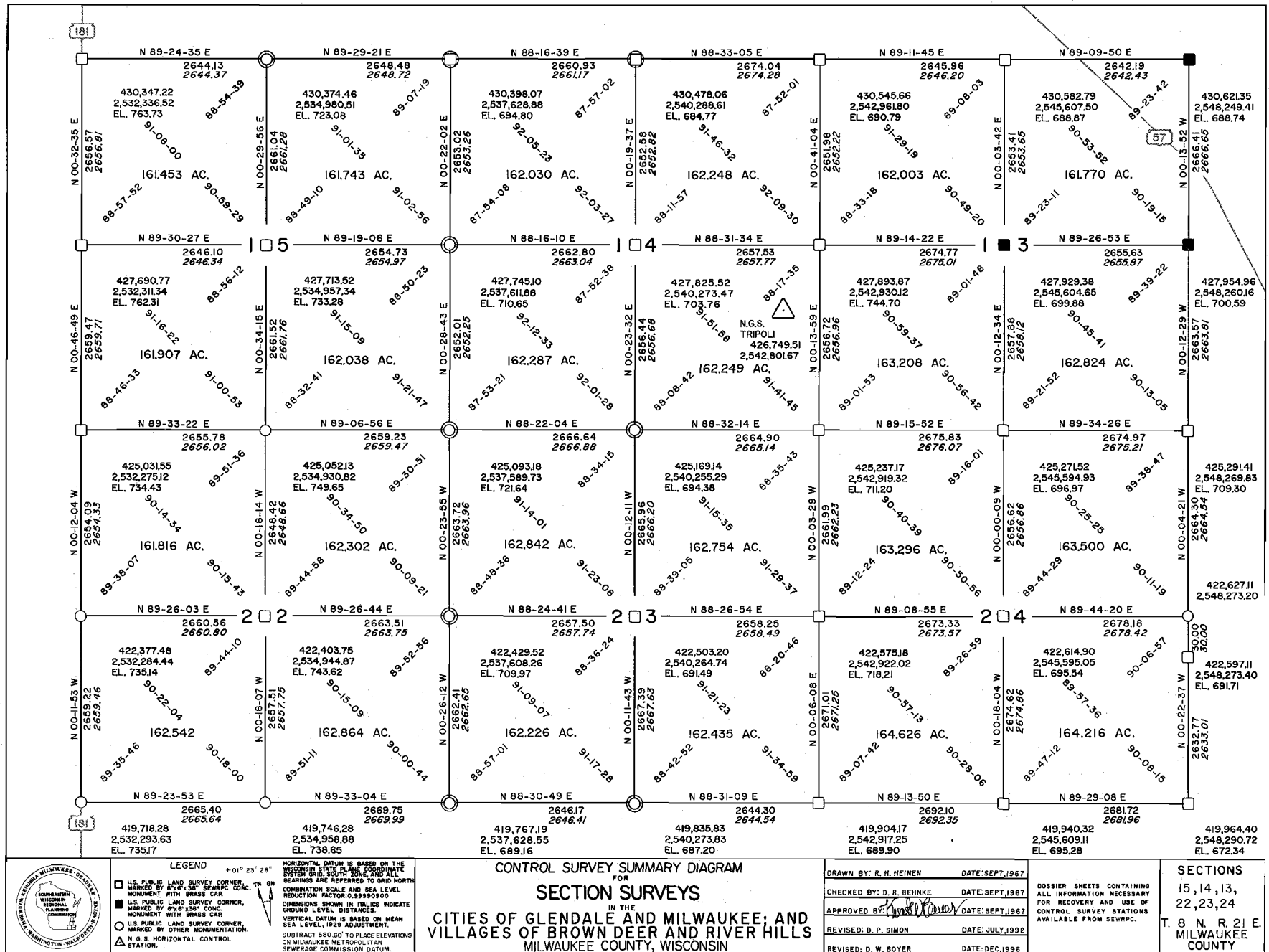


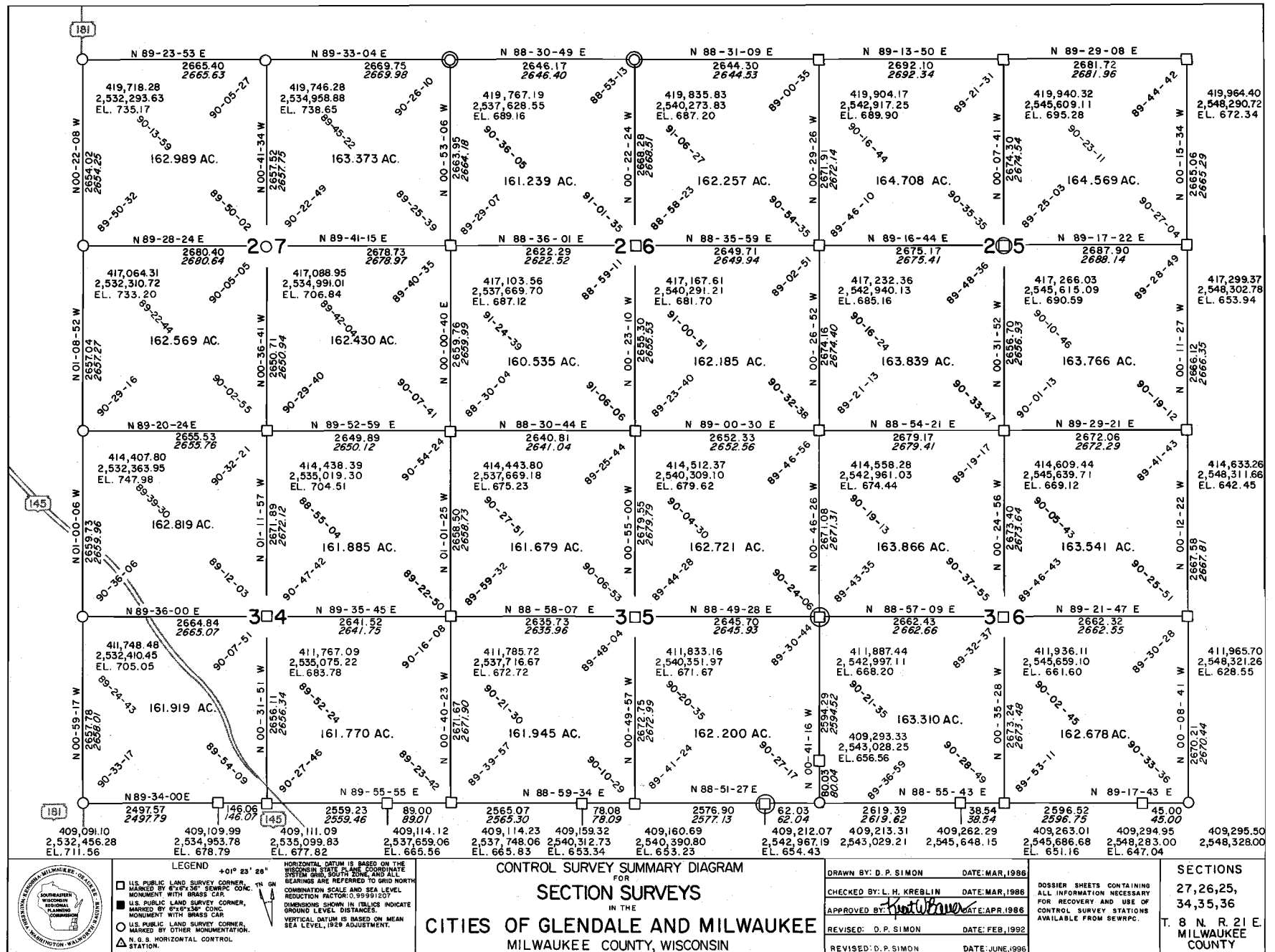


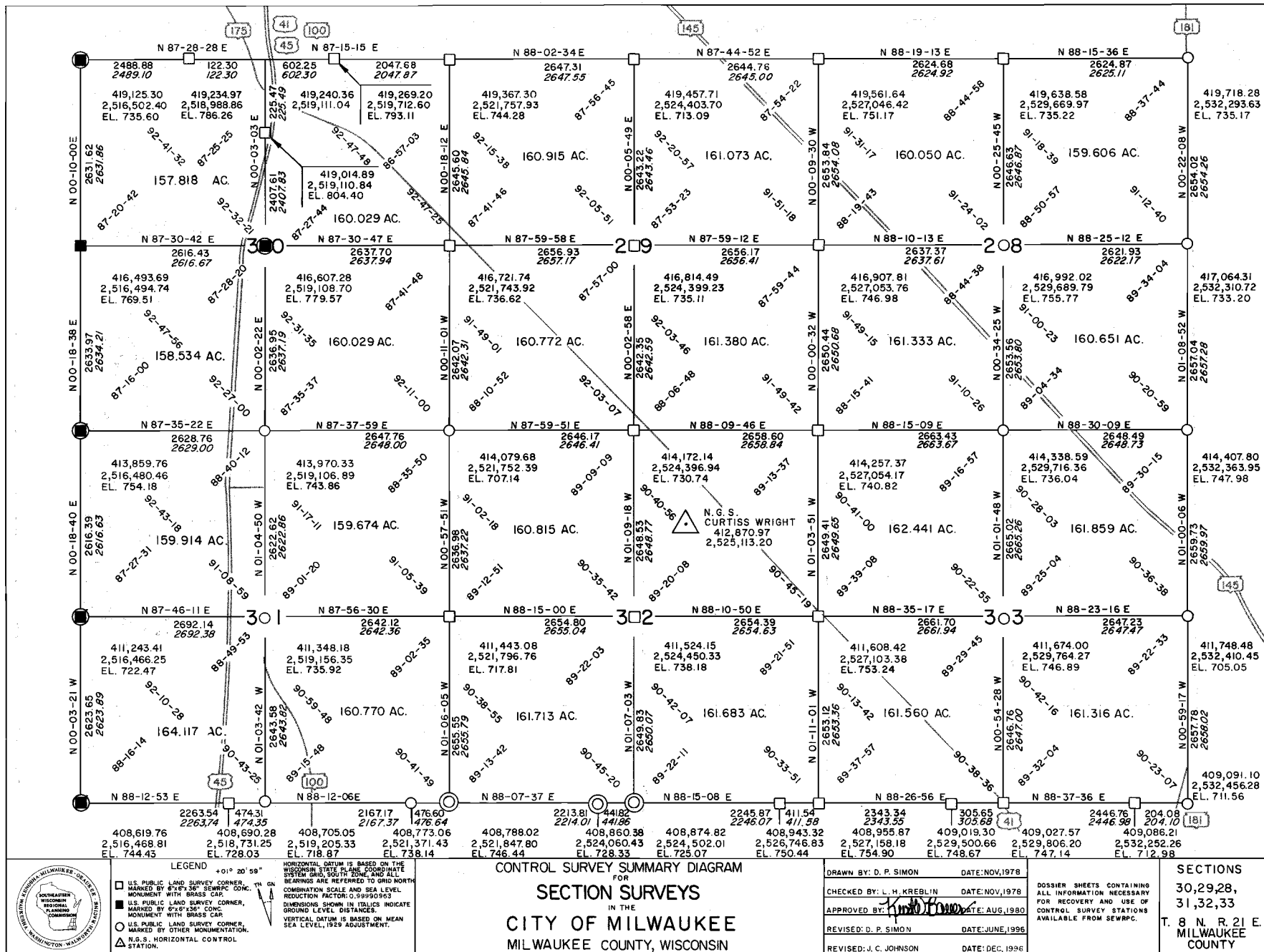


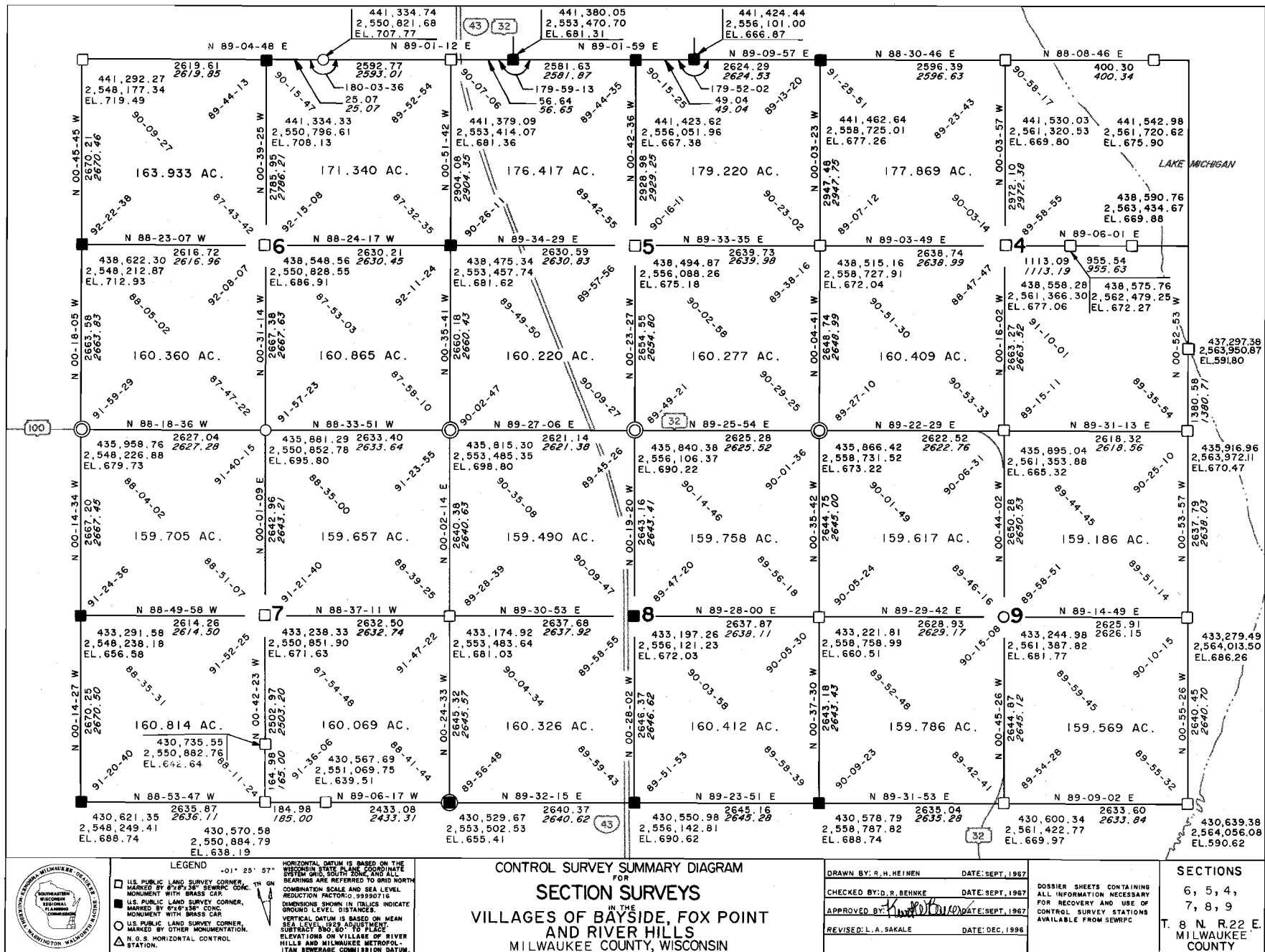


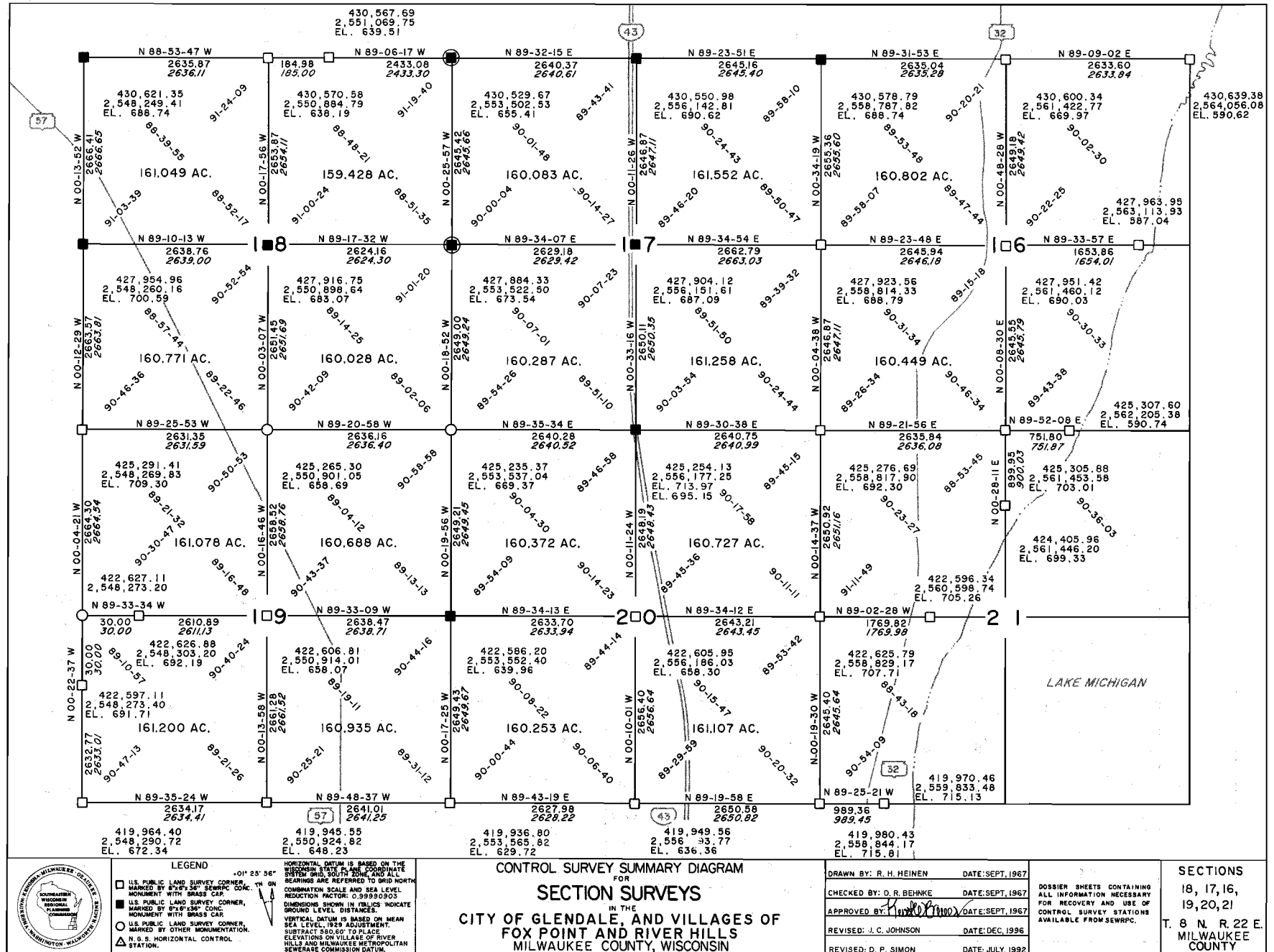


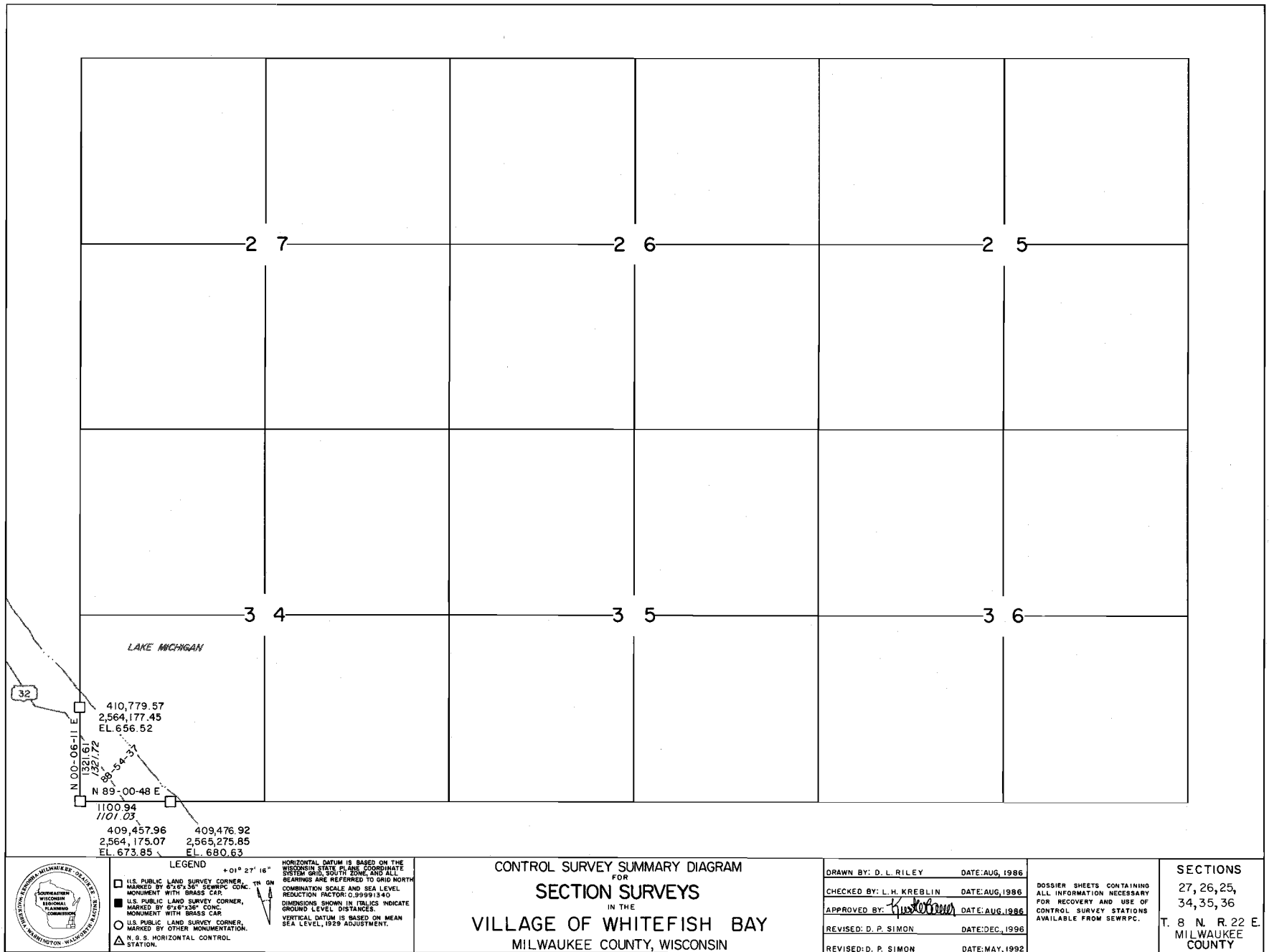


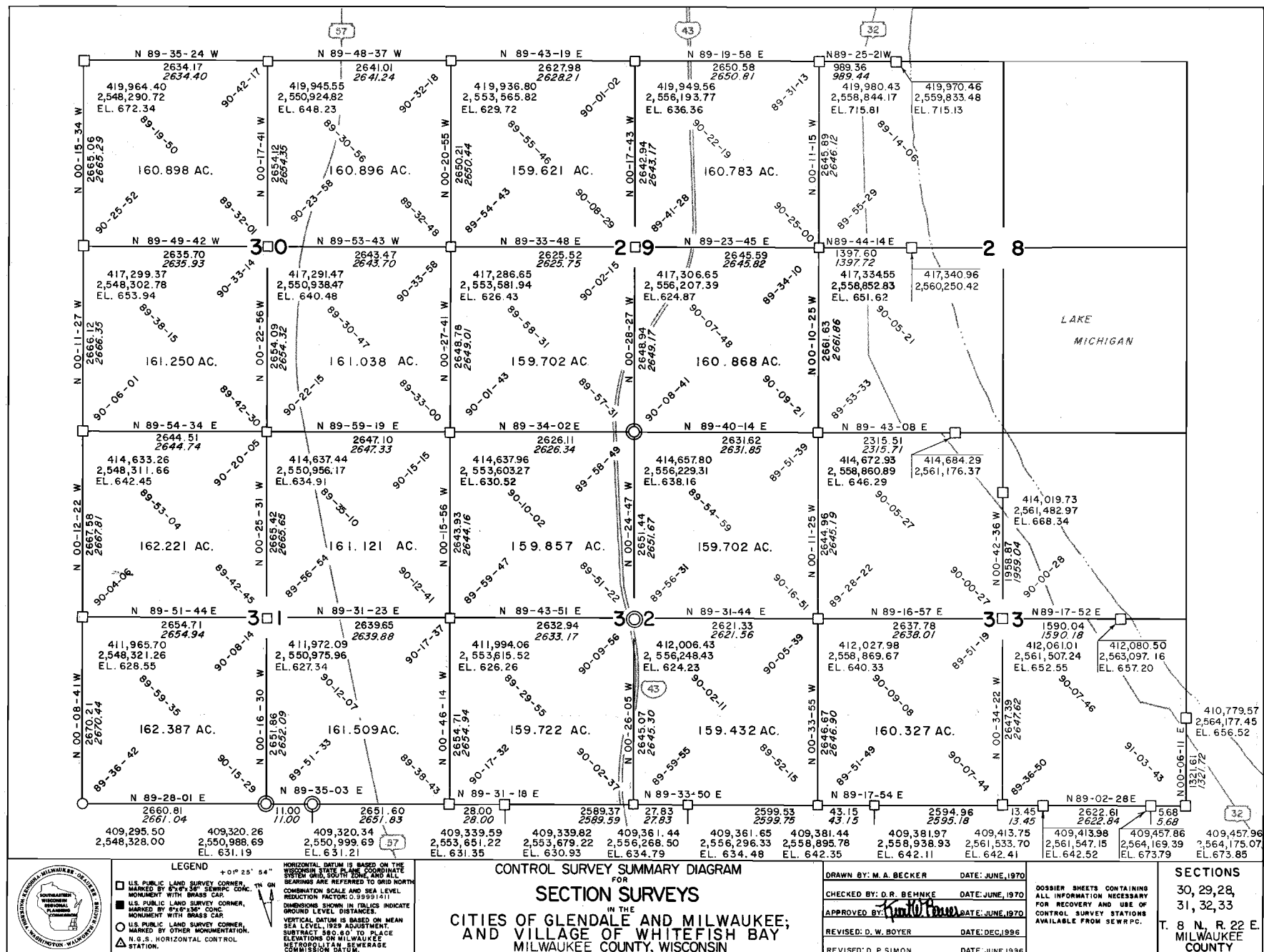




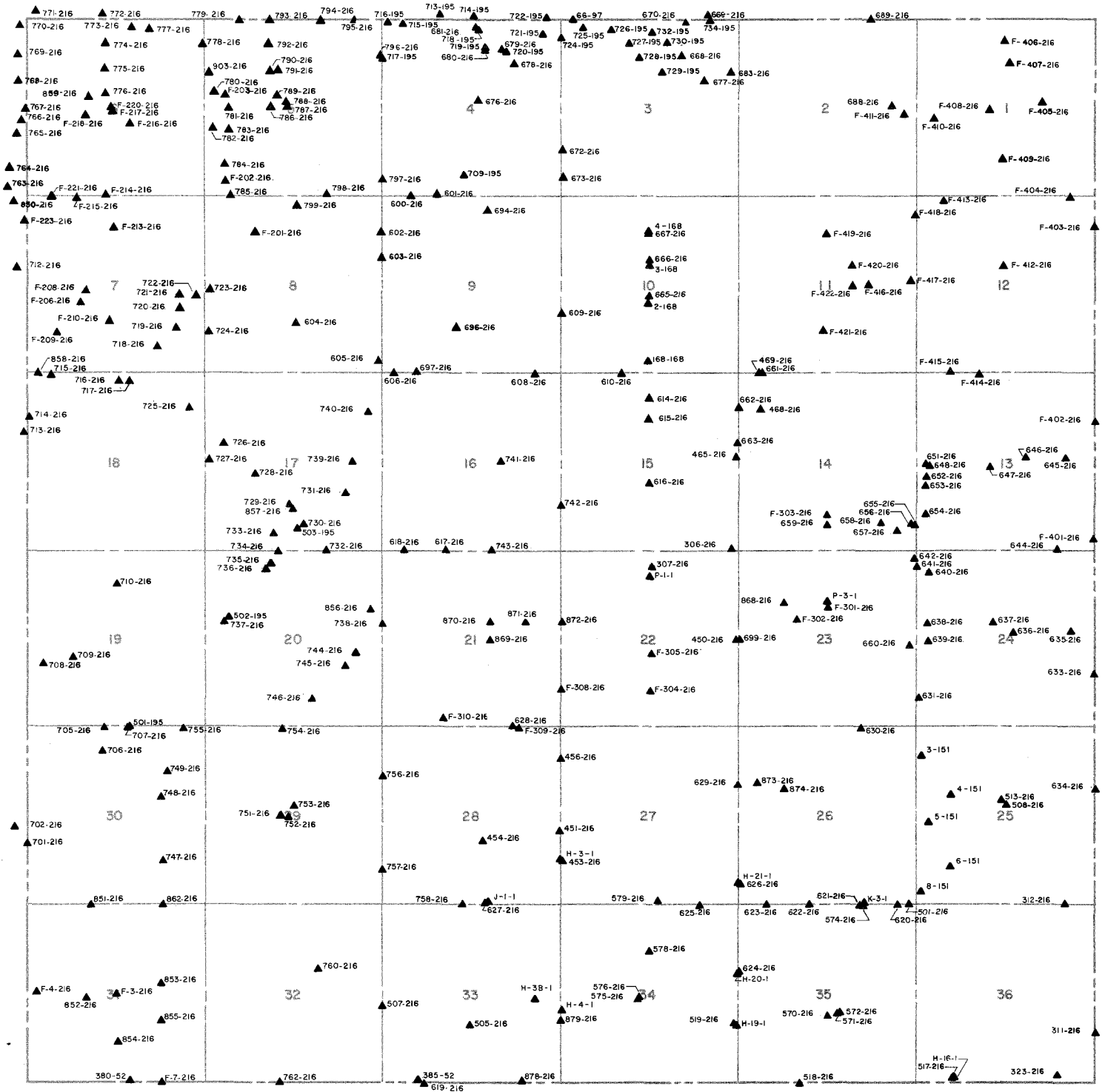




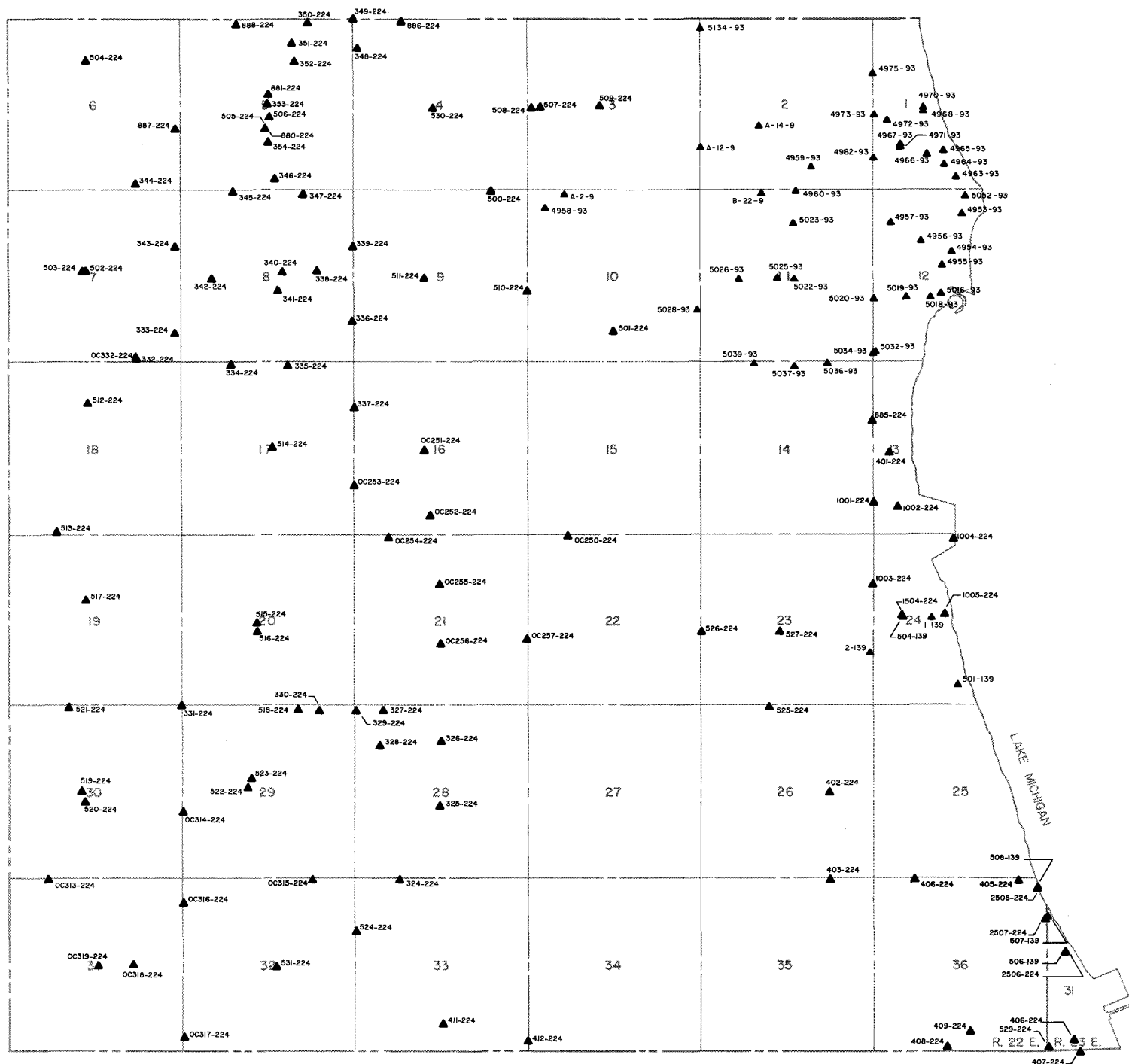




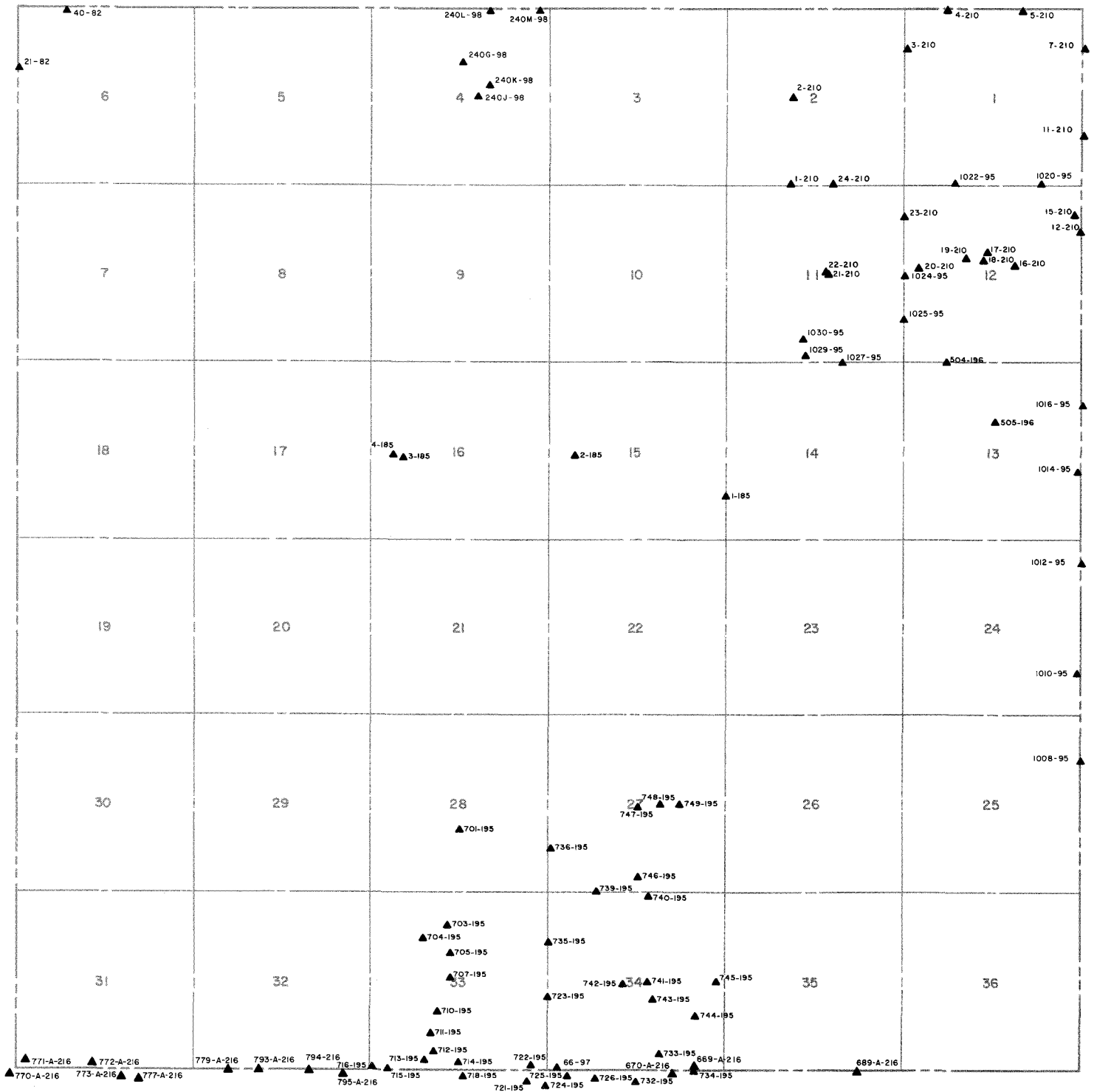
TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 21 EAST
MILWAUKEE COUNTY



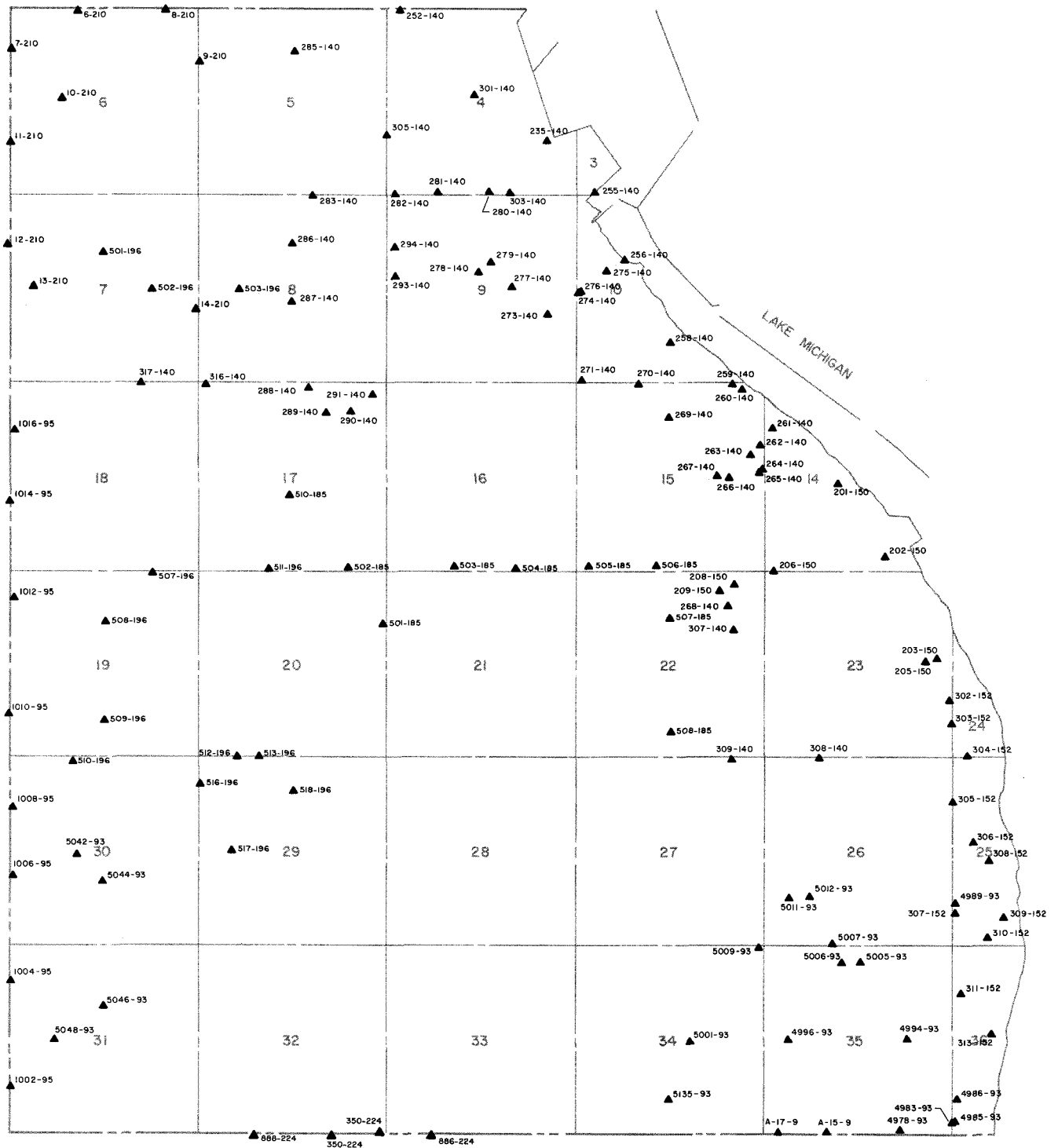
TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 22 EAST, AND TOWNSHIP 5 NORTH, RANGE 23 EAST, MILWAUKEE COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 21 EAST MILWAUKEE COUNTY

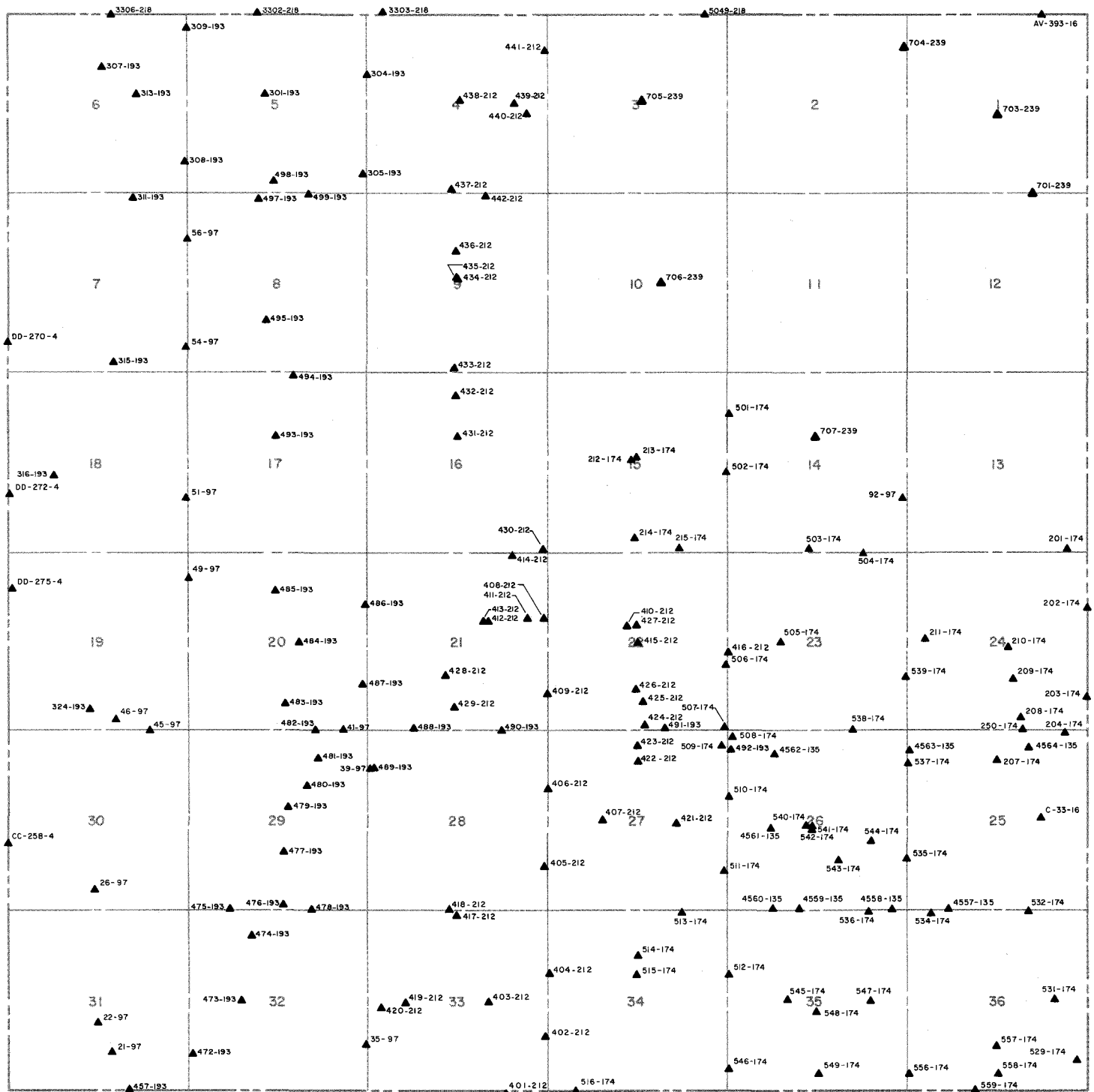


TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 22 EAST MILWAUKEE COUNTY

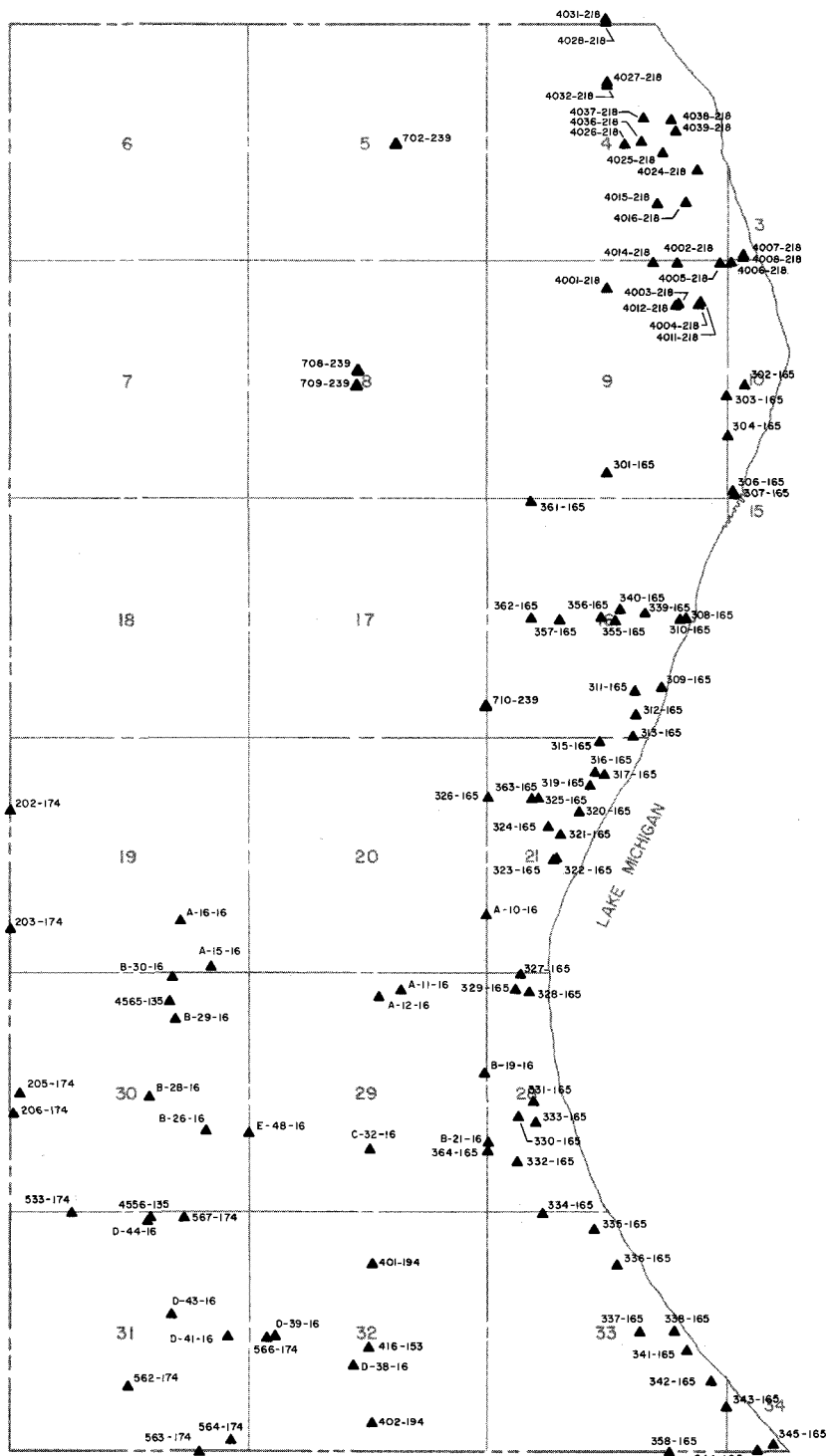


[illegible]

TRAVERSE DIAGRAM, TOWNSHIP 8 NORTH, RANGE 21 EAST MILWAUKEE COUNTY

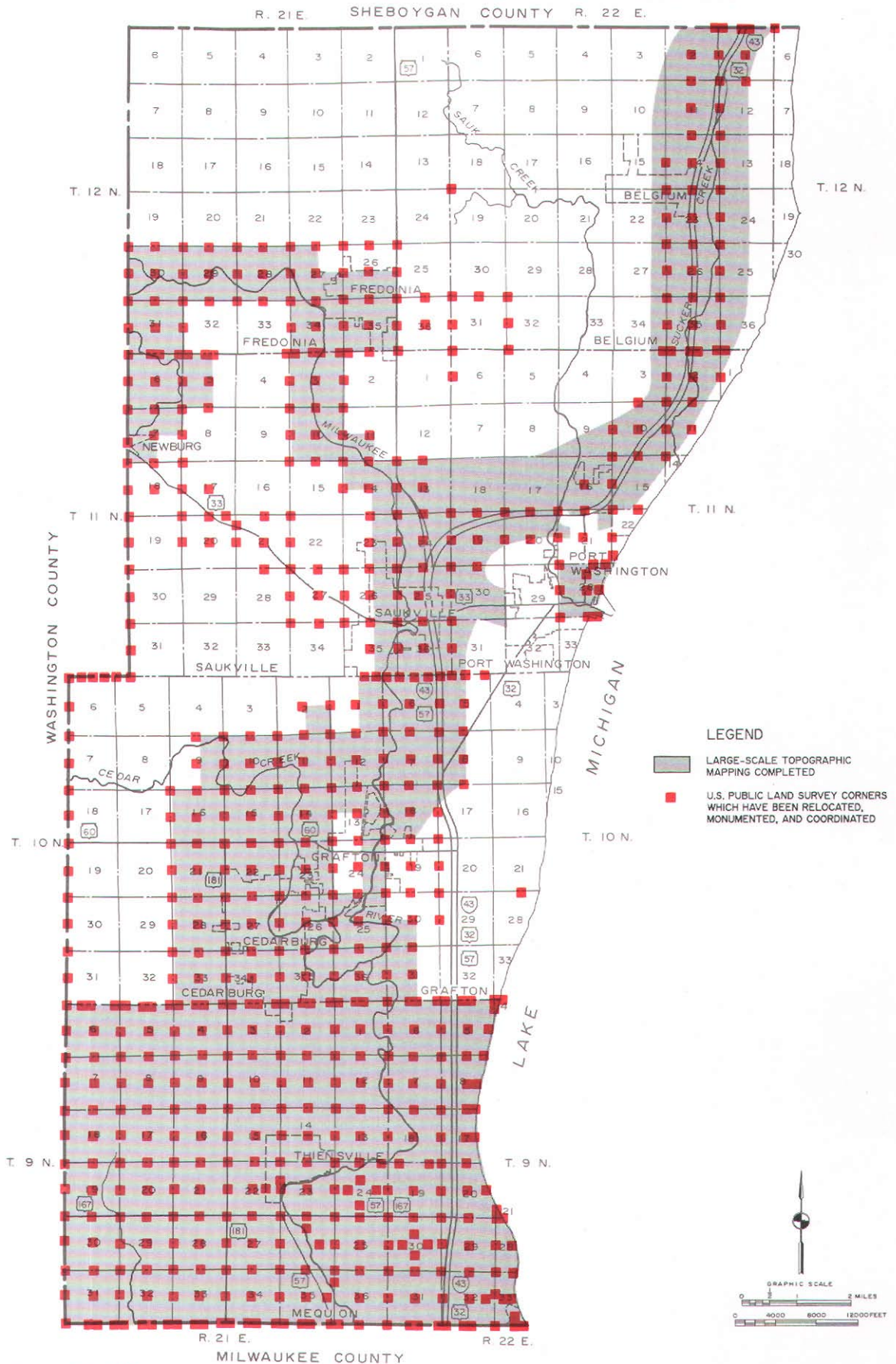


TRAVERSE DIAGRAM, TOWNSHIP 8 NORTH, RANGE 22 EAST MILWAUKEE COUNTY

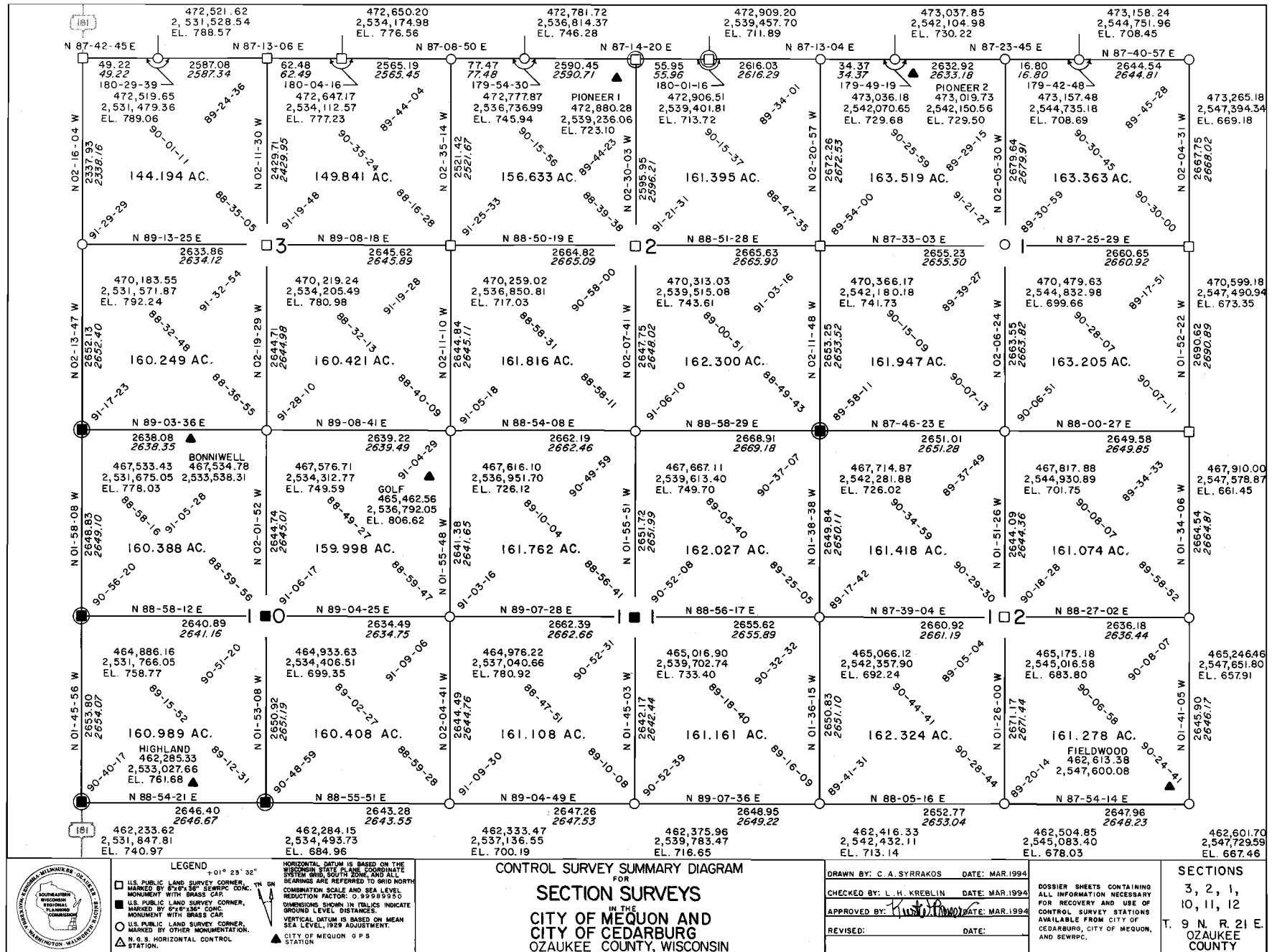


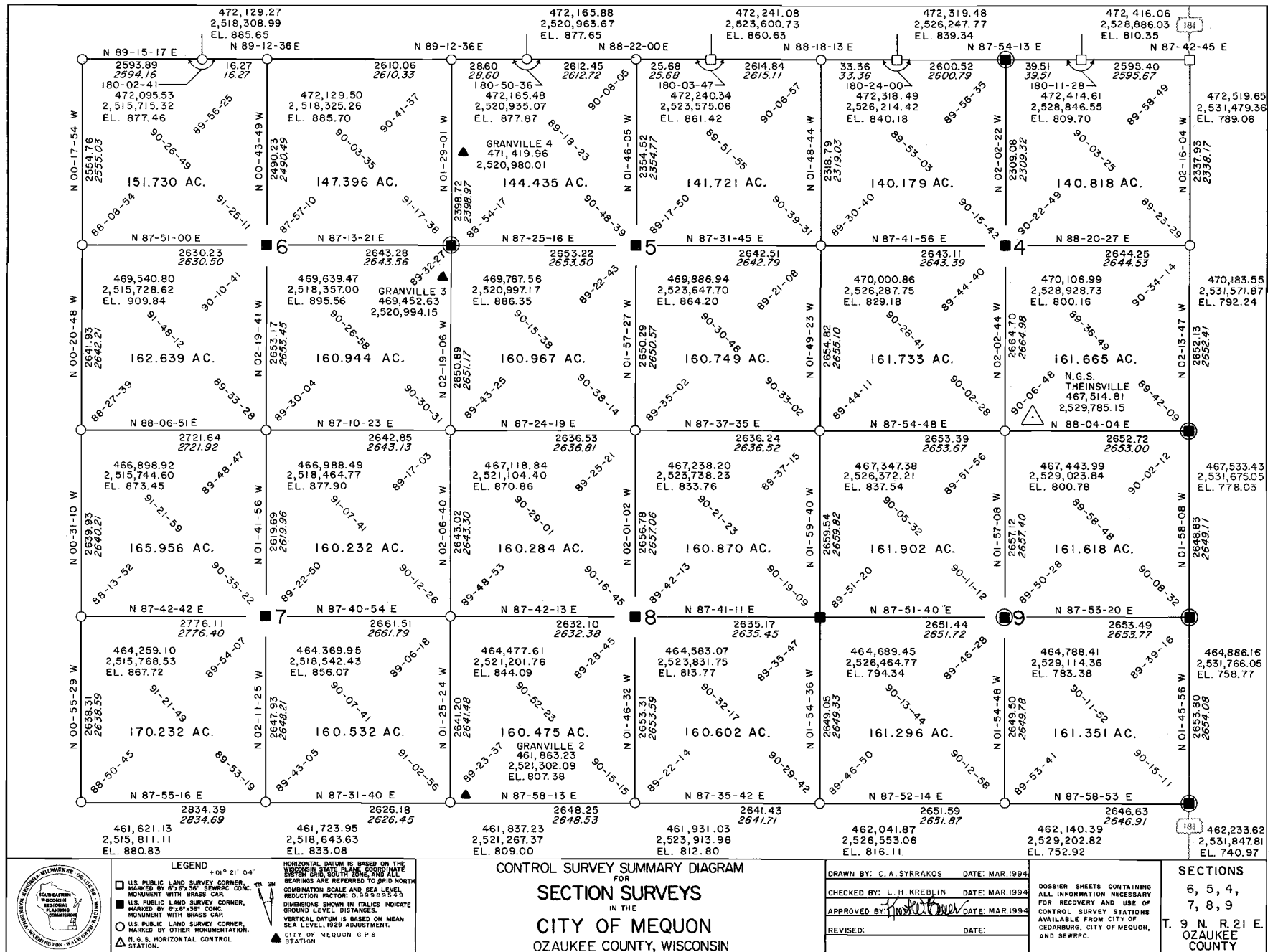
Map C-3

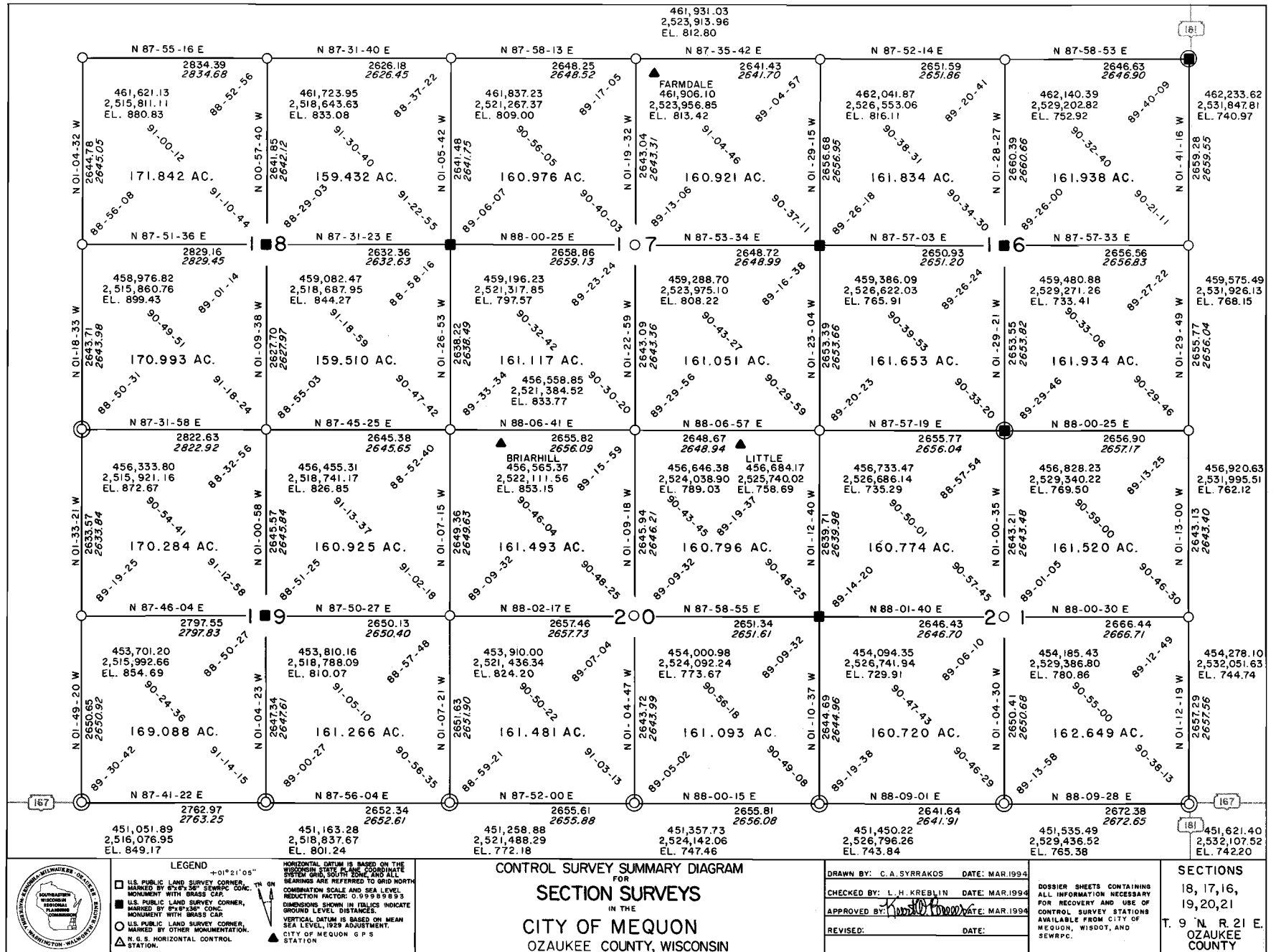
**STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE
RELOCATION, MONUMENTION, AND COORDINATION OF U. S. PUBLIC
LAND SURVEY CORNERS IN OZAUKEE COUNTY: SEPTEMBER 1996**

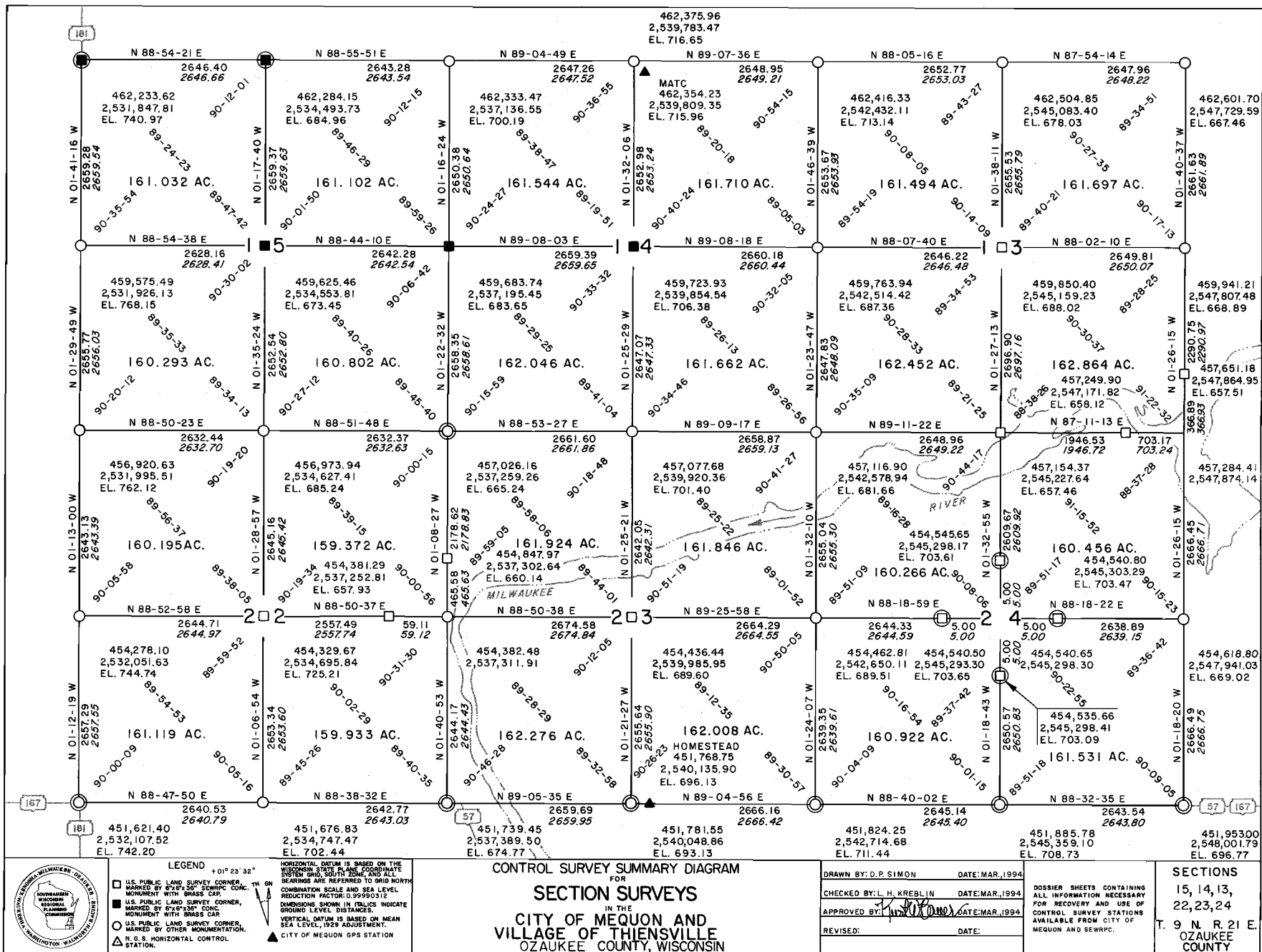


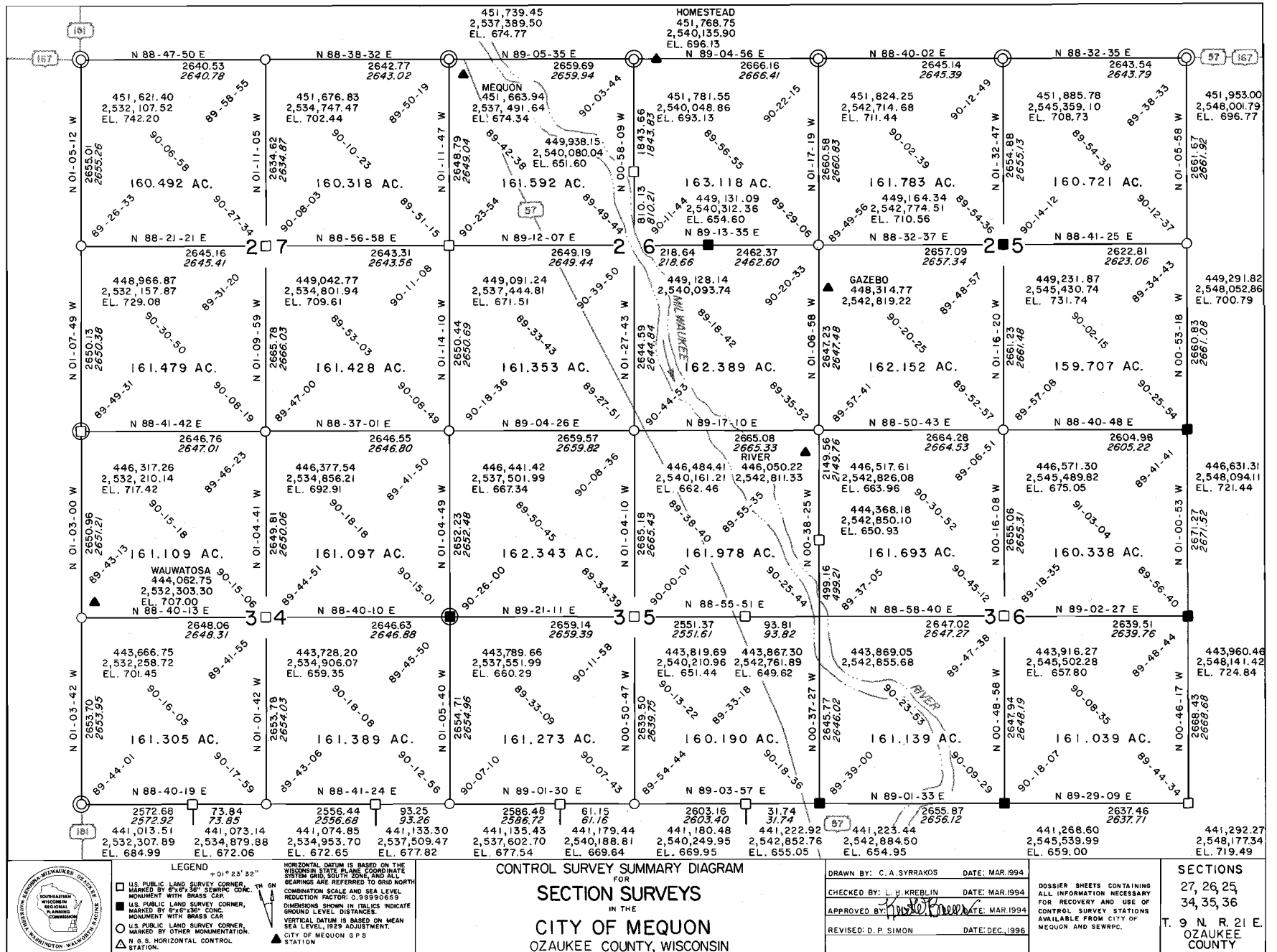
Source: SEWRPC.

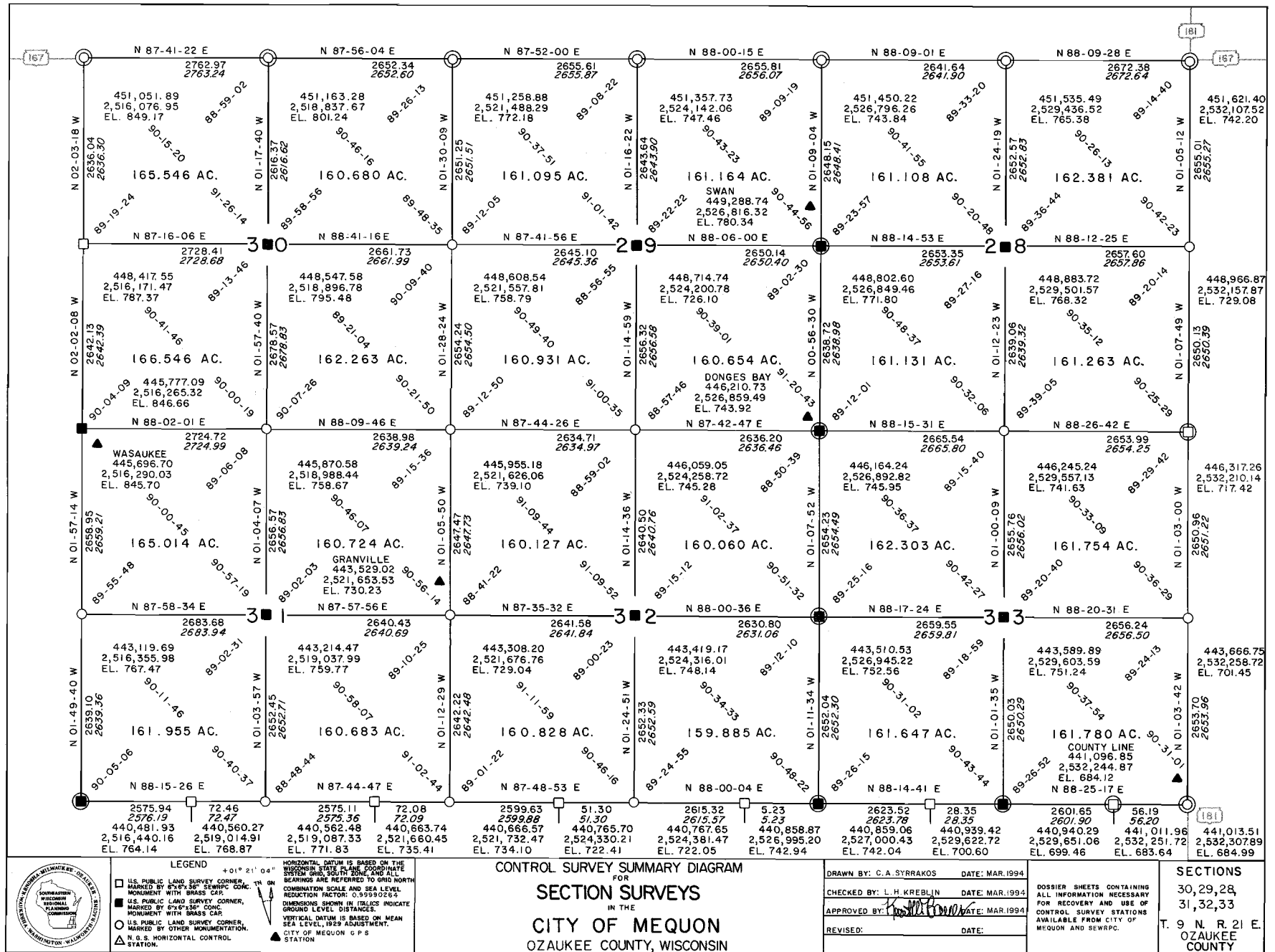


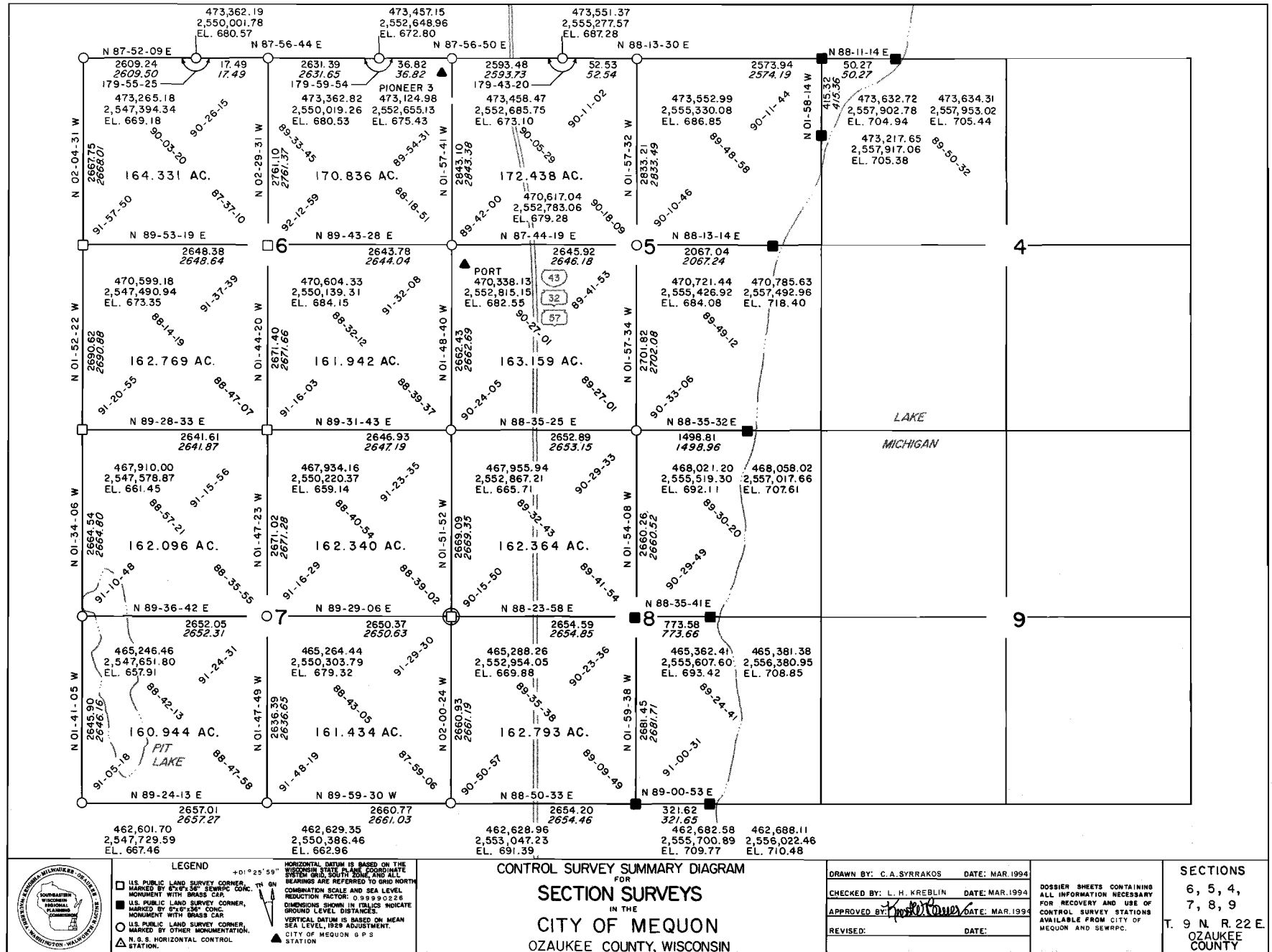


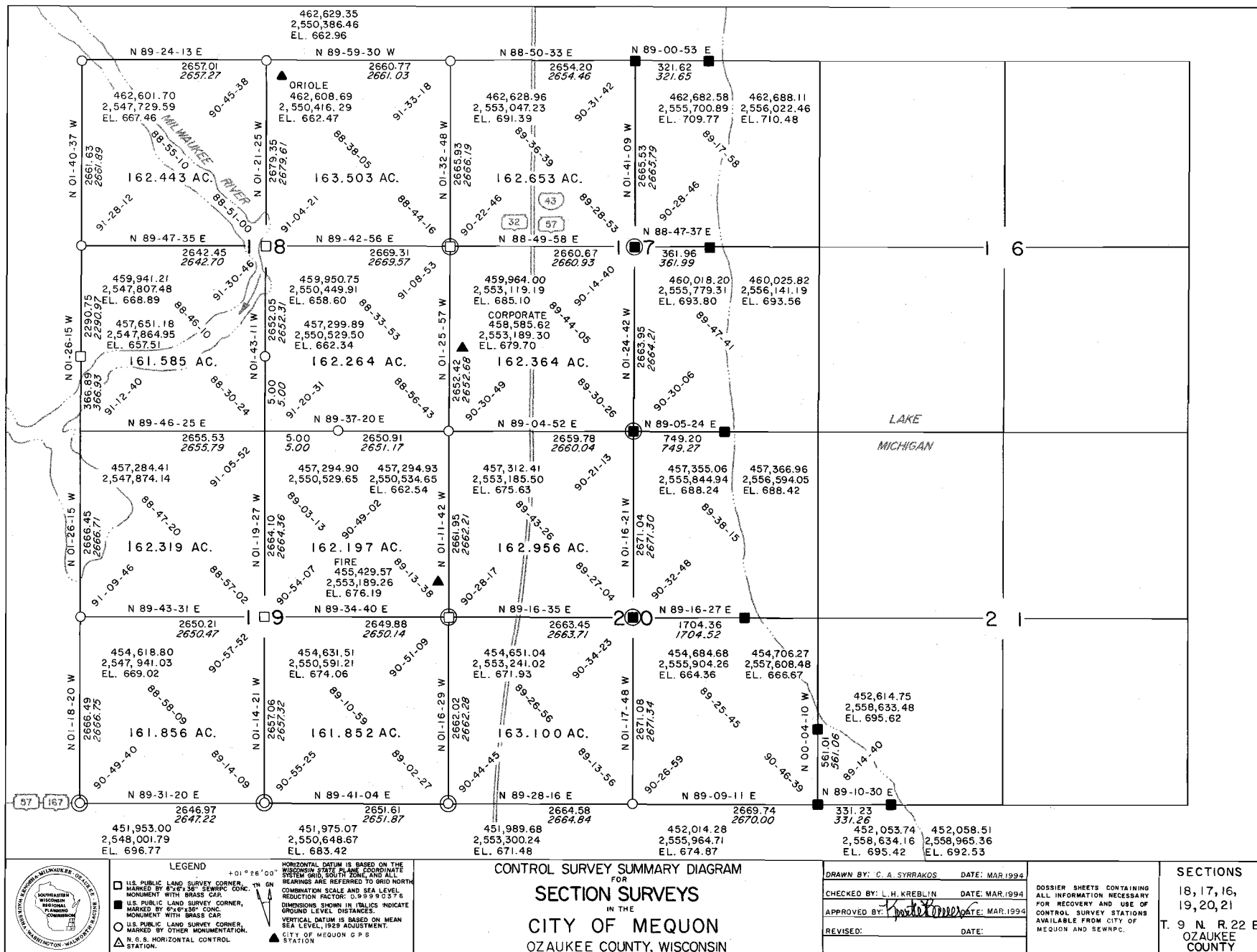












□ U.S. PUBLIC LAND SURVEY CORNER,
 MARKED BY 8"X6"X6" SEMPW COR.
 MONUMENT WITH BRASS CAP.

□ U.S. PUBLIC LAND SURVEY CORNER,
 MARKED BY 6"X6"X6" CORNER,
 MONUMENT WITH BRASS CAP.

□ U.S. PUBLIC LAND SURVEY CORNER,
 MARKED BY OTHER MONUMENTATION.

▲ N.G.S. HORIZONTAL CONTROL
 STATION.

▲ CITY OF MEQUON GPS STATION

BEARINGS ARE REFERRED TO GRID NORTH
 COMBINATION SCALE AND SEA LEVEL
 REDUCTION FACTOR: 0.99990538
 DIMENSIONS SHOWN IN ITALICS INDICATE
 GROUND LEVEL DISTANCE
 VERTICAL DATUM IS BASED ON MEAN
 SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
CITY OF MEQUON AND
VILLAGE OF BAYSIDE
OZAUKEE COUNTY, WISCONSIN

DRAWN BY: D. P. SIMON DATE: MAR, 1994

CHECKED BY: L. H. KREBLIN DATE: MAR, 1994

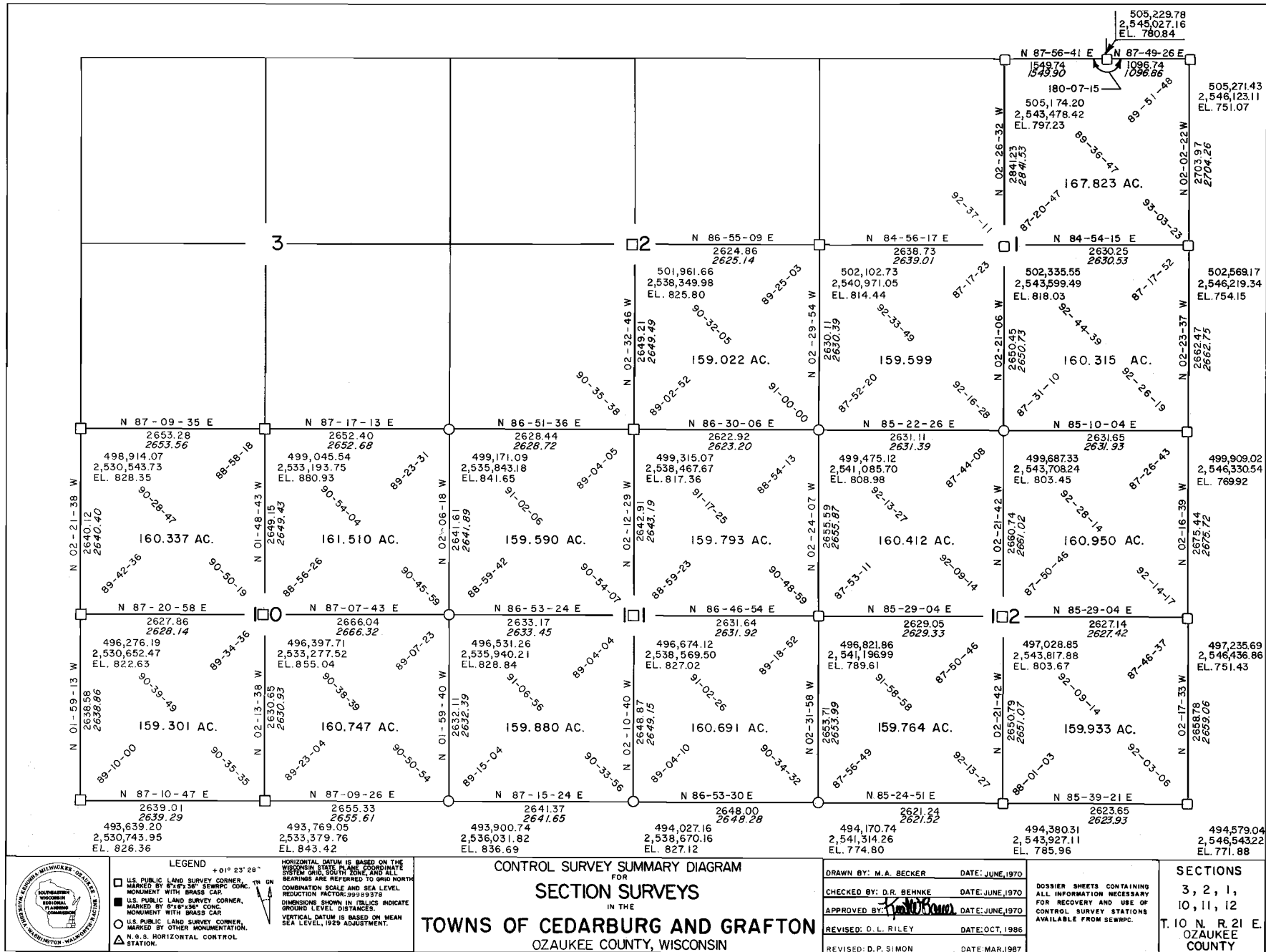
APPROVED BY: [Signature] / DATE: MAR, 1994

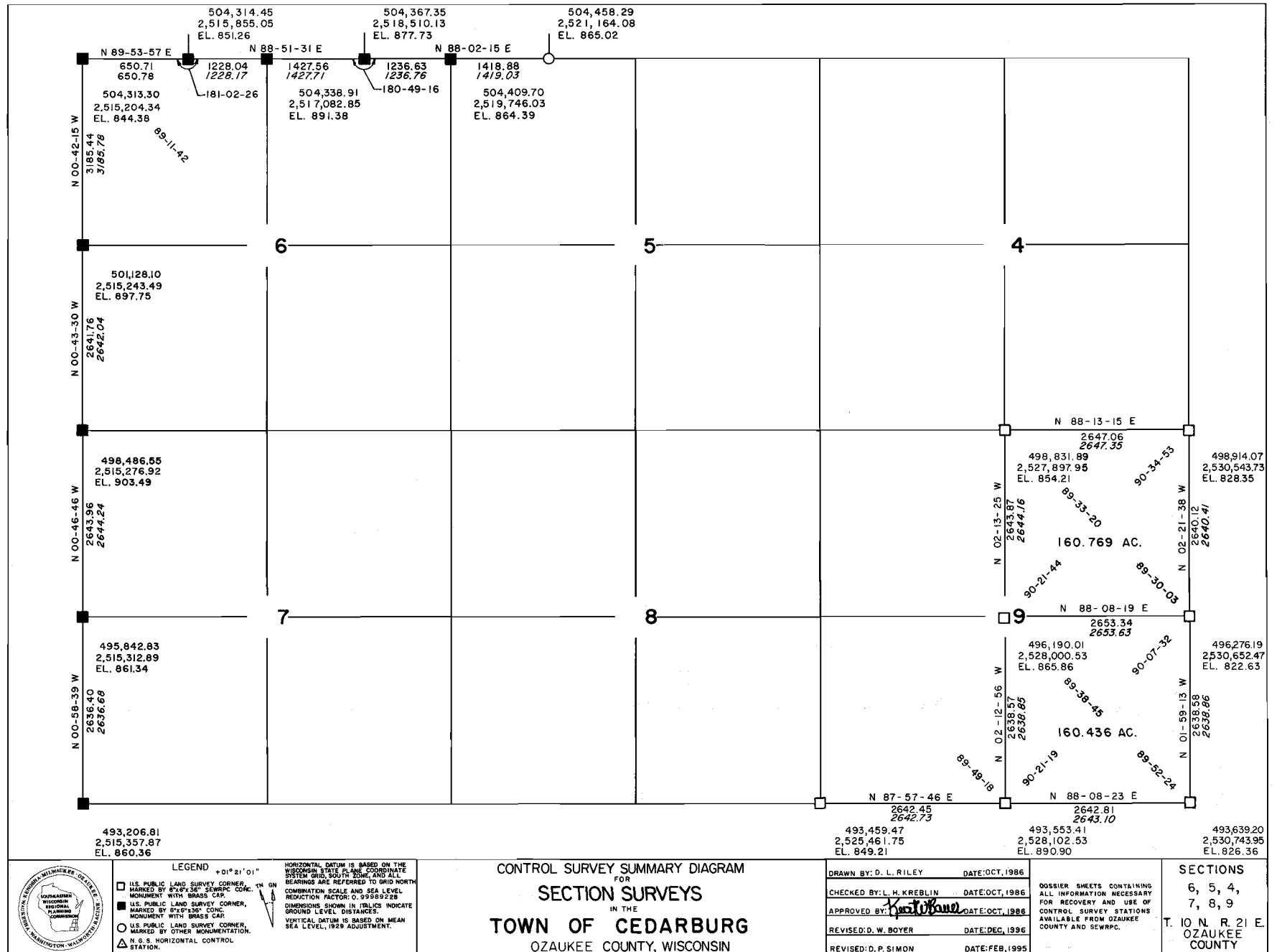
REVISOR: R.H. HEINEN DATE: APR, 1994

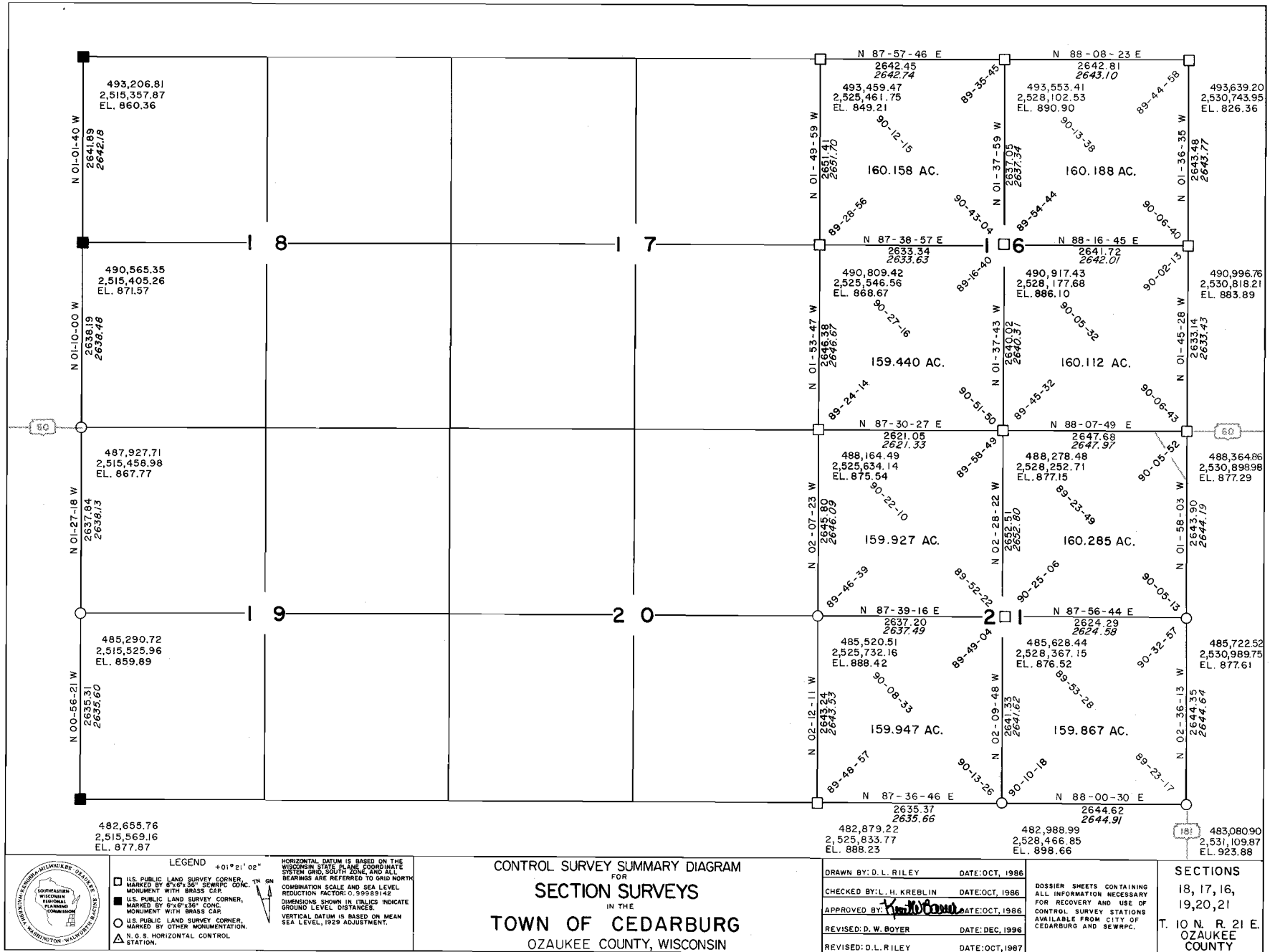
REVISED: D. P. SIMON	DATE: DEC., 1996
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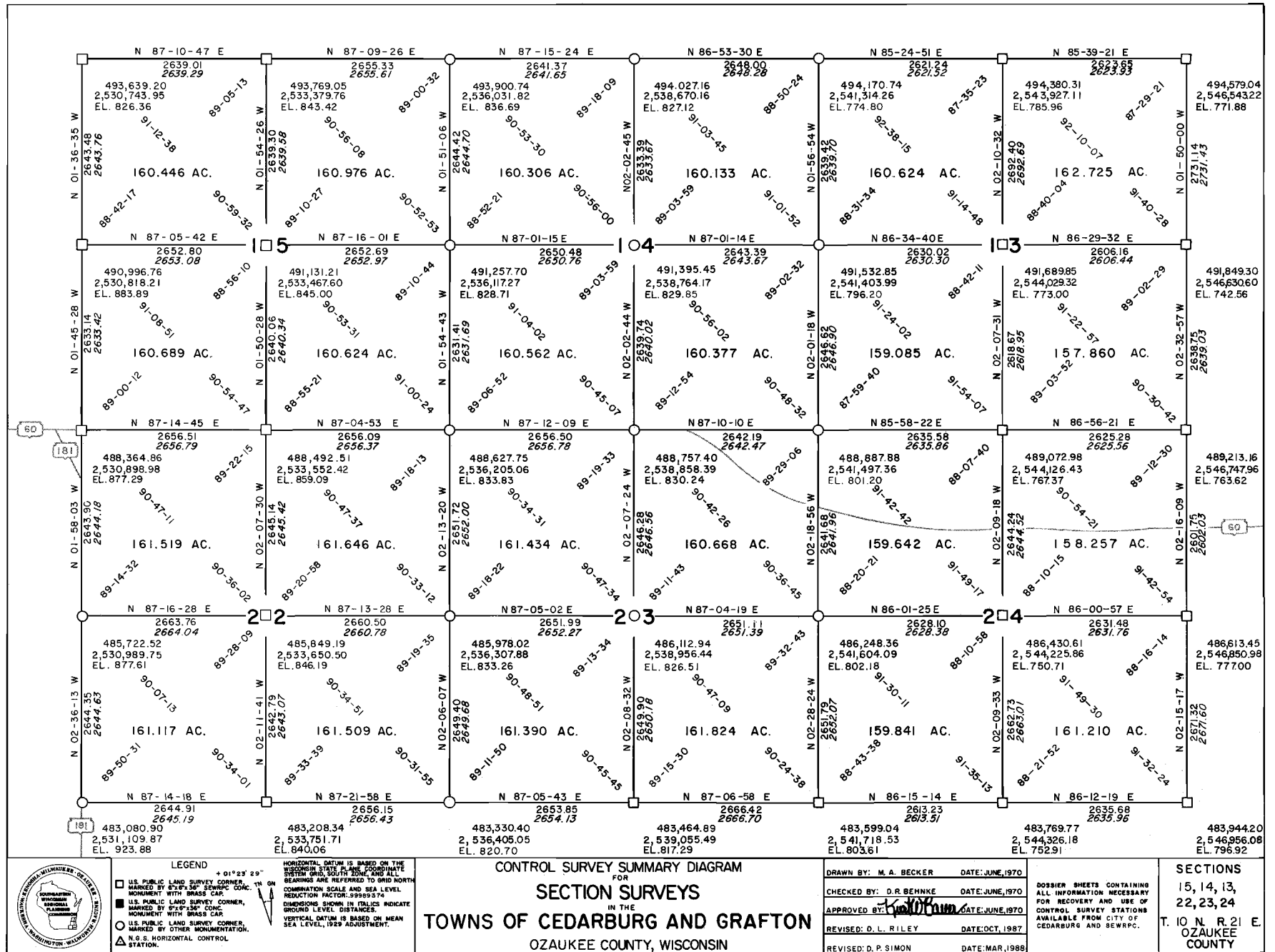
DOSSIER SHEETS CONTAINING
ALL INFORMATION NECESSARY
FOR RECOVERY AND USE OF
CONTROL SURVEY STATIONS
AVAILABLE FROM CITY OF
MEQUON AND SEWRPC.

SECTIONS
30,29,28,
31,32,33
9 N. R.22 E.
OZAUKEE
COUNTY

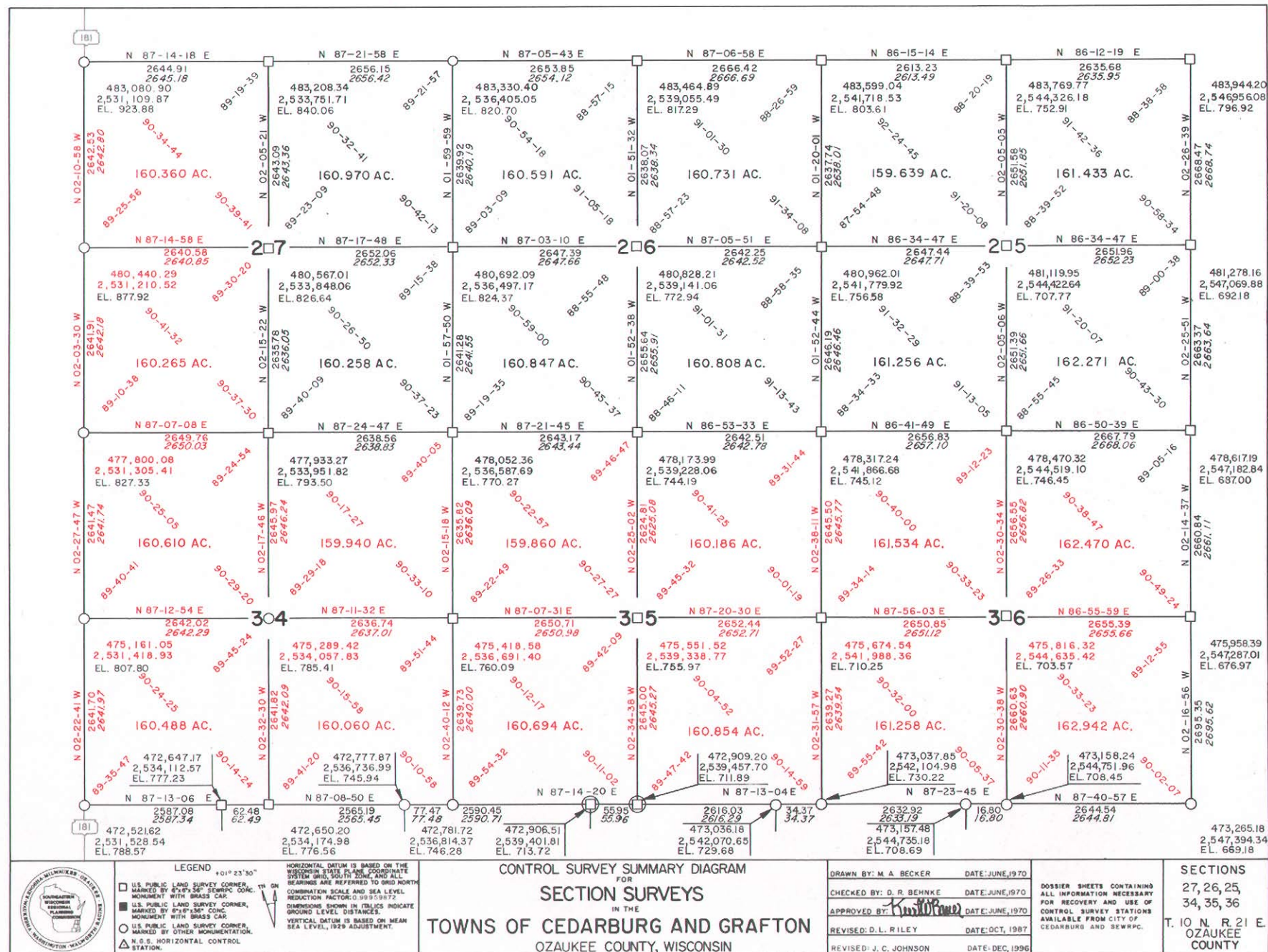






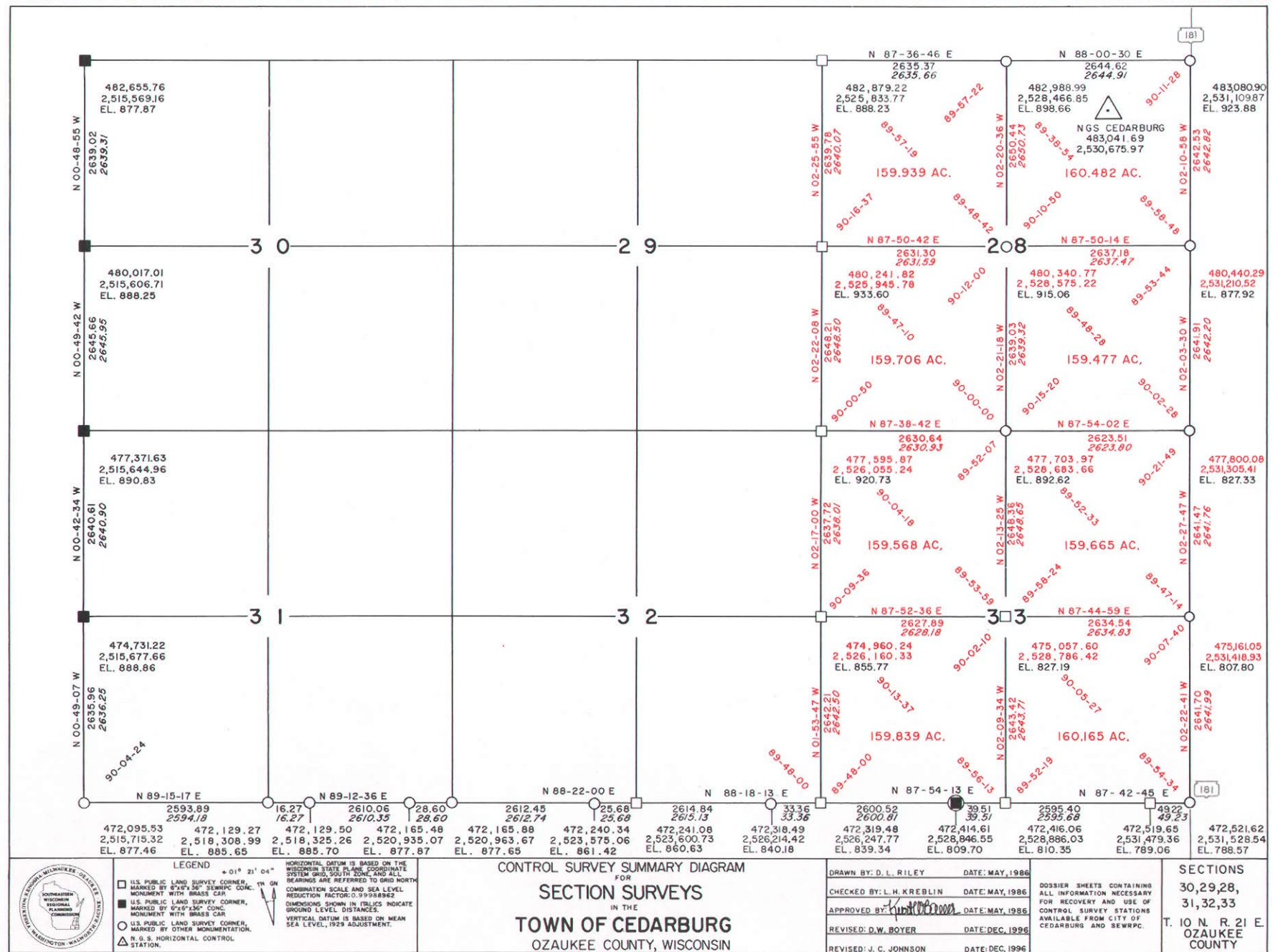


THE HORIZONTAL CONTROL SURVEY DATA SHOWN IN RED WERE DERIVED BY A READJUSTMENT OF PREVIOUSLY ADJUSTED DATA AND, AS SUCH, MAY NOT MEET THIRD ORDER, CLASS I ACCURACY. FIELD VERIFICATION OF THE DATA SHOWN IN RED MAY BE DESIRABLE, AND THE REQUIRED ADDITIONAL FIELD SURVEYS NECESSARY TO CORRECT ANY CONTROL SURVEY DEFICIENCIES ARE BEING SCHEDULED.

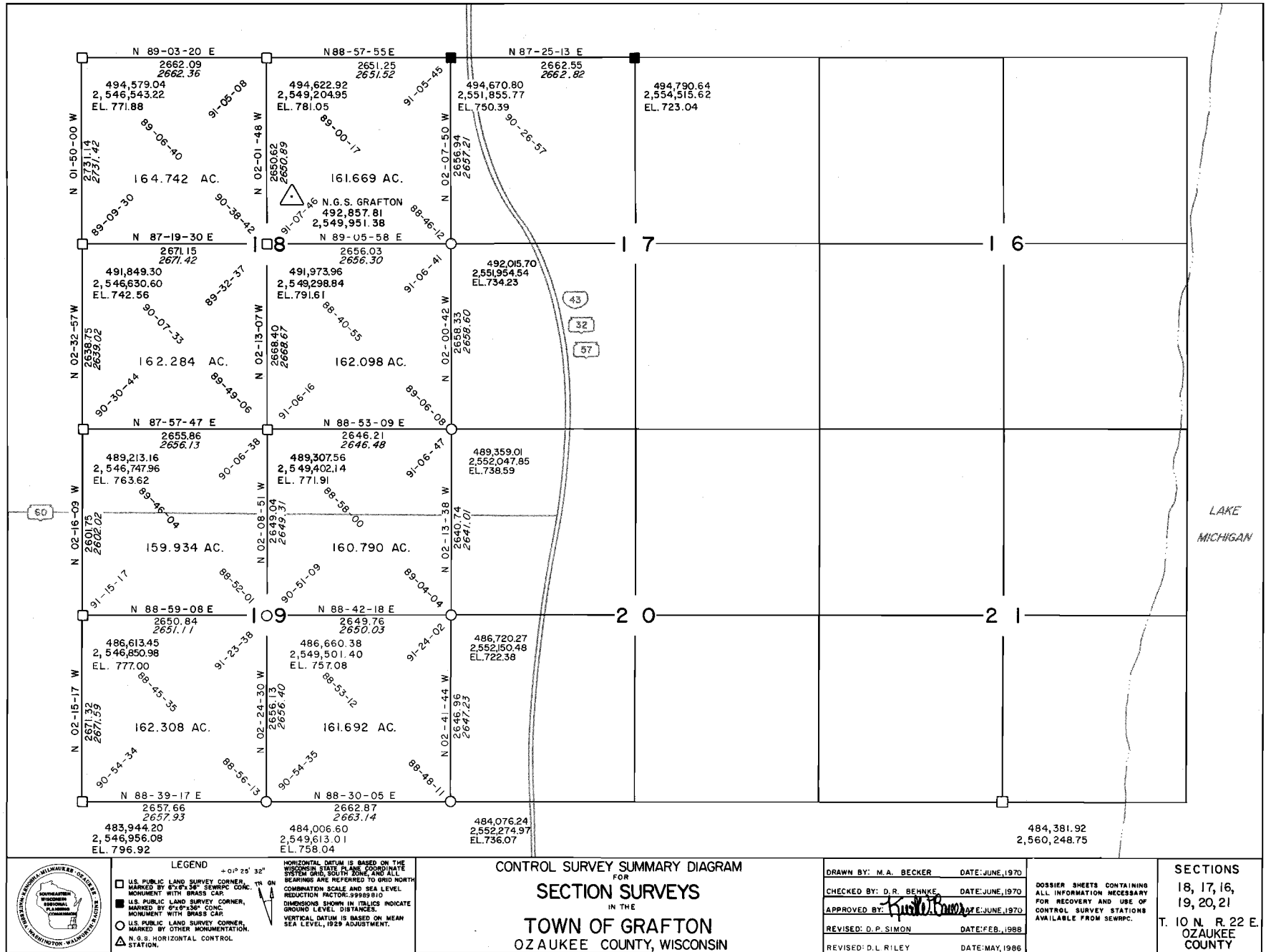


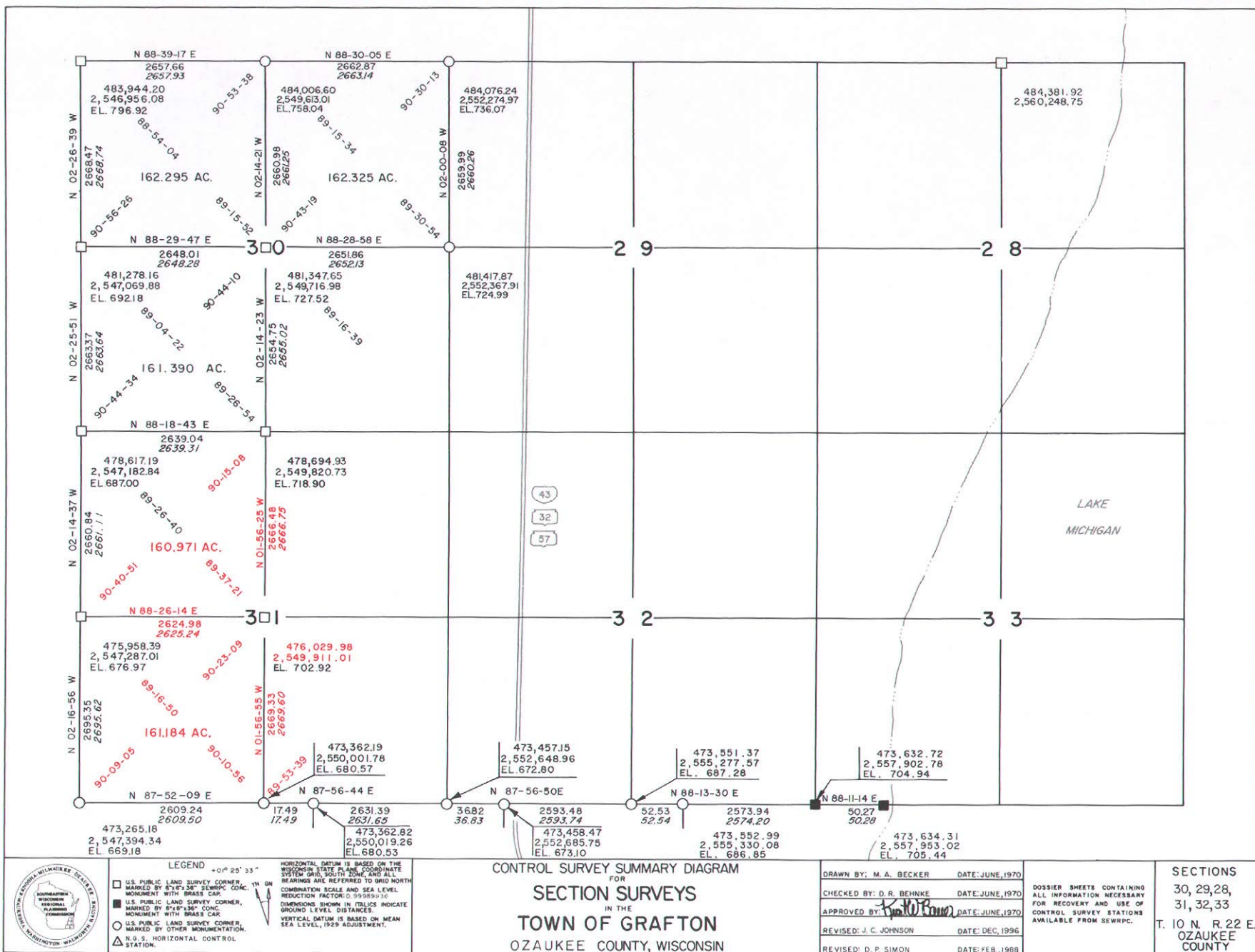
THE HORIZONTAL CONTROL SURVEY DATA SHOWN IN RED WERE DERIVED BY A READJUSTMENT OF PREVIOUSLY ADJUSTED DATA AND, AS SUCH, MAY NOT MEET THIRD ORDER, CLASS II SURVEY. FIELD VERIFICATION OF THE DATA SHOWN IN RED MAY BE DESIRABLE, AND THE REQUIRED ADDITIONAL FIELD SURVEYS NECESSARY TO CORRECT ANY CONTROL SURVEY DEFICIENCIES ARE BEING SCHEDULED.

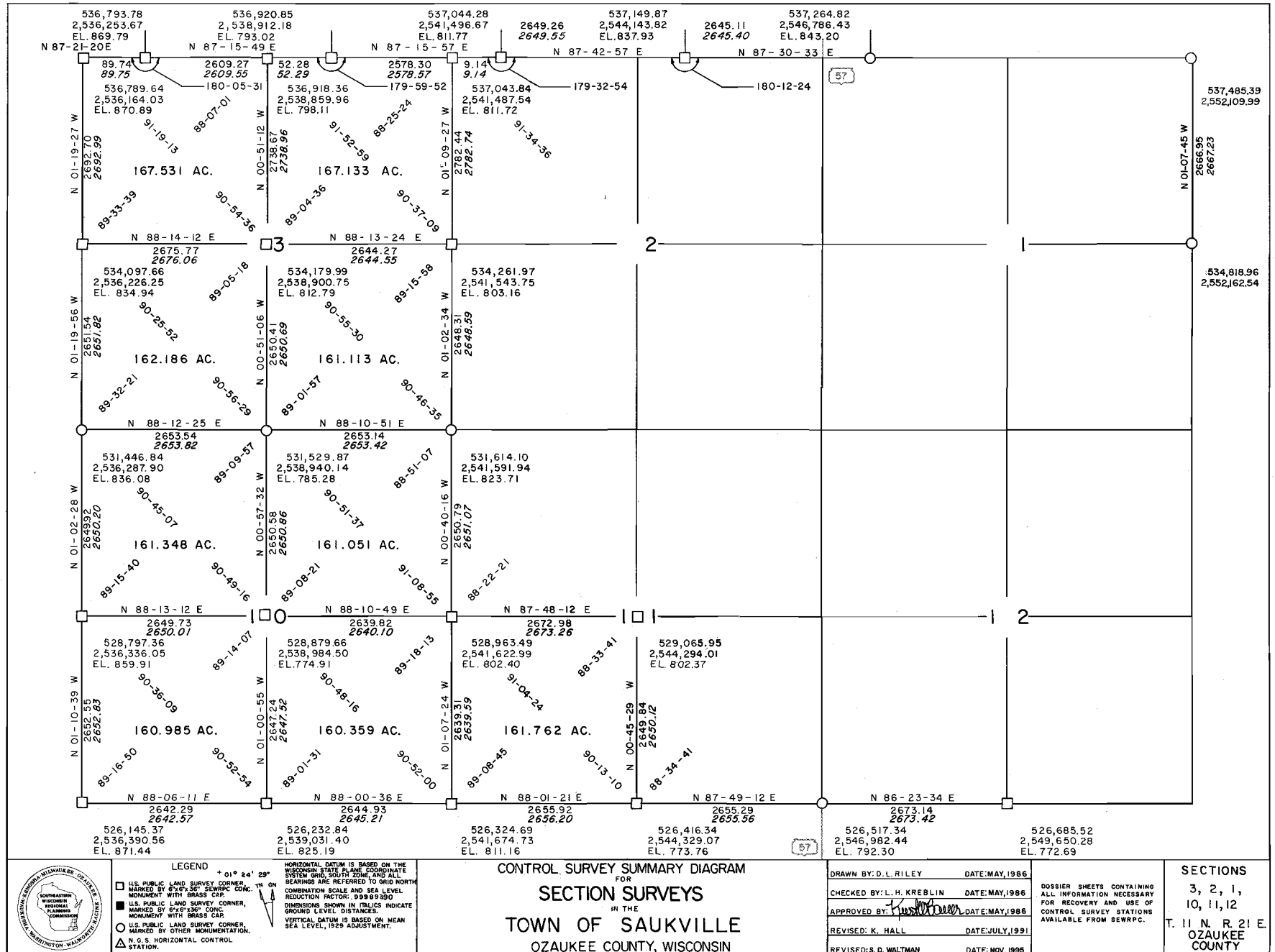
226

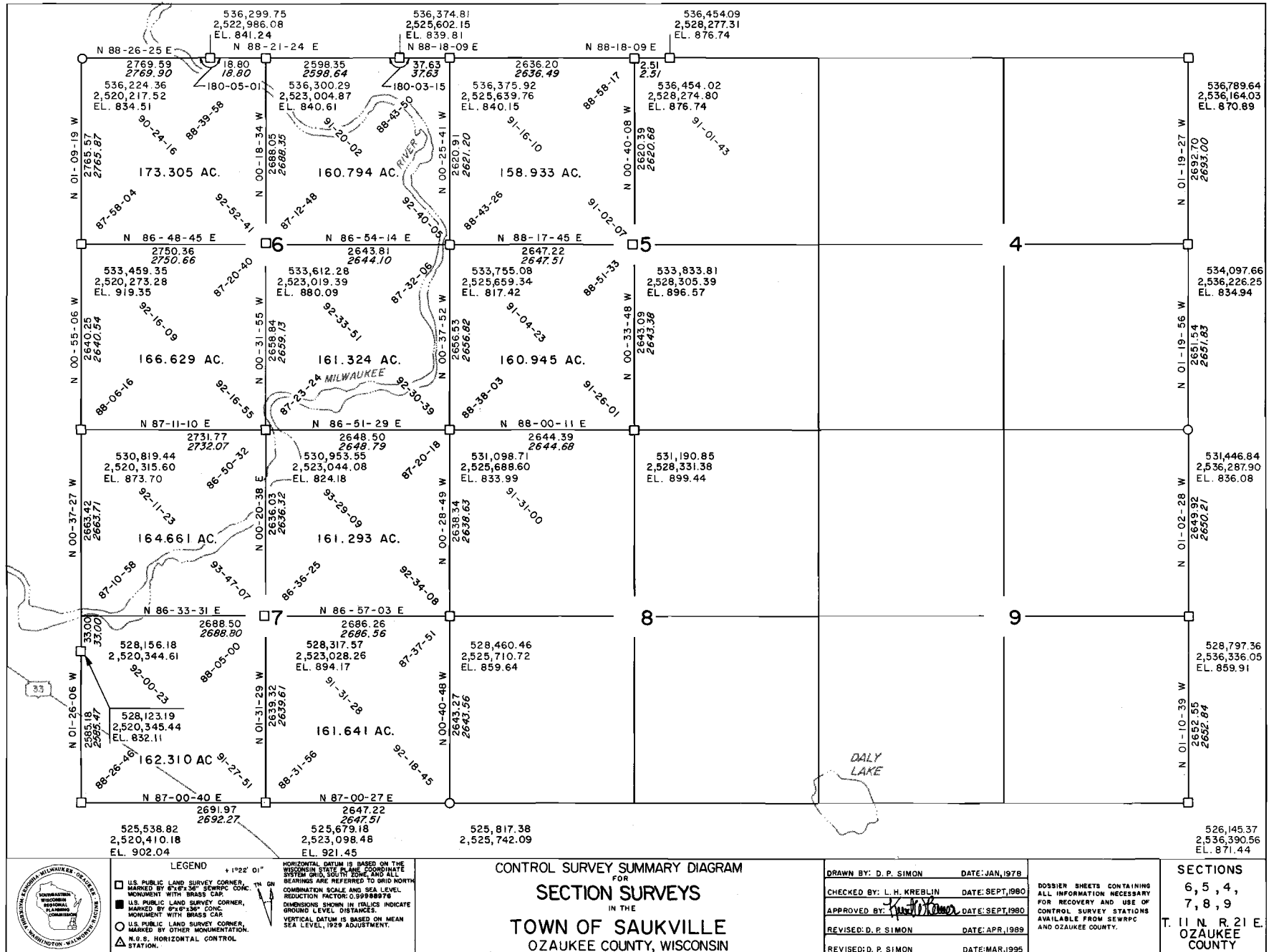


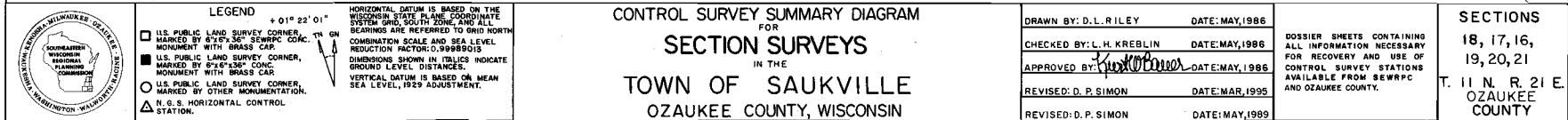
		<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>3</p> <p>2</p> <p>1</p> </div> <div style="text-align: center;"> <p>10</p> <p>11</p> <p>12</p> </div> </div>												
	<p style="text-align: center; margin-bottom: 5px;">LEGEND</p> <div style="display: flex; align-items: flex-start;"> <div style="margin-right: 10px;"> <p><input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEWRPC CONC. MONUMENT WITH BRASS CAP.</p> <p><input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.</p> <p><input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.</p> <p><input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.</p> </div> <div style="font-size: 0.8em;"> <p>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.</p> <p>COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.</p> <p>VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</p> </div> </div>	<p>CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF GRAFTON OZAUKEE COUNTY, WISCONSIN</p>		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">DRAWN BY:</td> <td>DATE:</td> </tr> <tr> <td>CHECKED BY:</td> <td>DATE:</td> </tr> <tr> <td>APPROVED BY:</td> <td>DATE:</td> </tr> <tr> <td>REVISED:</td> <td>DATE:</td> </tr> </table>	DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:	<p>COSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM</p>	<p>SECTIONS</p> <p>3, 2, 1, 10, 11, 12</p> <p>T. 10 N. R. 22 E. OZAUKEE COUNTY</p>
DRAWN BY:	DATE:													
CHECKED BY:	DATE:													
APPROVED BY:	DATE:													
REVISED:	DATE:													

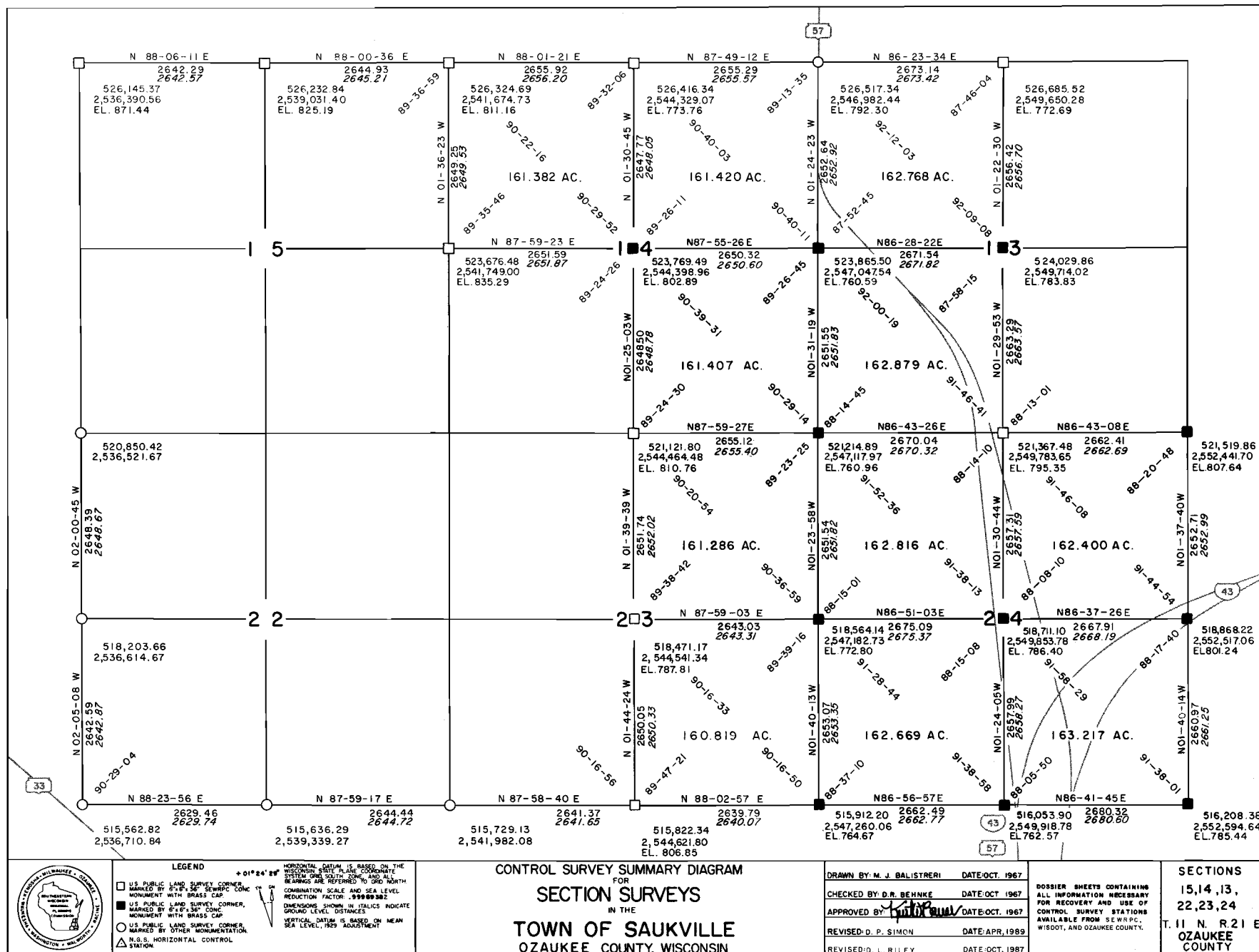


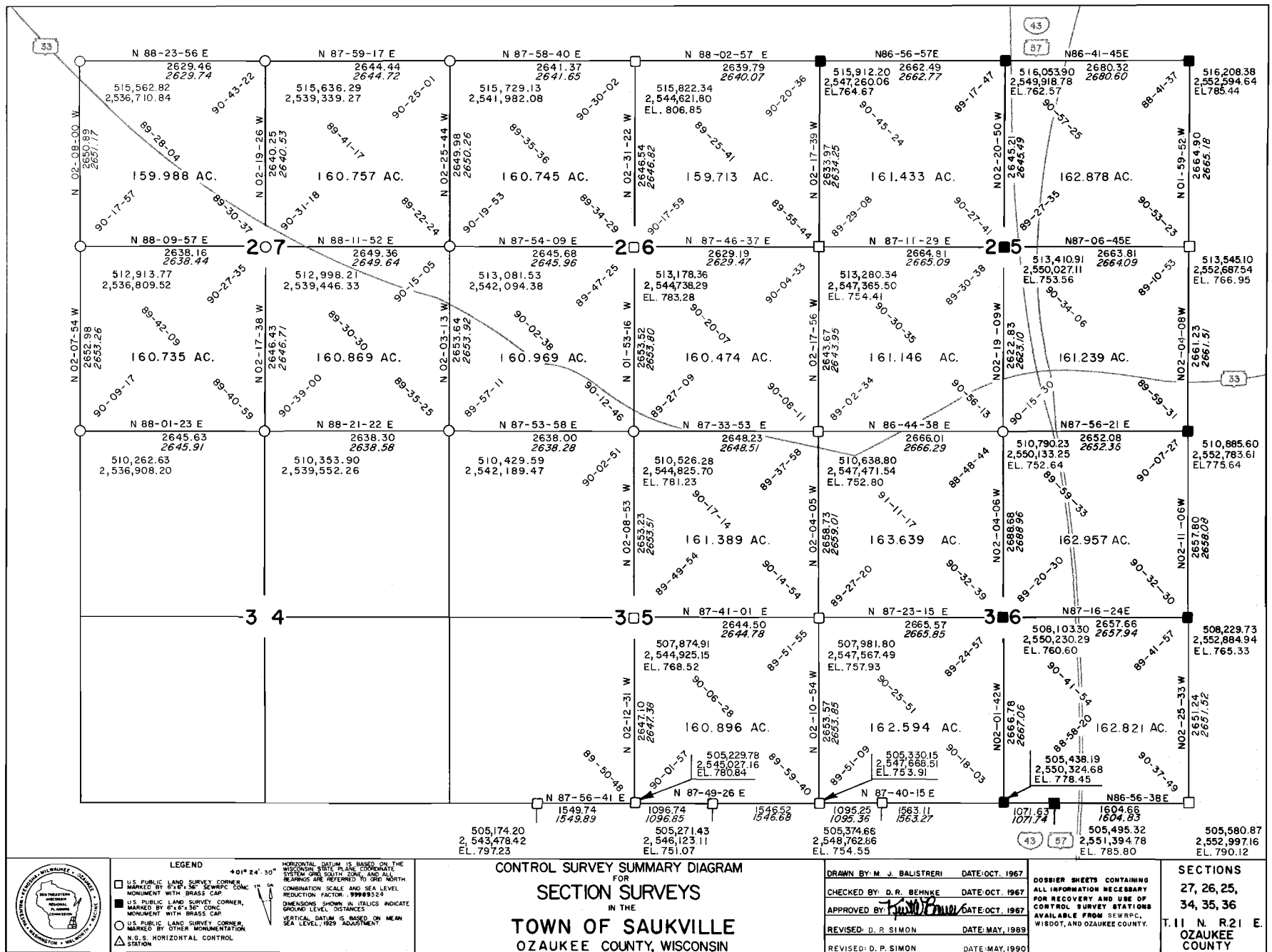


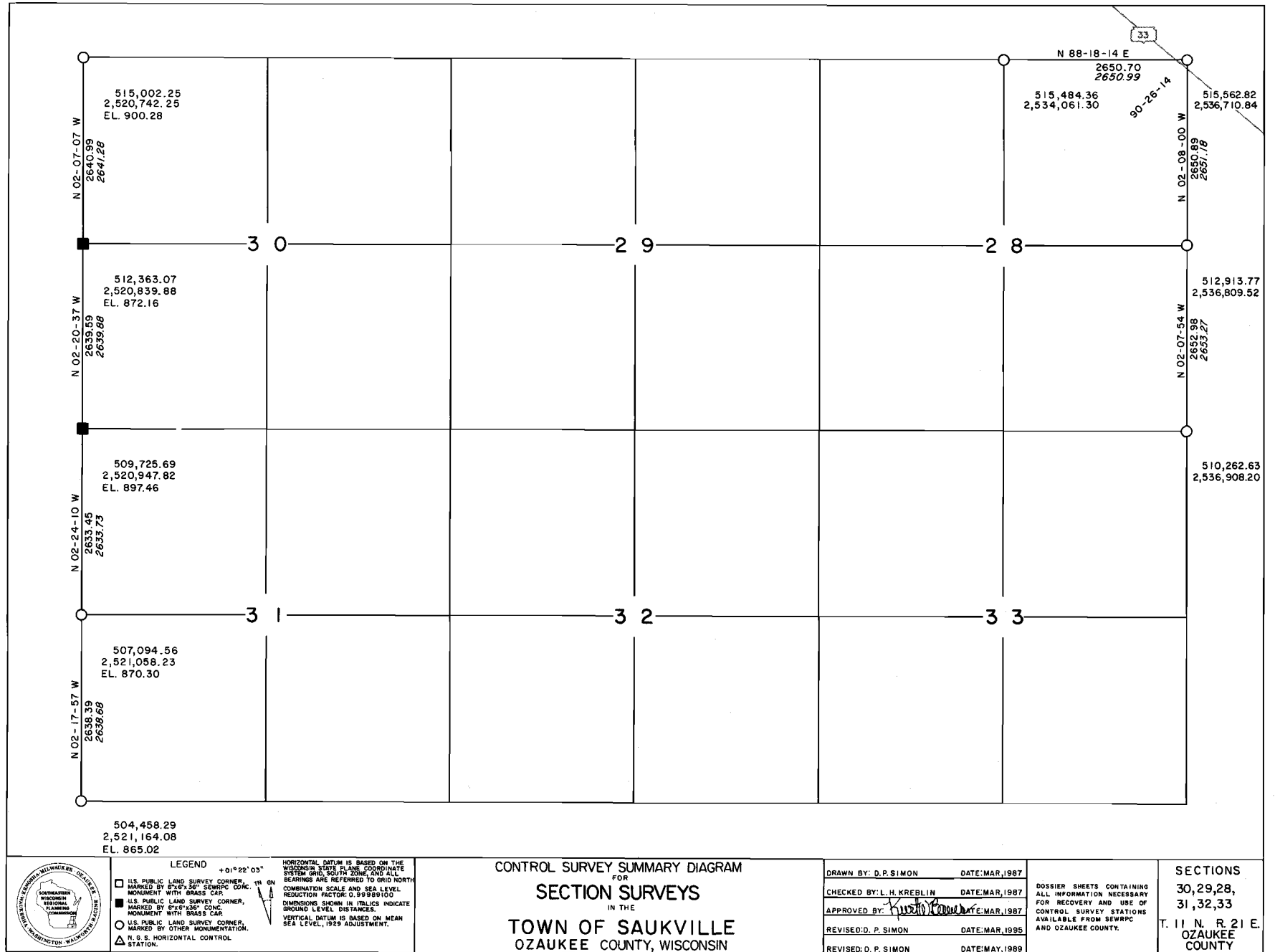


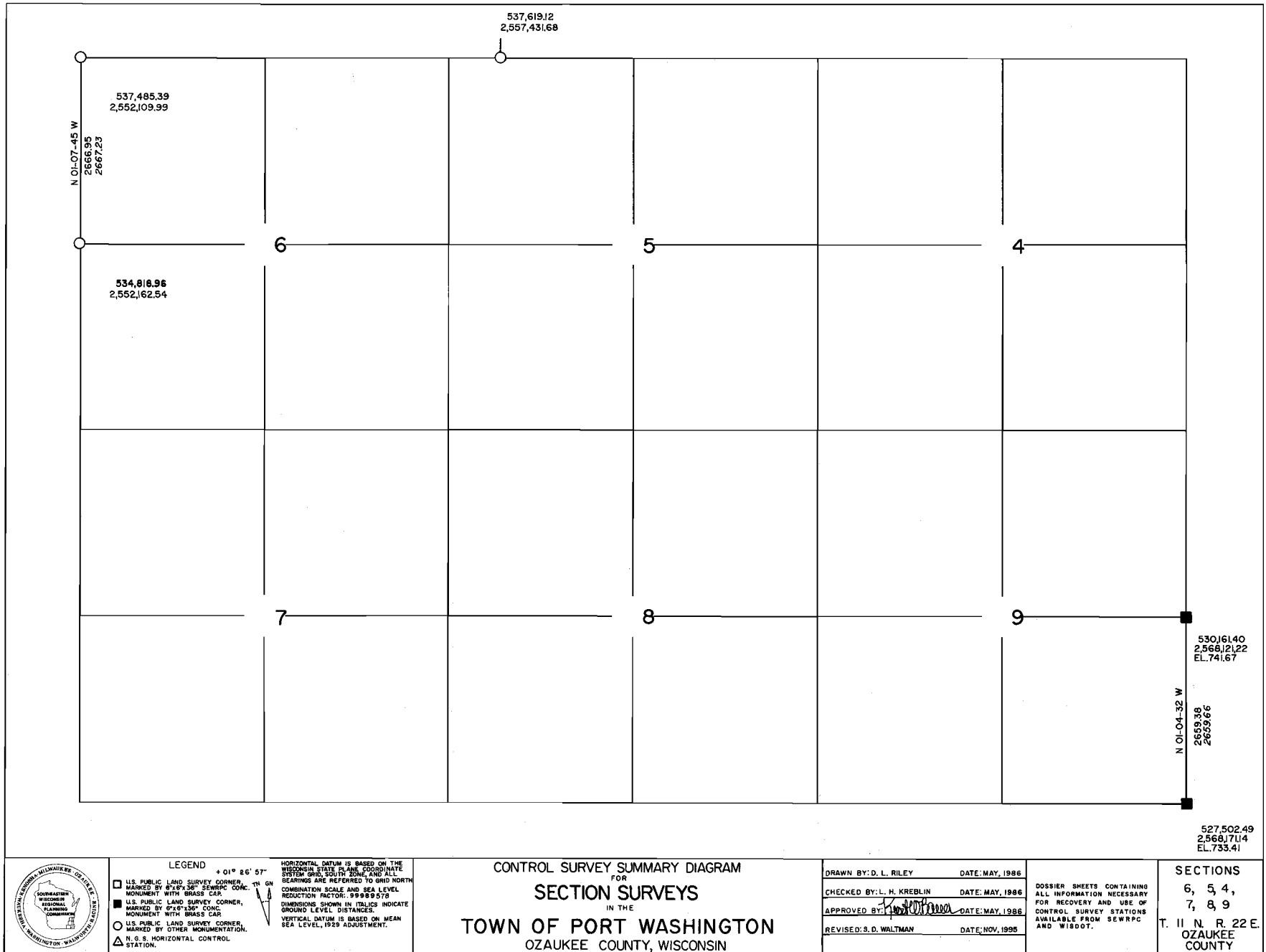


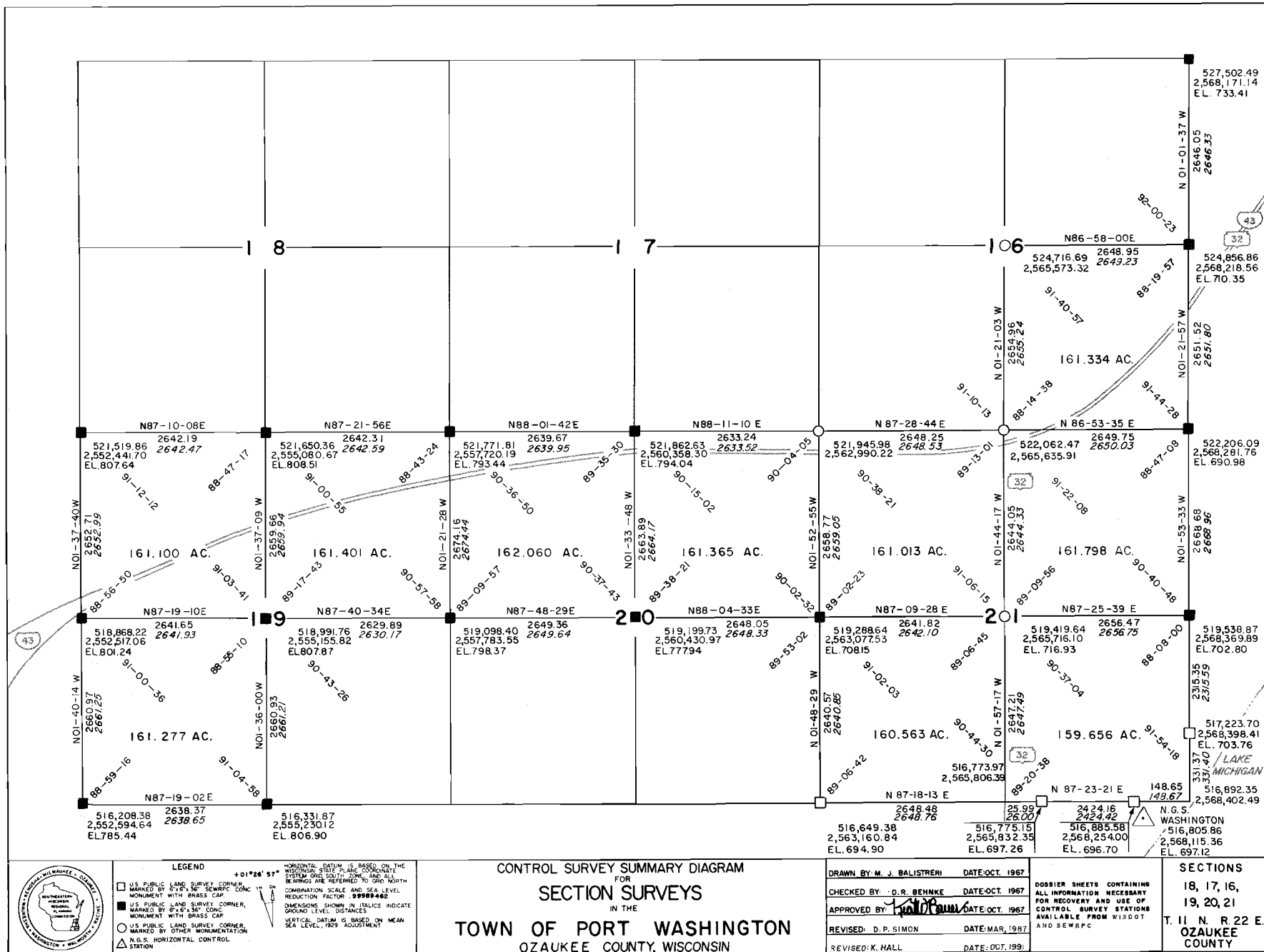


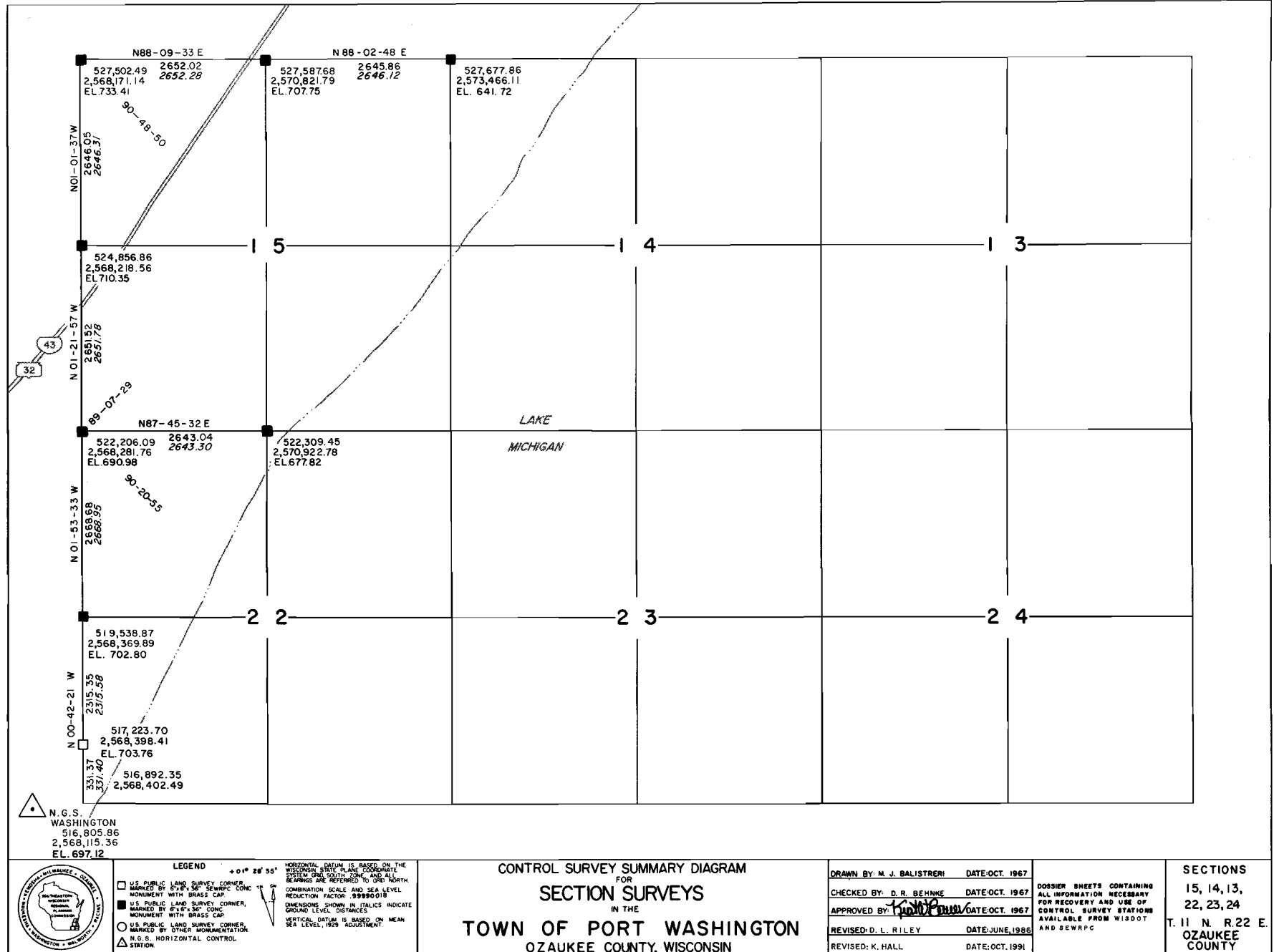




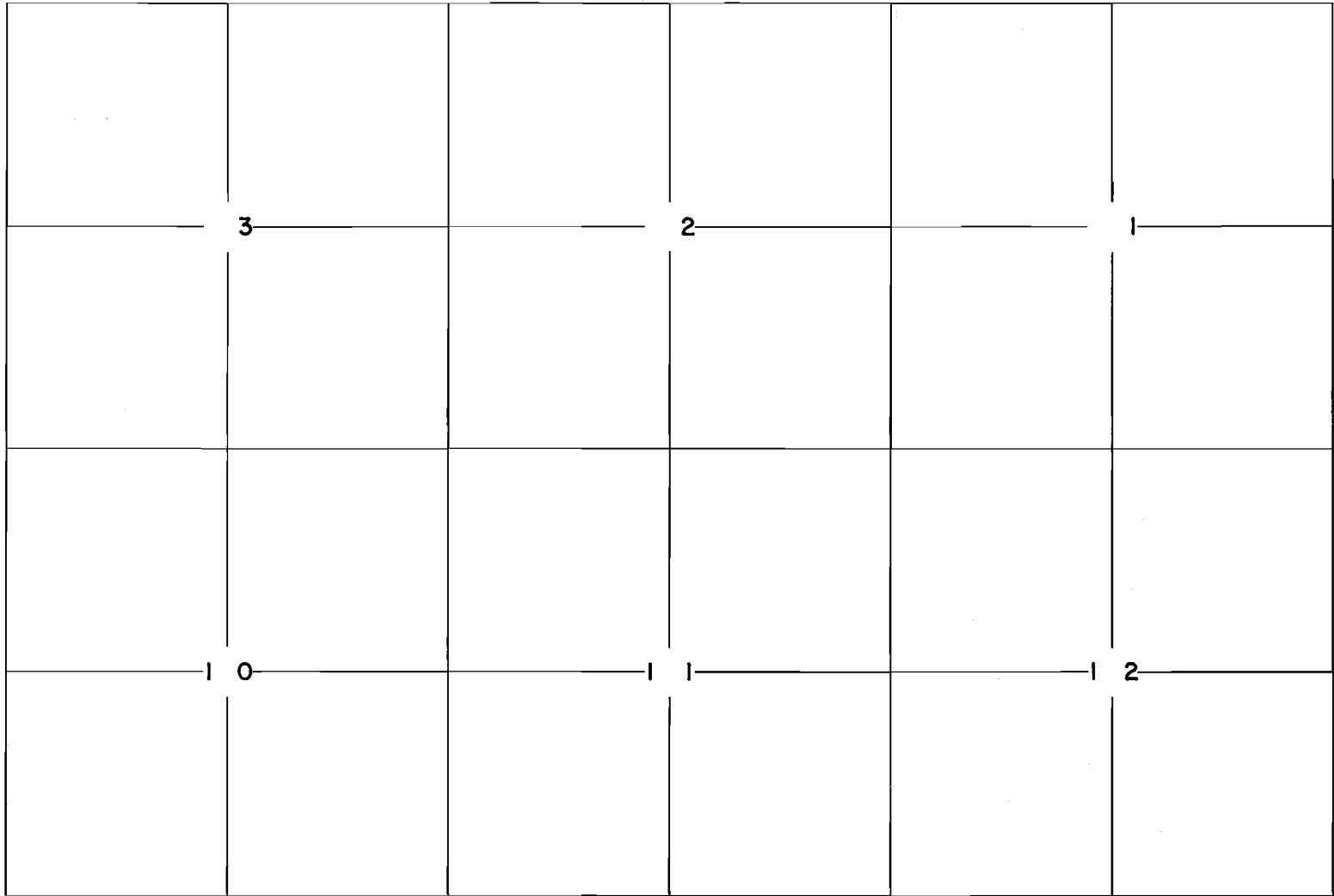












LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6" 36" CONC. MONUMENT WITH BRASS CAP
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6" 36" CONC. MONUMENT WITH BRASS CAP
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION
- ☐ N. G. S. HORIZONTAL CONTROL STATION

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH

REDUCTION FACTOR:

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF FREDONIA
OZAUKEE COUNTY, WISCONSIN

DRAWN BY: _____ DATE: _____

CHECKED BY: _____ DATE: _____

APPROVED BY: _____ DATE: _____

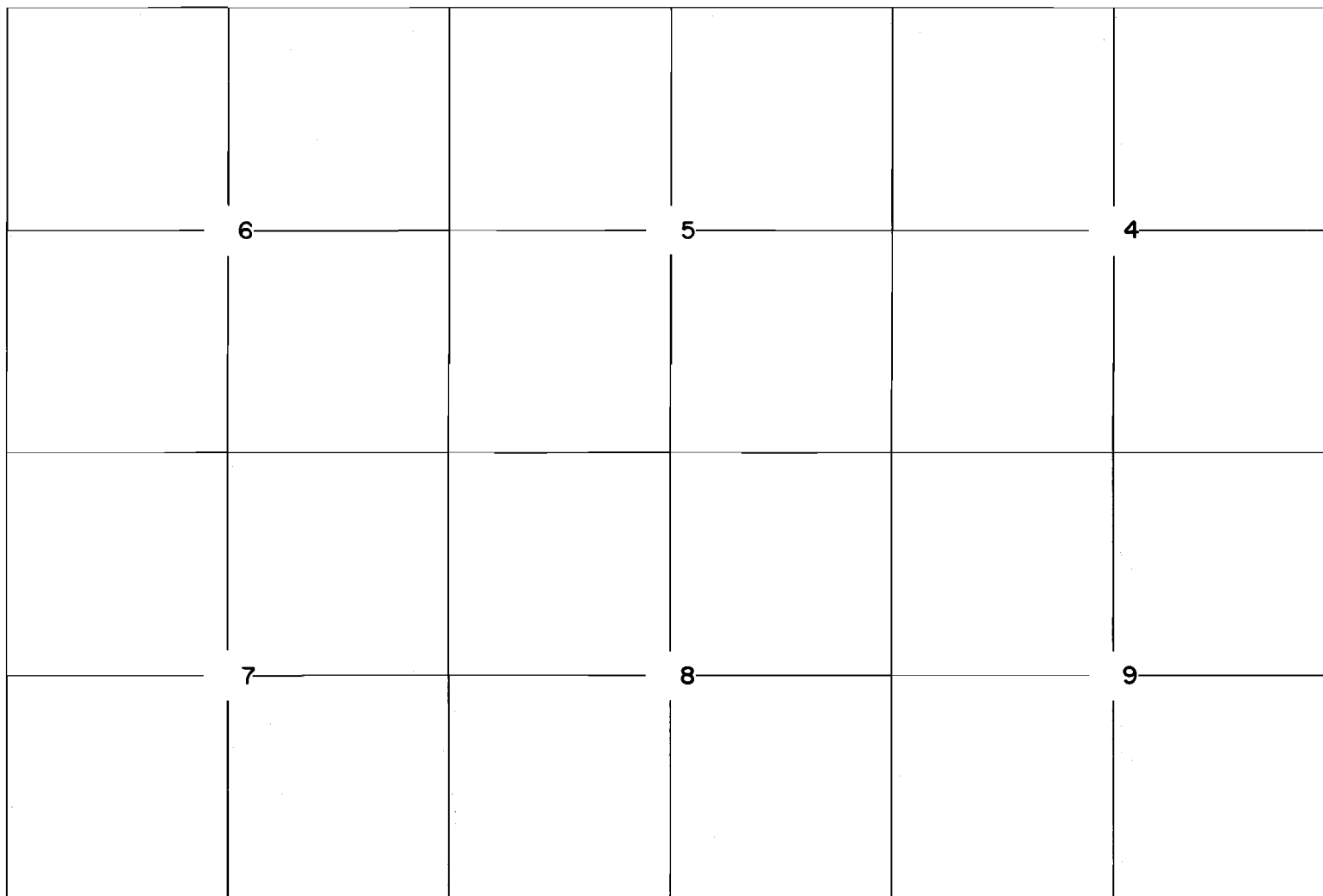
REVISED: _____ DATE: _____

DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS

3, 2, 1,
10, 11, 12

T. 12 N. R. 21 E.
OZAUKEE COUNTY



LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N. S. S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

REDUCTION FACTOR:
DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

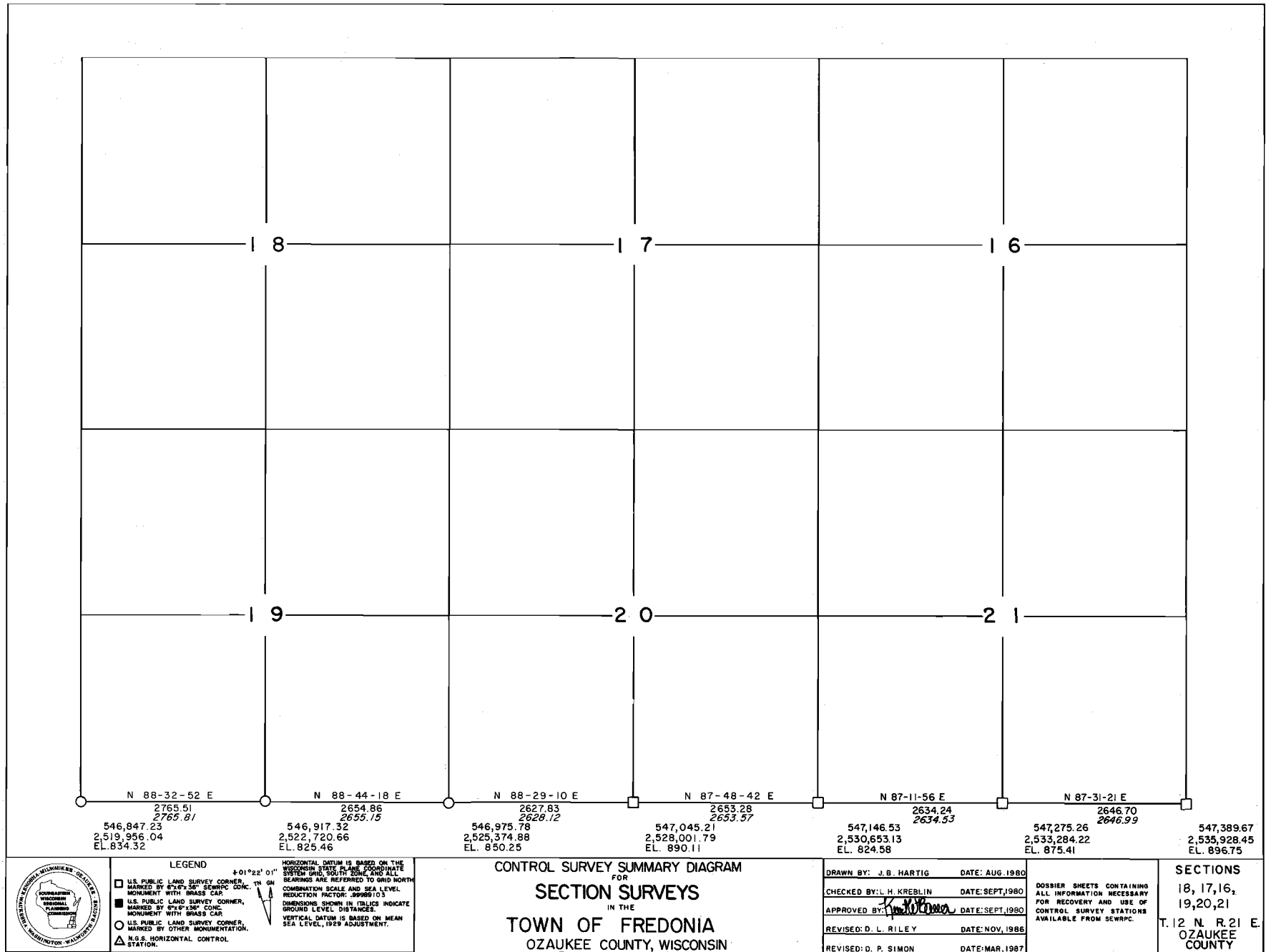
CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF FREDONIA OZAUKEE COUNTY, WISCONSIN

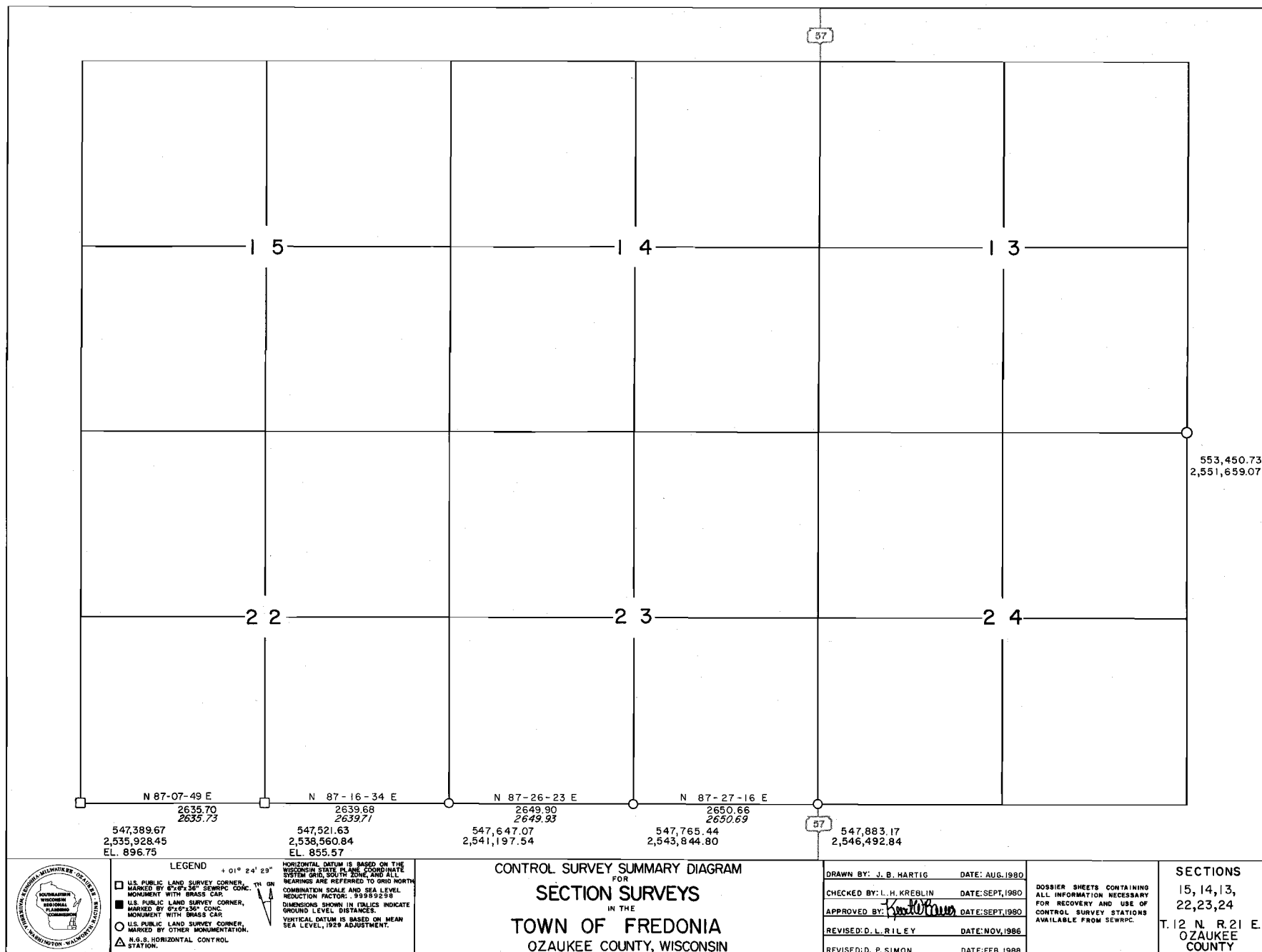
DRAWN BY:	DATE:
CHECKED BY:	DATE:
APPROVED BY:	DATE:
REVISED:	DATE:

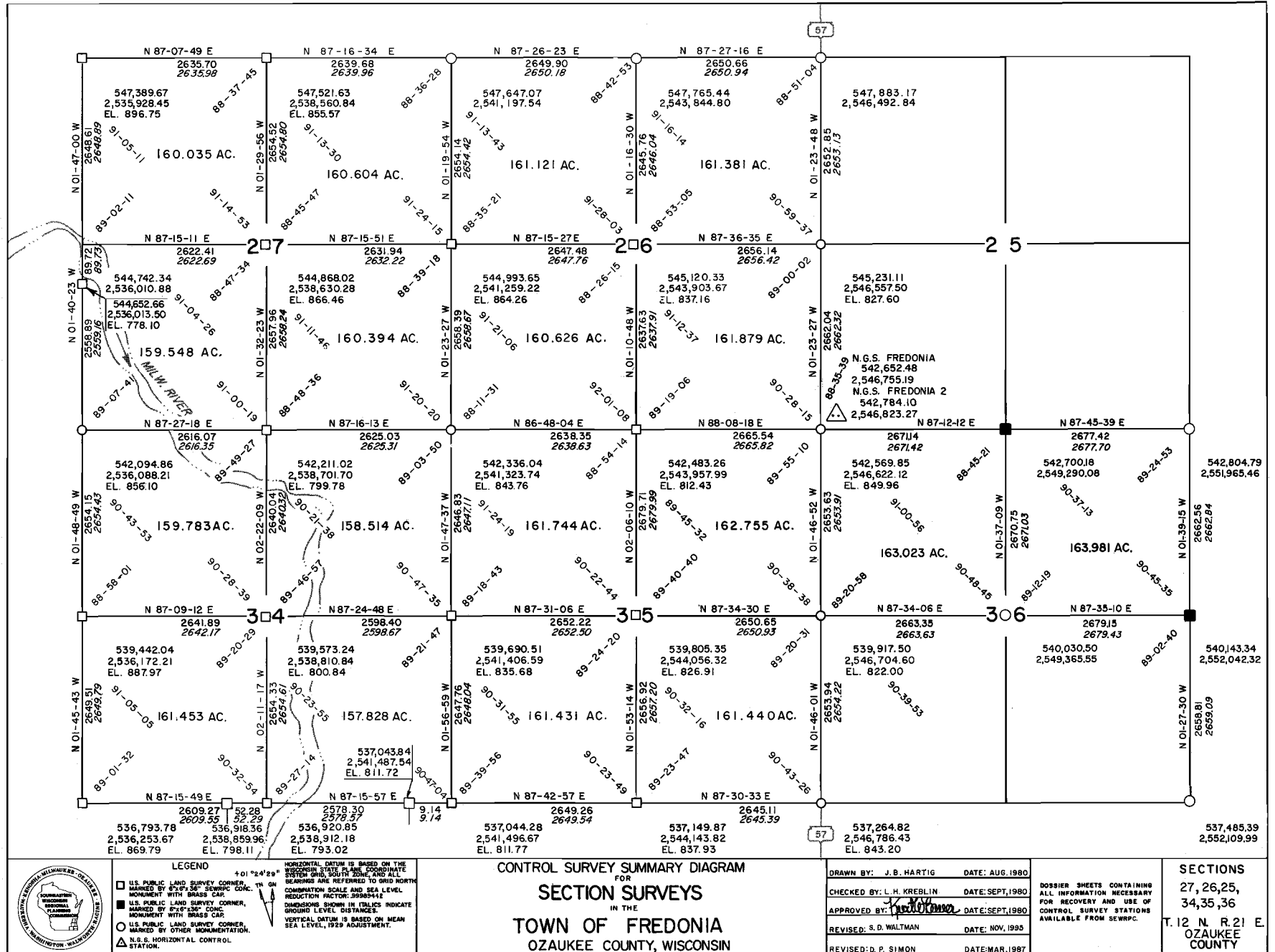
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

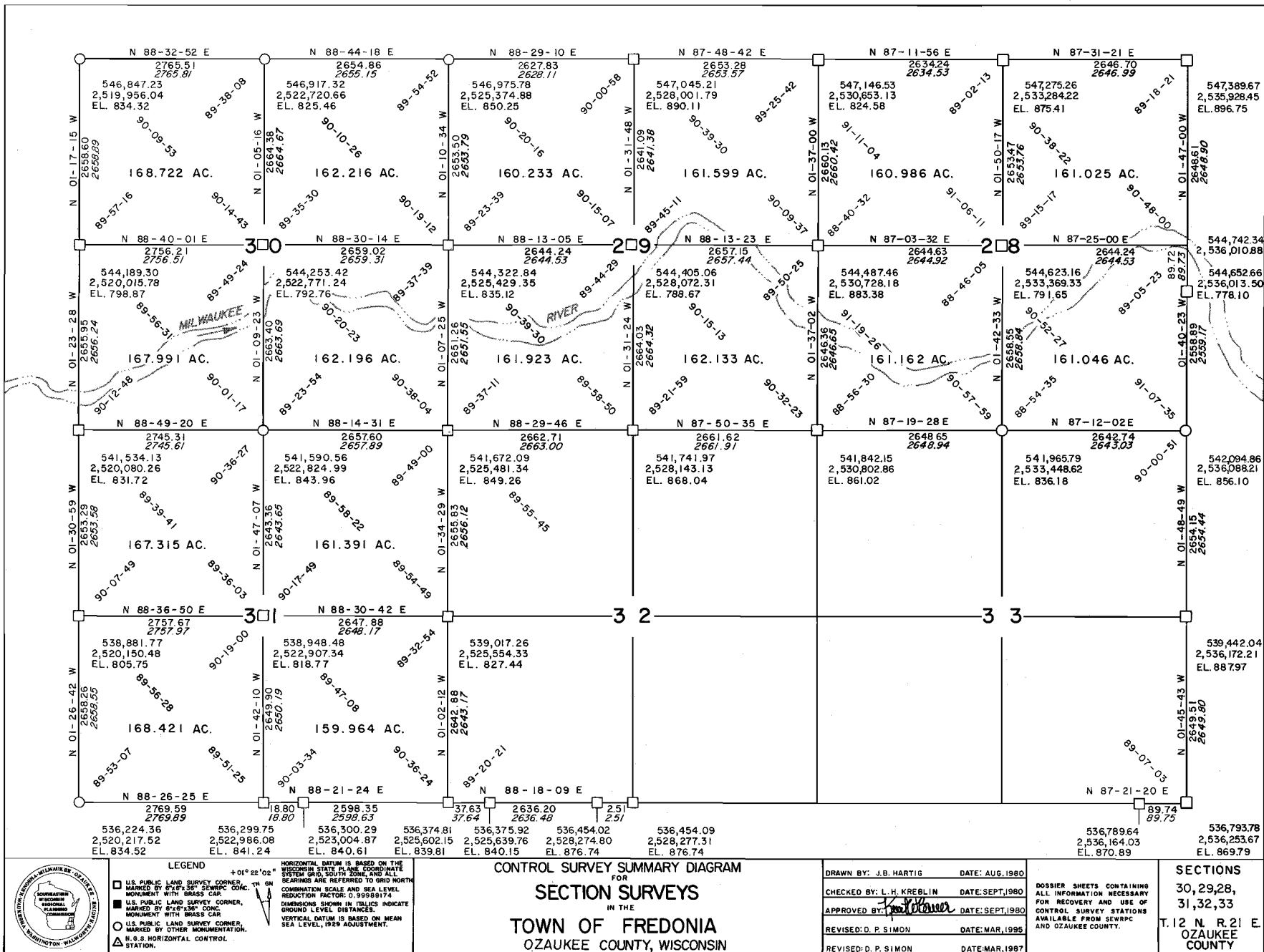
SECTIONS

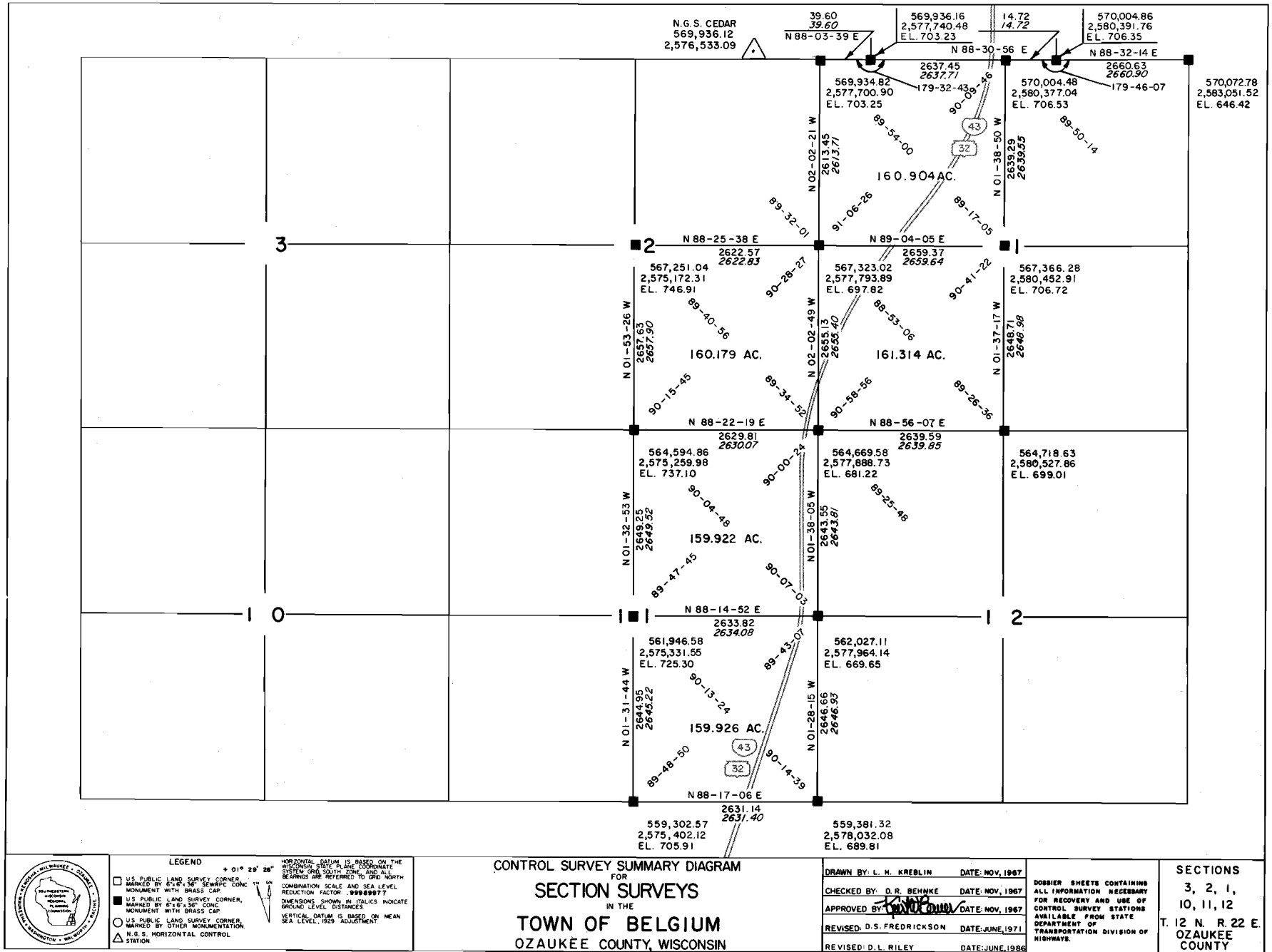
6, 5, 4,
7, 8, 9
T. 12 N. R. 21 E.
OZAUKEE
COUNTY

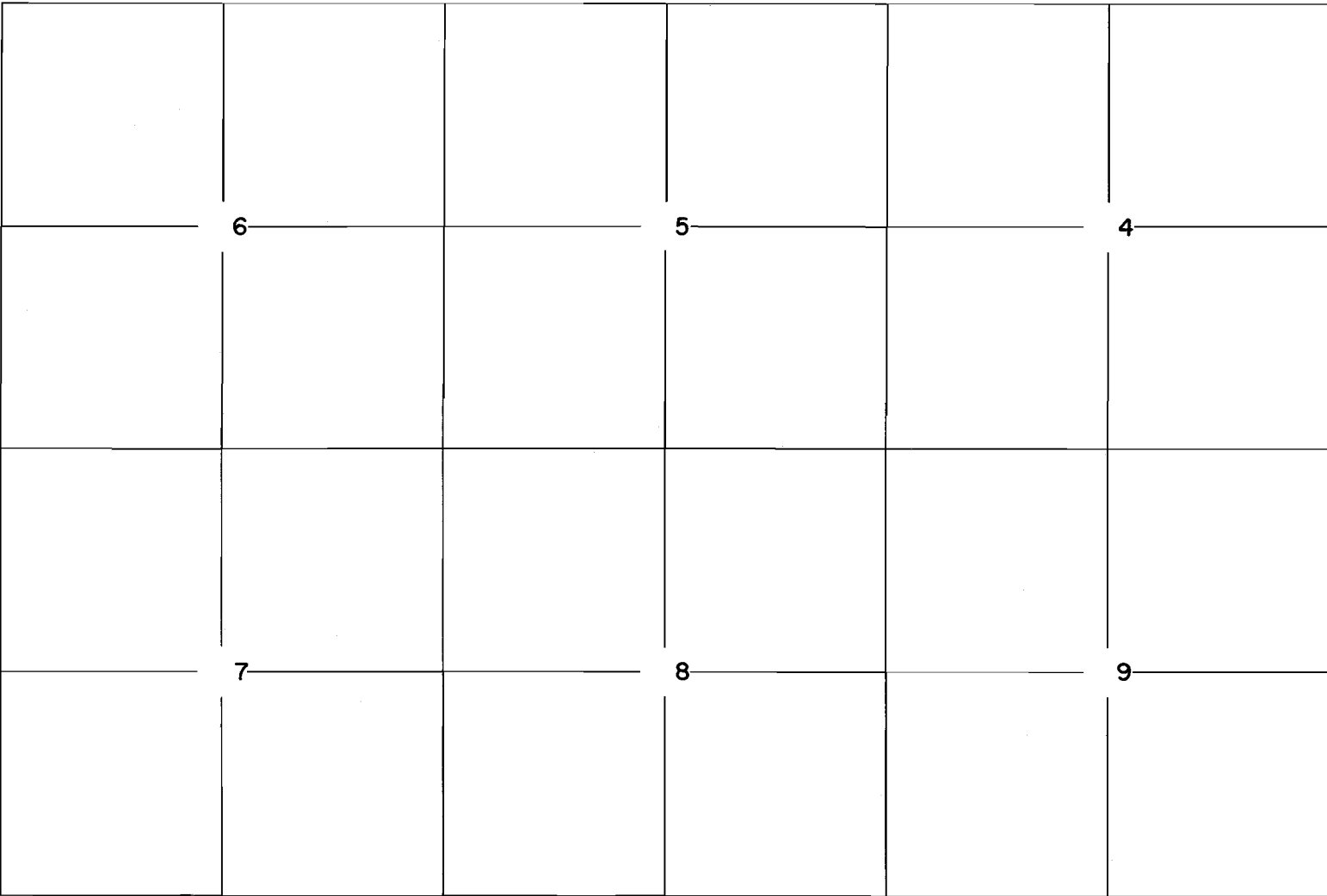



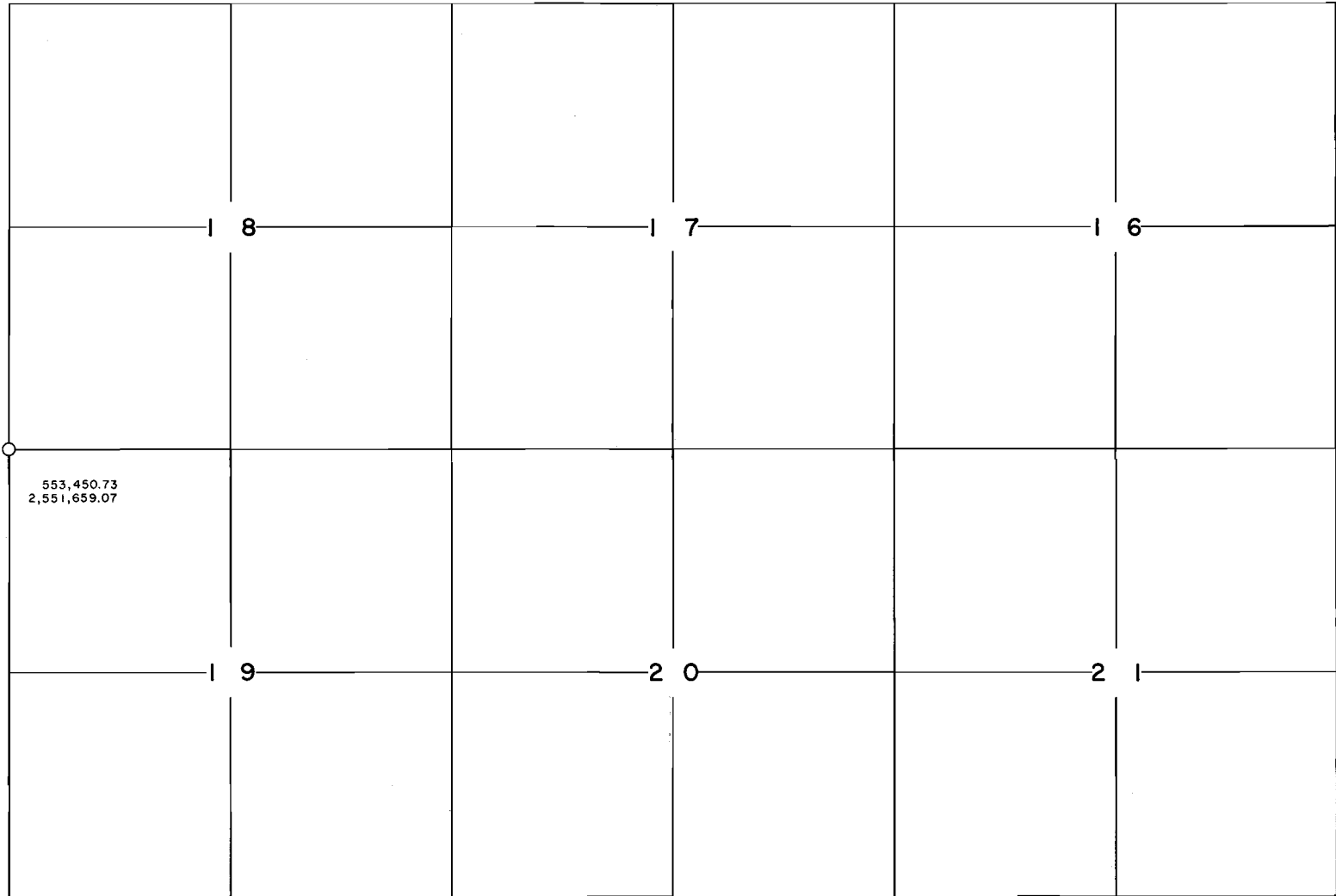








						
	LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N. S. S. HORIZONTAL CONTROL STATION.	HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, GRID SOUTH ZONE AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.	CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF BELGIUM OZAUKEE COUNTY, WISCONSIN	DRAWN BY: _____ DATE: _____ CHECKED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____ REVISED: _____ DATE: _____	DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM	SECTIONS 6, 5, 4, 7, 8, 9 T. 12 N. R. 22 E. OZAUKEE COUNTY



LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" SEWRPC CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- △ N. G. S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: .99989582

DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF BELGIUM
OZAUKEE COUNTY, WISCONSIN

DRAWN BY: D. P. SIMON DATE: FEB., 1988

CHECKED BY: L. H. KREBLIN DATE: FEB., 1988

APPROVED BY: *[Signature]* DATE: FEB., 1988

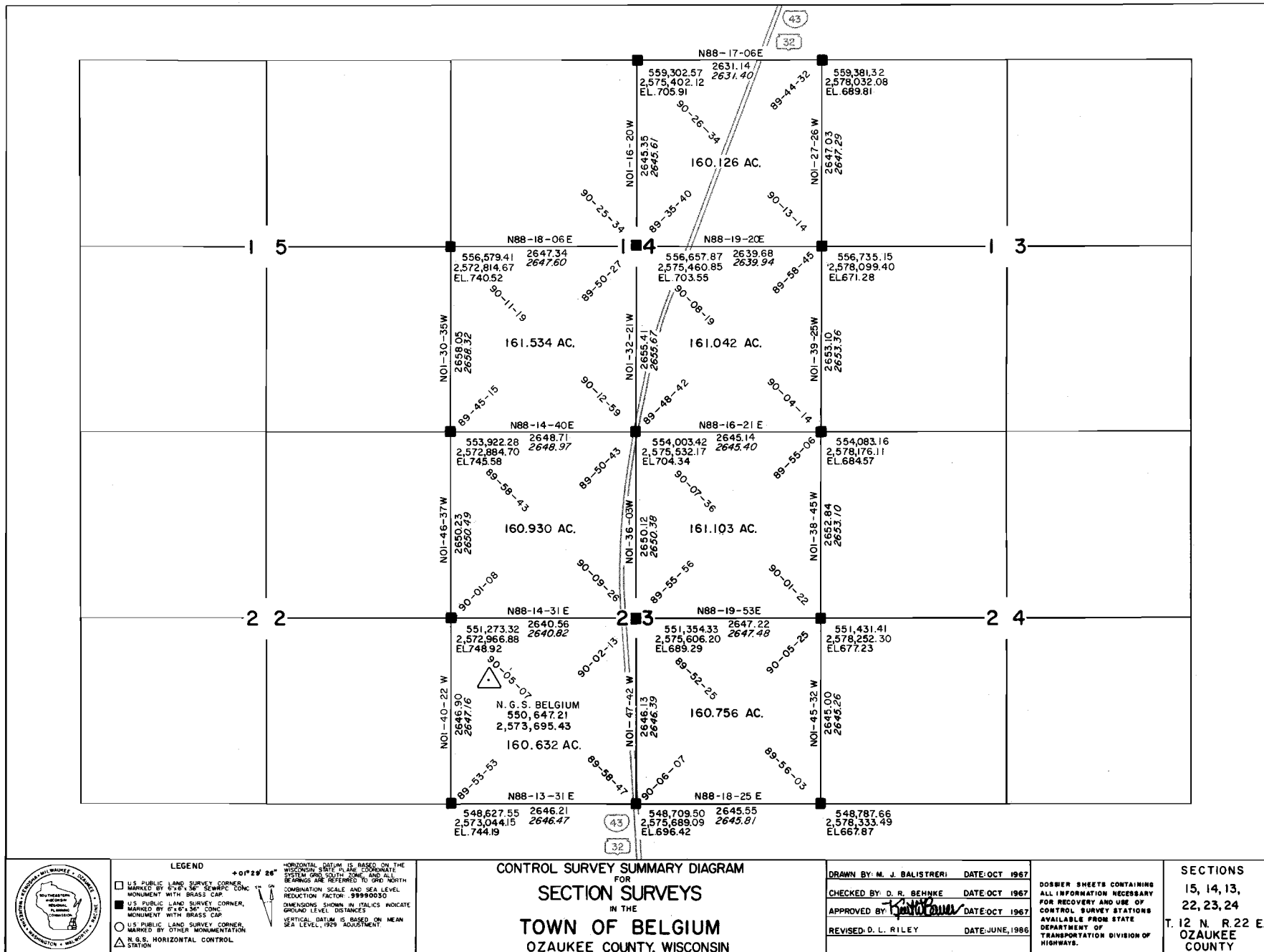
REVISED: DATE:

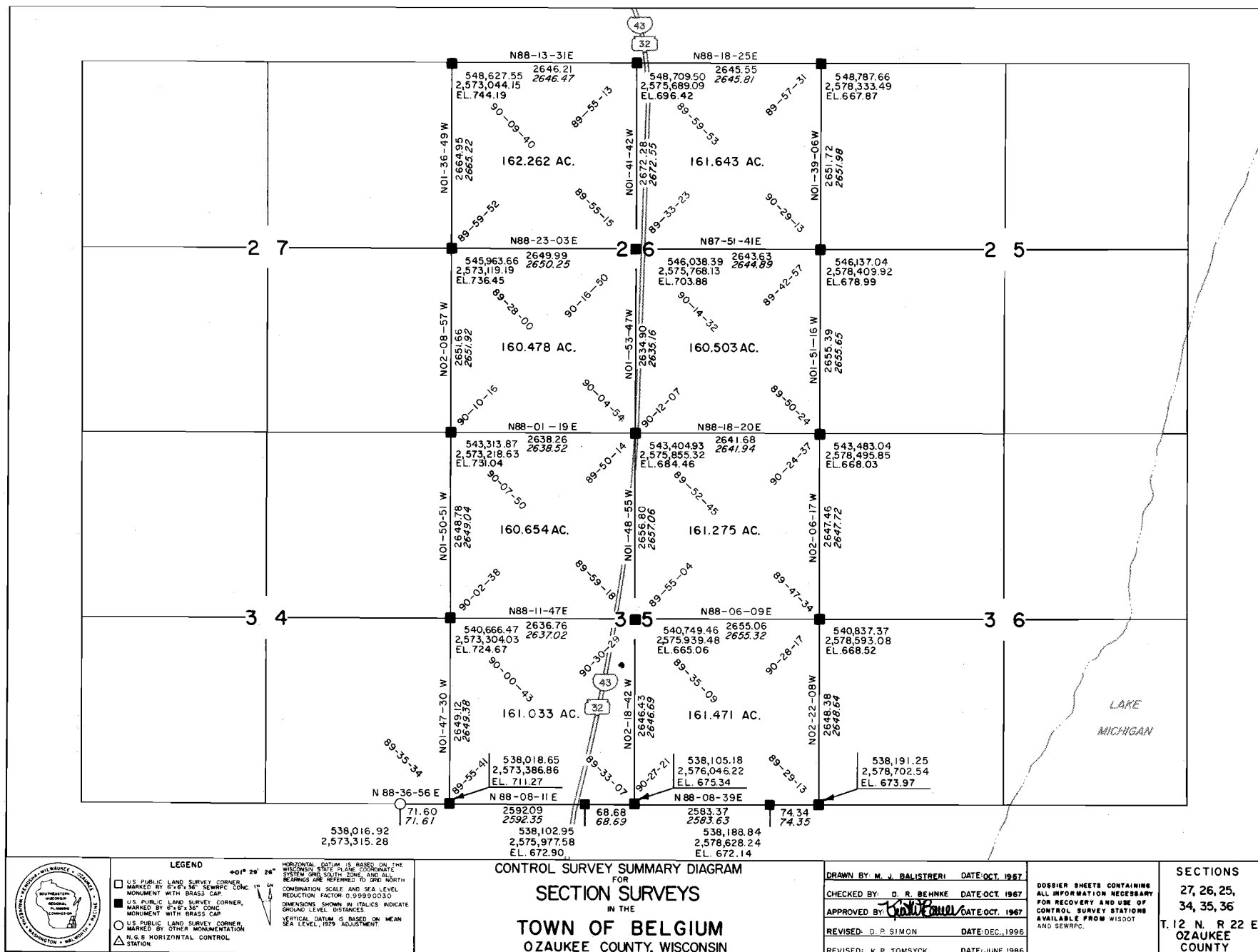
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM SEWRPC.

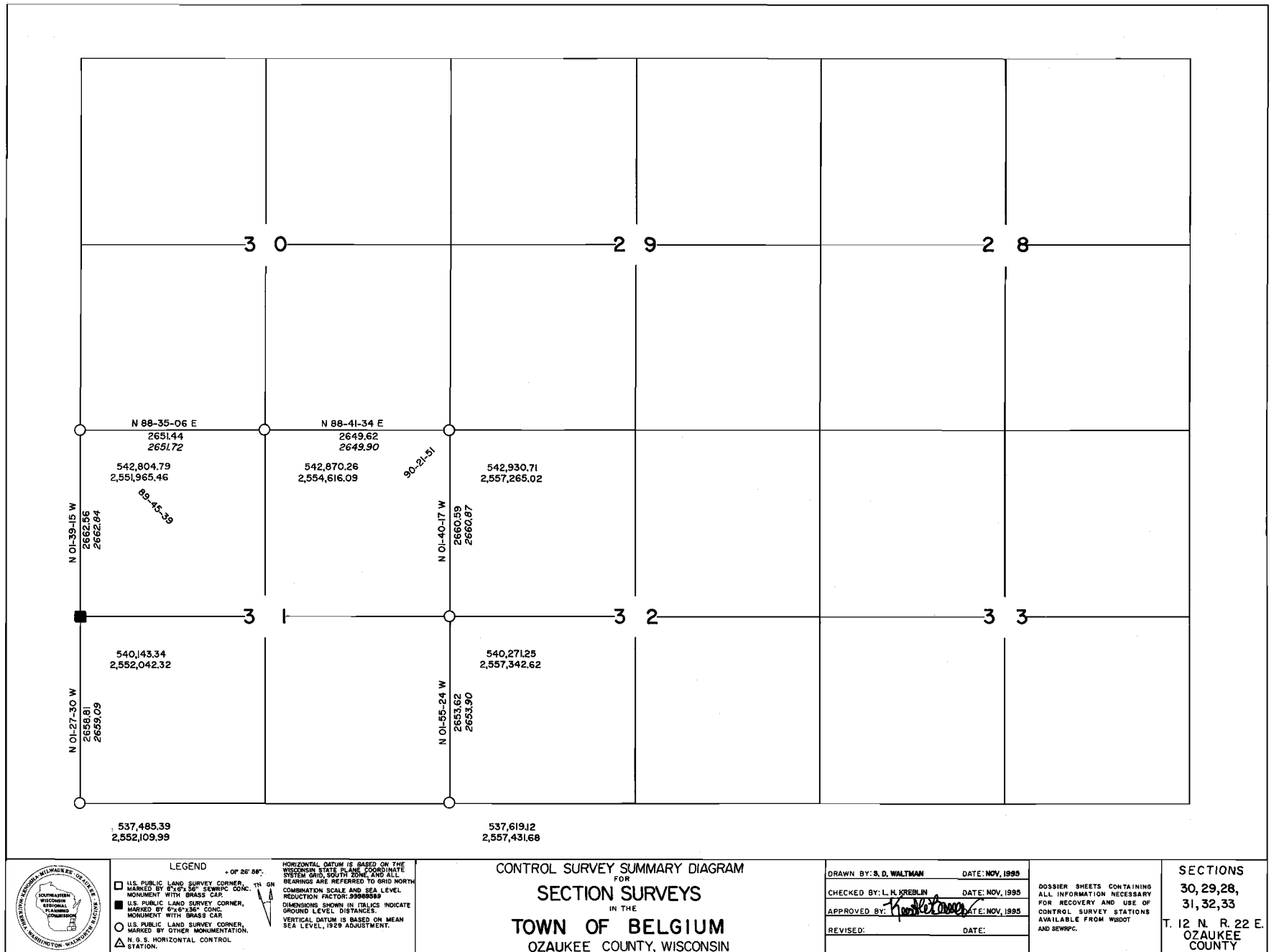
SECTIONS

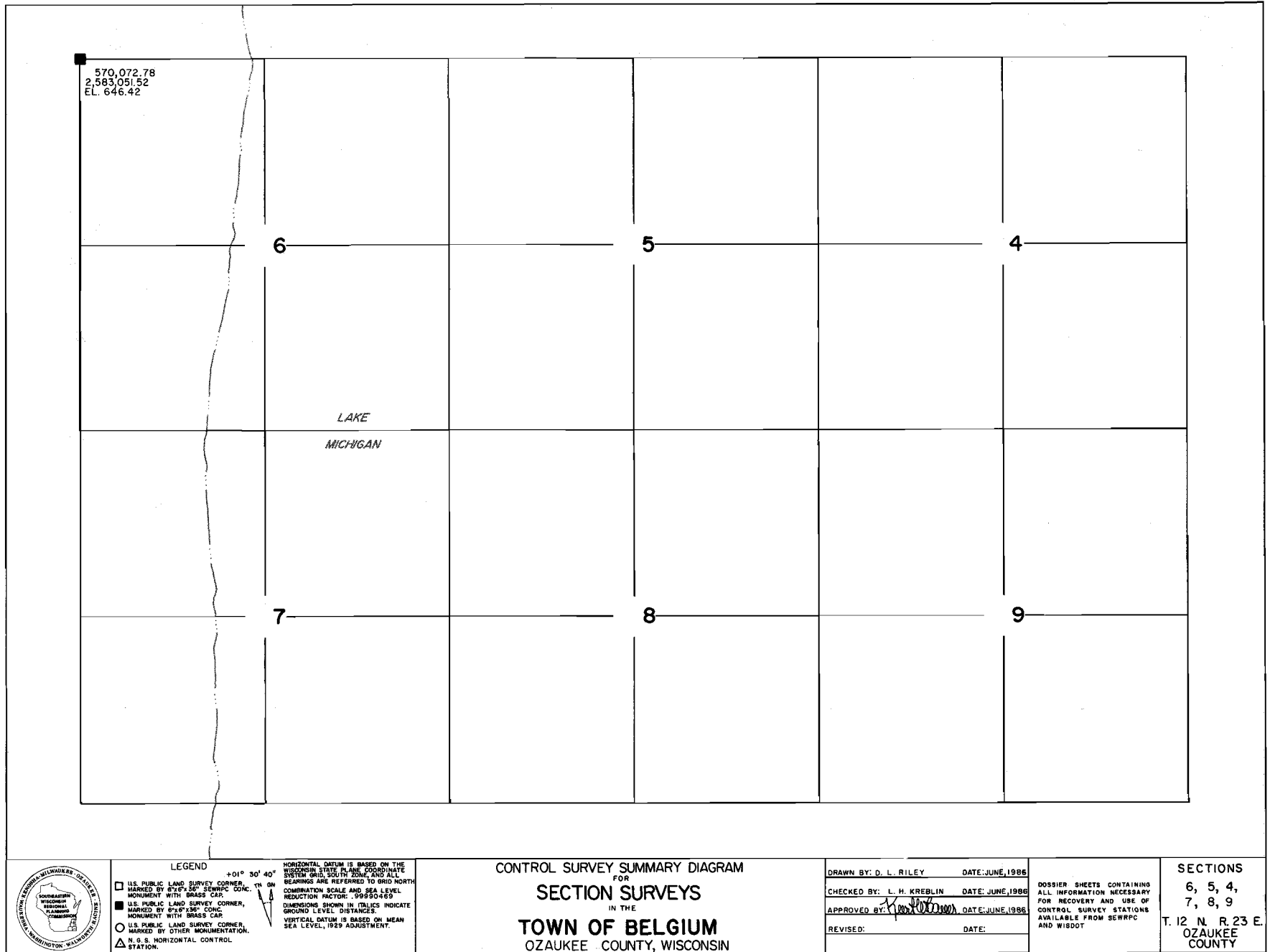
18, 17, 16,
19, 20, 21

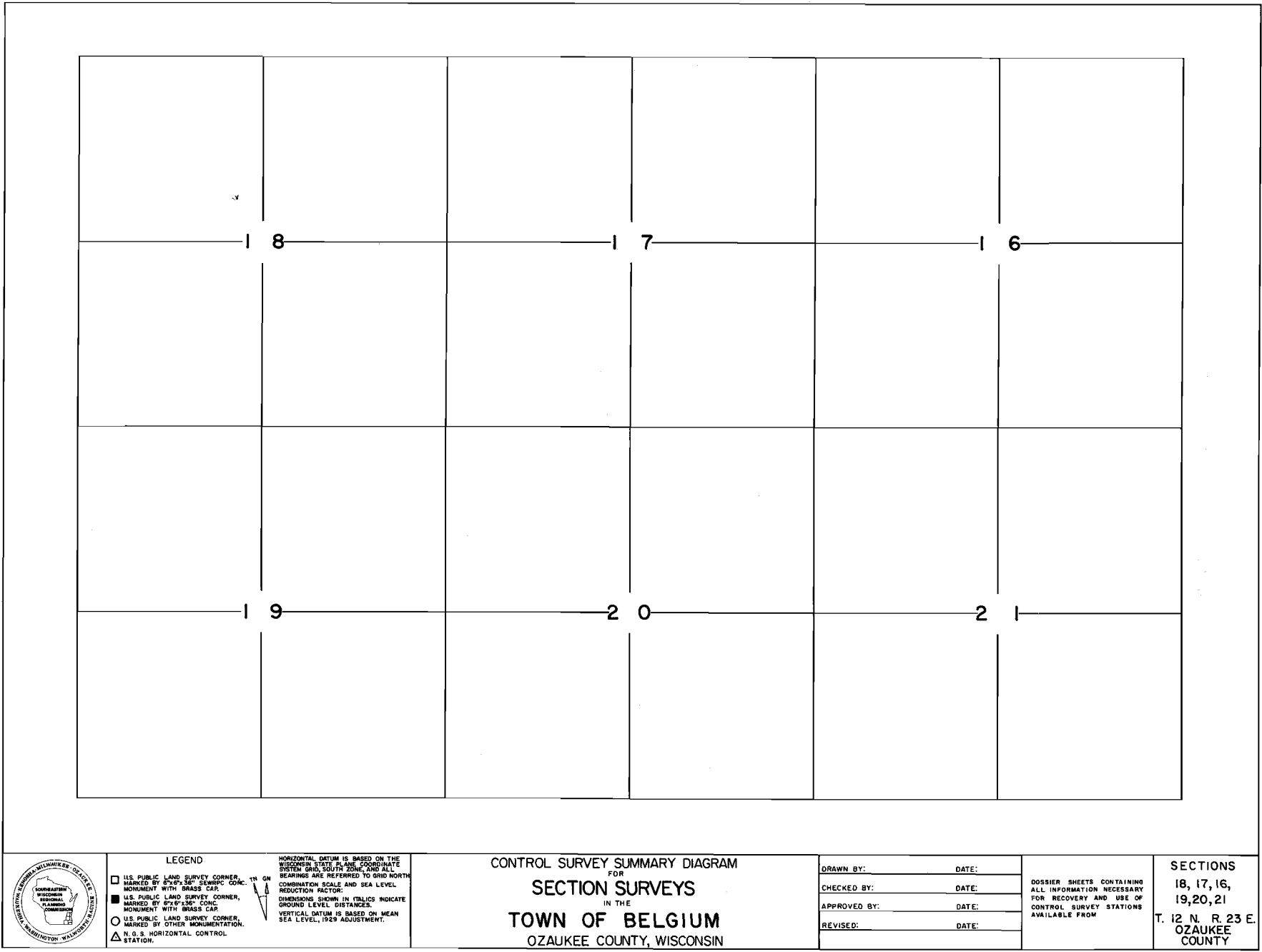
T. 12 N. R. 22 E.
OZAUKEE
COUNTY





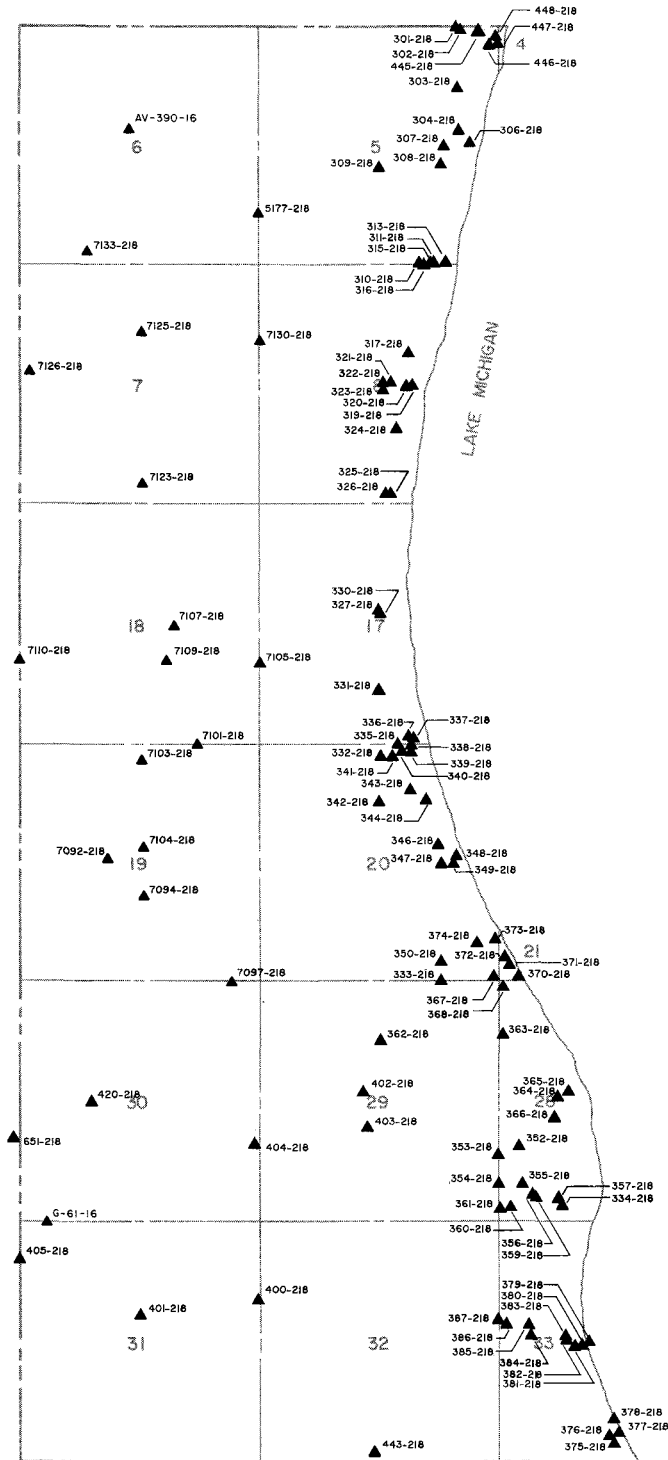




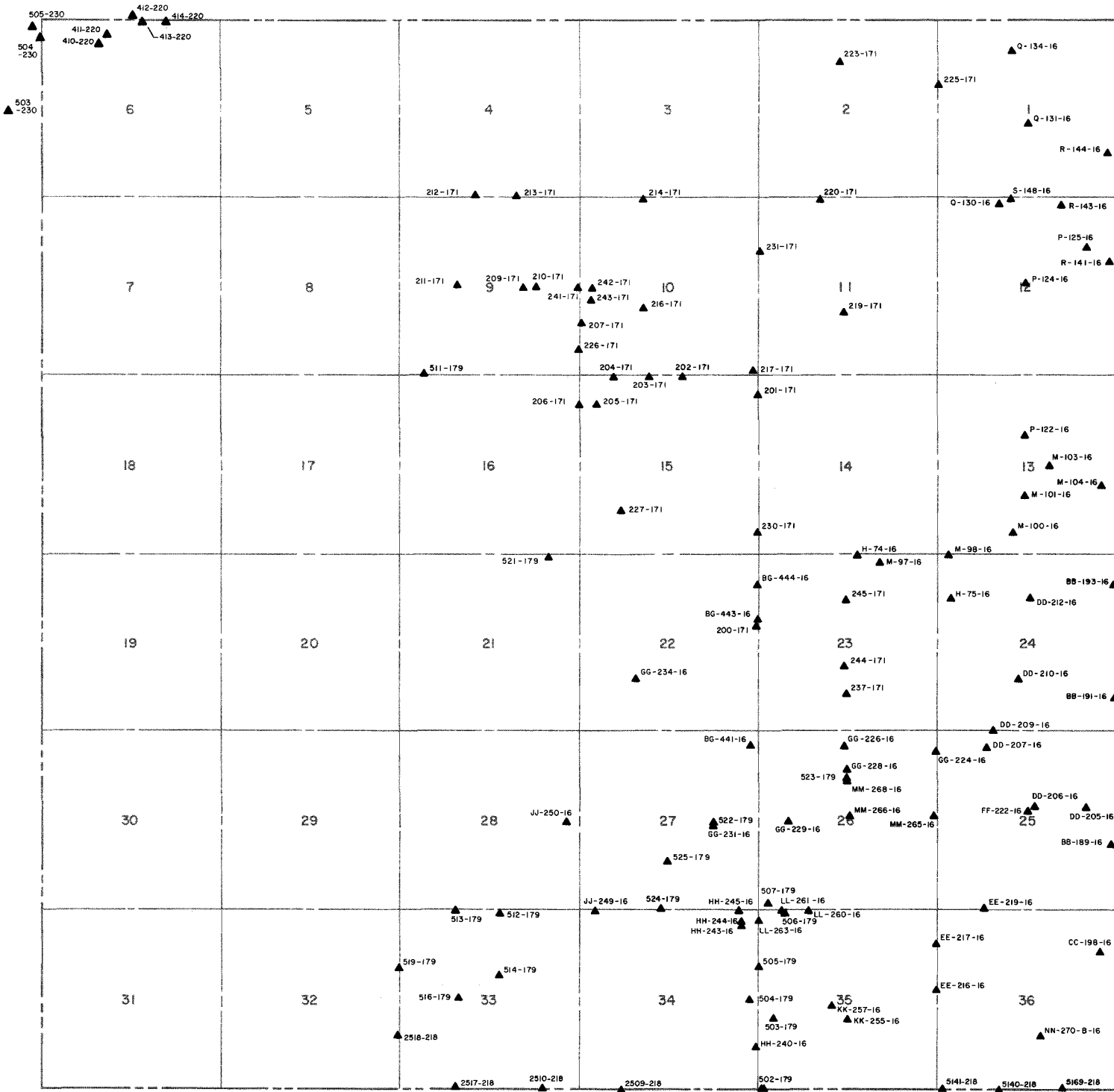


[illegible]

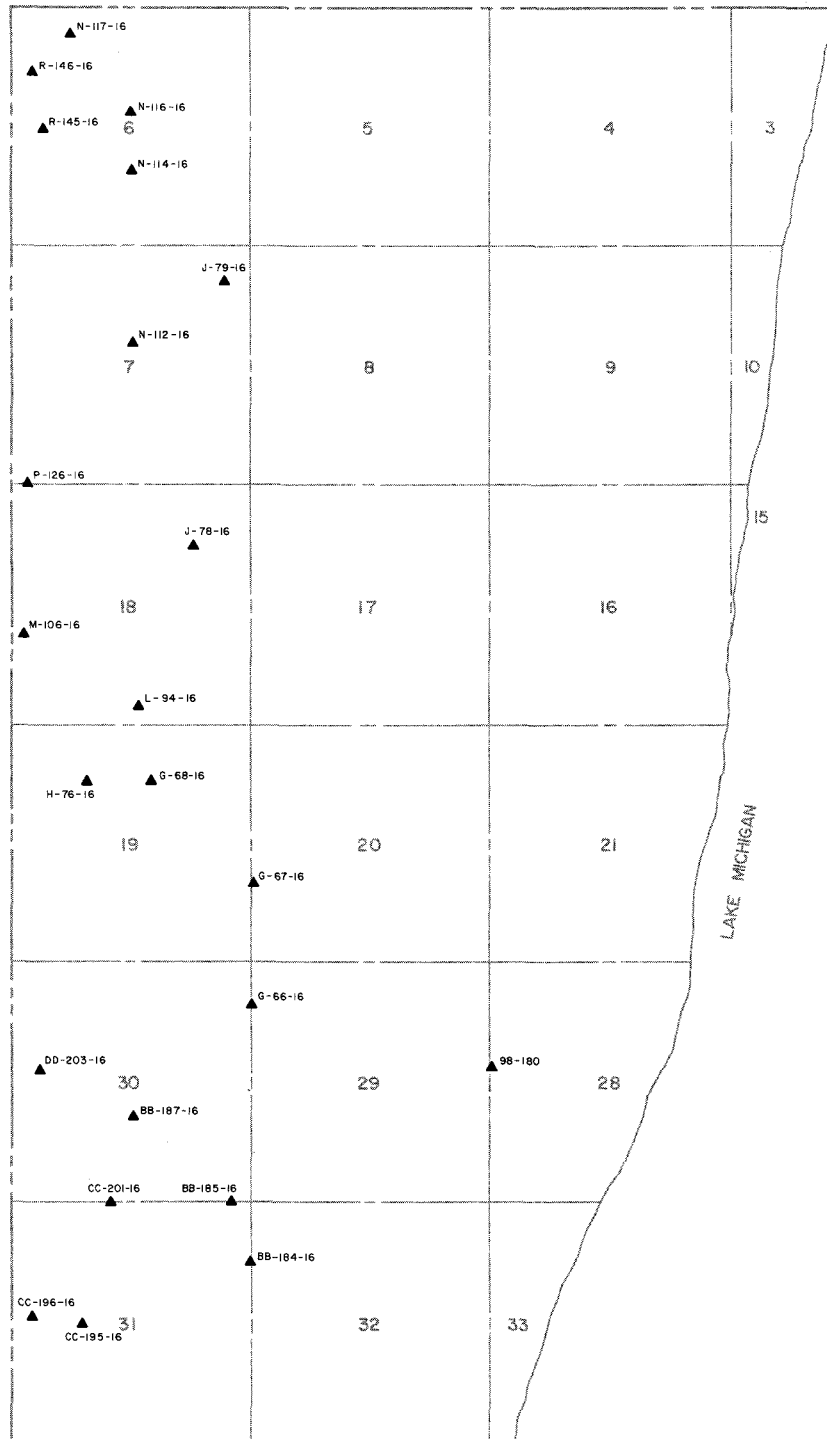
**TRAVERSE DIAGRAM, TOWNSHIP 9 NORTH, RANGE 22 EAST
OZAUKEE COUNTY**



TRAVERSE DIAGRAM, TOWNSHIP 10 NORTH, RANGE 21 EAST
OZAUKEE COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 10 NORTH, RANGE 22 EAST
OZAUKEE COUNTY

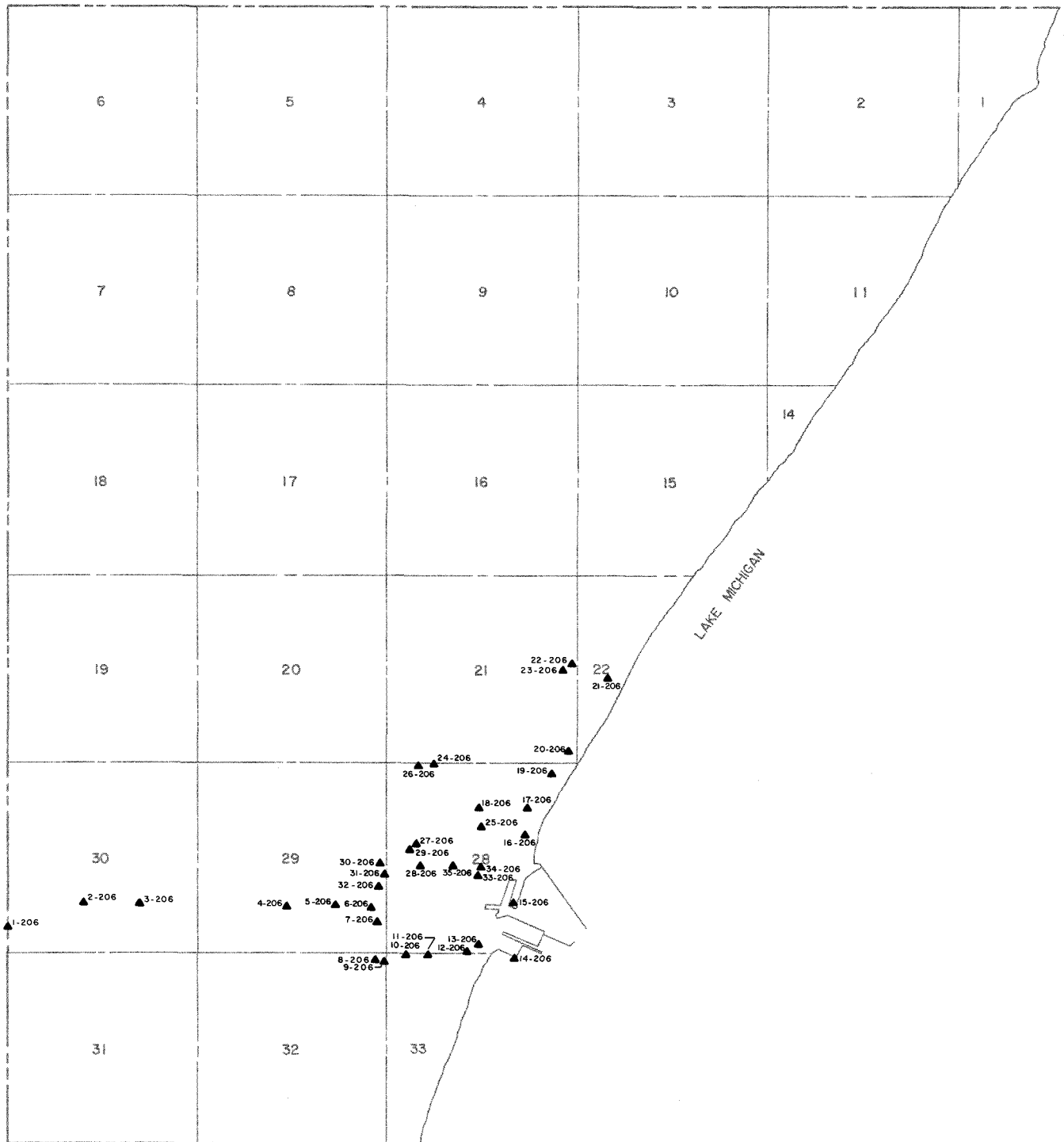


This map displays a grid of numbered squares (1-36) across the Pacific Ocean region, bounded by 10°N to 30°N latitude and 120°E to 160°E longitude. The grid is overlaid on a background of latitude and longitude lines. Various data points are marked with triangles and alphanumeric codes, indicating specific locations and measurements. The data points are distributed across the grid, with some clusters and others isolated. The map also includes a scale bar at the bottom, indicating distances in miles and kilometers.

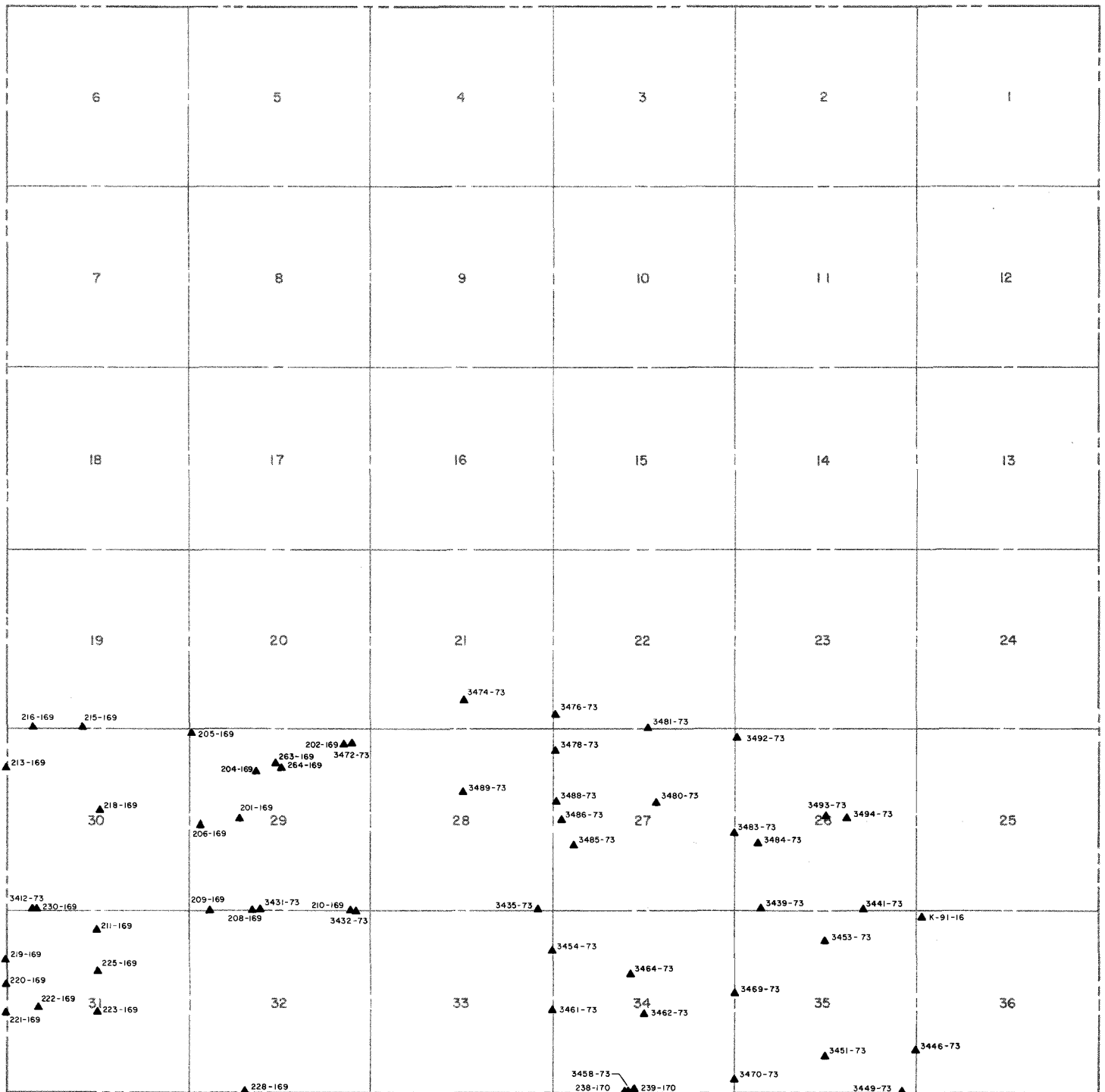
Grid Squares and Data Points:

- Square 1:** 3449-73
- Square 2:** 224-170
- Square 3:** 213-170, 225-170, 226-170, 227-170, 228-170, 229-170, 238-170, 239-170, 3458-73
- Square 4:** 238-169, 239-169, 240-169, 241-169, 242-169, 243-169, 244-169, 245-169, 246-169, 247-169, 248-169, 249-169, 250-169, 251-169, 252-169, 253-169, 254-169, 255-169, 256-169, 257-169, 258-169, 259-169, 260-169, 261-169, 262-169, 263-169, 264-169, 265-169, 266-169, 267-169, 268-169, 269-169, 270-169, 271-169, 272-169, 273-169, 274-169, 275-169, 276-169, 277-169, 278-169, 279-169, 280-169, 281-169, 282-169, 283-169, 284-169, 285-169, 286-169, 287-169, 288-169, 289-169, 290-169, 291-169, 292-169, 293-169, 294-169, 295-169, 296-169, 297-169, 298-169, 299-169, 300-169, 301-169, 302-169, 303-169, 304-169, 305-169, 306-169, 307-169, 308-169, 309-169, 310-169, 311-169, 312-169, 313-169, 314-169, 315-169, 316-169, 317-169, 318-169, 319-169, 320-169, 321-169, 322-169, 323-169, 324-169, 325-169, 326-169, 327-169, 328-169, 329-169, 330-169, 331-169, 332-169, 333-169, 334-169, 335-169, 336-169, 337-169, 338-169, 339-169, 340-169, 341-169, 342-169, 343-169, 344-169, 345-169, 346-169, 347-169, 348-169, 349-169, 350-169, 351-169, 352-169, 353-169, 354-169, 355-169, 356-169, 357-169, 358-169, 359-169, 360-169, 361-169, 362-169, 363-169, 364-169, 365-169, 366-169, 367-169, 368-169, 369-169, 370-169, 371-169, 372-169, 373-169, 374-169, 375-169, 376-169, 377-169, 378-169, 379-169, 380-169, 381-169, 382-169, 383-169, 384-169, 385-169, 386-169, 387-169, 388-169, 389-169, 390-169, 391-169, 392-169, 393-169, 394-169, 395-169, 396-169, 397-169, 398-169, 399-169, 400-169, 401-169, 402-169, 403-169, 404-169, 405-169, 406-169, 407-169, 408-169, 409-169, 410-169, 411-169, 412-169, 413-169, 414-169, 415-169, 416-169, 417-169, 418-169, 419-169, 420-169, 421-169, 422-169, 423-169, 424-169, 425-169, 426-169, 427-169, 428-169, 429-169, 430-169, 431-169, 432-169, 433-169, 434-169, 435-169, 436-169, 437-169, 438-169, 439-169, 440-169, 441-169, 442-169, 443-169, 444-169, 445-169, 446-169, 447-169, 448-169, 449-169, 450-169, 451-169, 452-169, 453-169, 454-169, 455-169, 456-169, 457-169, 458-169, 459-169, 460-169, 461-169, 462-169, 463-169, 464-169, 465-169, 466-169, 467-169, 468-169, 469-169, 470-169, 471-169, 472-169, 473-169, 474-169, 475-169, 476-169, 477-169, 478-169, 479-169, 480-169, 481-169, 482-169, 483-169, 484-169, 485-169, 486-169, 487-169, 488-169, 489-169, 490-169, 491-169, 492-169, 493-169, 494-169, 495-169, 496-169, 497-169, 498-169, 499-169, 500-169, 501-169, 502-169, 503-169, 504-169, 505-169, 506-169, 507-169, 508-169, 509-169, 510-169, 511-169, 512-169, 513-169, 514-169, 515-169, 516-169, 517-169, 518-169, 519-169, 520-169, 521-169, 522-169, 523-169, 524-169, 525-169, 526-169, 527-169, 528-169, 529-169, 530-169, 531-169, 532-169, 533-169, 534-169, 535-169, 536-169, 537-169, 538-169, 539-169, 540-169, 541-169, 542-169, 543-169, 544-169, 545-169, 546-169, 547-169, 548-169, 549-169, 550-169, 551-169, 552-169, 553-169, 554-169, 555-169, 556-169, 557-169, 558-169, 559-169, 560-169, 561-169, 562-169, 563-169, 564-169, 565-169, 566-169, 567-169, 568-169, 569-169, 570-169, 571-169, 572-169, 573-169, 574-169, 575-169, 576-169, 577-169, 578-169, 579-169, 580-169, 581-169, 582-169, 583-169, 584-169, 585-169, 586-169, 587-169, 588-169, 589-169, 590-169, 591-169, 592-169, 593-169, 594-169, 595-169, 596-169, 597-169, 598-169, 599-169, 600-169, 601-169, 602-169, 603-169, 604-169, 605-169, 606-169, 607-169, 608-169, 609-169, 610-169, 611-169, 612-169, 613-169, 614-169, 615-169, 616-169, 617-169, 618-169, 619-169, 620-169, 621-169, 622-169, 623-169, 624-169, 625-169, 626-169, 627-169, 628-169, 629-169, 630-169, 631-169, 632-169, 633-169, 634-169, 635-169, 636-169, 637-169, 638-169, 639-169, 640-169, 641-169, 642-169, 643-169, 644-169, 645-169, 646-169, 647-169, 648-169, 649-169, 650-169, 651-169, 65

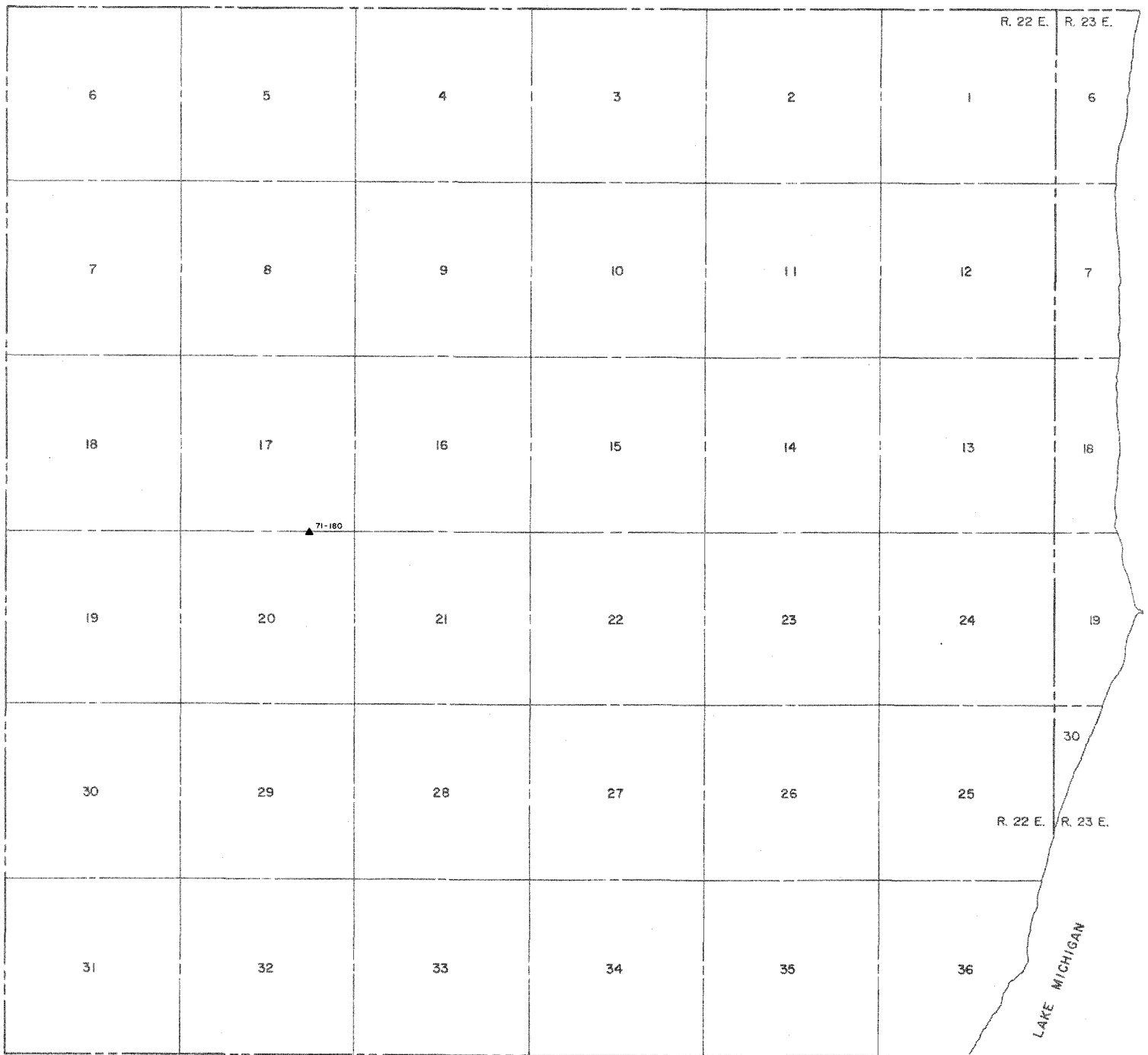
TRAVERSE DIAGRAM, TOWNSHIP 11 NORTH, RANGE 22 EAST
OZAUKEE COUNTY



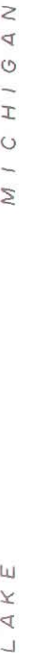
**TRAVERSE DIAGRAM, TOWNSHIP 12 NORTH, RANGE 21 EAST
OZAUKEE COUNTY**



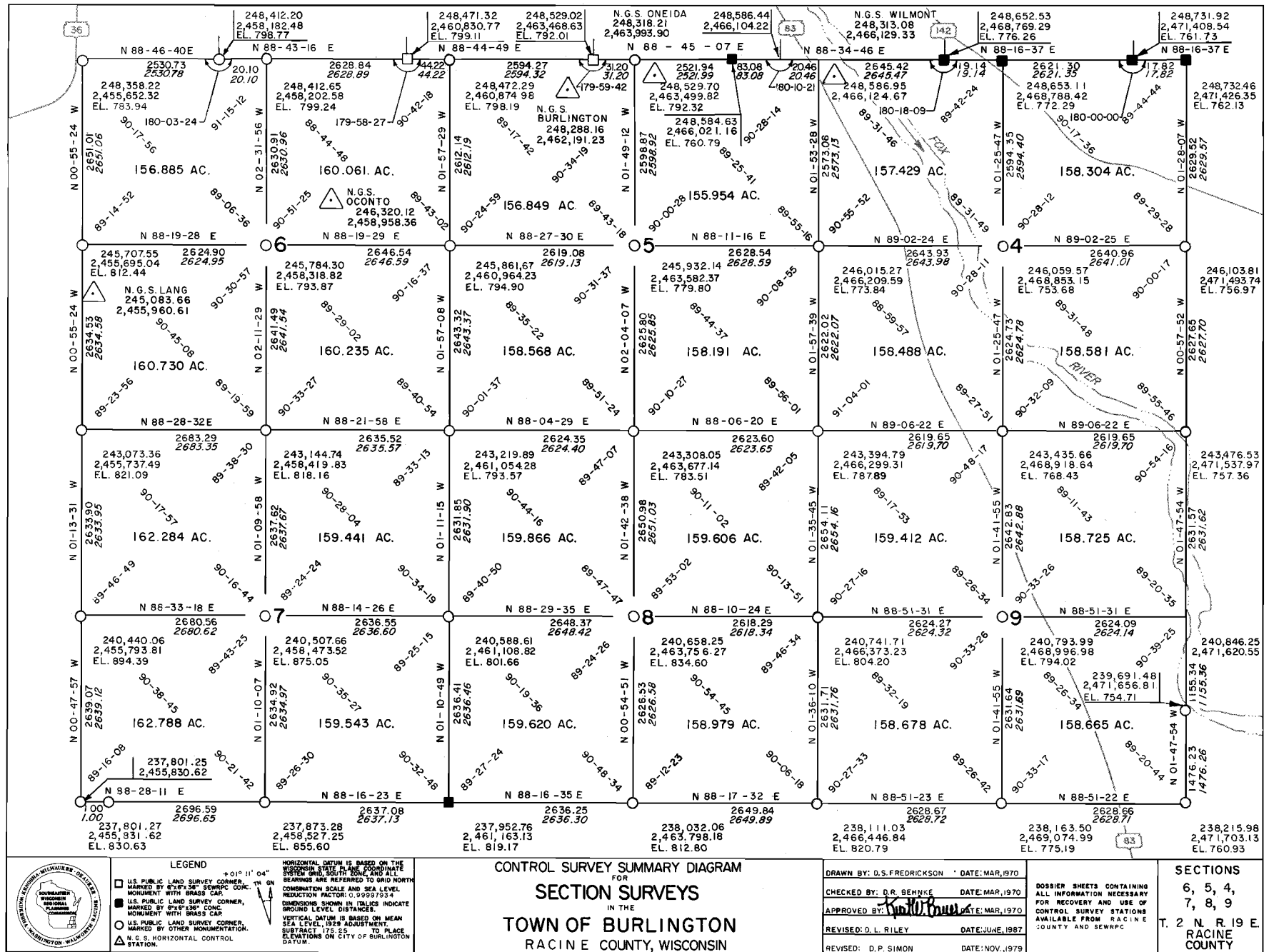
**TRAVERSE DIAGRAM, TOWNSHIP 12 NORTH, RANGE 22 EAST,
AND TOWNSHIP 12 NORTH, RANGE 23 EAST, OZAUKEE COUNTY**



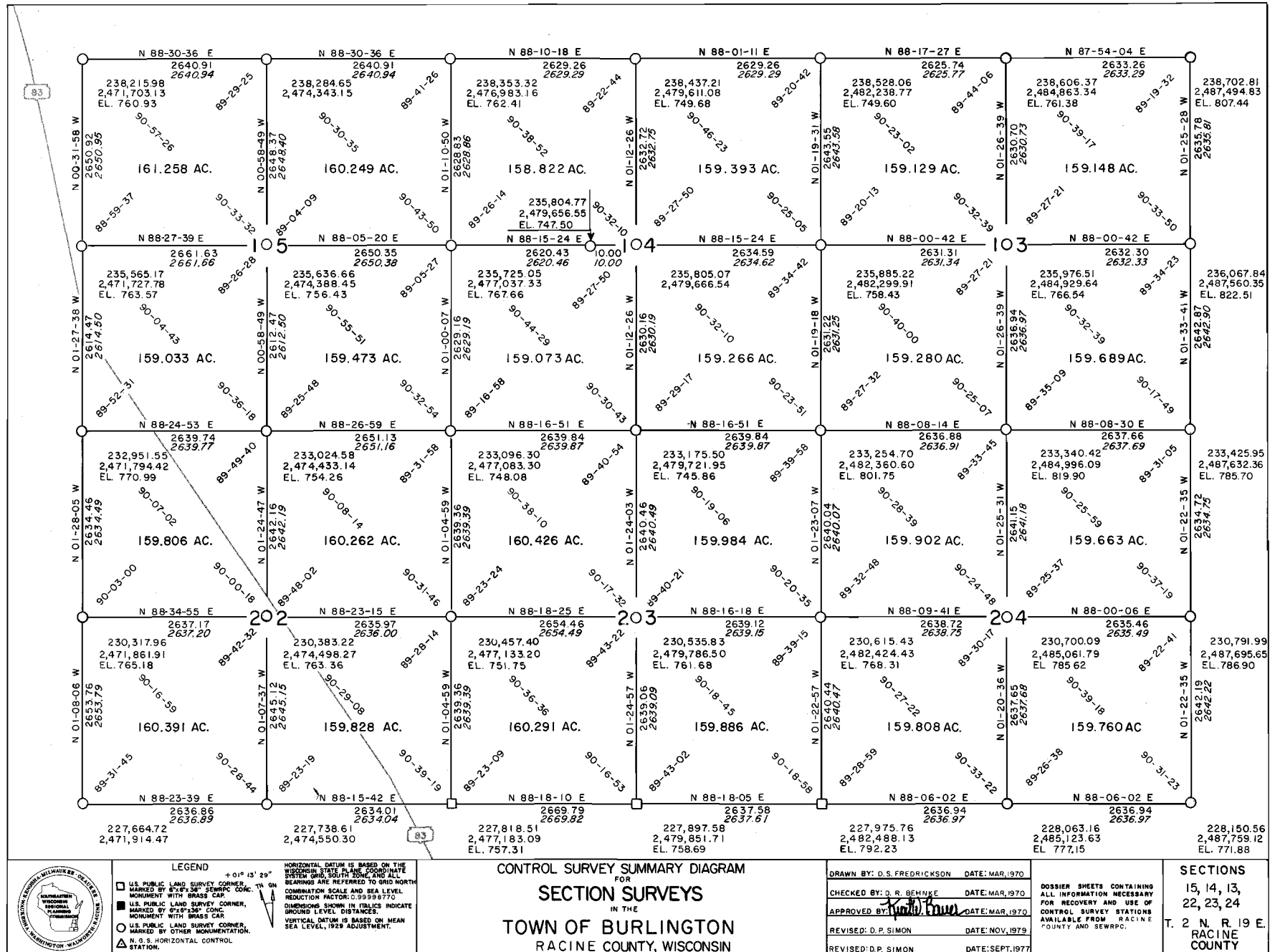
R. 19 E. WAUKESHA COUNTY R. 20 E. R. 21 E. MILWAUKEE COUNTY R. 22 E. R. 23 E.

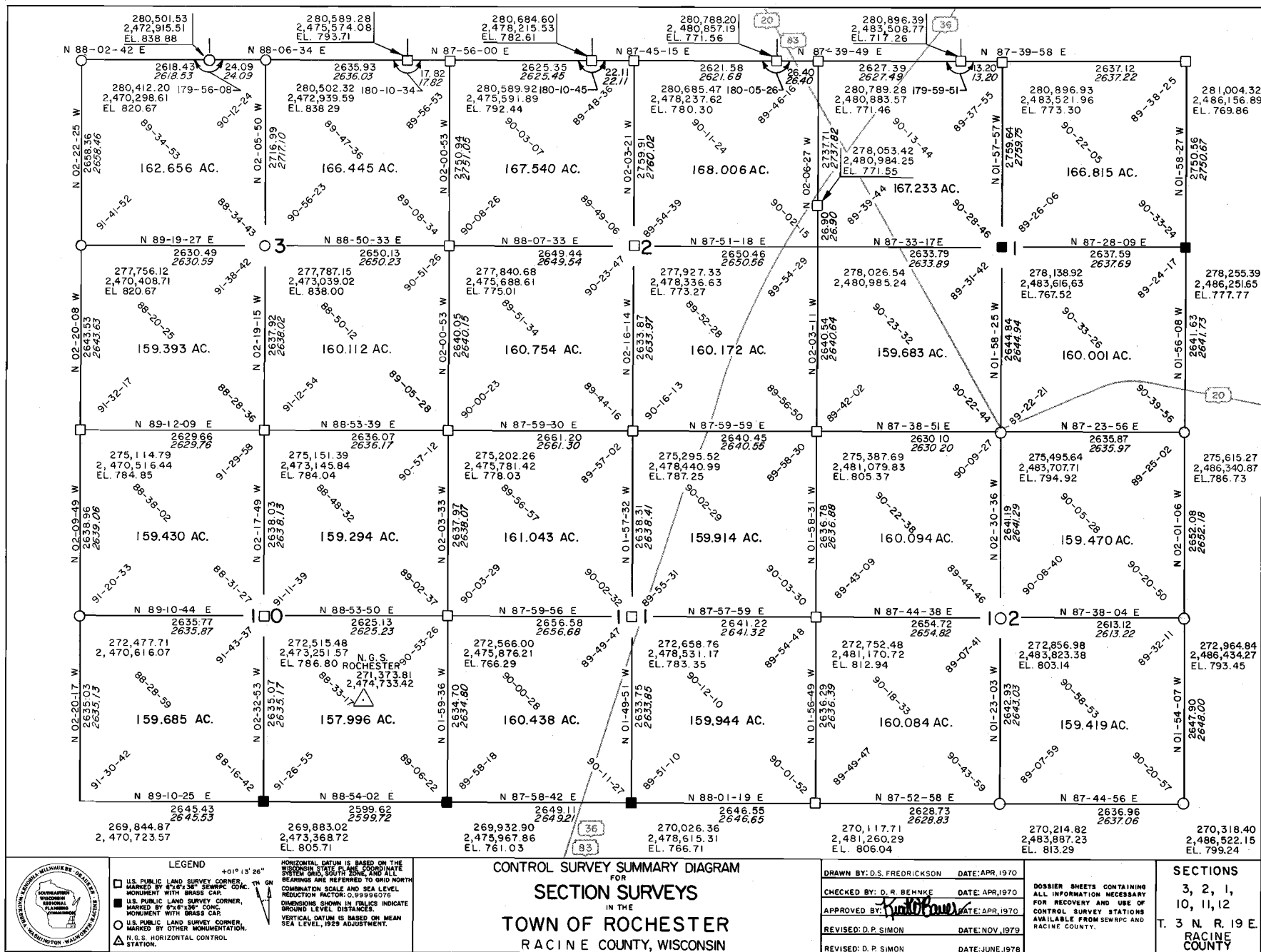


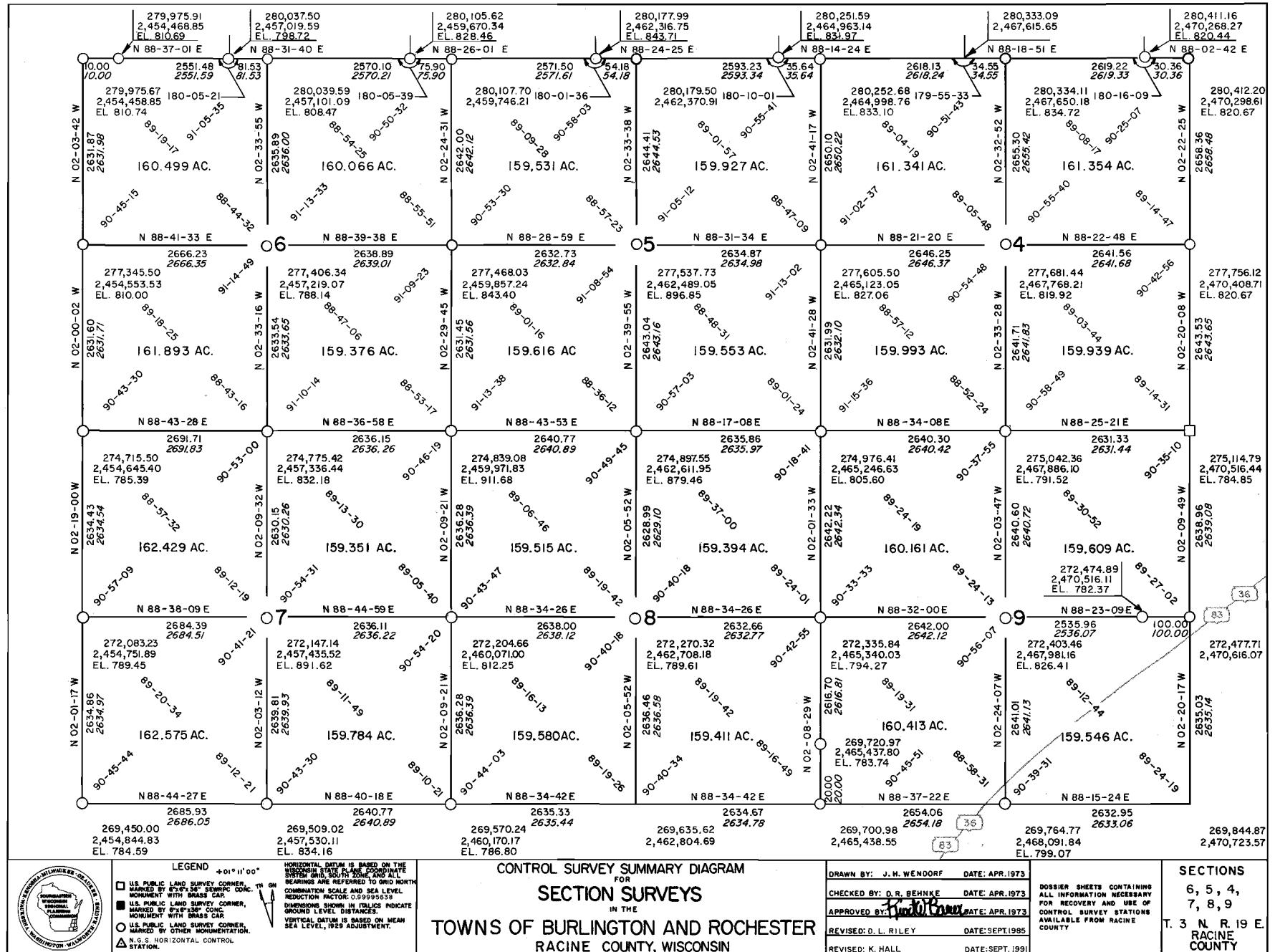
U.S. PUBLIC LAND SURVEY CORNERS
WHICH HAVE BEEN RELOCATED,
MONUMENTED, AND COORDINATED

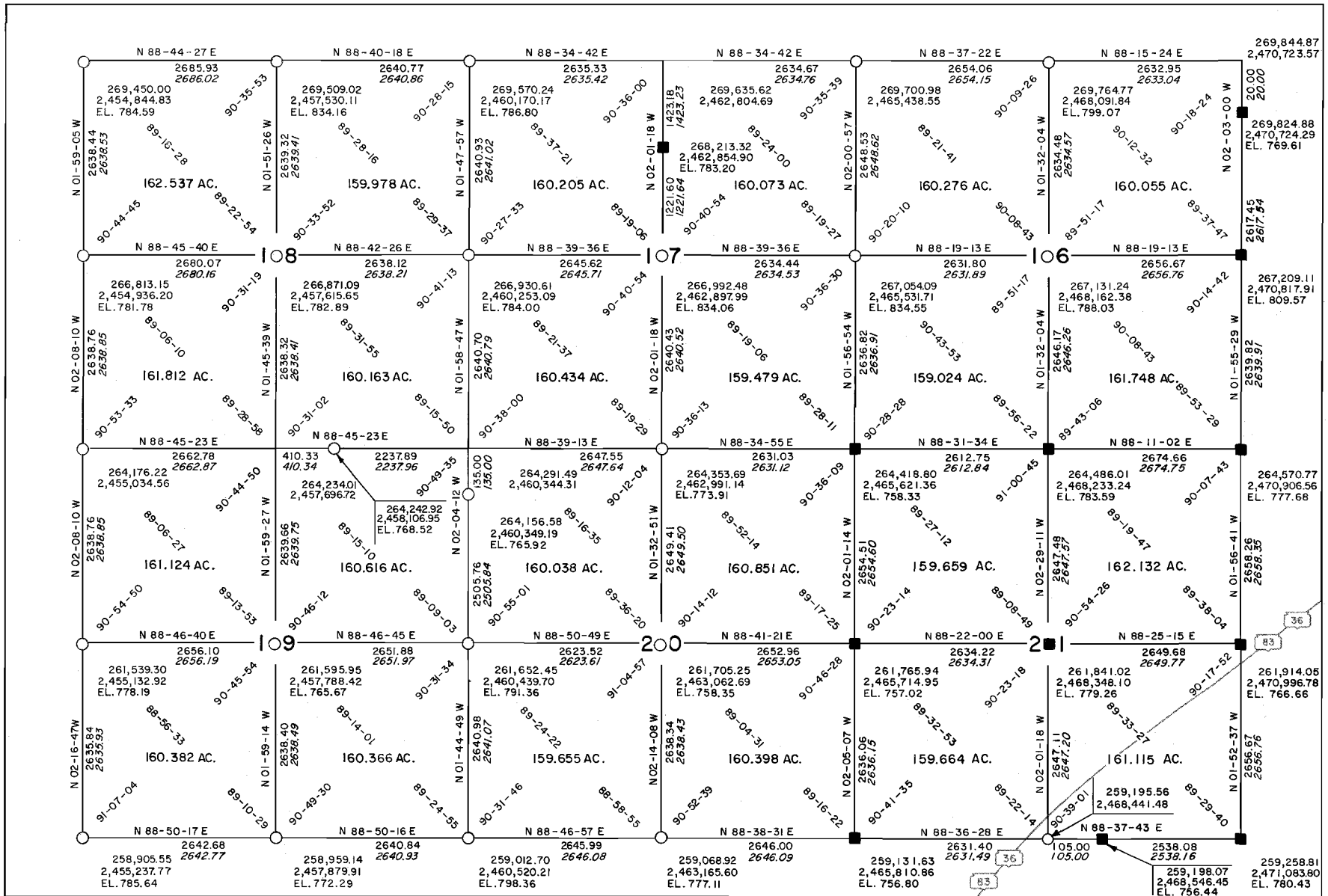












LEGEND

□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 6" x 3/8" BRASS CAP.

■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 6" x 3/8" CONC. MONUMENT WITH BRASS CAP.

○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.

△ N.G.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM AND SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99996732.

DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM

FOR

SECTION SURVEYS

IN THE

TOWNS OF BURLINGTON AND ROCHESTER

RACINE COUNTY, WISCONSIN

DRAWN BY: L.H. KREBLIN DATE: APR, 1970

CHECKED BY: D.R. BEHNKE DATE: APR, 1970

APPROVED BY: *[Signature]* DATE: APR, 1970

REVISED: D.P. SIMON DATE: JUNE, 1978

REVISED: D.L. RILEY DATE: SEPT, 1986

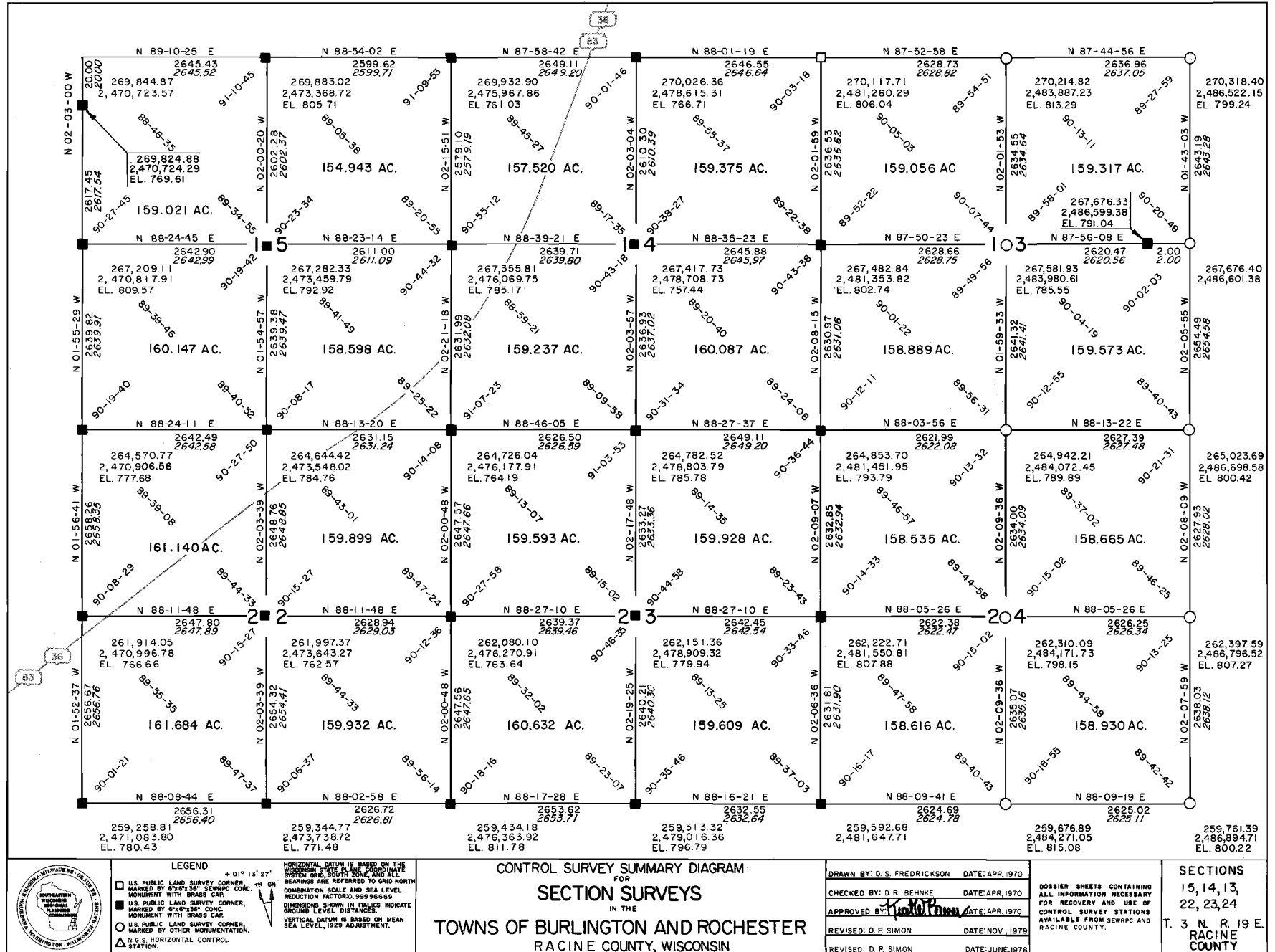
SECTIONS

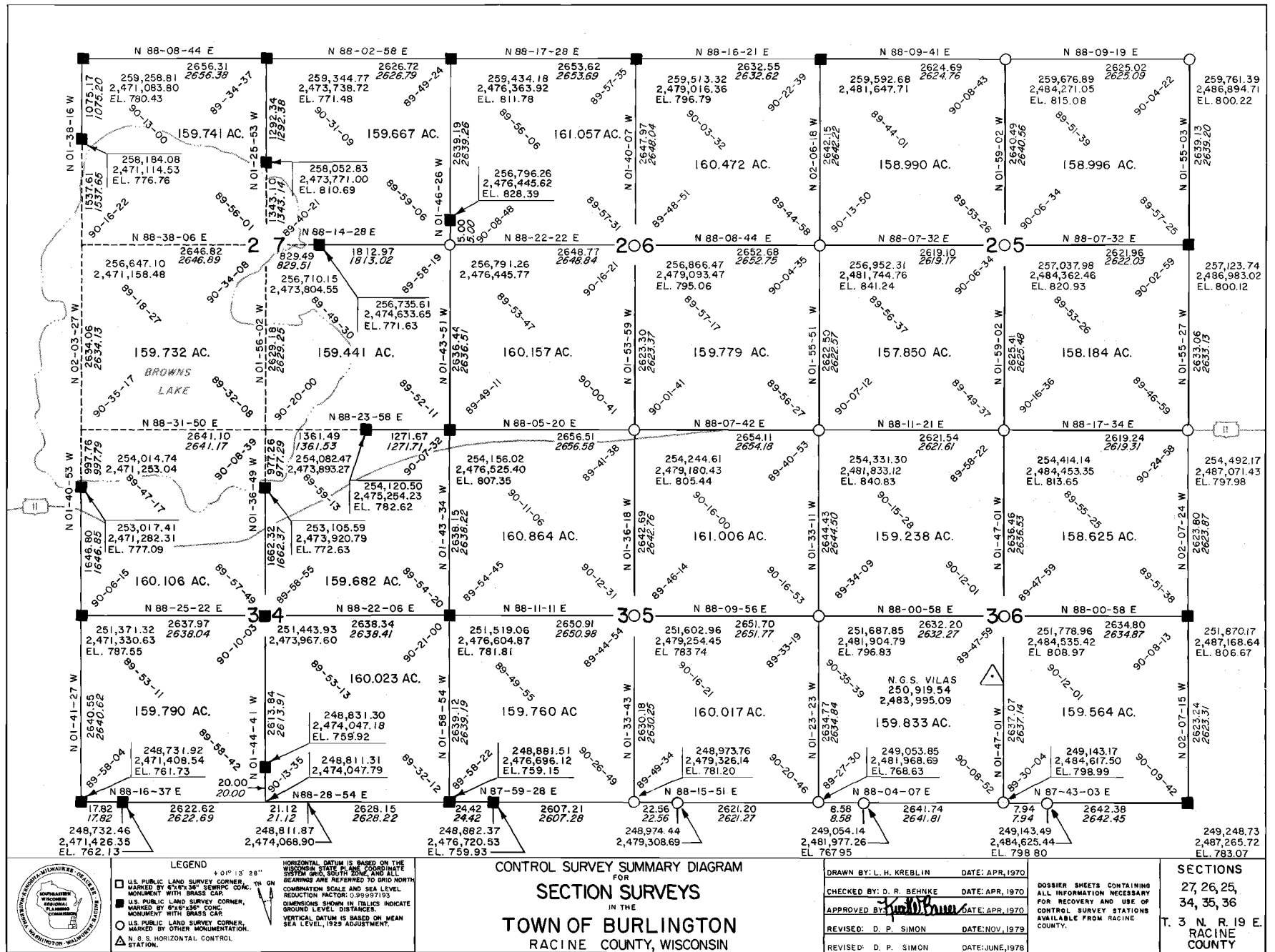
18, 17, 16,

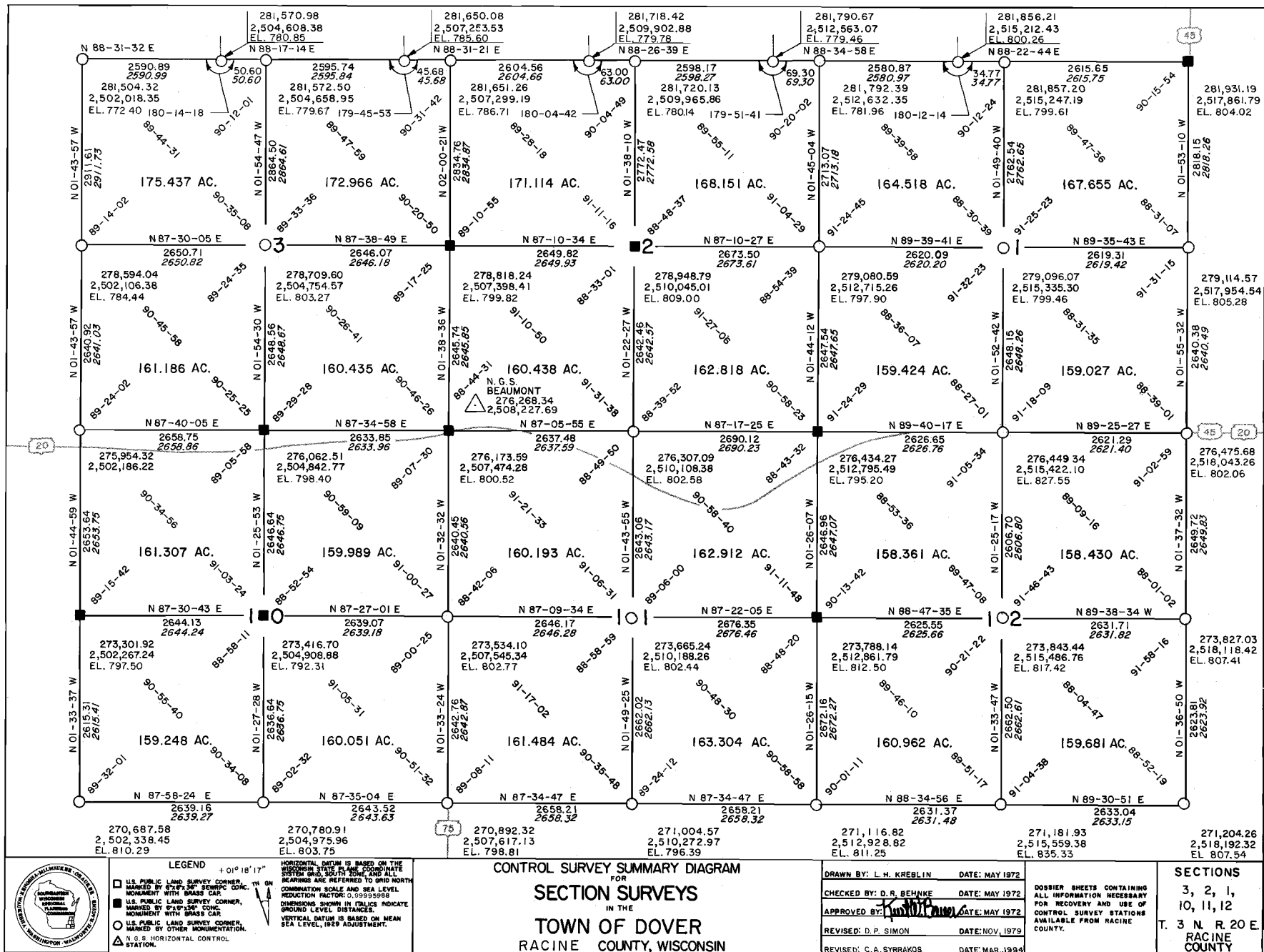
19, 20, 21

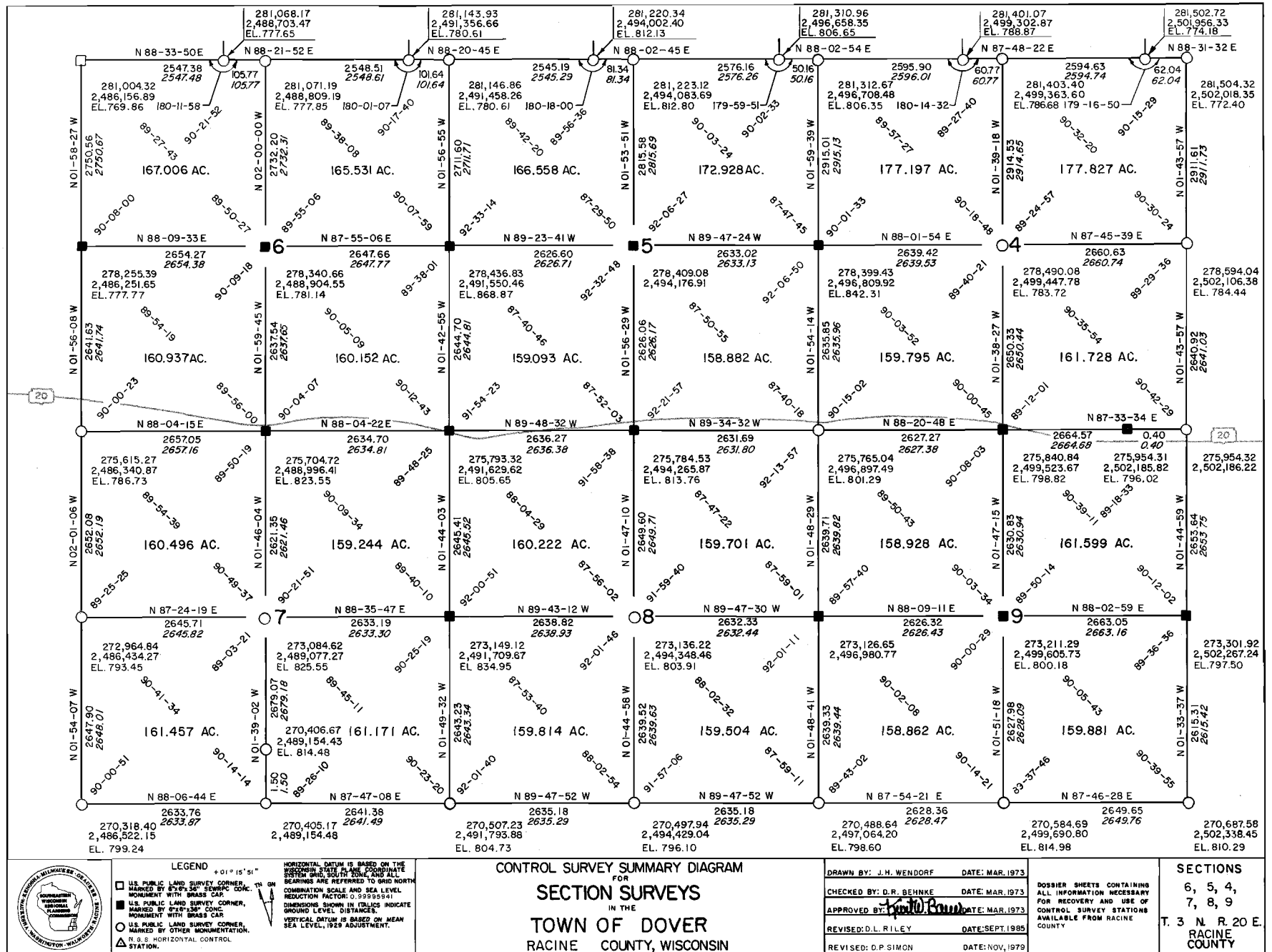
T. 3 N. R. 19 E.

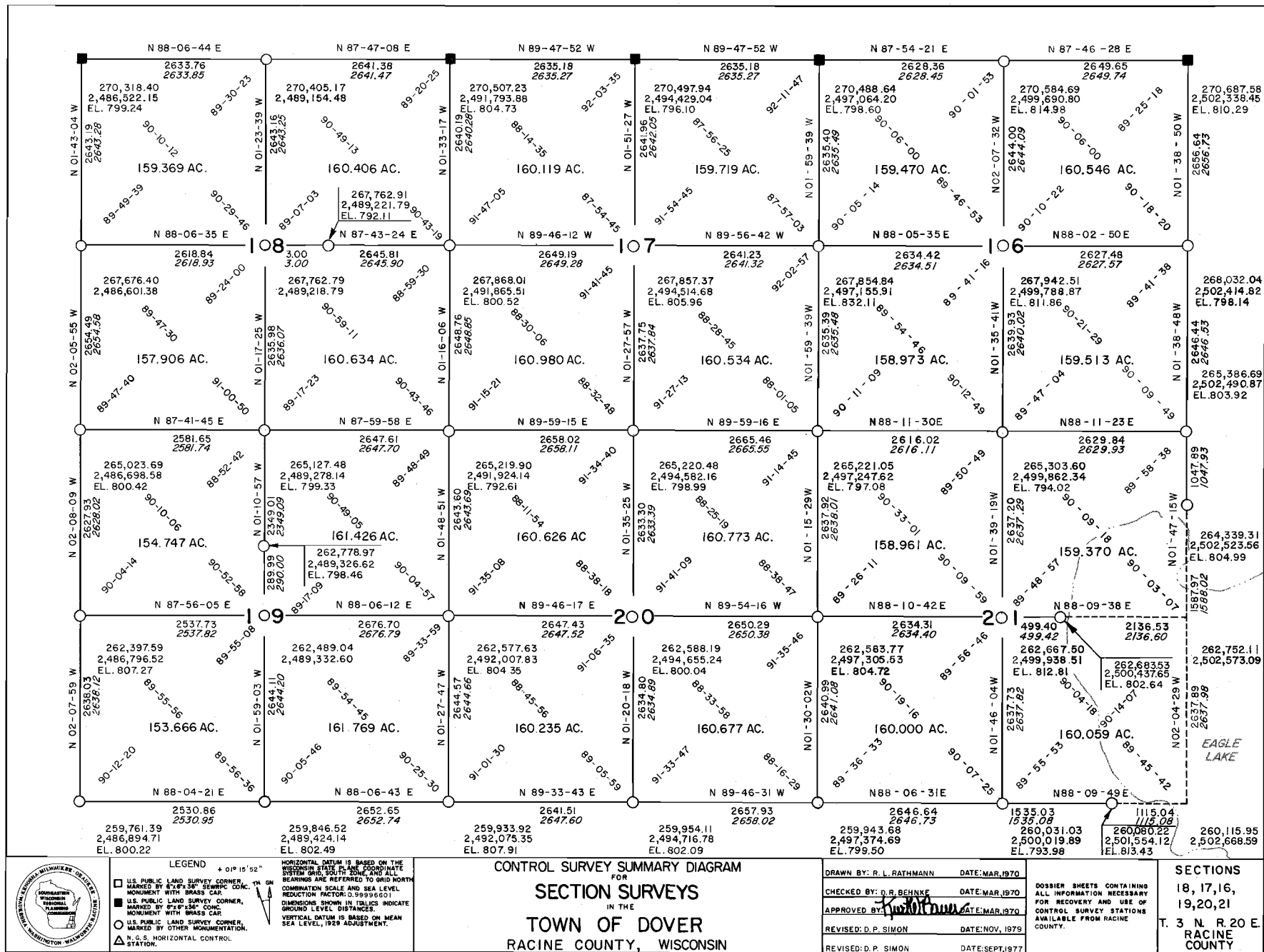
RACINE COUNTY

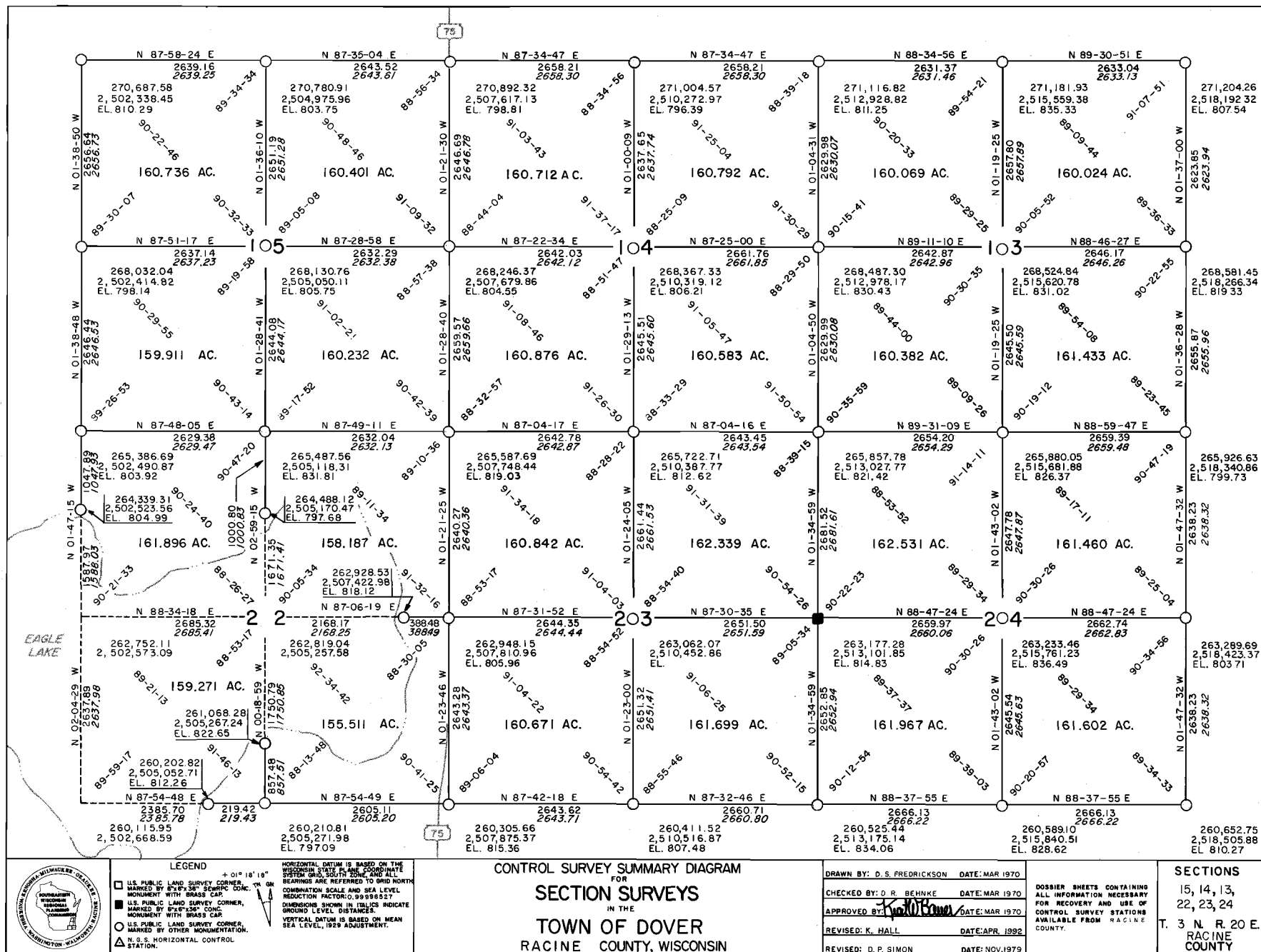


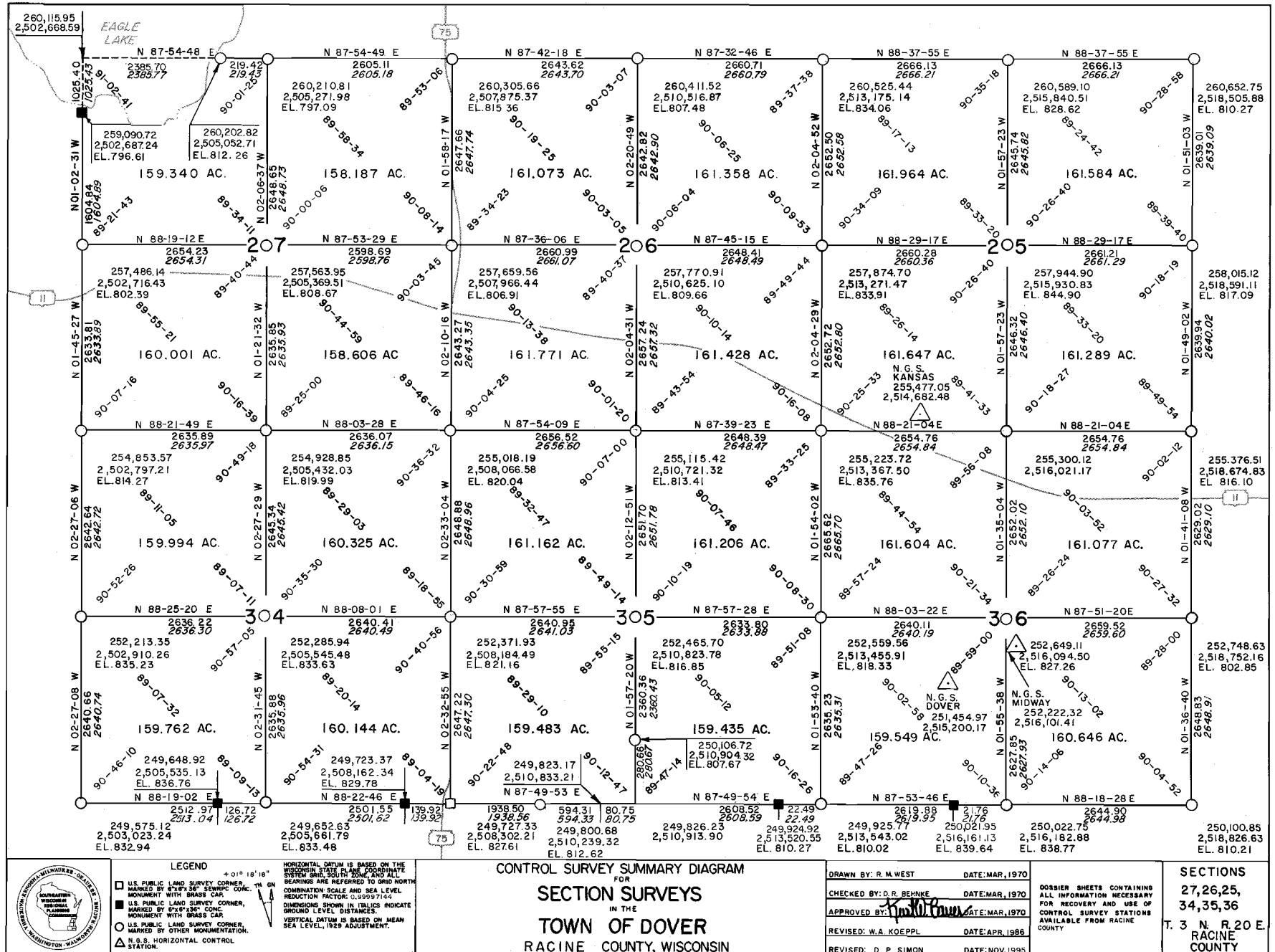


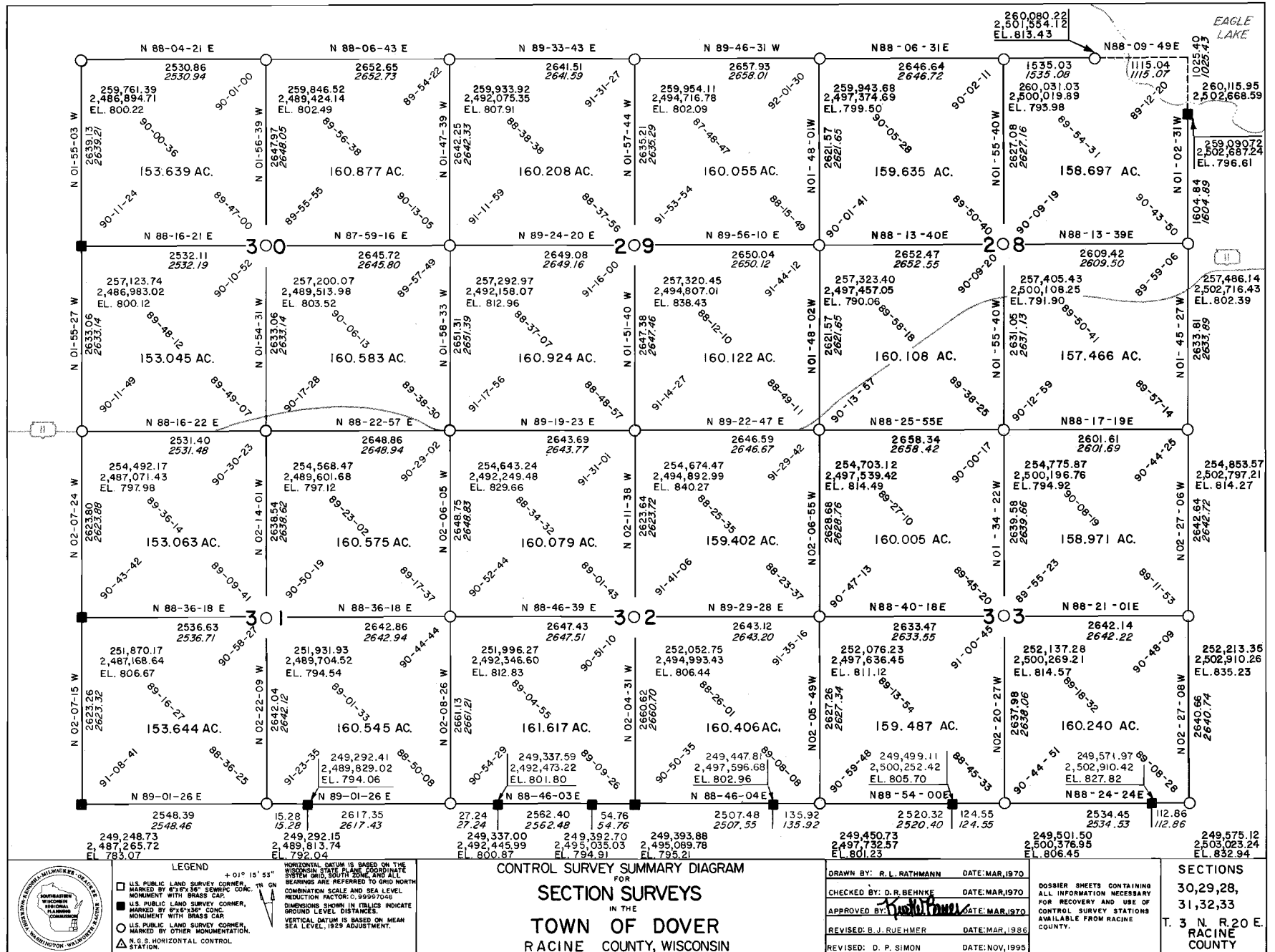


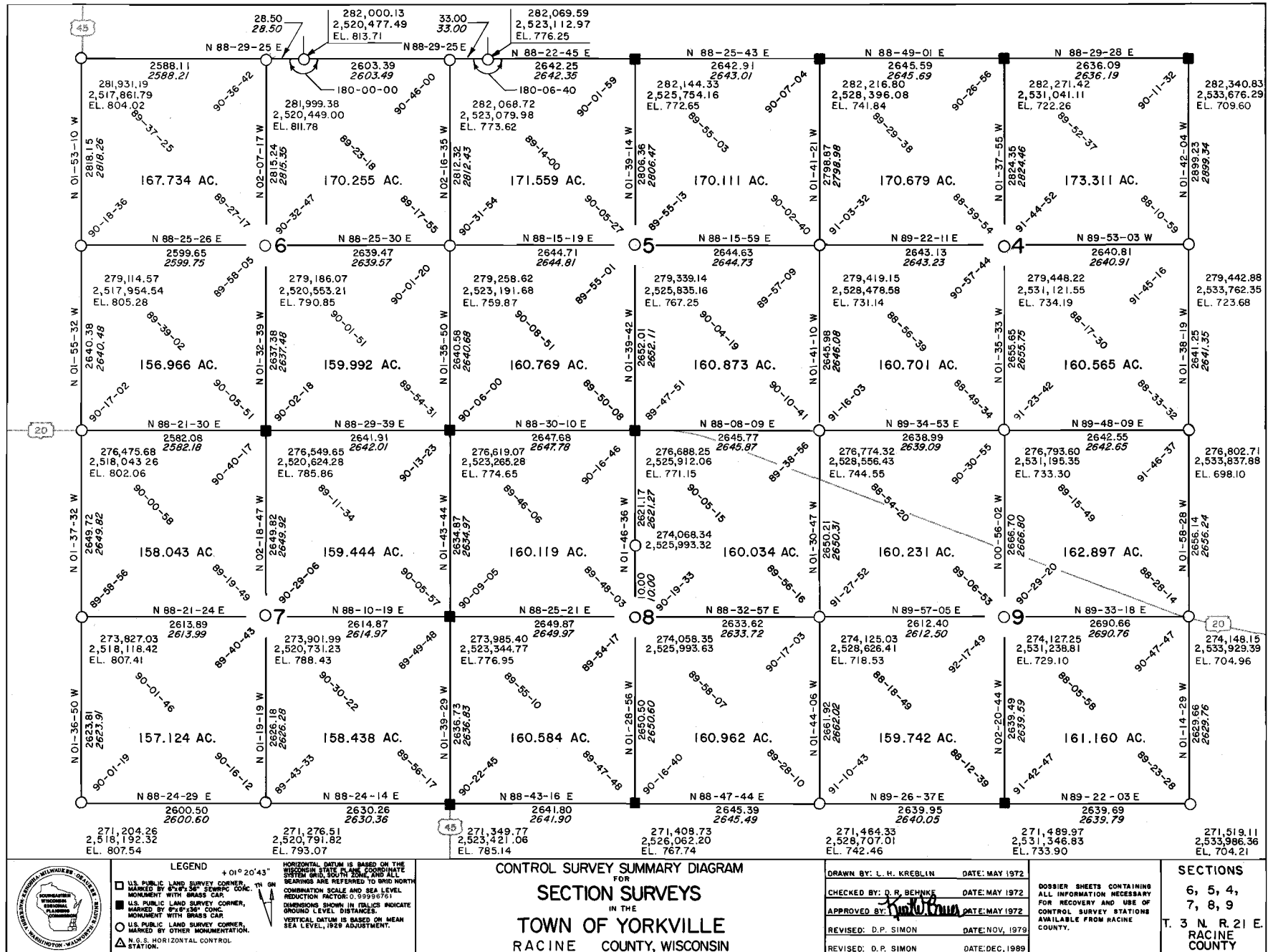


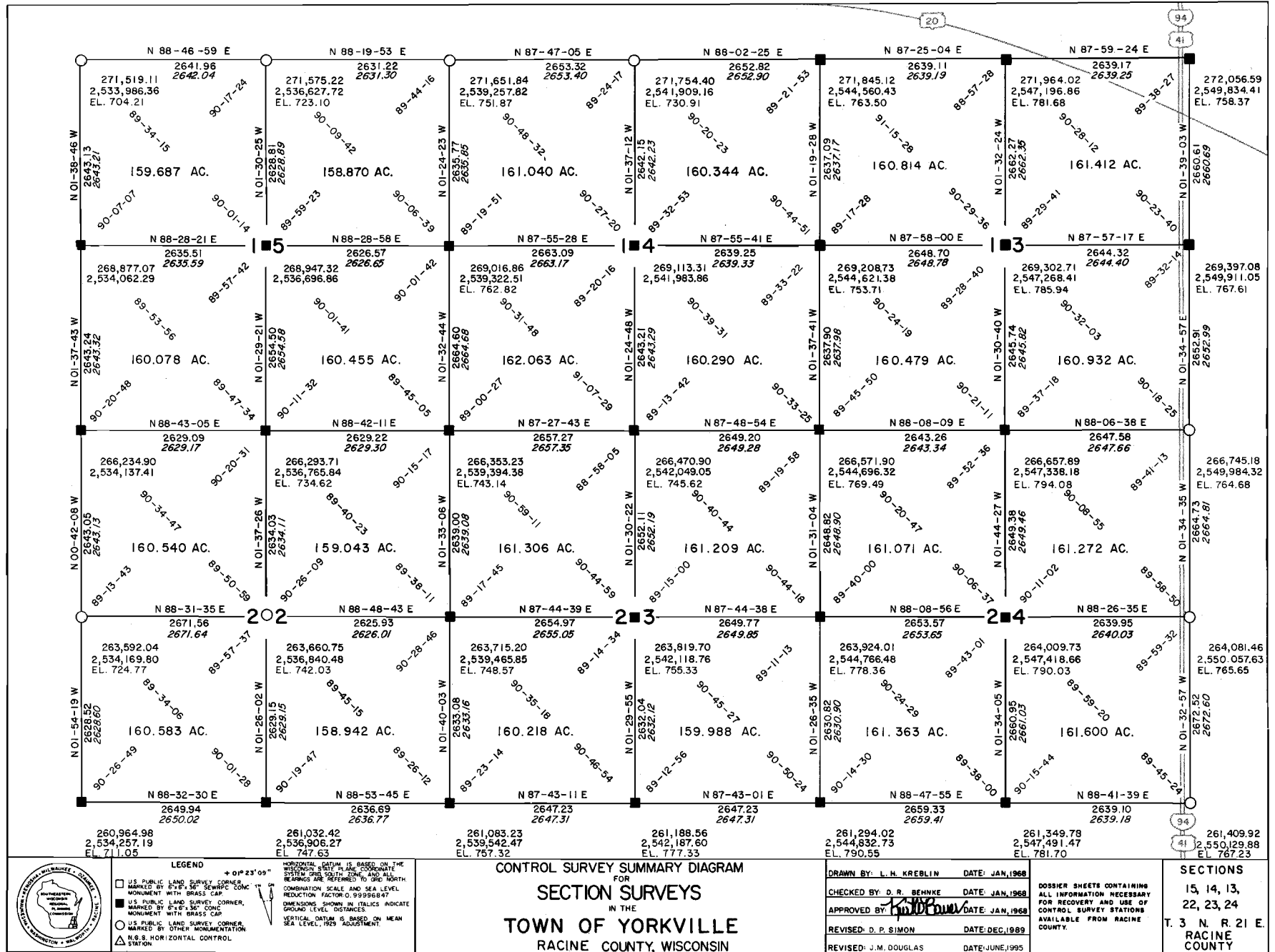


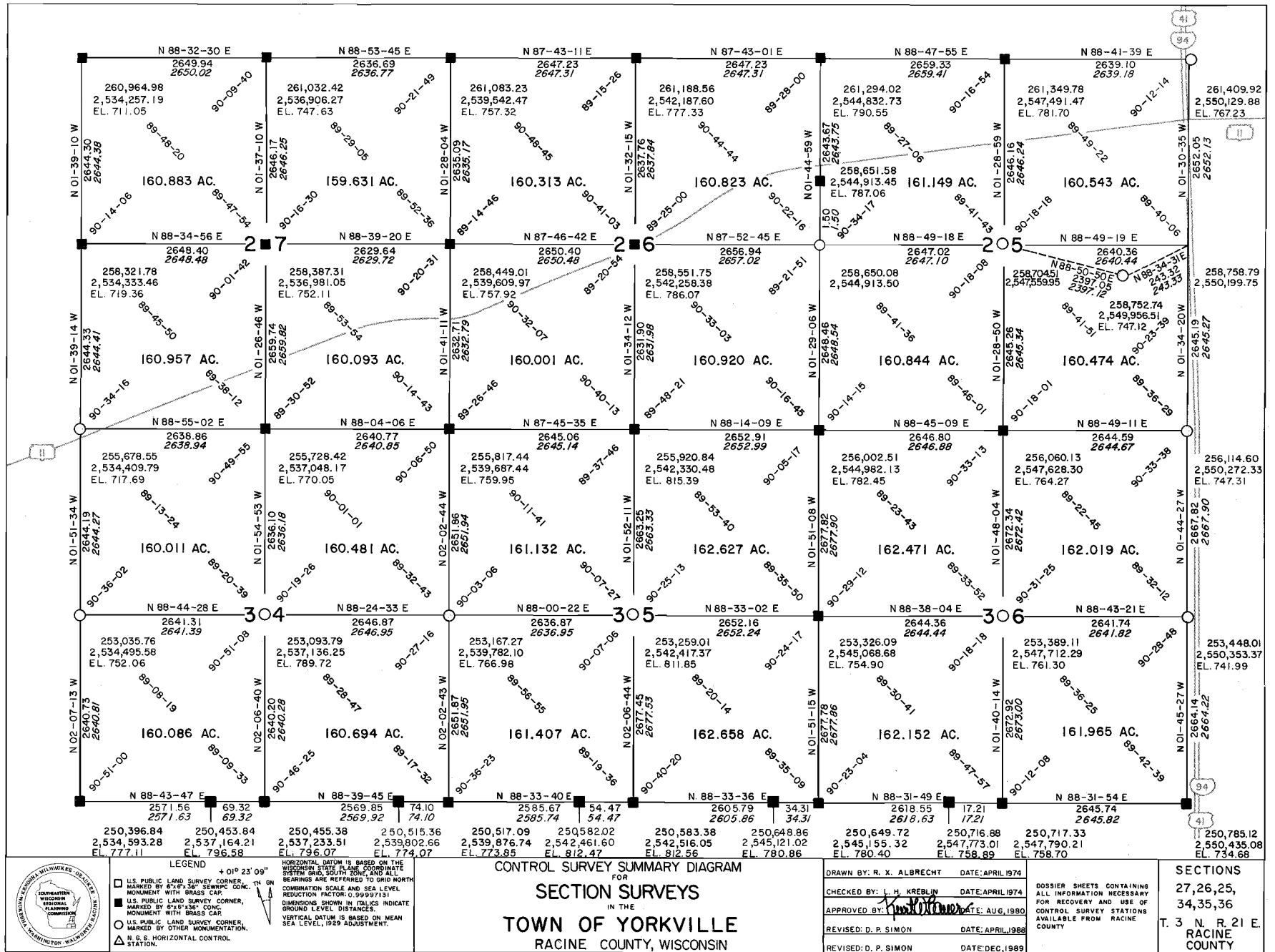


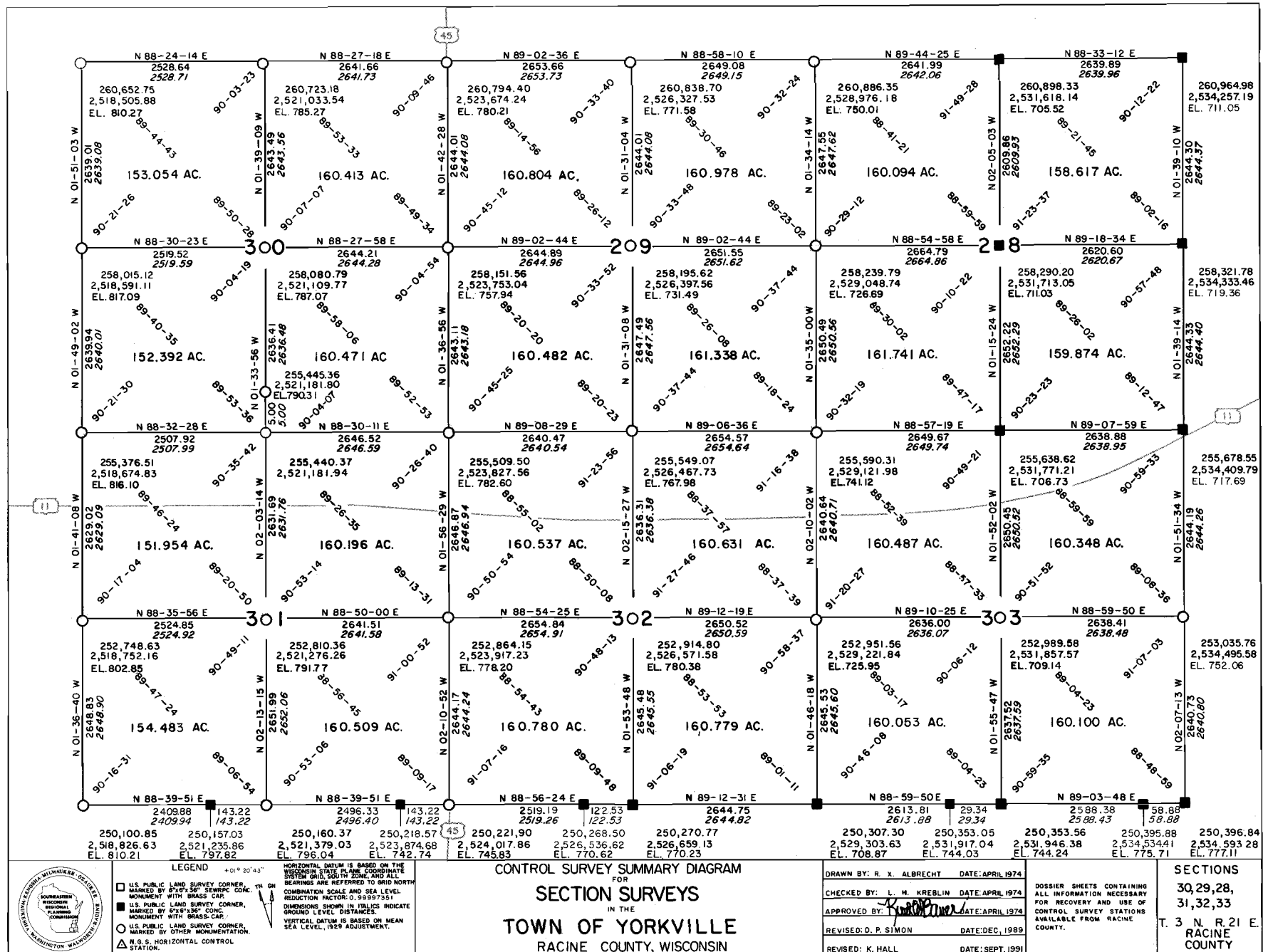


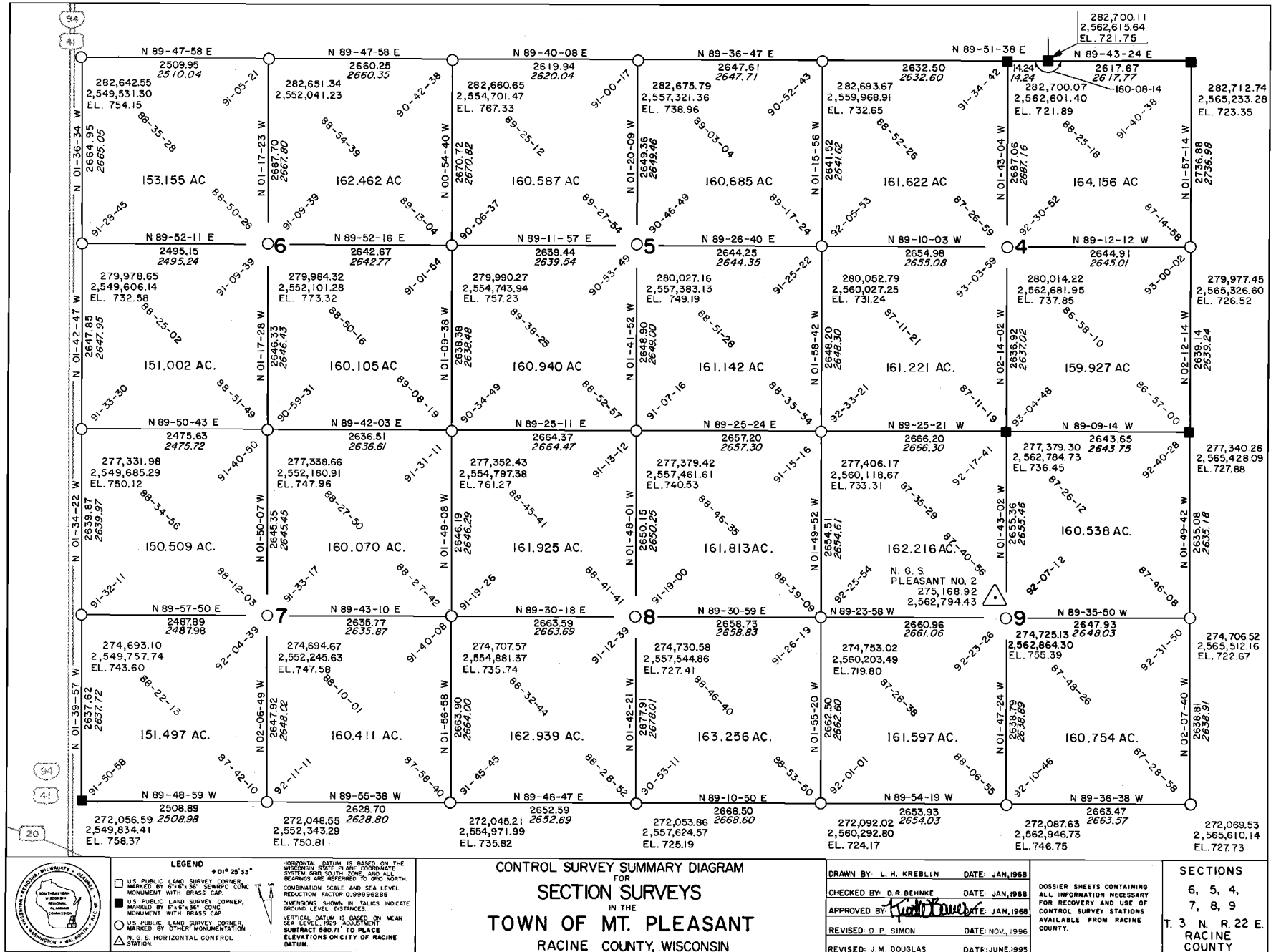


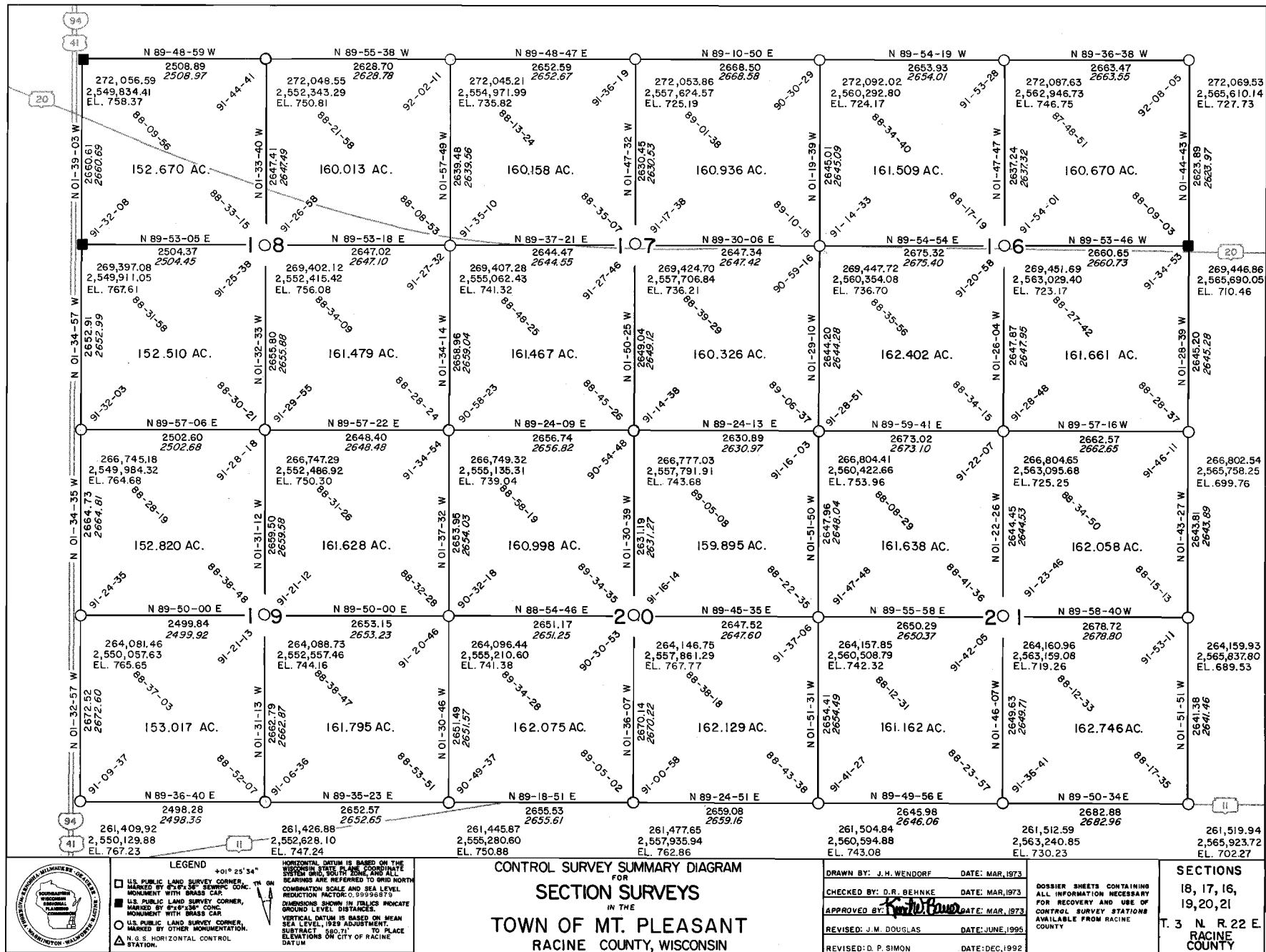


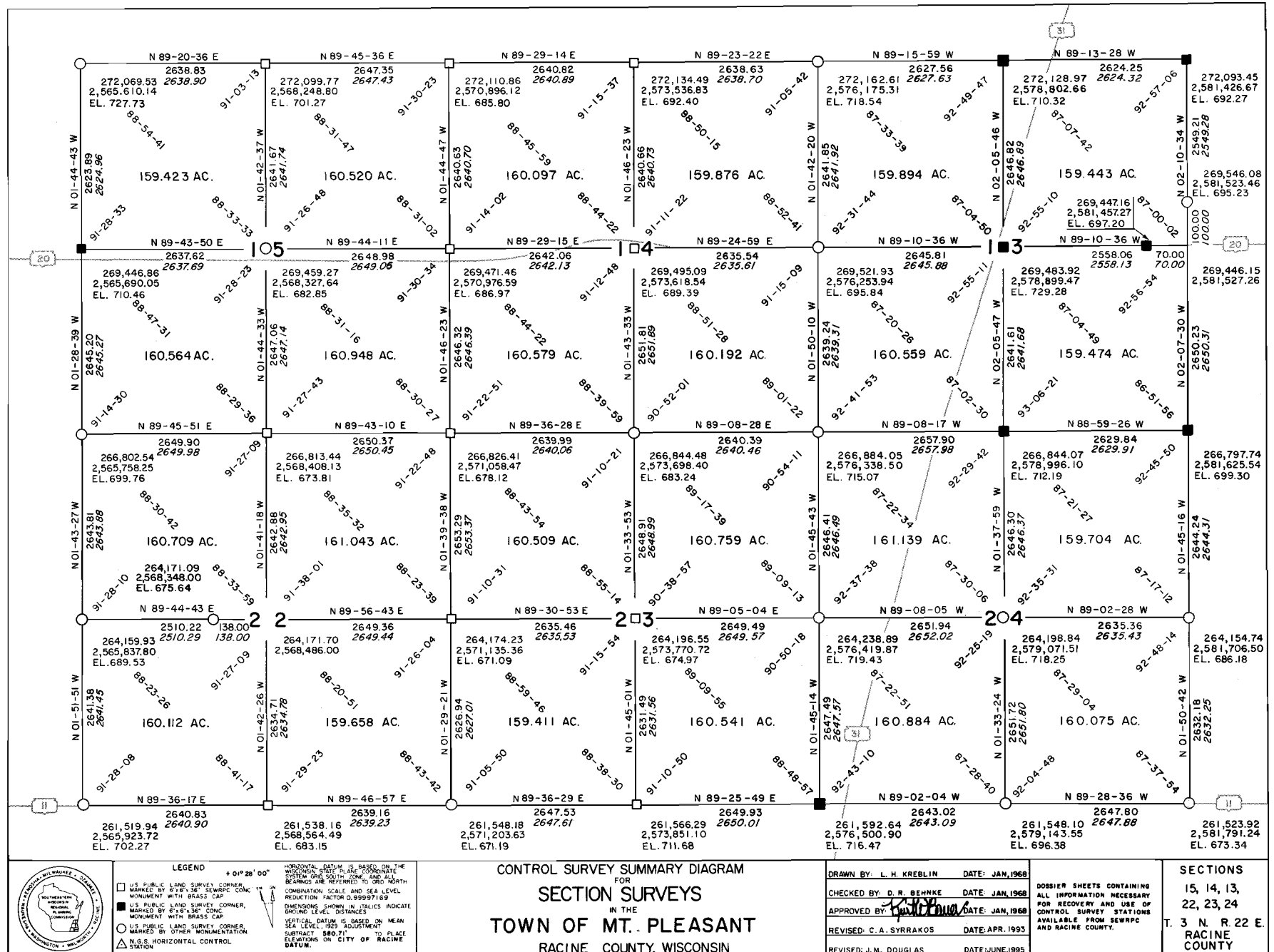


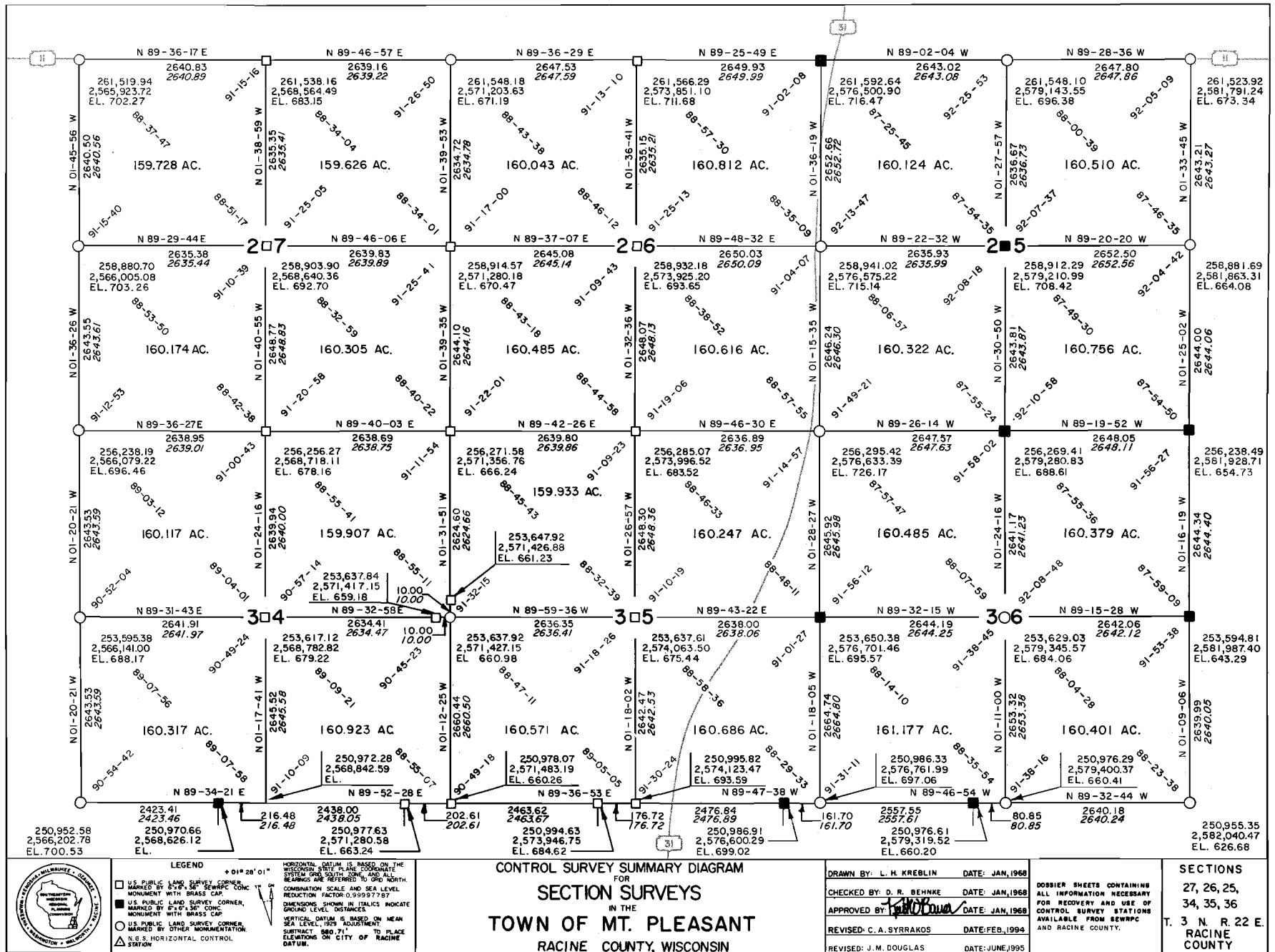


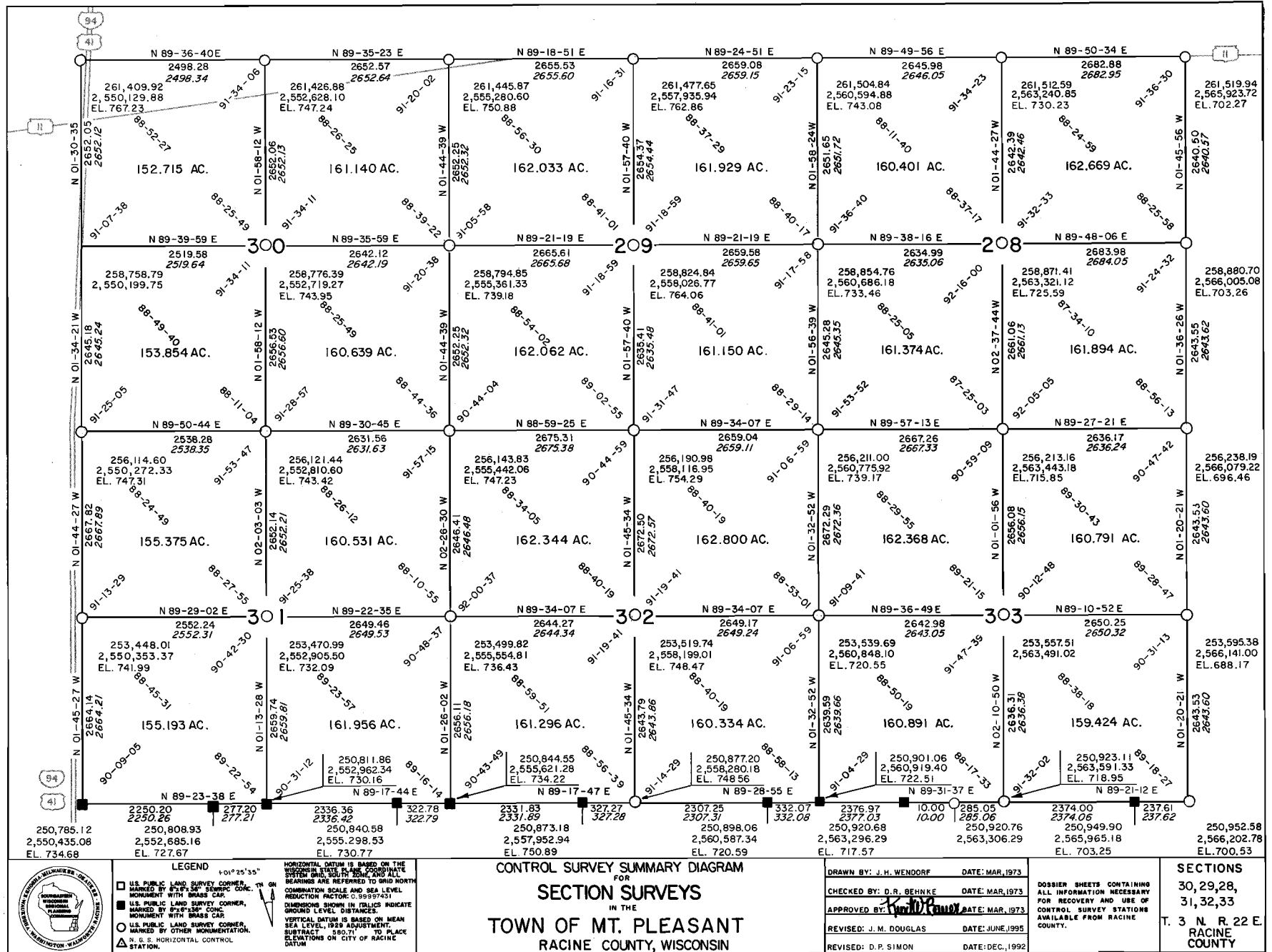


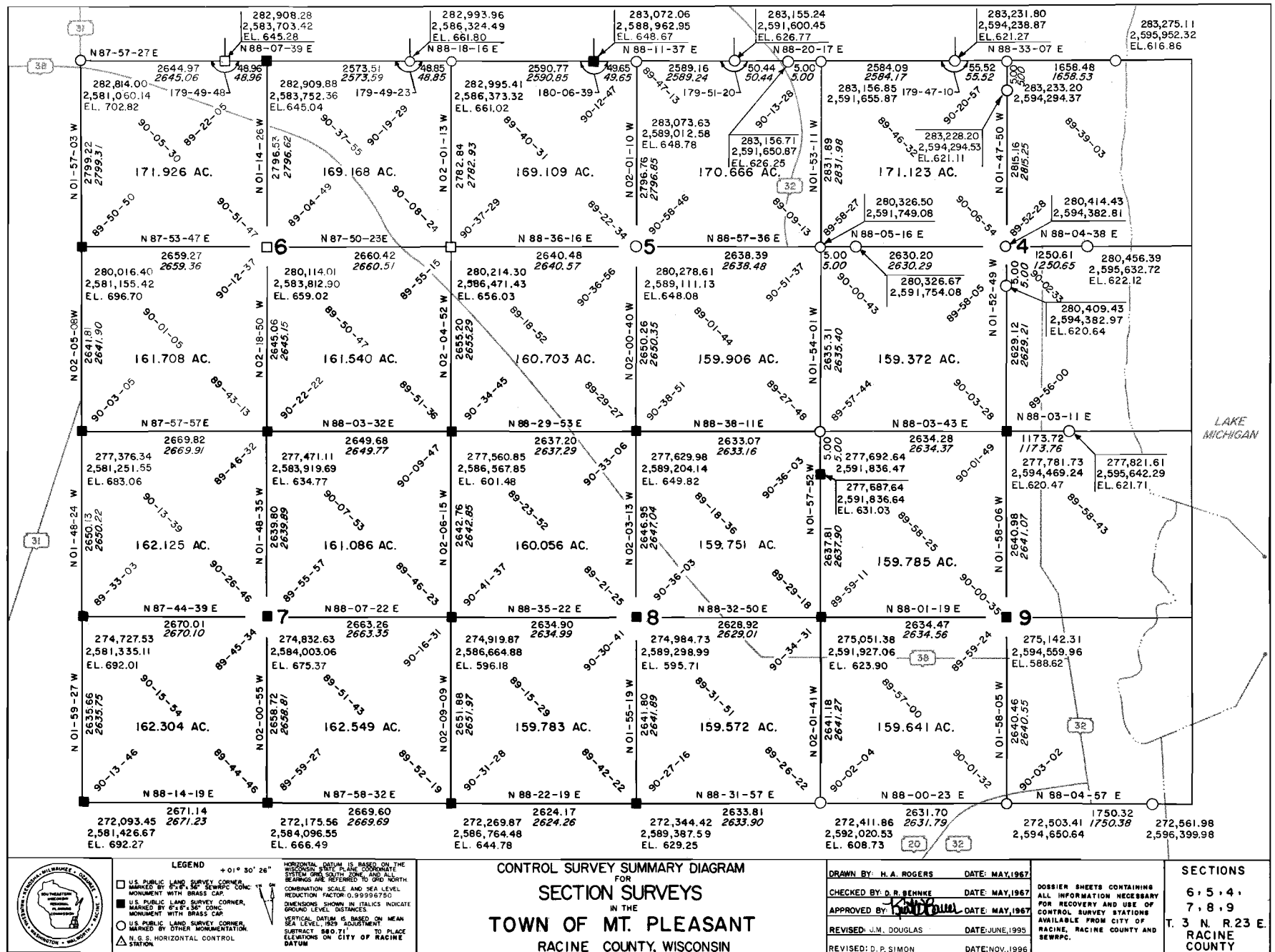


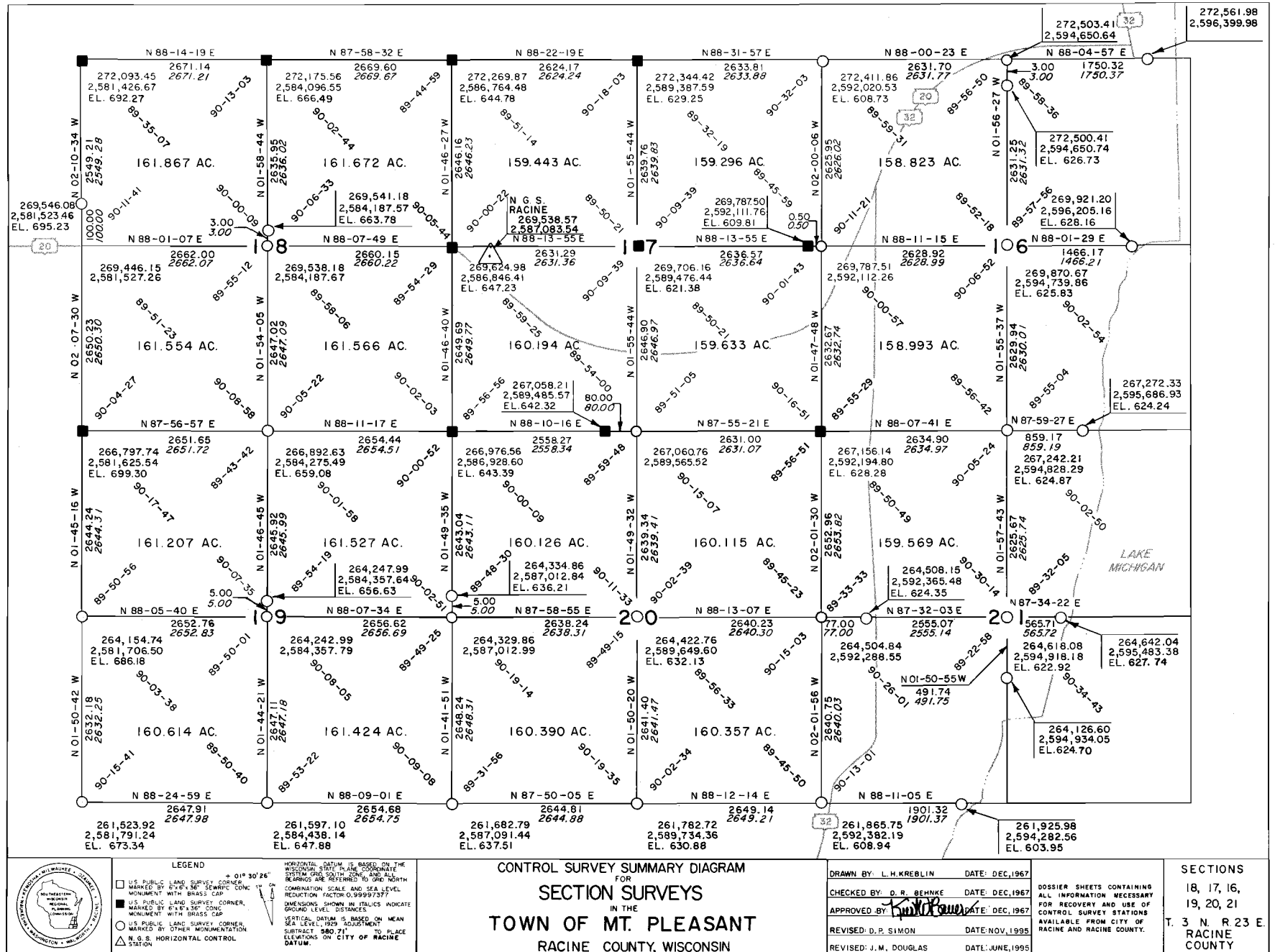


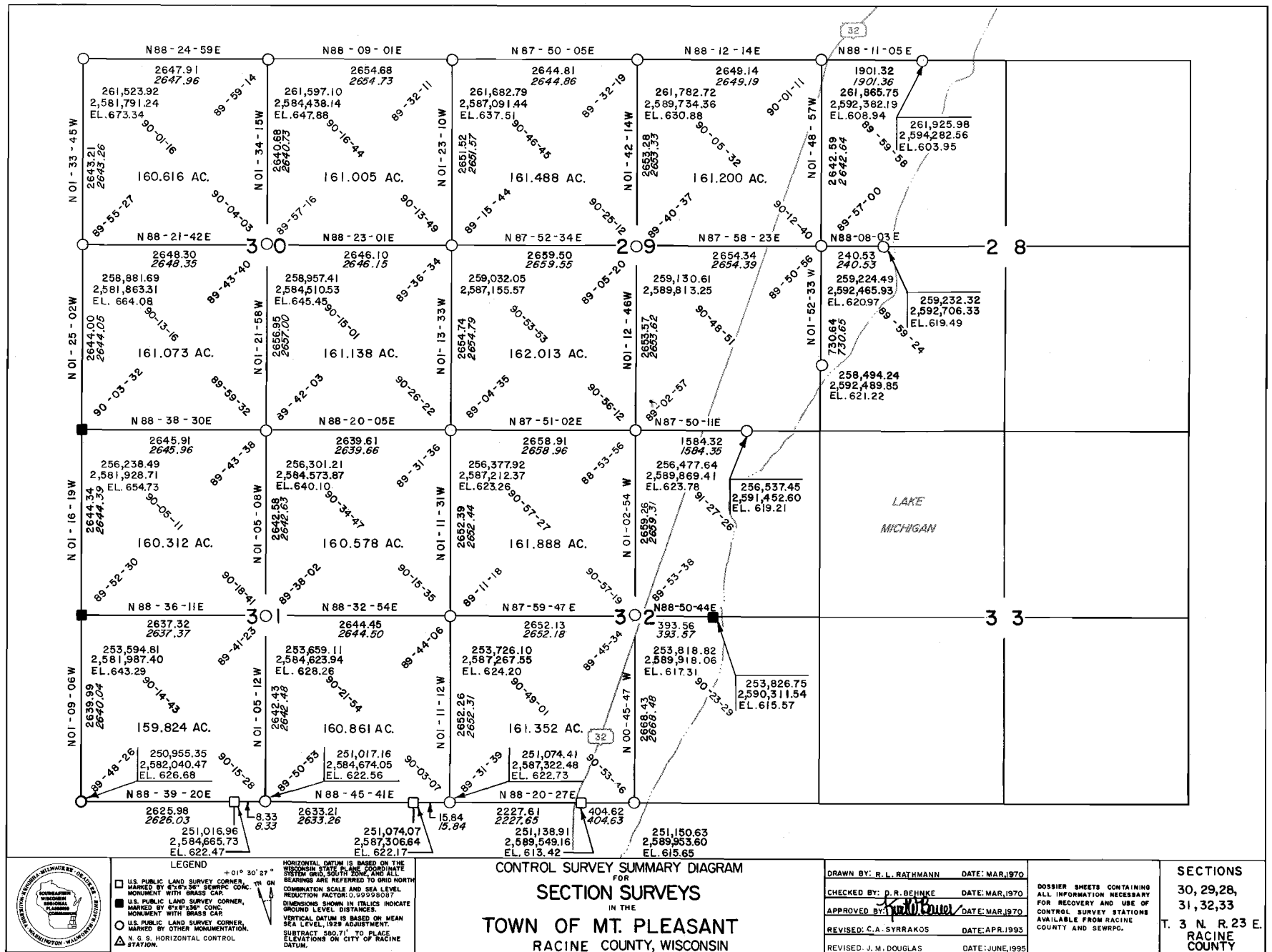


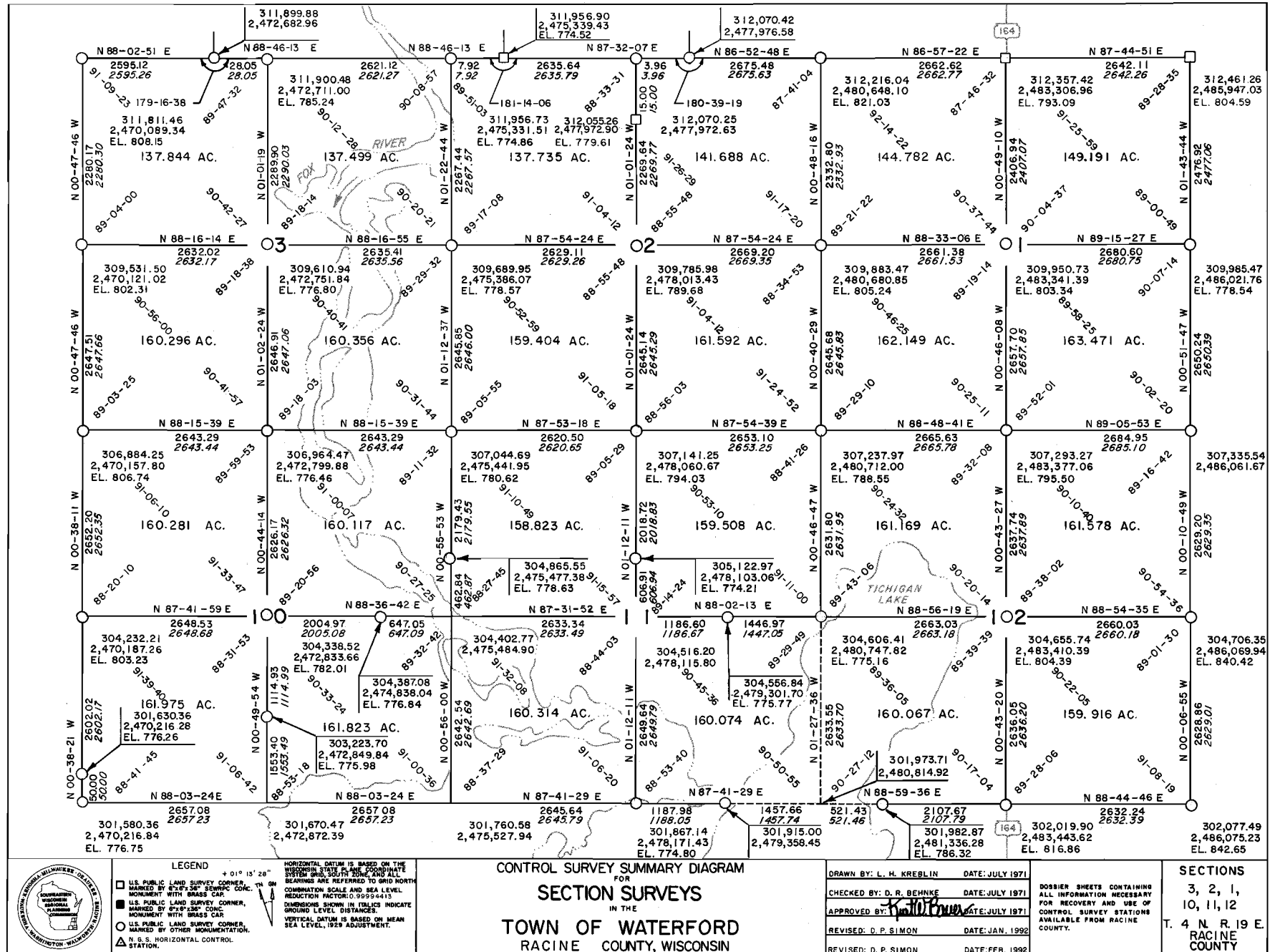


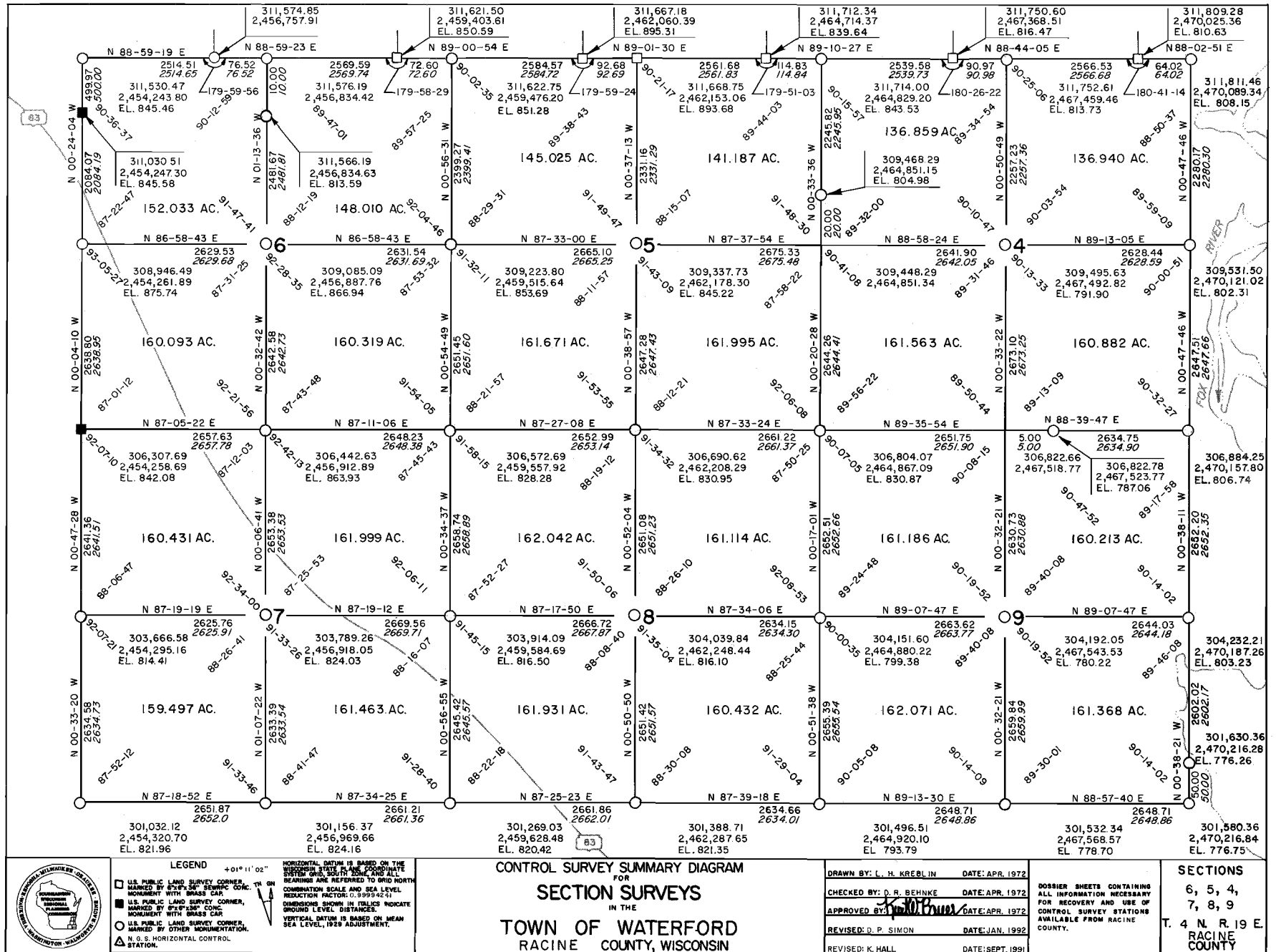


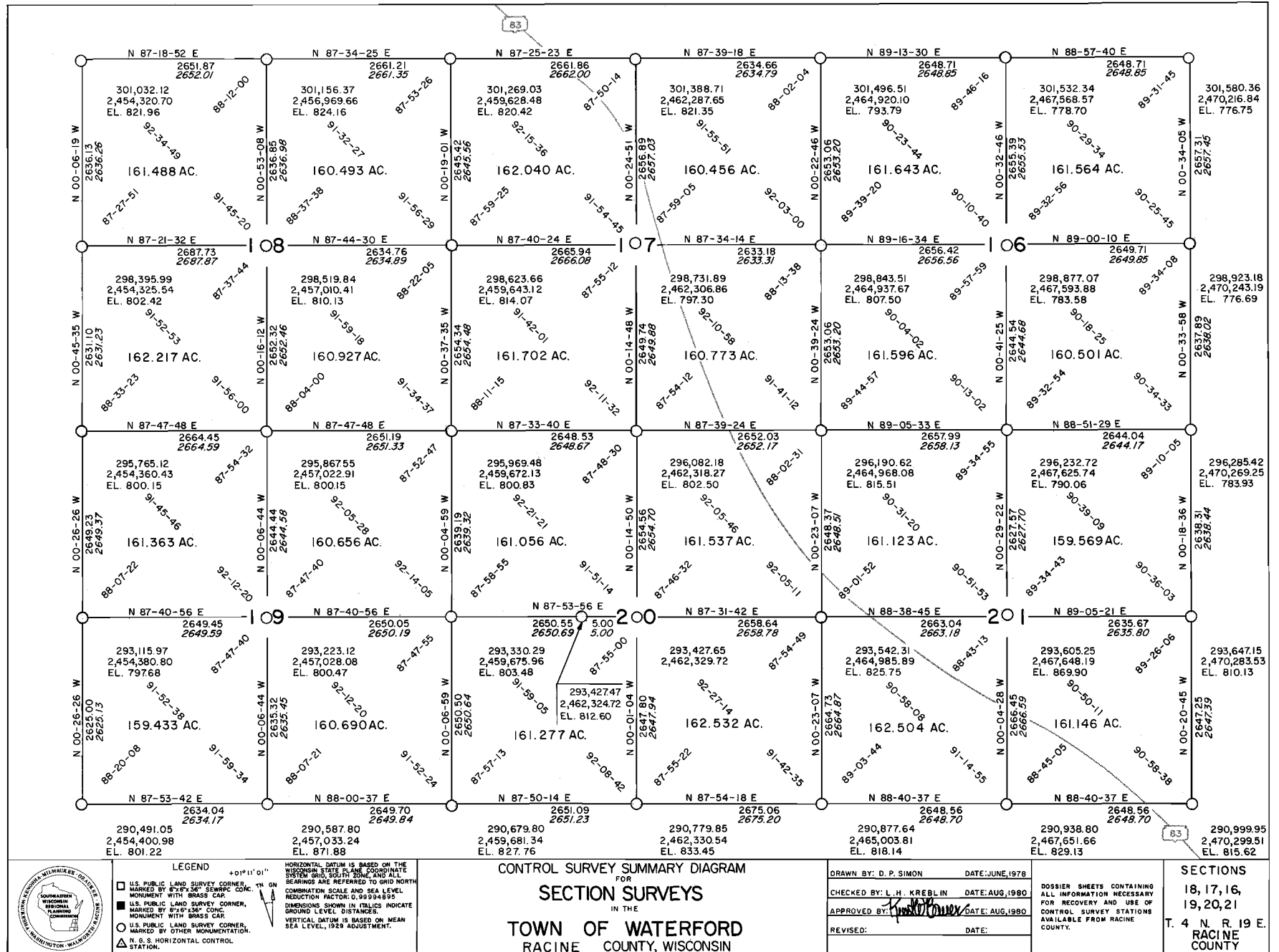


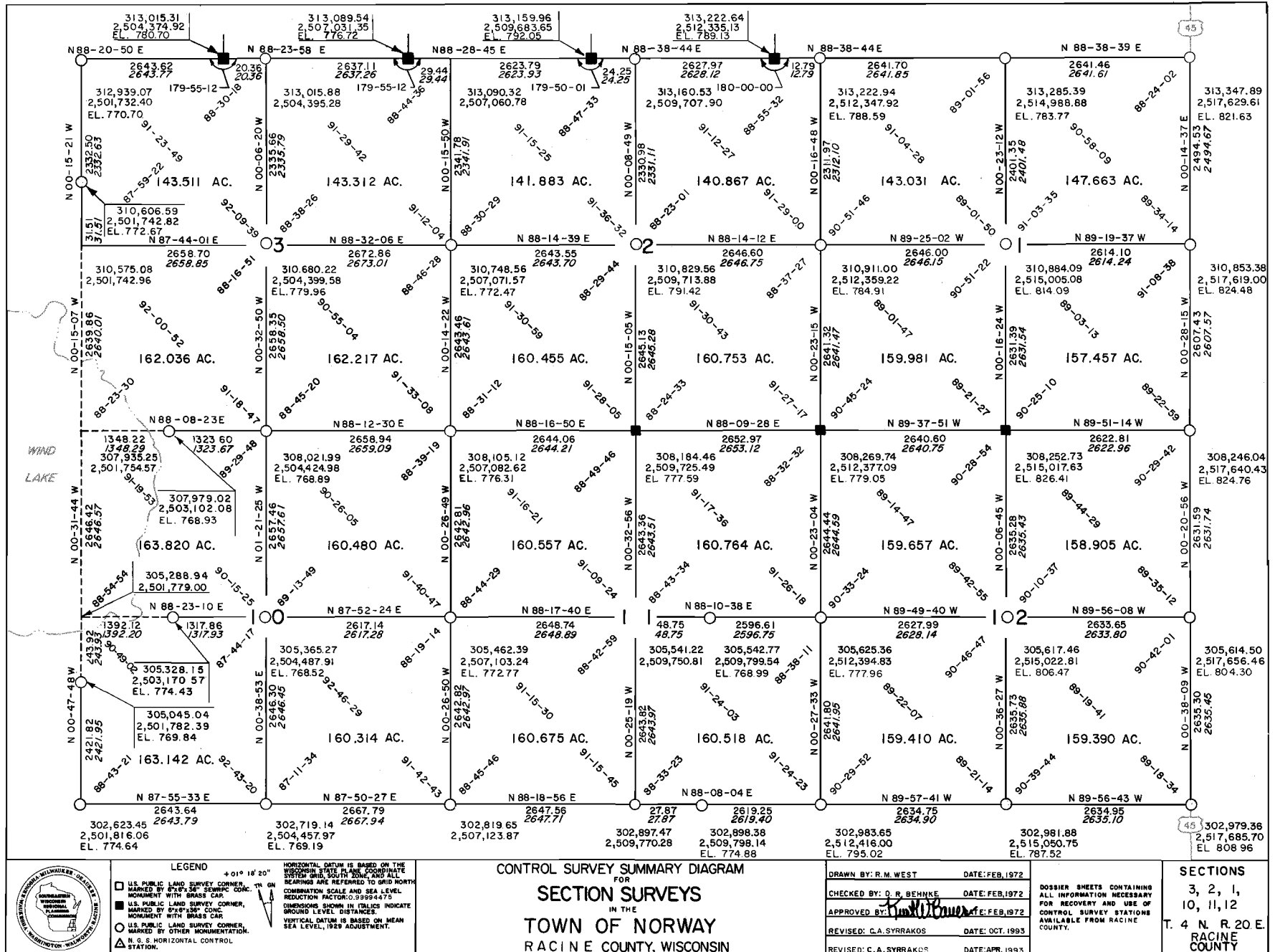


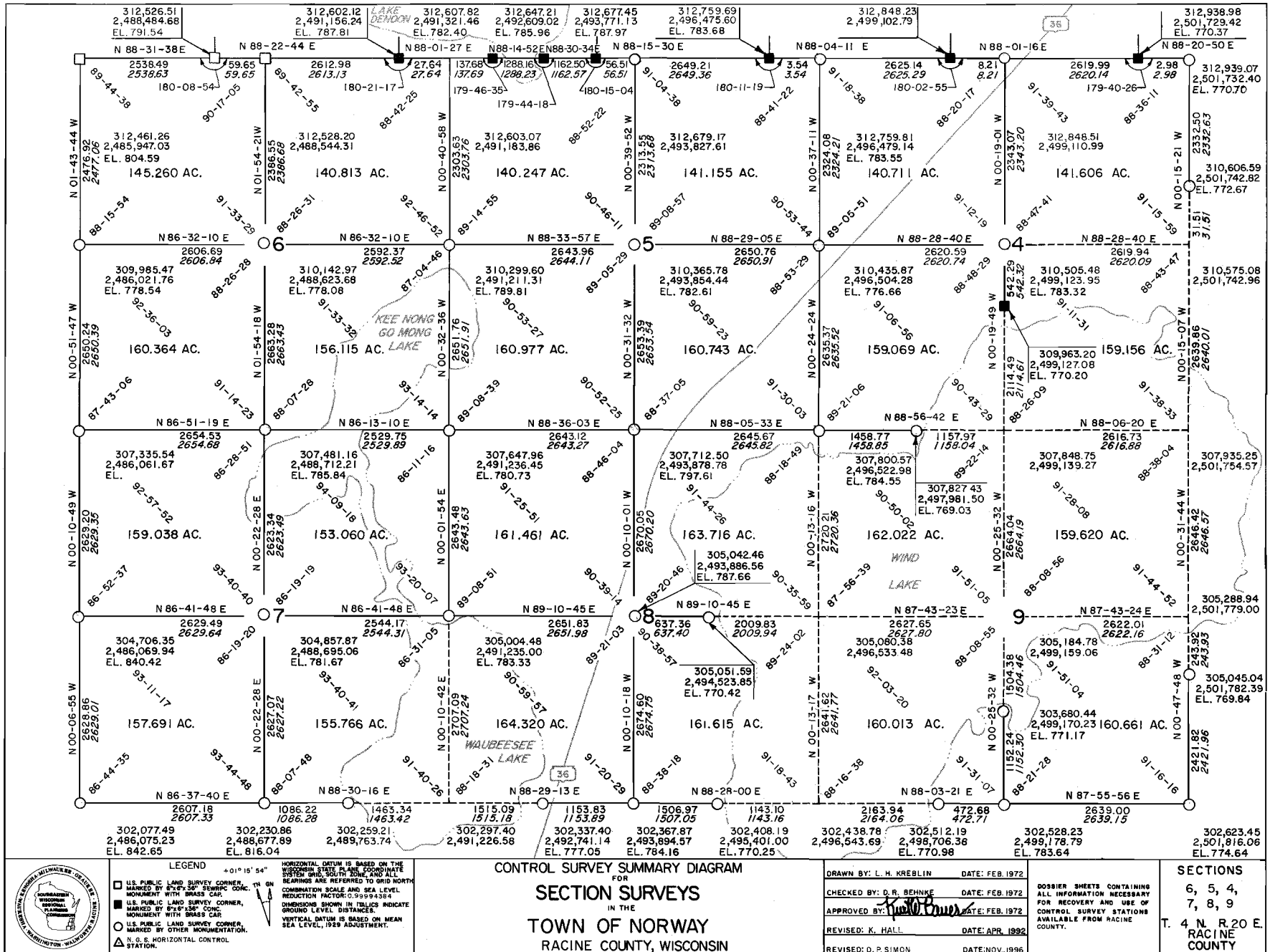


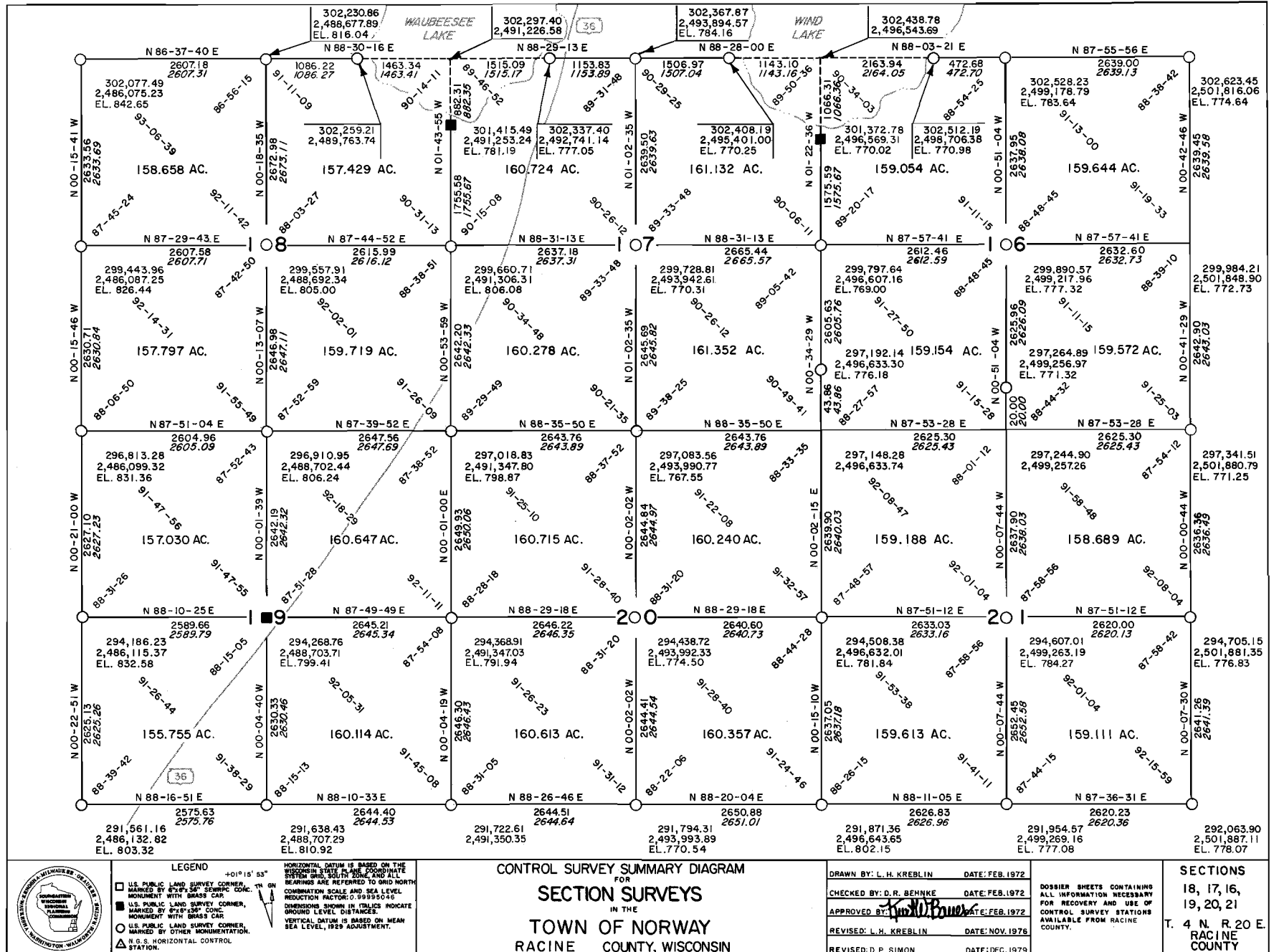


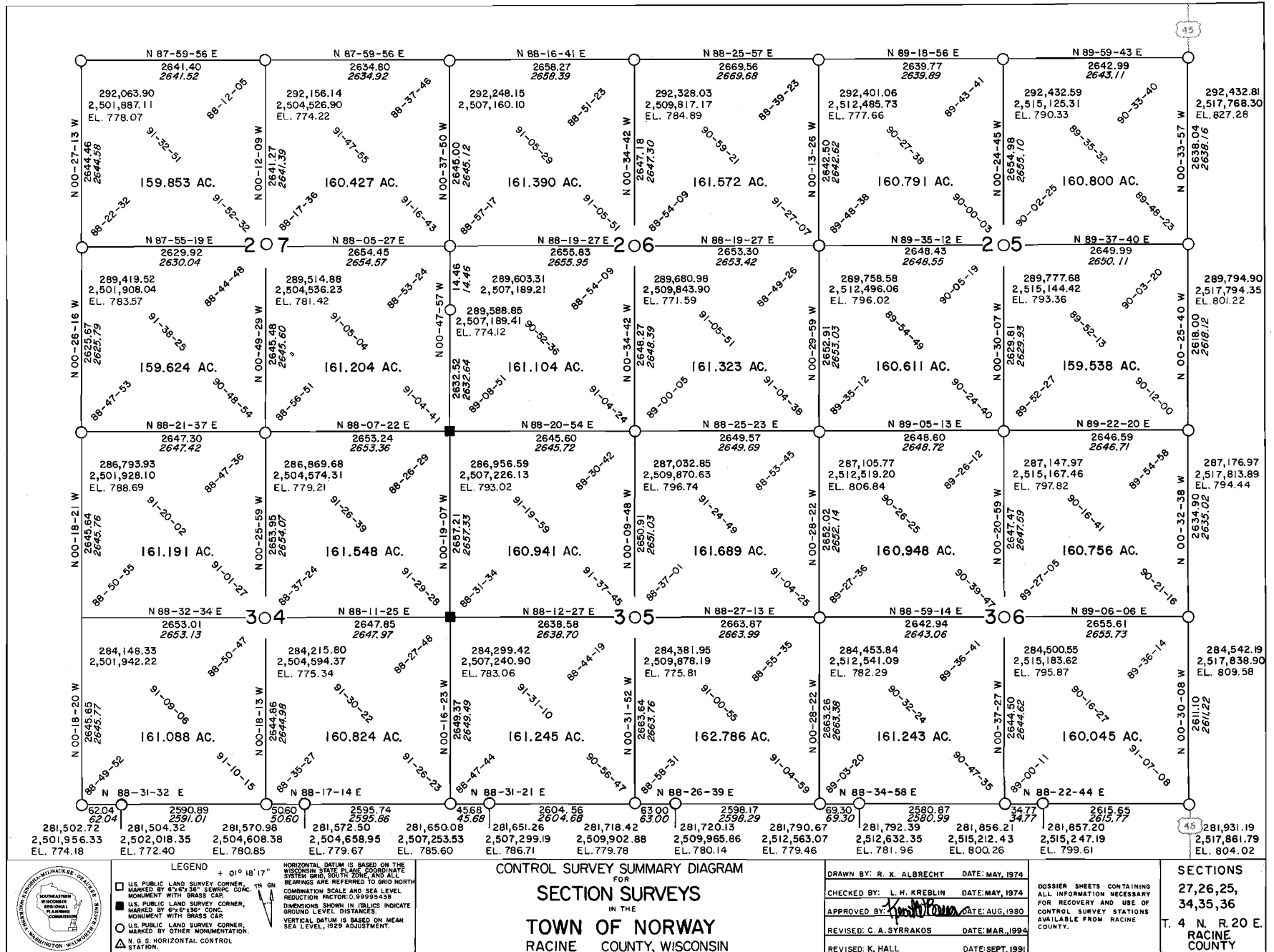


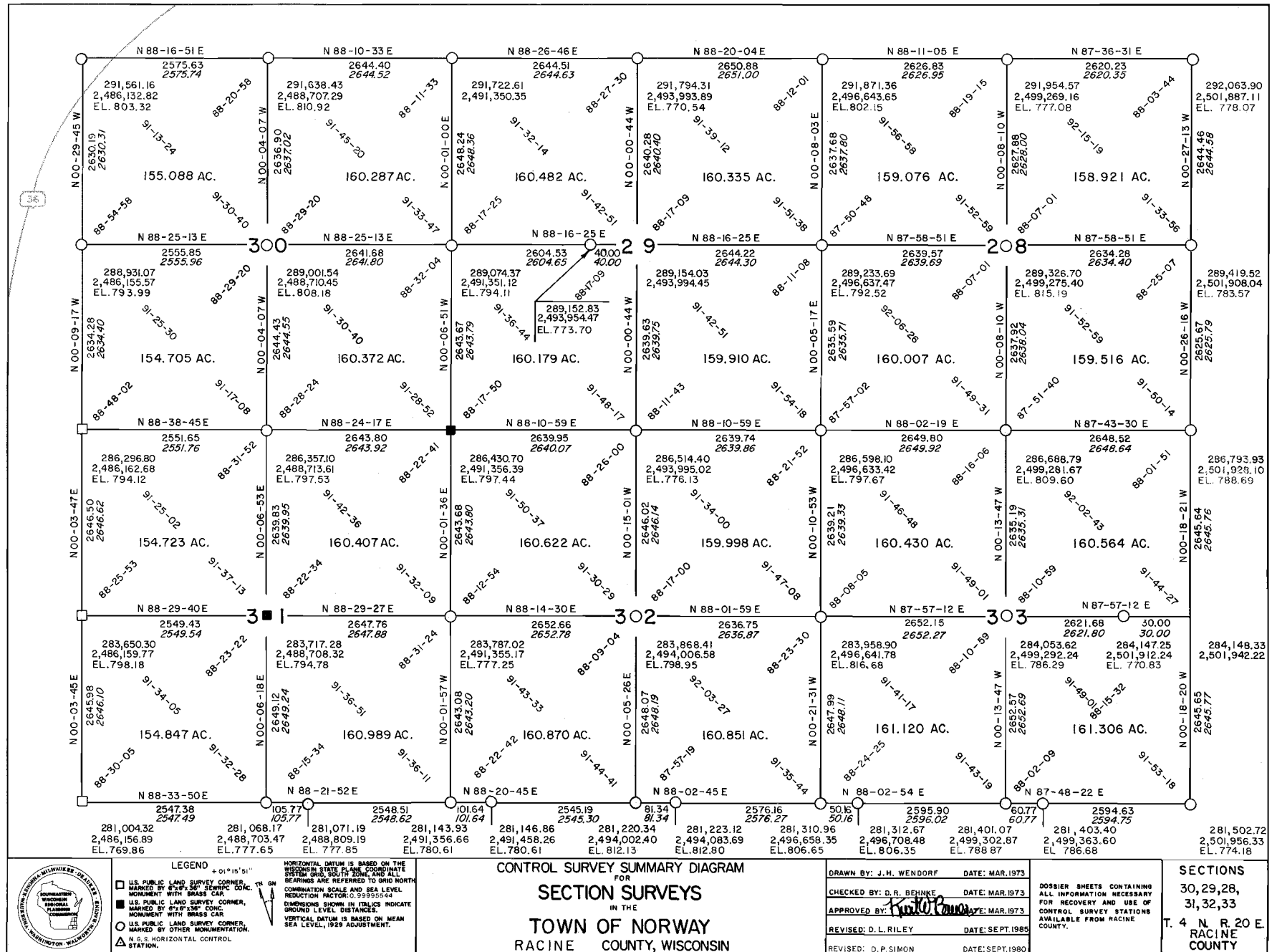


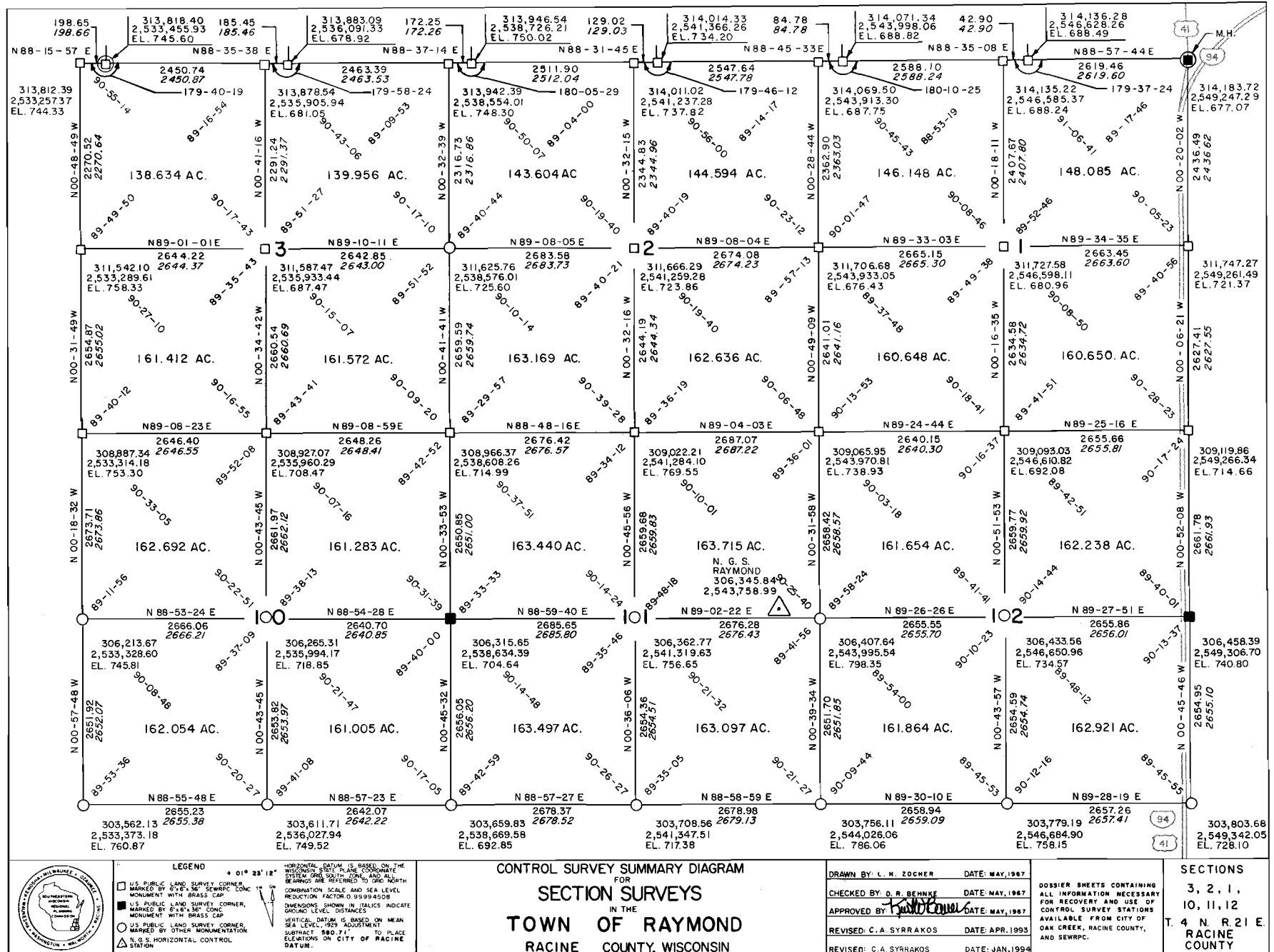


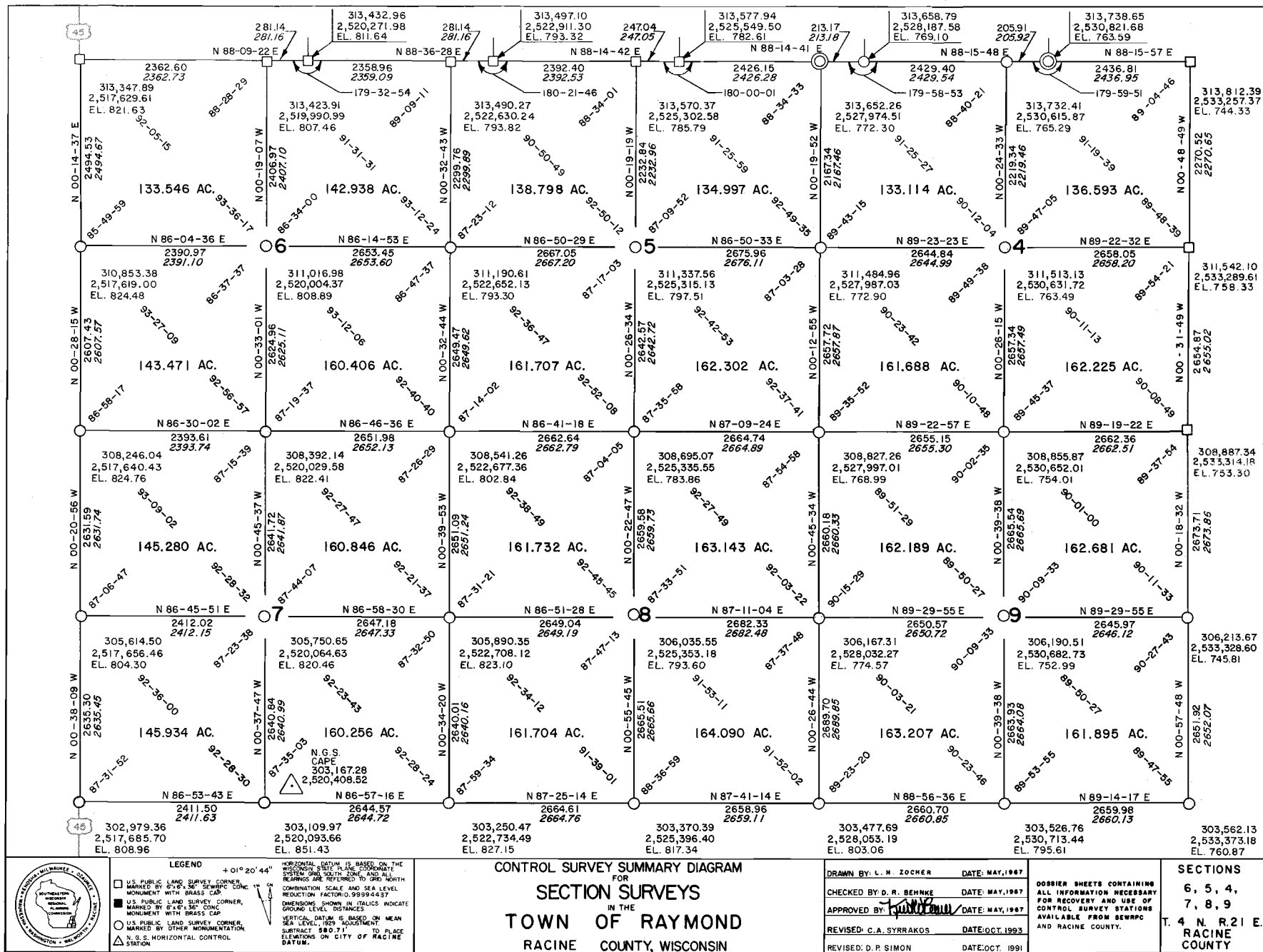


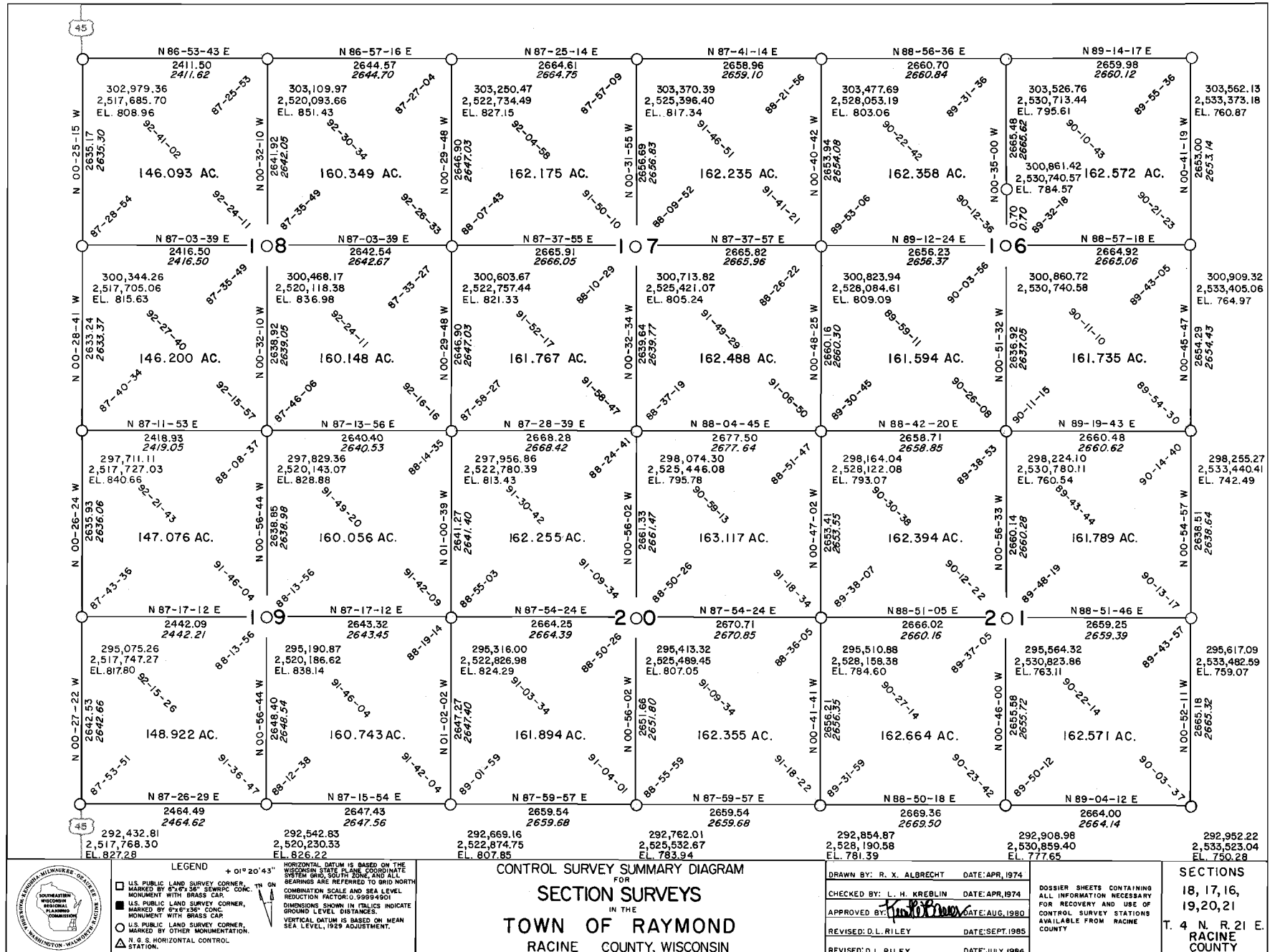


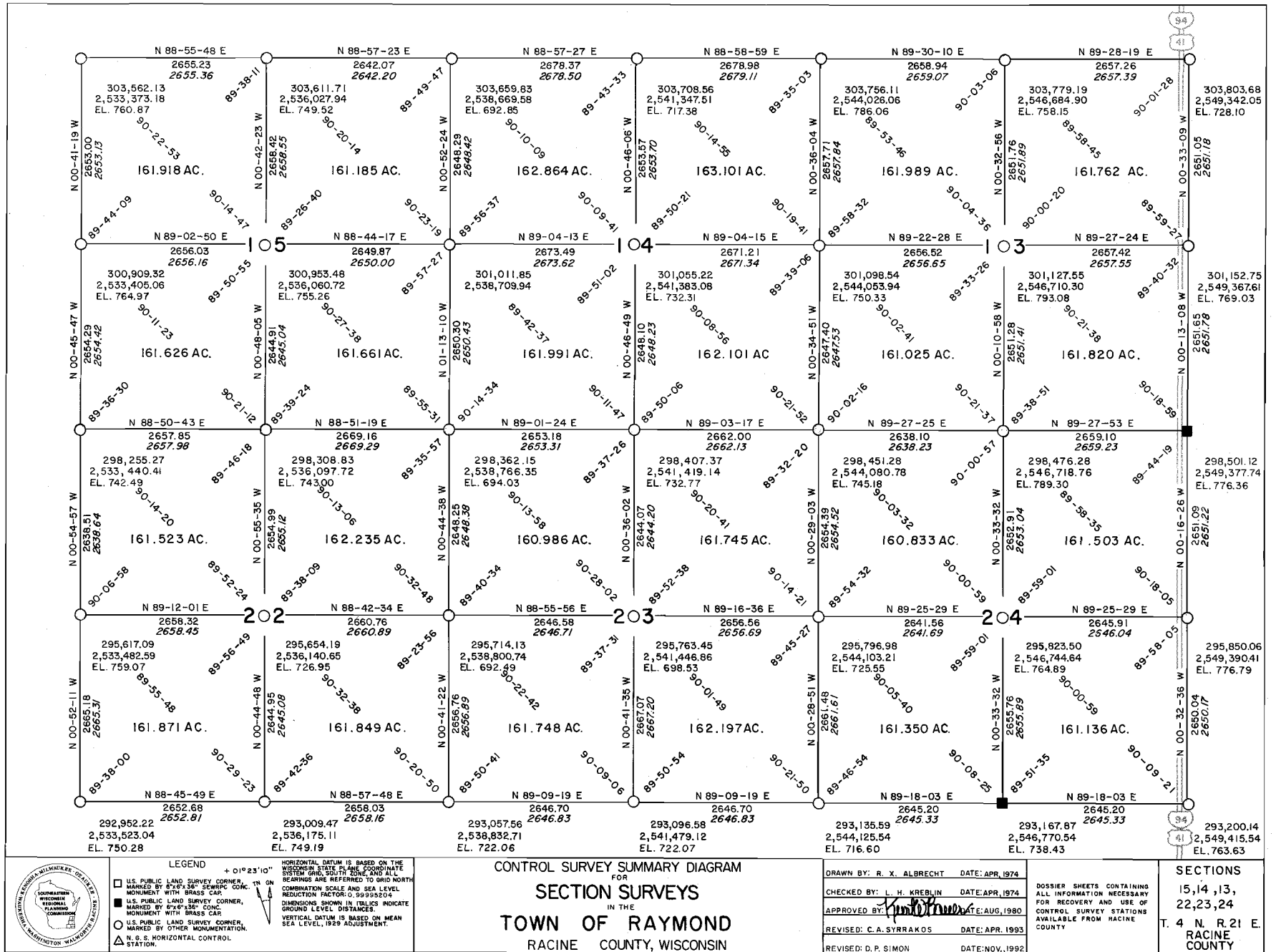


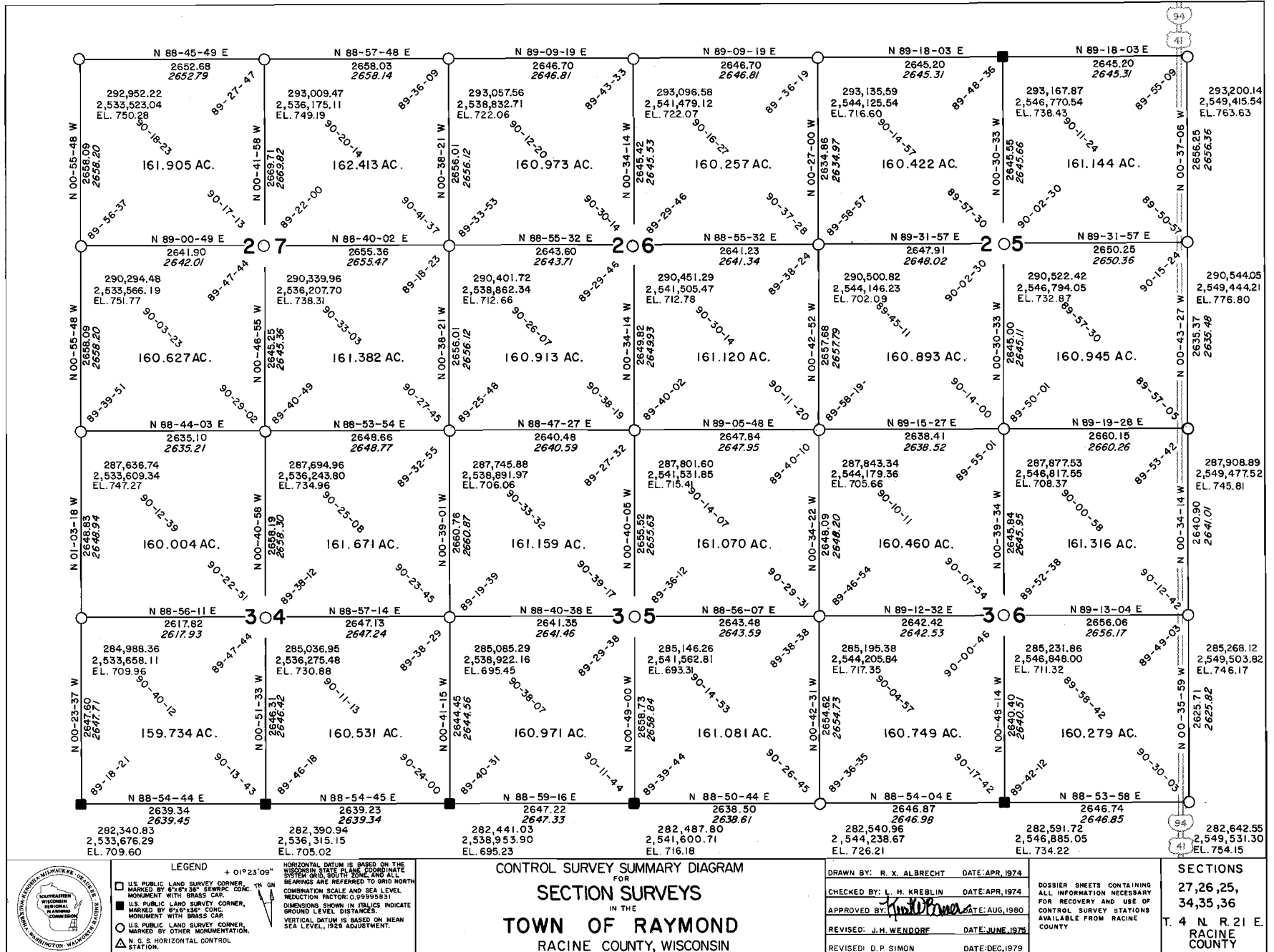


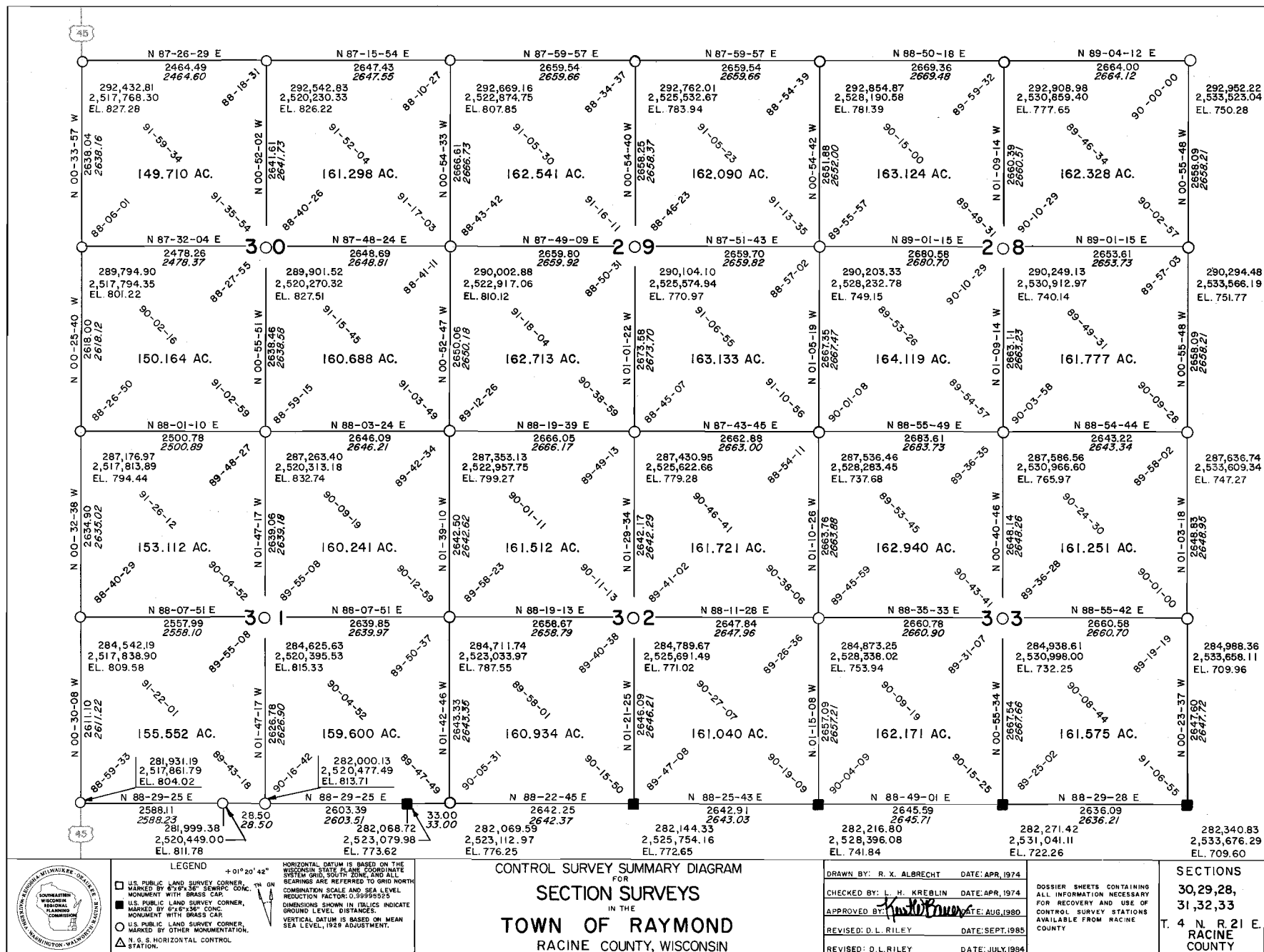


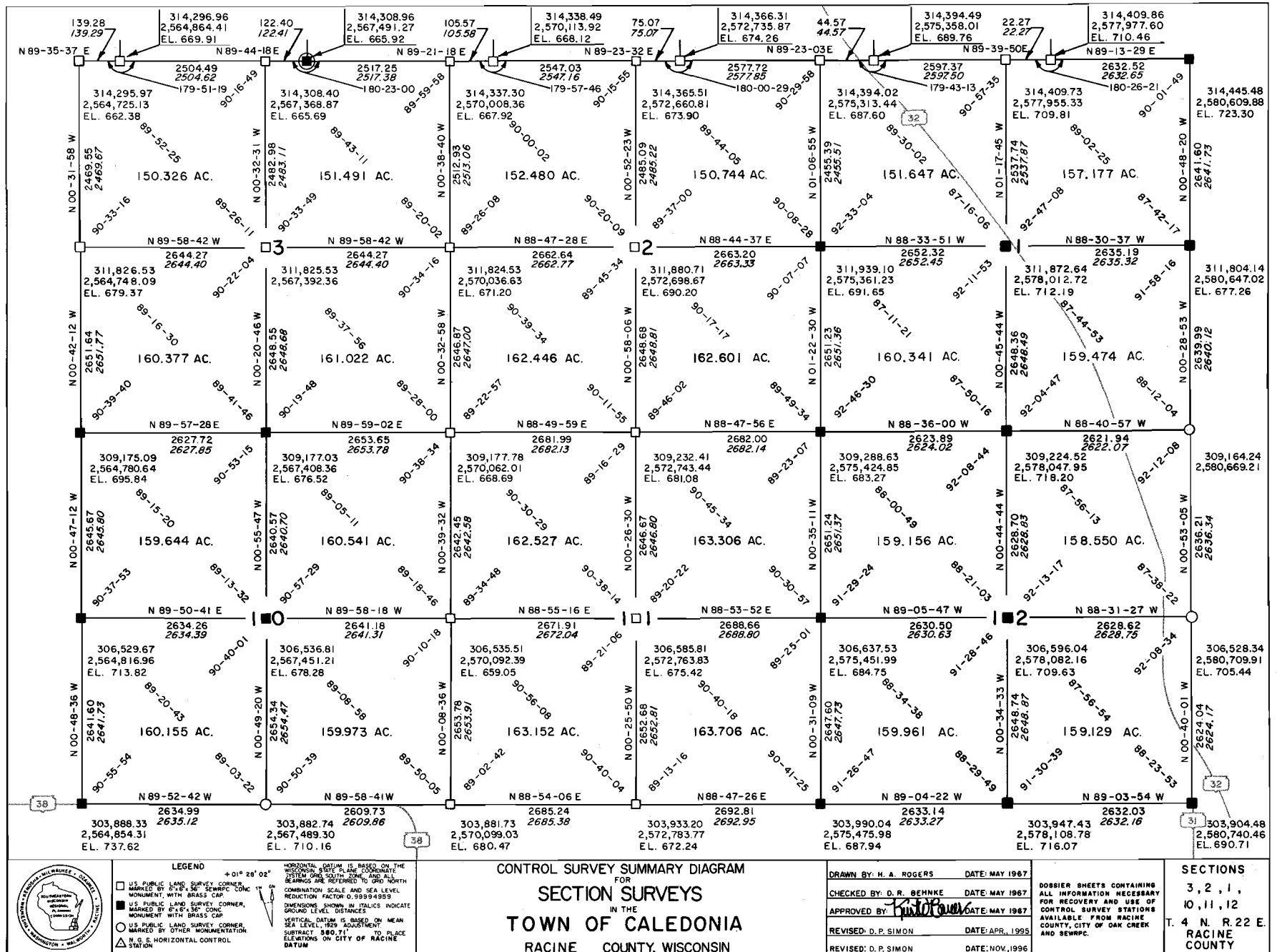


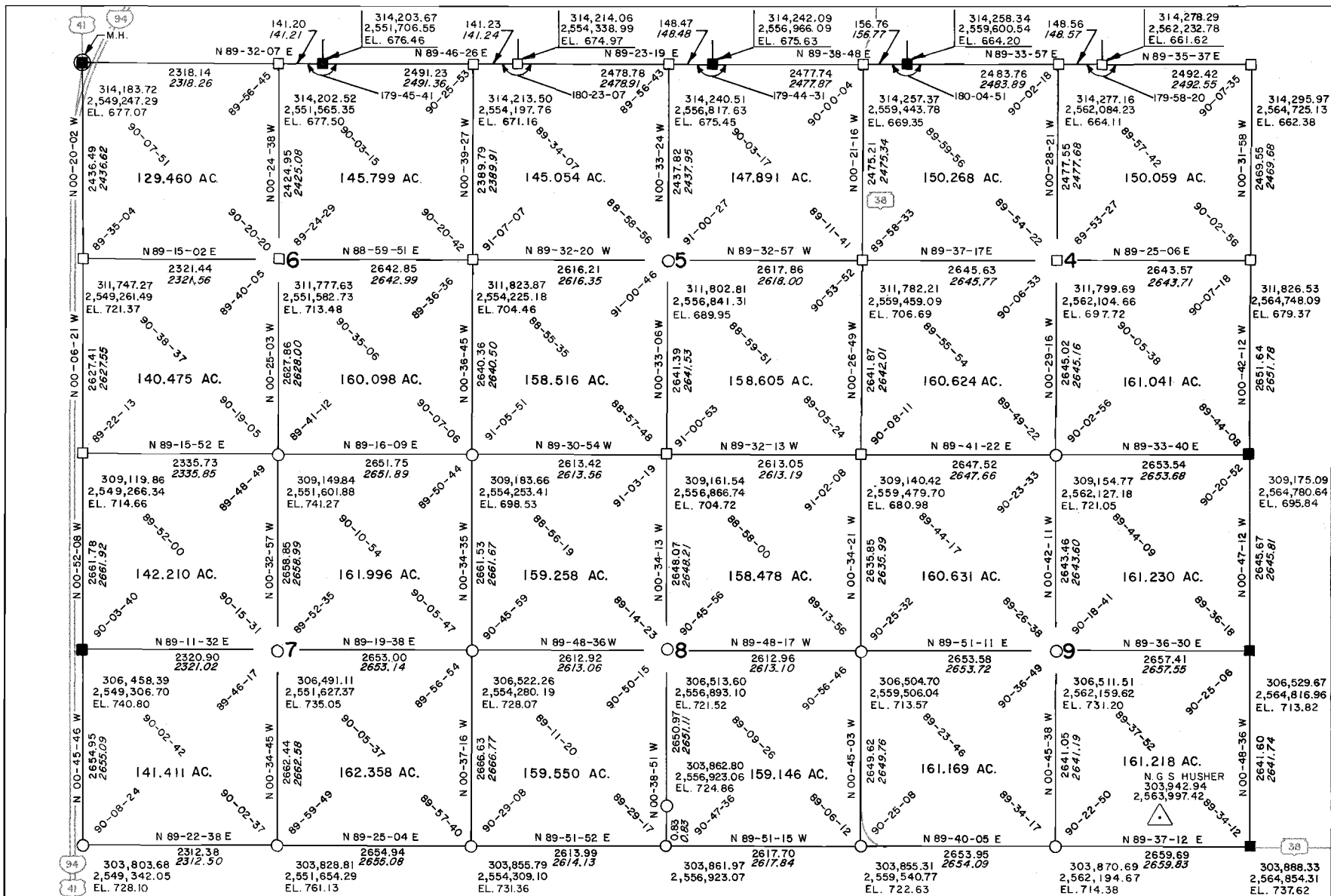












LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 6" x 36" CONCRETE MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 6" x 36" CONCRETE MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION
- △ N. & S. HORIZONTAL CONTROL STATION

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF CALEDONIA, RACINE COUNTY, WISCONSIN

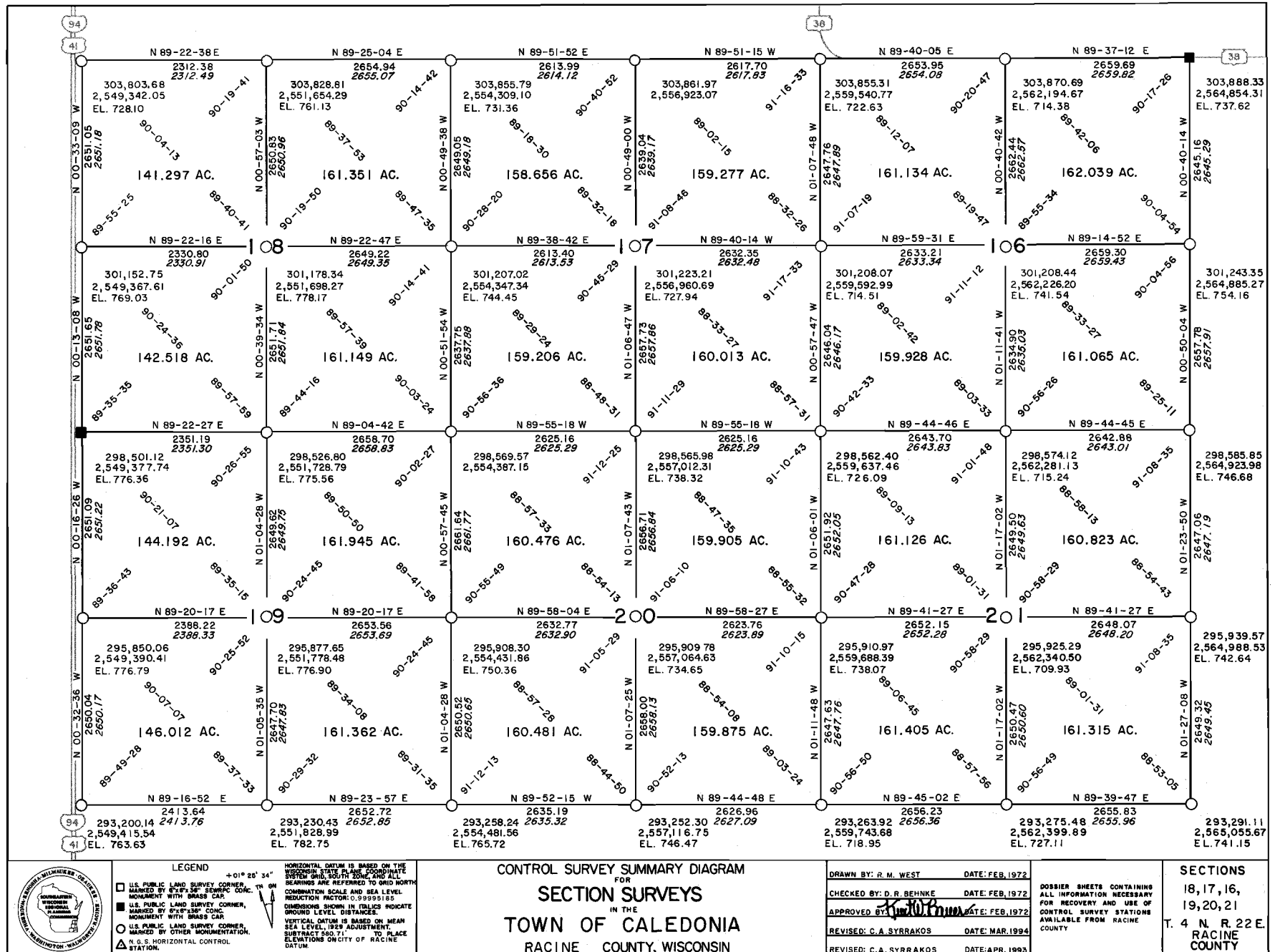
DRAWN BY: H. A. ROGERS **DATE:** MAY 1967
CHECKED BY: D. R. BENNKE **DATE:** MAY 1967
APPROVED BY: [Signature] **DATE:** MAY 1967
REVISED: C. A. SYRRAKOS **DATE:** MAR 1994
REVISED: D. P. SIMON **DATE:** APR 1995

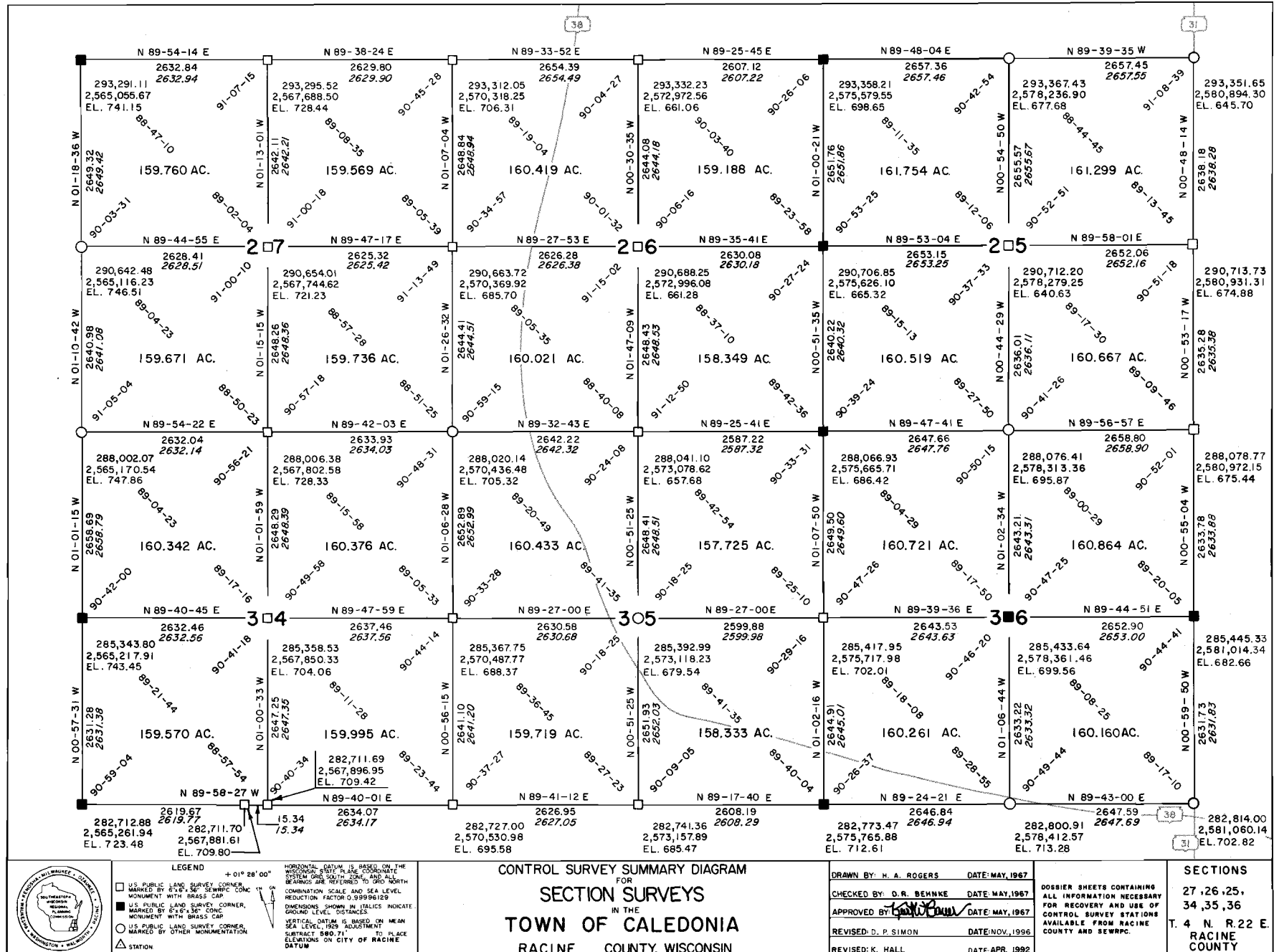
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM CITY OF OAK CREEK, RACINE COUNTY, AND SEWRPC.

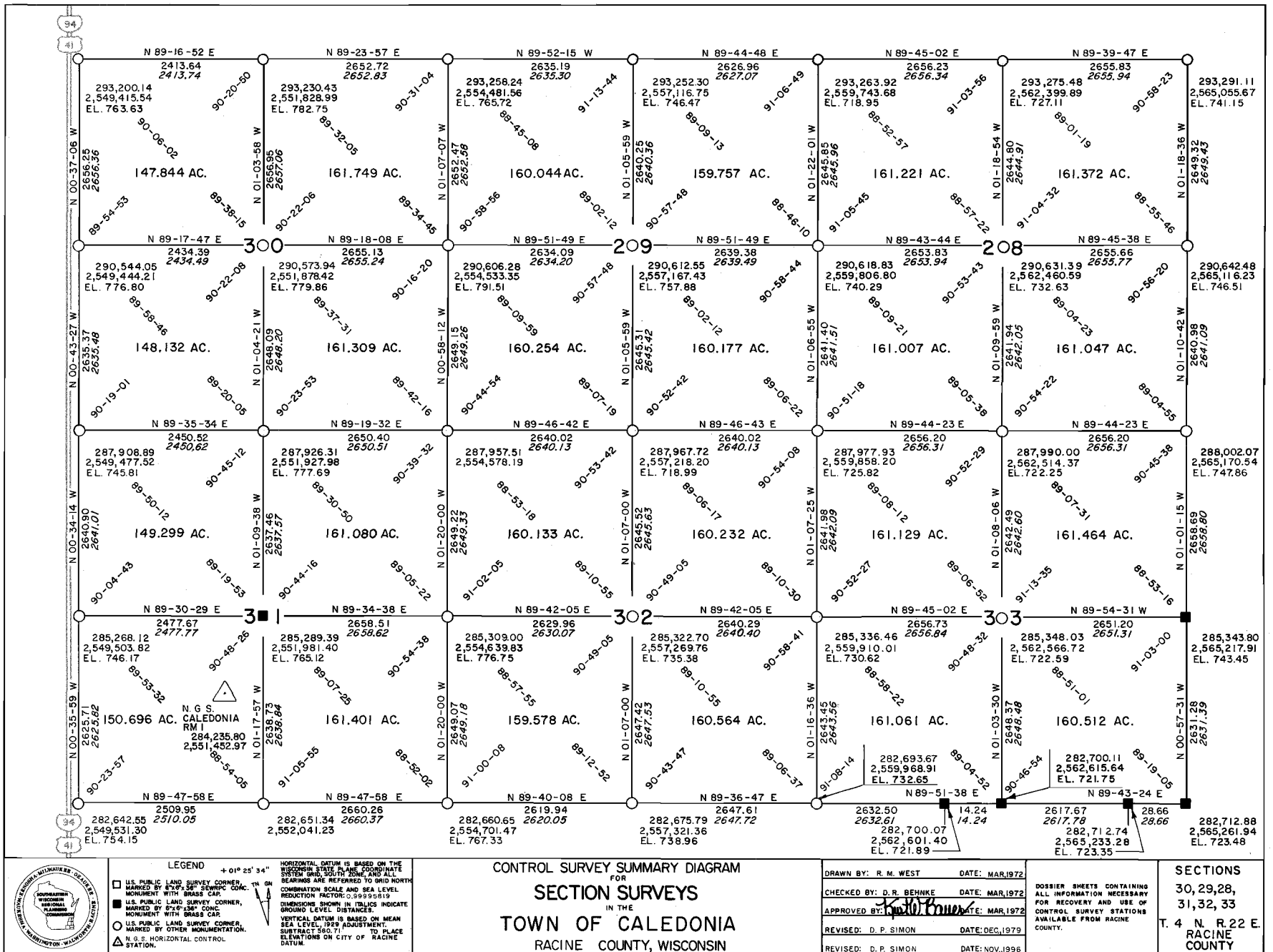
SECTIONS

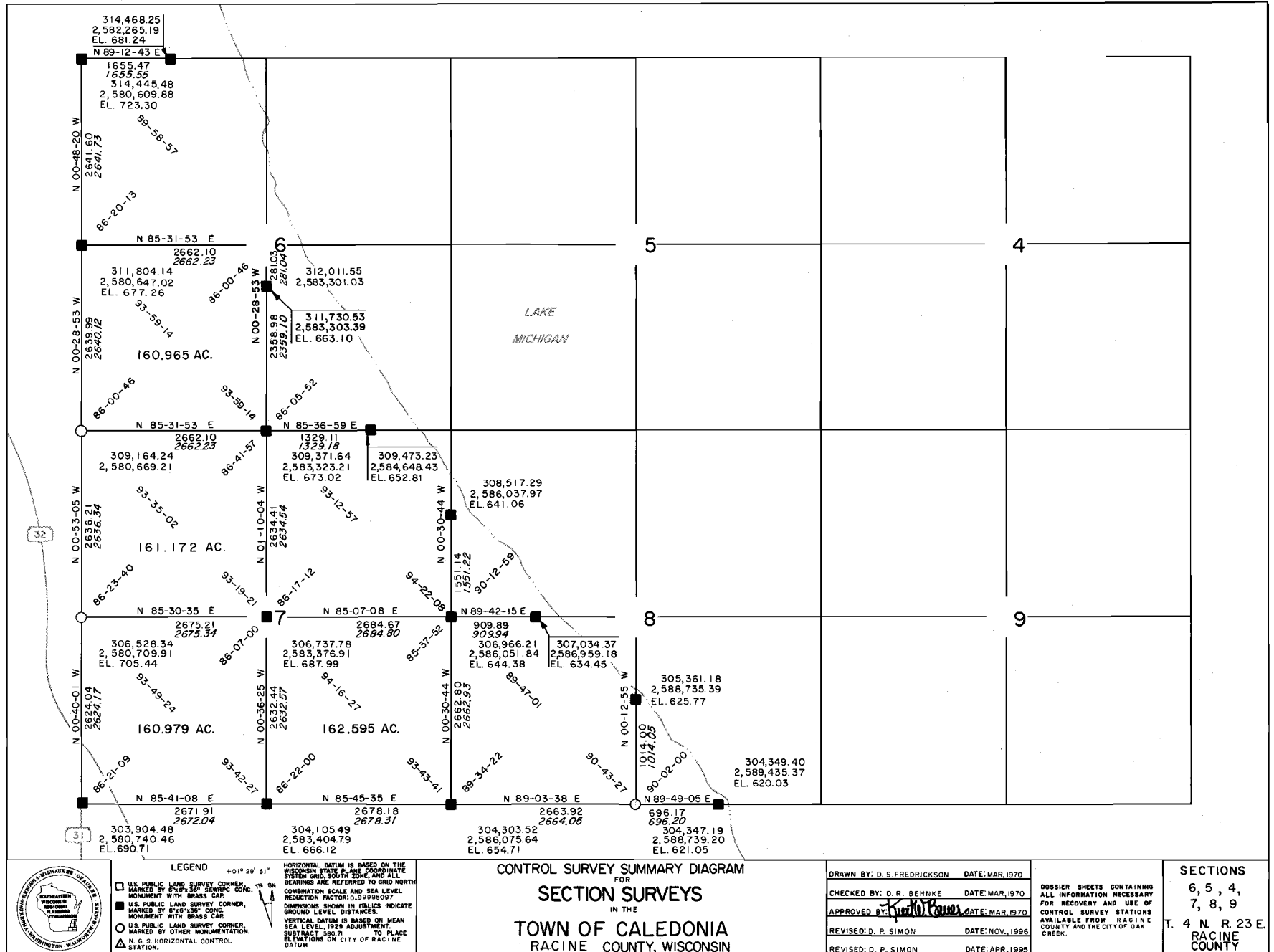
6, 5, 4, 7, 8, 9

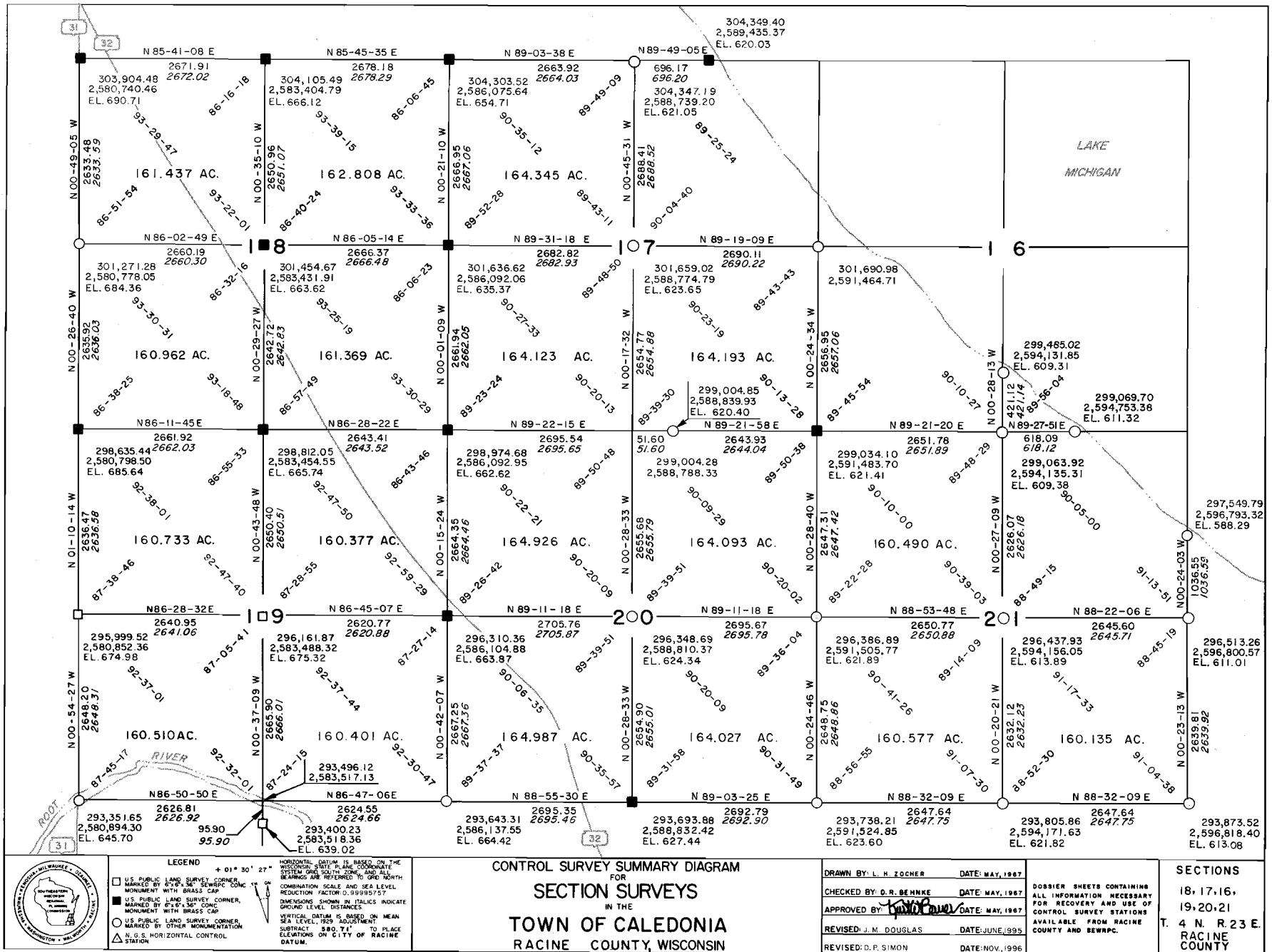
T. 4 N. R. 22 E. RACINE COUNTY

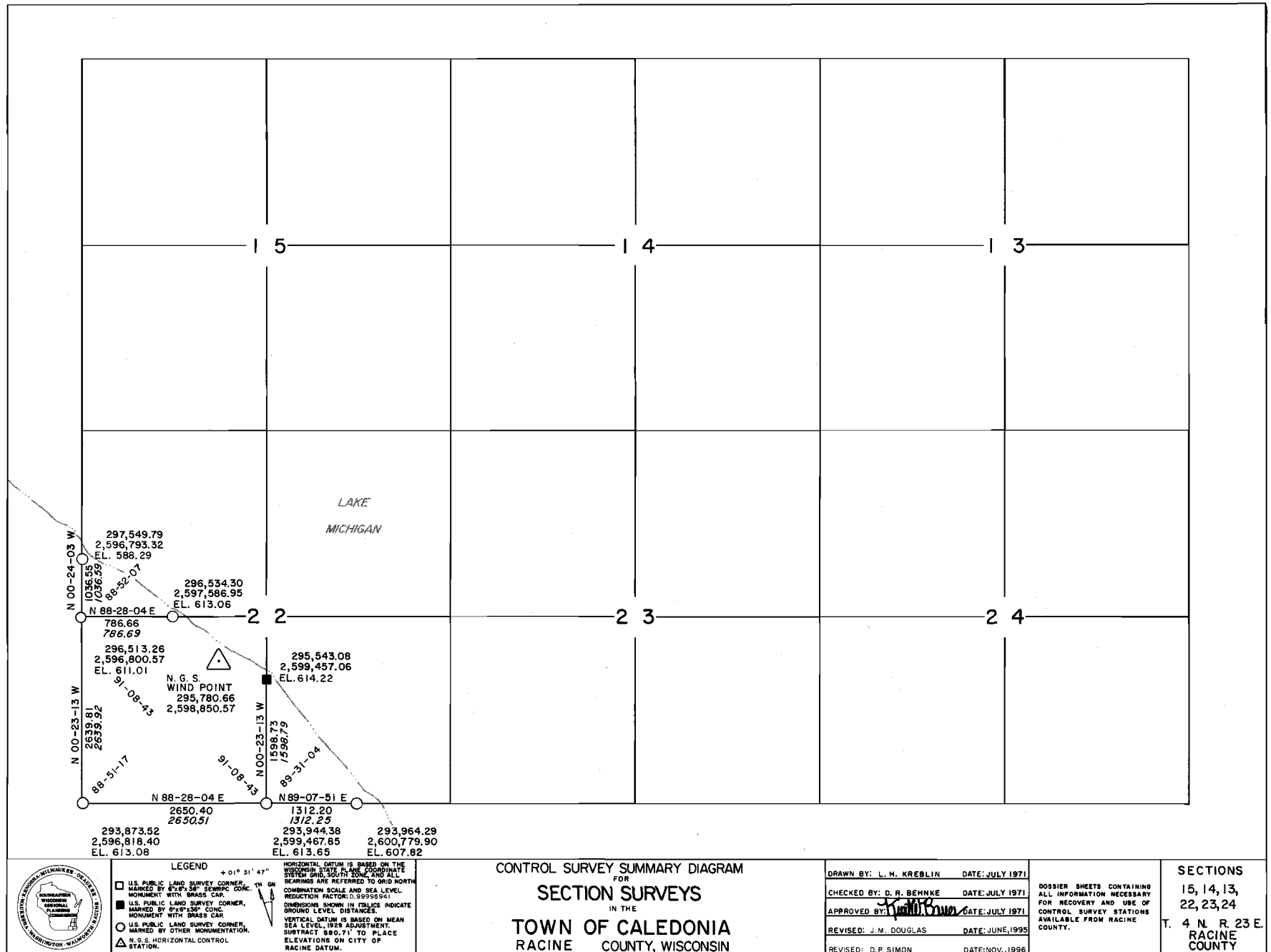


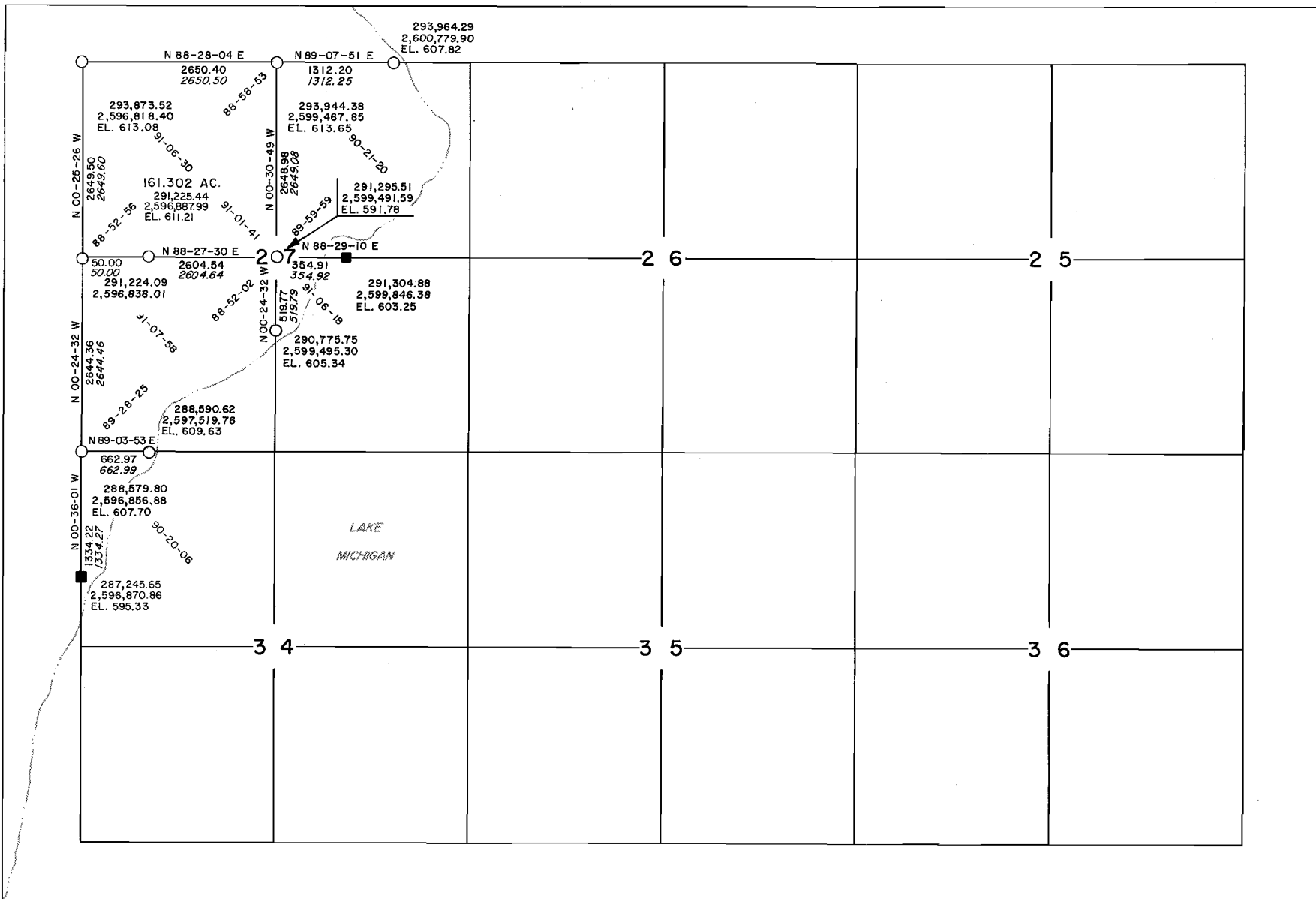















LEGEND

□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 36" SEMI-CONC. MONUMENT WITH BRASS CAP.

■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 36" CONC. MONUMENT WITH BRASS CAP.

○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.

△ N.O.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99996274.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT. SUBTRACT 580.71' TO PLACE ELEVATIONS ON CITY OF RACINE DATUM.

CONTROL SURVEY SUMMARY DIAGRAM

FOR

SECTION SURVEYS

IN THE

TOWN OF CALEDONIA

RACINE COUNTY, WISCONSIN

DRAWN BY: B.L. RICHARDSON	DATE: DEC., 1971
CHECKED BY: D.R. BEHNKE	DATE: DEC., 1971
APPROVED BY: <i>[Signature]</i>	DATE: DEC., 1971
REVISED: D.P. SIMON	DATE: SEPT. 1980
REVISED: J.M. DOUGLAS	DATE: JUNE, 1995

SECTIONS

27, 26, 25,
34, 35, 36

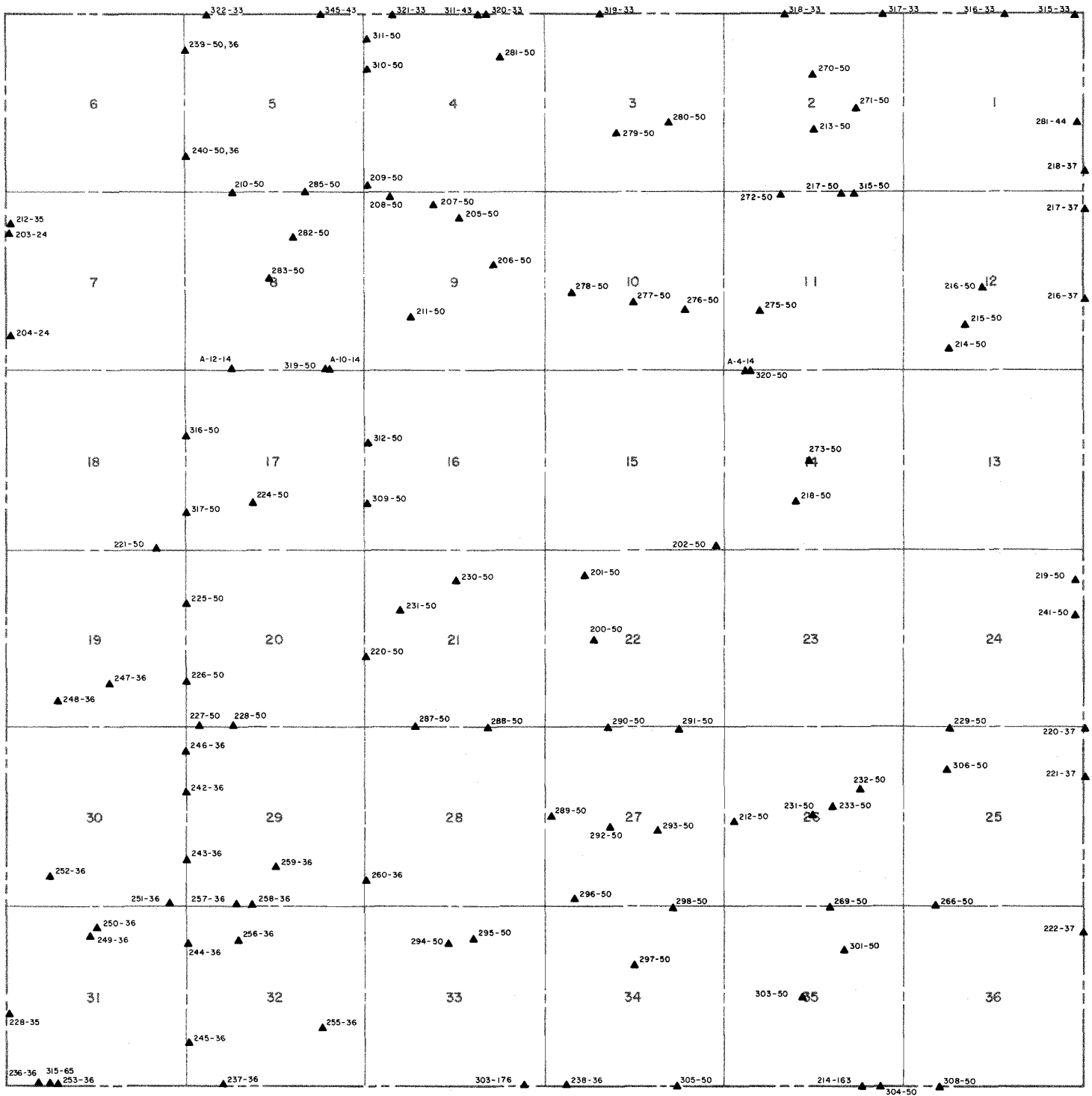
T. 4 N. R. 23 E.
RACINE
COUNTY

This map displays a grid of 36 numbered sections, likely representing a land survey or a planning area. The sections are numbered 1 through 36, with some numbers appearing in multiple locations (e.g., 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36). The map includes numerous labeled points, often with codes like '239-23', 'A-299-14', 'J-363-14', and 'K-368-14'. The labels 'RACINE CO.' and 'KENOSHA CO.' are prominently displayed in the lower-middle section. The map is oriented with North at the top.

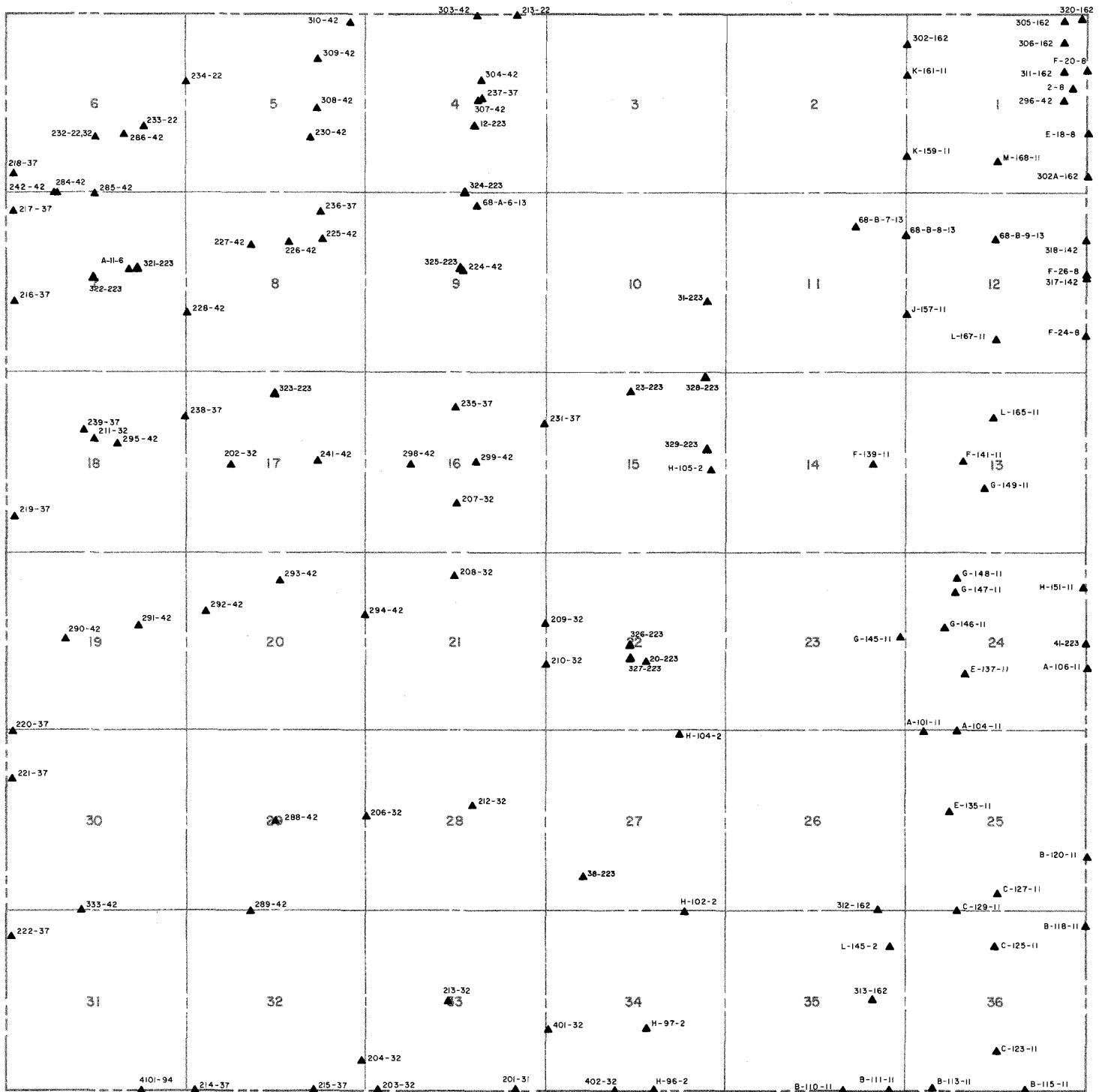
The map displays the following stations (numbered 1-36) with their call letters and frequencies:

- 1: 279-63, 405-63
- 2: 277-31, 888-387-10, 246-31, 242-31, 409-60, 245-31, 244-31, 243-31
- 3: 406-63, 391-63, 389-63, 388-63, 390-63, 300-30
- 4: 226-63, 212-63, 290-30, 291-30, 289-30, 208-63, 307-30, 288-30, 287-30
- 5: 396-63, 392-63, 240-63, 231-63, 293-30, 292-30, 295-30, 296-30, 294-30, 299-30, 301-30
- 6: 278-63, 398-63, 404-63, 399-63, 400-63, 401-63, 402-63, 403-63, 408-60, 378-60, 207-63
- 7: 297-30, 293-30, 292-30, 289-30, 208-63, 307-30, 288-30, 287-30
- 8: 296-30, 294-30, 299-30, 301-30
- 9: 289-30, 208-63, 307-30, 288-30, 287-30
- 10: 404-63, 399-63, 400-63, 401-63, 402-63, 403-63, 408-60, 378-60, 207-63
- 11: 402-63, 403-63, 408-60, 378-60, 207-63
- 12: 409-60, 245-31, 244-31, 243-31
- 13: 411-60, 205-63, 412-60
- 14: 277-31, 888-387-10, 246-31, 242-31, 409-60, 245-31, 244-31, 243-31
- 15: 278-63, 398-63, 404-63, 399-63, 400-63, 401-63, 402-63, 403-63, 408-60, 378-60, 207-63
- 16: 226-63, 212-63, 290-30, 291-30, 289-30, 208-63, 307-30, 288-30, 287-30
- 17: 396-63, 392-63, 240-63, 231-63, 293-30, 292-30, 295-30, 296-30, 294-30, 299-30, 301-30
- 18: 279-63, 405-63
- 19: 275-30, 298-30
- 20: 270-30, 269-30, 260-30, 259-30, 261-30, 262-30, 254-30, 251-30, 255-30, 249-30, 253-30, 252-30, 257-30
- 21: 282-30, 283-30, 320-34, 284-30, 285-30, 271-30, 272-30, 286-30, 287-30, 288-30, 289-30, 290-30, 291-30, 292-30, 293-30, 294-30, 295-30, 296-30, 297-30, 298-30, 299-30, 300-30, 301-30, 302-30, 303-30, 304-30, 305-30, 306-30, 307-30, 308-30, 309-30, 310-30, 311-30, 312-30, 313-30, 314-30, 315-30, 316-30, 317-30, 318-30, 319-30, 320-30, 321-30, 322-30, 323-30, 324-30, 325-30, 326-30, 327-30, 328-30, 329-30, 330-30, 331-30, 332-30, 333-30, 334-30, 335-30, 336-30, 337-30, 338-30, 339-30, 340-30, 341-30, 342-30, 343-30, 344-30, 345-30, 346-30, 347-30, 348-30, 349-30, 350-30, 351-30, 352-30, 353-30, 354-30, 355-30, 356-30, 357-30, 358-30, 359-30, 360-30, 361-30, 362-30, 363-30, 364-30, 365-30, 366-30, 367-30, 368-30, 369-30, 370-30, 371-30, 372-30, 373-30, 374-30, 375-30, 376-30, 377-30, 378-30, 379-30, 380-30, 381-30, 382-30, 383-30, 384-30, 385-30, 386-30, 387-30, 388-30, 389-30, 390-30, 391-30, 392-30, 393-30, 394-30, 395-30, 396-30, 397-30, 398-30, 399-30, 400-30, 401-30, 402-30, 403-30, 404-30, 405-30, 406-30, 407-30, 408-30, 409-30, 410-30, 411-30, 412-30, 413-30, 414-30, 415-30, 416-30, 417-30, 418-30, 419-30, 420-30, 421-30, 422-30, 423-30, 424-30, 425-30, 426-30, 427-30, 428-30, 429-30, 430-30, 431-30, 432-30, 433-30, 434-30, 435-30, 436-30, 437-30, 438-30, 439-30, 440-30, 441-30, 442-30, 443-30, 444-30, 445-30, 446-30, 447-30, 448-30, 449-30, 450-30, 451-30, 452-30, 453-30, 454-30, 455-30, 456-30, 457-30, 458-30, 459-30, 460-30, 461-30, 462-30, 463-30, 464-30, 465-30, 466-30, 467-30, 468-30, 469-30, 470-30, 471-30, 472-30, 473-30, 474-30, 475-30, 476-30, 477-30, 478-30, 479-30, 480-30, 481-30, 482-30, 483-30, 484-30, 485-30, 486-30, 487-30, 488-30, 489-30, 490-30, 491-30, 492-30, 493-30, 494-30, 495-30, 496-30, 497-30, 498-30, 499-30, 500-30
- 22: 278-63, 398-63, 404-63, 399-63, 400-63, 401-63, 402-63, 403-63, 408-60, 378-60, 207-63
- 23: 277-31, 888-387-10, 246-31, 242-31, 409-60, 245-31, 244-31, 243-31
- 24: 411-60, 205-63, 412-60
- 25: 411-60, 205-63, 412-60
- 26: 277-31, 888-387-10, 246-31, 242-31, 409-60, 245-31, 244-31, 243-31
- 27: 278-63, 398-63, 404-63, 399-63, 400-63, 401-63, 402-63, 403-63, 408-60, 378-60, 207-63
- 28: 226-63, 212-63, 290-30, 291-30, 289-30, 208-63, 307-30, 288-30, 287-30
- 29: 396-63, 392-63, 240-63, 231-63, 293-30, 292-30, 295-30, 296-30, 294-30, 299-30, 301-30
- 30: 279-63, 405-63
- 31: 275-30, 298-30
- 32: 270-30, 269-30, 260-30, 259-30, 261-30, 262-30, 254-30, 251-30, 255-30, 249-30, 253-30, 252-30, 257-30
- 33: 282-30, 283-30, 320-34, 284-30, 285-30, 271-30, 272-30, 286-30, 287-30, 288-30, 289-30, 290-30, 291-30, 292-30, 293-30, 294-30, 295-30, 296-30, 297-30, 298-30, 299-30, 300-30, 301-30

TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 21 EAST RACINE COUNTY

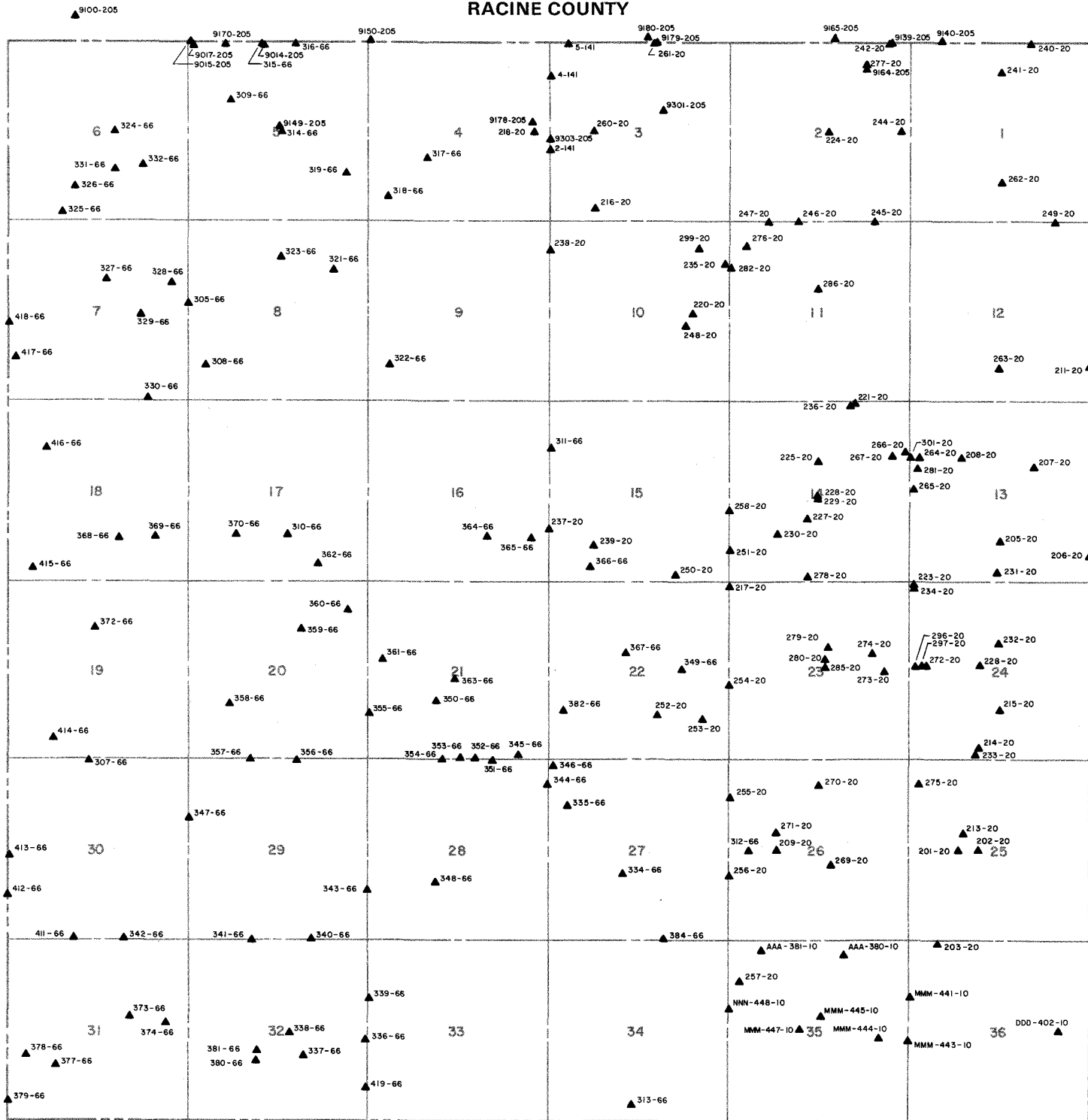


TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 22 EAST RACINE COUNTY

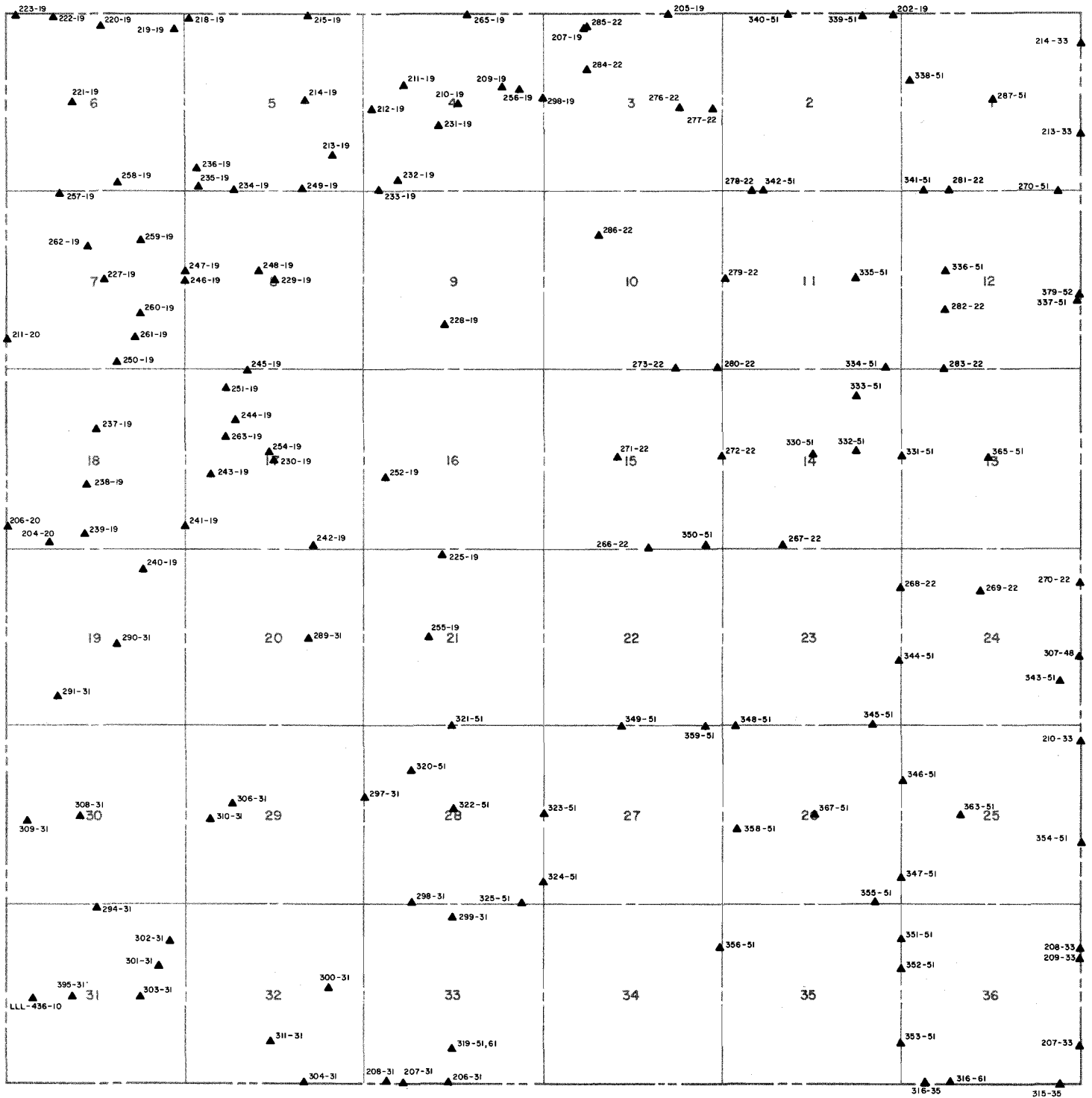


A map of Lake Michigan divided into 32 numbered regions. The regions are labeled with numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, and 32. The map shows the coastline of Lake Michigan, with the shoreline curving from the top right towards the bottom right. Various station identifiers are marked with small black triangles and labeled with alphanumeric codes. These codes include: A-7-1, F-20-8, E-17-8, A-9-1, E-18-8, 302A-162, A-10-1, H-54-8, H-52-8, H-51-8, 210-25, 211-25, H-49-8, H-47-8, H-46-8, H-44-8, 209-25, 293-142, 287-142, K-71-8, K-73-8, 288-142, K-74-8, 289-142, 290-142, 291-142, 292-142, 294-142, 295-142, 296-142, 297-142, 298-142, 299-142, 300-142, 301-142, 302-142, 303-142, 304-142, 305-142, 306-142, 307-142, 308-142, 309-142, 310-142, 311-142, 312-142, 313-142, 314-142, 315-142, 316-142, 317-142, 318-142, 319-142, 320-142, 321-142, 322-142, 323-142, 324-142, 325-142, 326-142, 327-142, 328-142, 329-142, 330-142, 331-142, 332-142, 333-142, 334-142, 335-142, 336-142, 337-142, 338-142, 339-142, 340-142, 341-142, 342-142, 343-142, 344-142, 345-142, 346-142, 347-142, 348-142, 349-142, 350-142, 351-142, 352-142, 353-142, 354-142, 355-142, 356-142, 357-142, 358-142, 359-142, 360-142, 361-142, 362-142, 363-142, 364-142, 365-142, 366-142, 367-142, 368-142, 369-142, 370-142, 371-142, 372-142, 373-142, 374-142, 375-142, 376-142, 377-142, 378-142, 379-142, 380-142, 381-142, 382-142, 383-142, 384-142, 385-142, 386-142, 387-142, 388-142, 389-142, 390-142, 391-142, 392-142, 393-142, 394-142, 395-142, 396-142, 397-142, 398-142, 399-142, 400-142, 401-142, 402-142, 403-142, 404-142, 405-142, 406-142, 407-142, 408-142, 409-142, 410-142, 411-142, 412-142, 413-142, 414-142, 415-142, 416-142, 417-142, 418-142, 419-142, 420-142, 421-142, 422-142, 423-142, 424-142, 425-142, 426-142, 427-142, 428-142, 429-142, 430-142, 431-142, 432-142, 433-142, 434-142, 435-142, 436-142, 437-142, 438-142, 439-142, 440-142, 441-142, 442-142, 443-142, 444-142, 445-142, 446-142, 447-142, 448-142, 449-142, 450-142, 451-142, 452-142, 453-142, 454-142, 455-142, 456-142, 457-142, 458-142, 459-142, 460-142, 461-142, 462-142, 463-142, 464-142, 465-142, 466-142, 467-142, 468-142, 469-142, 470-142, 471-142, 472-142, 473-142, 474-142, 475-142, 476-142, 477-142, 478-142, 479-142, 480-142, 481-142, 482-142, 483-142, 484-142, 485-142, 486-142, 487-142, 488-142, 489-142, 490-142, 491-142, 492-142, 493-142, 494-142, 495-142, 496-142, 497-142, 498-142, 499-142, 500-142, 501-142, 502-142, 503-142, 504-142, 505-142, 506-142, 507-142, 508-142, 509-142, 510-142, 511-142, 512-142, 513-142, 514-142, 515-142, 516-142, 517-142, 518-142, 519-142, 520-142, 521-142, 522-142, 523-142, 524-142, 525-142, 526-142, 527-142, 528-142, 529-142, 530-142, 531-142, 532-142, 533-142, 534-142, 535-142, 536-142, 537-142, 538-142, 539-142, 540-142, 541-142, 542-142, 543-142, 544-142, 545-142, 546-142, 547-142, 548-142, 549-142, 550-142, 551-142, 552-142, 553-142, 554-142, 555-142, 556-142, 557-142, 558-142, 559-142, 560-142, 561-142, 562-142, 563-142, 564-142, 565-142, 566-142, 567-142, 568-142, 569-142, 570-142, 571-142, 572-142, 573-142, 574-142, 575-142, 576-142, 577-142, 578-142, 579-142, 580-142, 581-142, 582-142, 583-142, 584-142, 585-142, 586-142, 587-142, 588-142, 589-142, 590-142, 591-142, 592-142, 593-142, 594-142, 595-142, 596-142, 597-142, 598-142, 599-142, 600-142, 601-142, 602-142, 603-142, 604-142, 605-142, 606-142, 607-142, 608-142, 609-142, 610-142, 611-142, 612-142, 613-142, 614-142, 615-142, 616-142, 617-142, 618-142, 619-142, 620-142, 621-142, 622-142, 623-142, 624-142, 625-142, 626-142, 627-142, 628-142, 629-142, 630-142, 631-142, 632-142, 633-142, 634-142, 635-142, 636-142, 637-142, 638-142, 639-142, 640-142, 641-142, 642-142, 643-142, 644-142, 645-142, 646-142, 647-142, 648-142, 649-142, 650-142, 651-142, 652-142, 653-142, 654-142, 655-142, 656-142, 657-142, 658-142, 659-142, 660-142, 661-142, 662-142, 663-142, 664-142, 665-142, 666-142, 667-142, 668-142, 669-142, 670-142, 671-142, 672-142, 673-142, 674-142, 675-142, 676-142, 677-142, 678-142, 679-142, 680-142, 681-142, 682-142, 683-142, 684-142, 685-142, 686-142, 687-142, 688-142, 689-142, 690-142, 691-142, 692-142, 693-142, 694-142, 695-142, 696-142, 697-142, 698-142, 699-142, 700-142, 701-142, 702-142, 703-

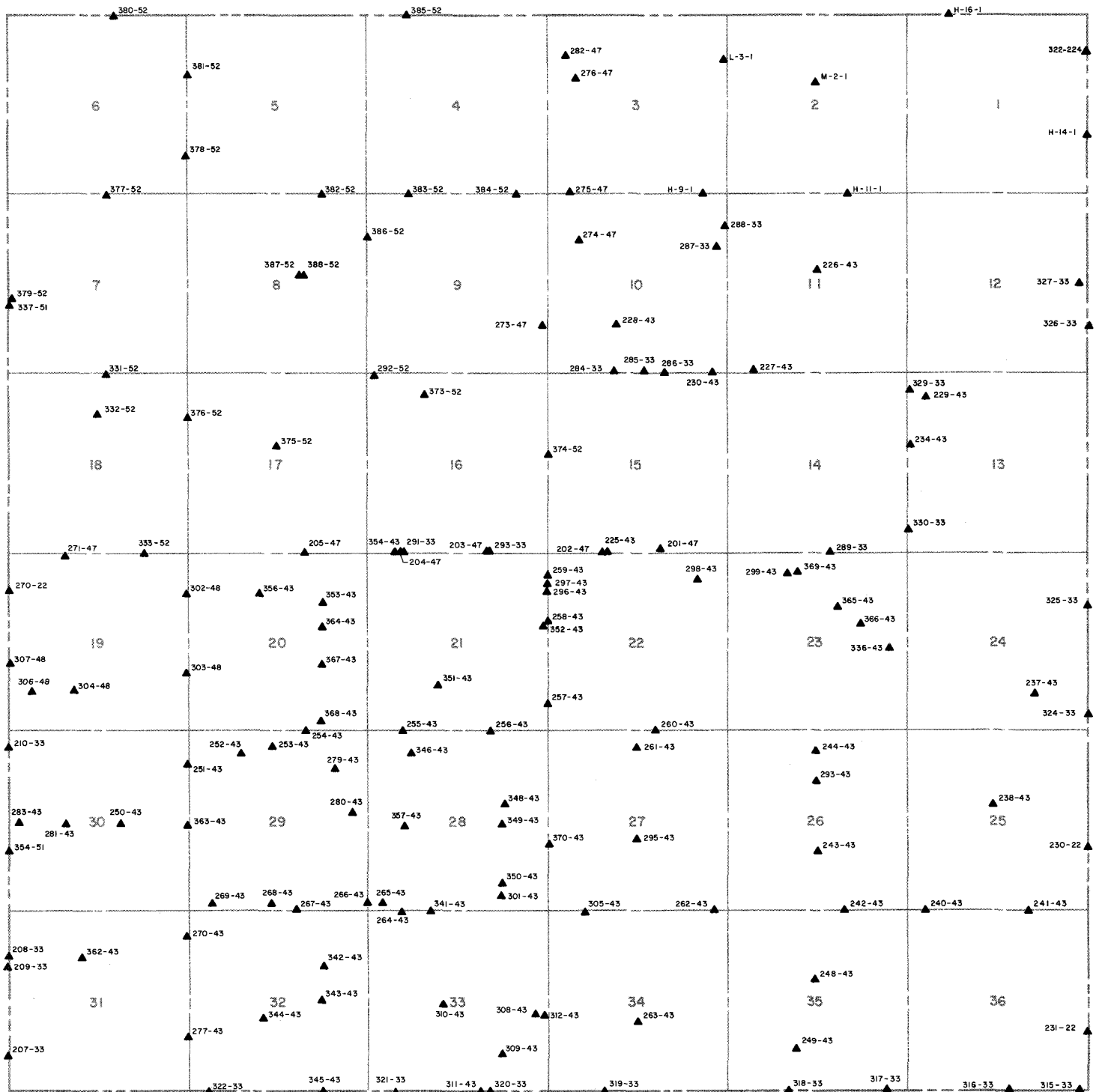
TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 19 EAST RACINE COUNTY



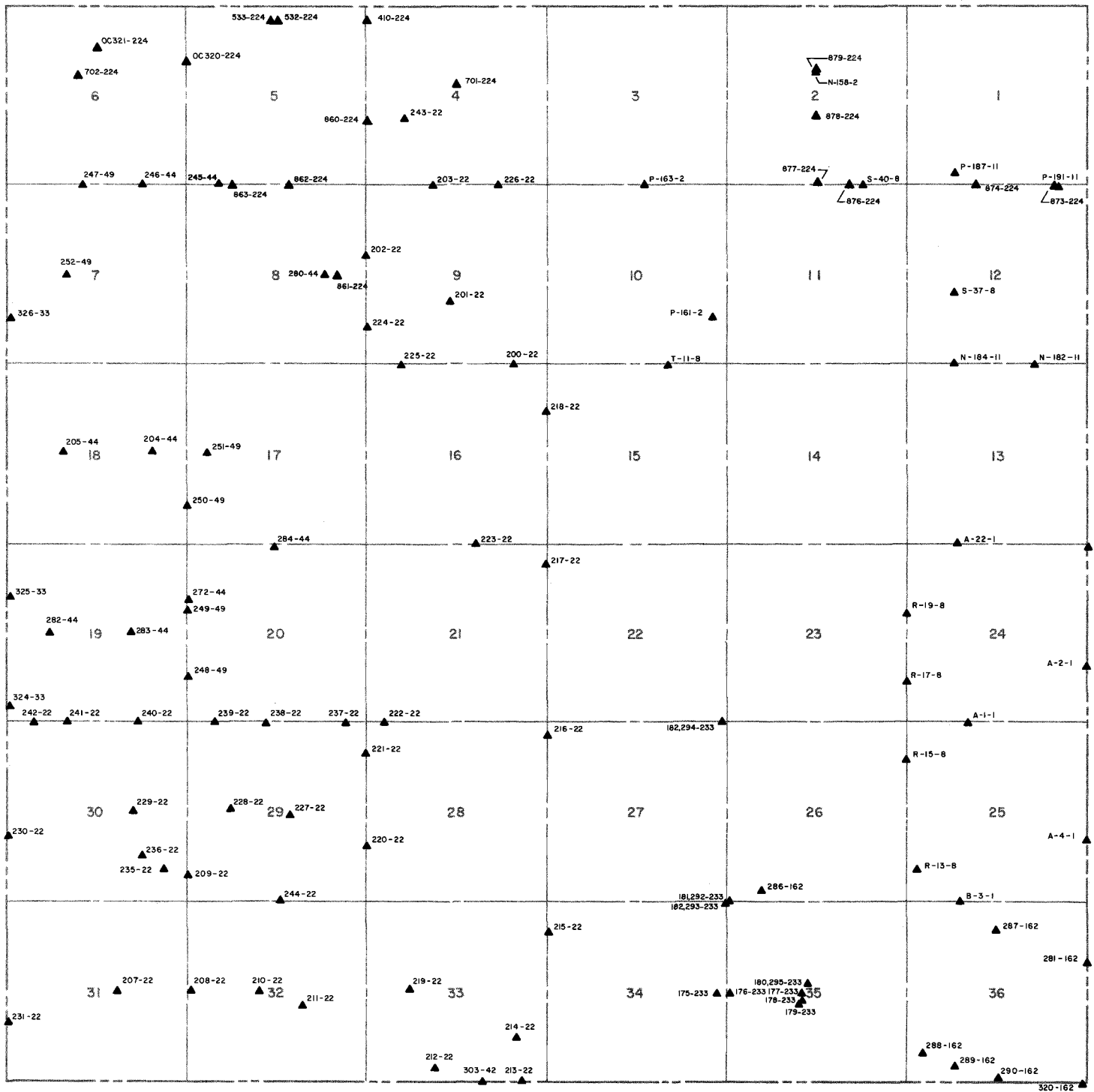
TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 20 EAST RACINE COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 21 EAST RACINE COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 22 EAST RACINE COUNTY



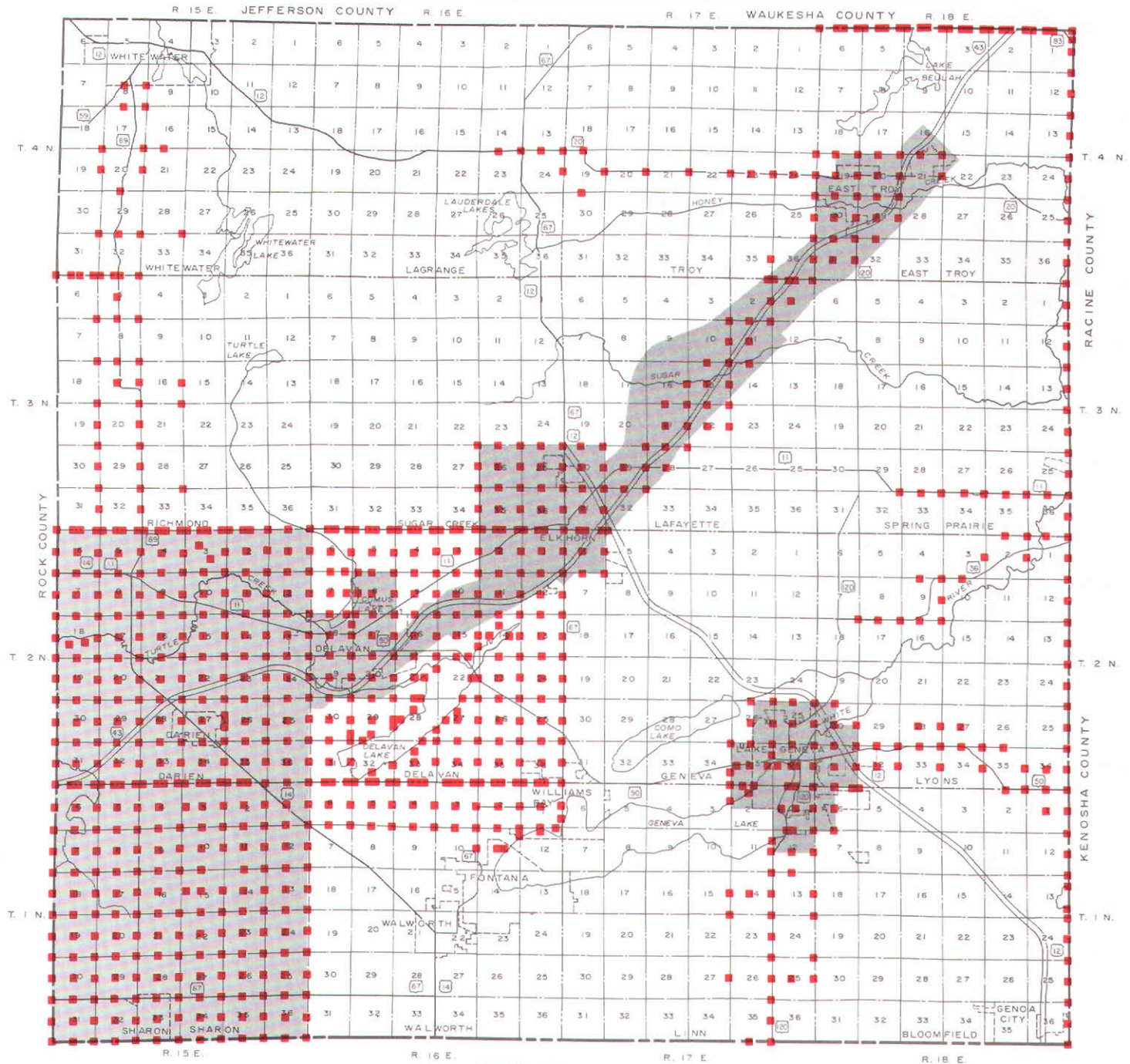
This map of Lake Michigan displays 34 numbered regions and numerous sampling stations. The stations are marked with triangles and labeled with alphanumeric codes, often followed by a date in parentheses. The regions are numbered 6, 7, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, and 34. The lake's shoreline is indicated by a solid line, and a grid of dashed lines is overlaid on the map.

Sampling stations include:



- P-193-11
- Q-204-11
- 872-224
- W-243-11
- W-241-11
- W-240-11
- W-238-11
- R-214-11
- Q-199-11
- S-220-11
- 282-143
- 18
- T-228-11
- 279-143
- R-211-11
- S-216-11
- 278-143
- A-20-1
- 280-143
- 226-21
- 220-21
- 225-21
- 218-21
- 217-21
- 216-21
- 227-21
- 172-233
- 228-21
- 229-21
- 230-21
- 231-21
- 233-21
- 234-21
- 235-21
- 237-21
- 236-21
- 238-21
- 239-21
- 205-21
- 204-21
- 222-21
- 223-21
- 224-21
- 221-21
- 203-21
- 202-21
- 201-21
- 400-21
- 250-21
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Map C-5

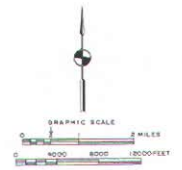
STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE RELOCATION, MONUMENTATION, AND COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS IN WALWORTH COUNTY: SEPTEMBER 1996



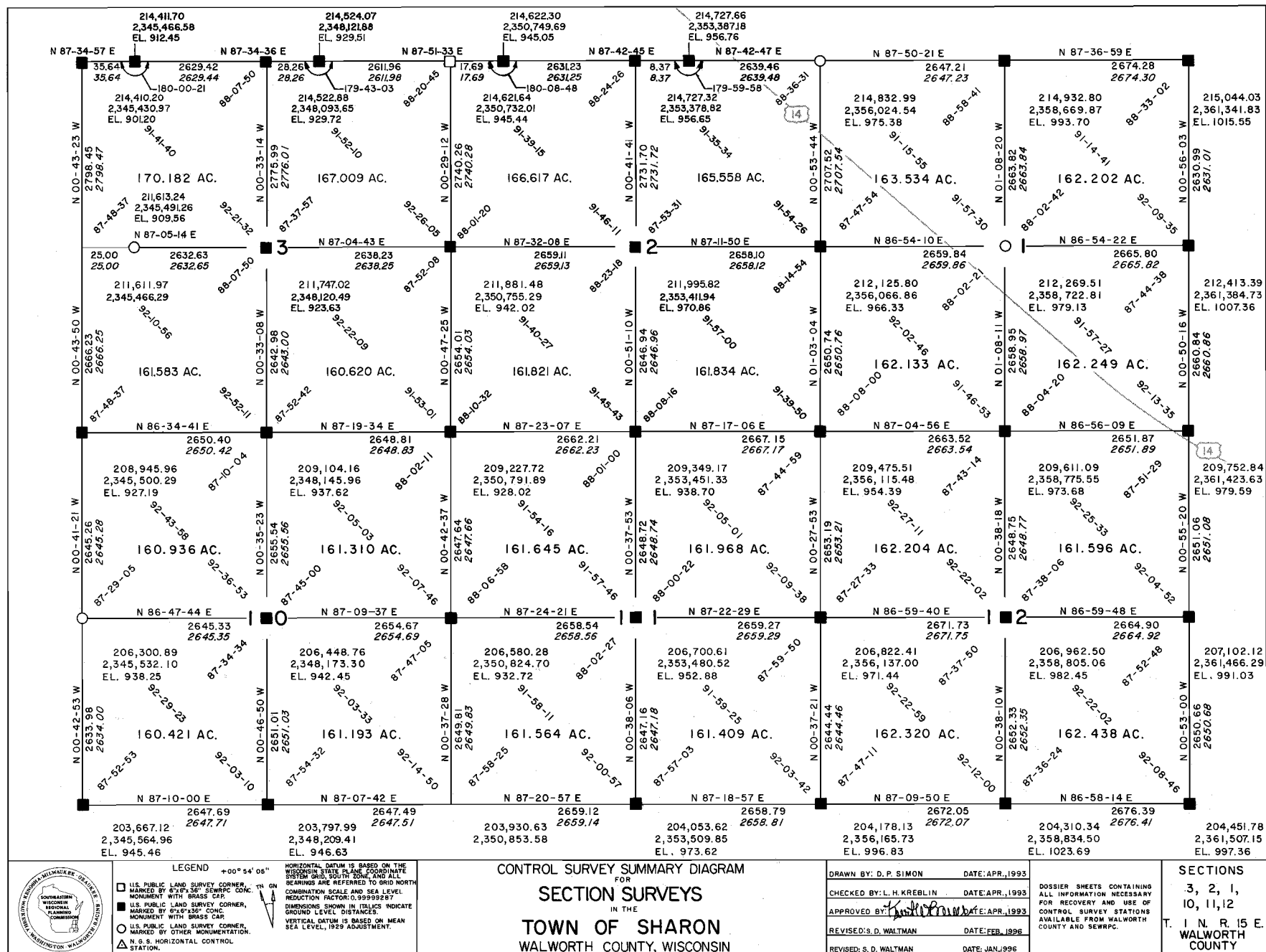
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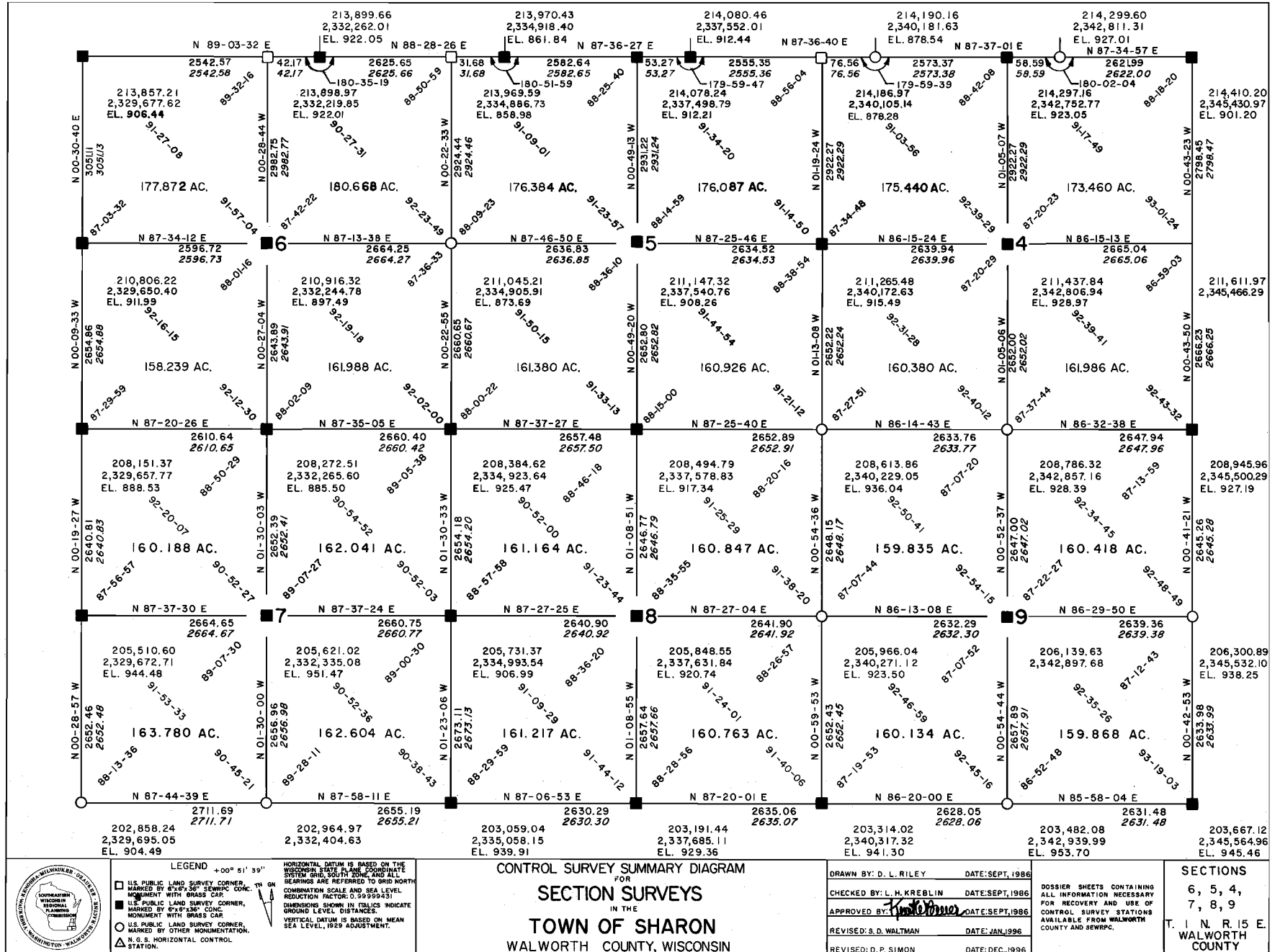
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-  U. S. PUBLIC LAND SURVEY CORNERS WHICH HAVE BEEN RELOCATED, MONUMENTED, AND COORDINATED

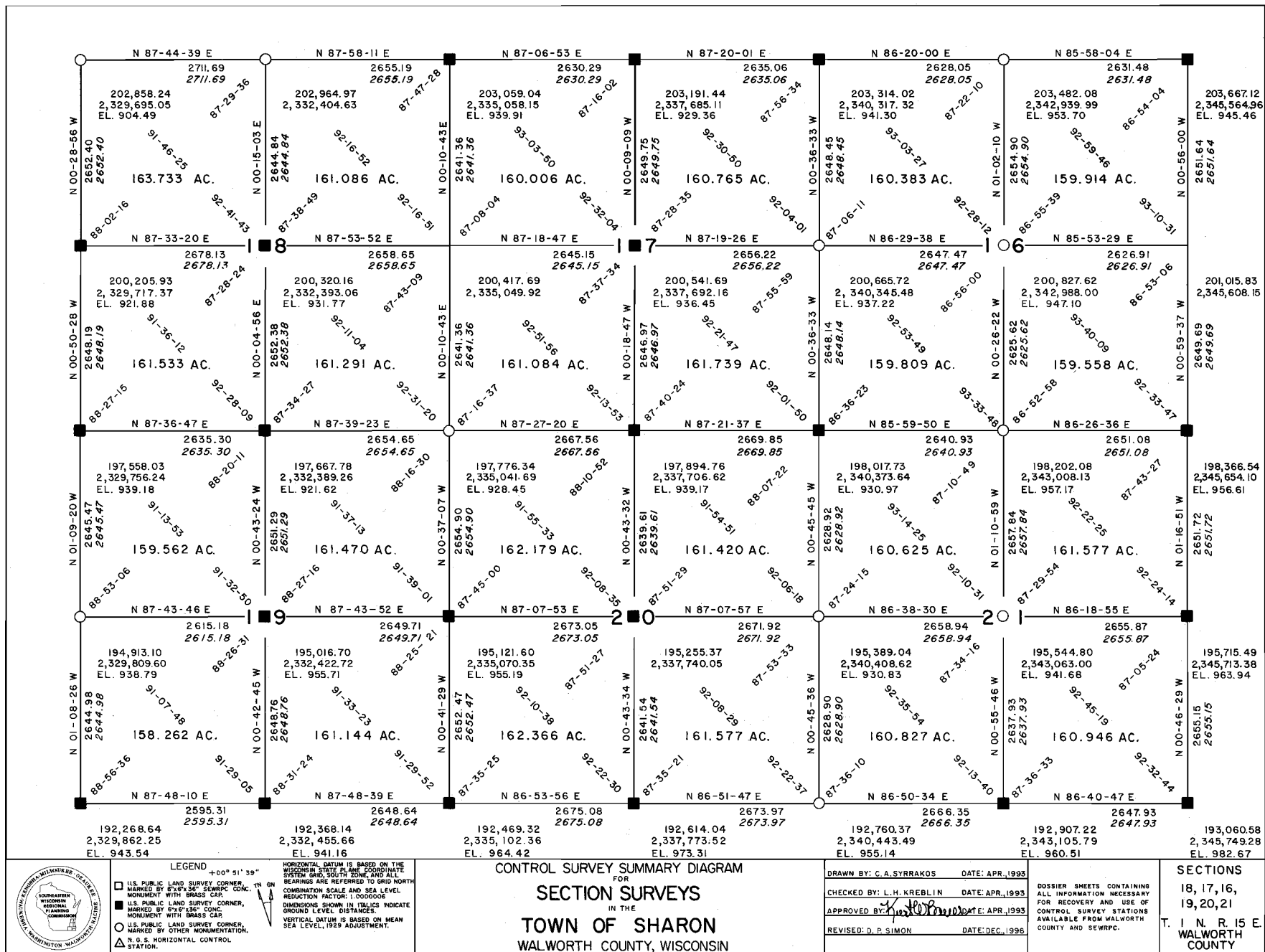
STATE OF ILLINOIS

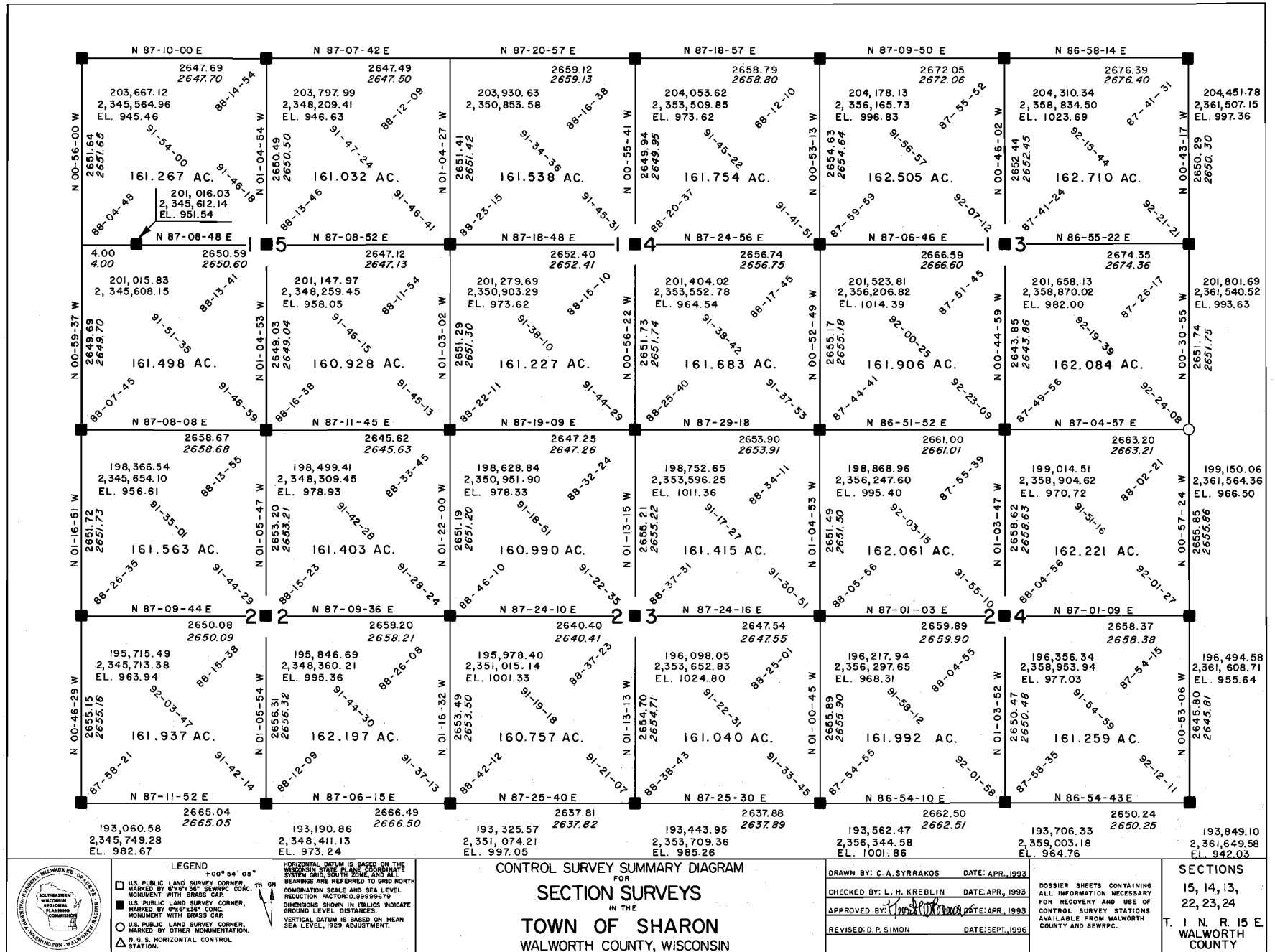


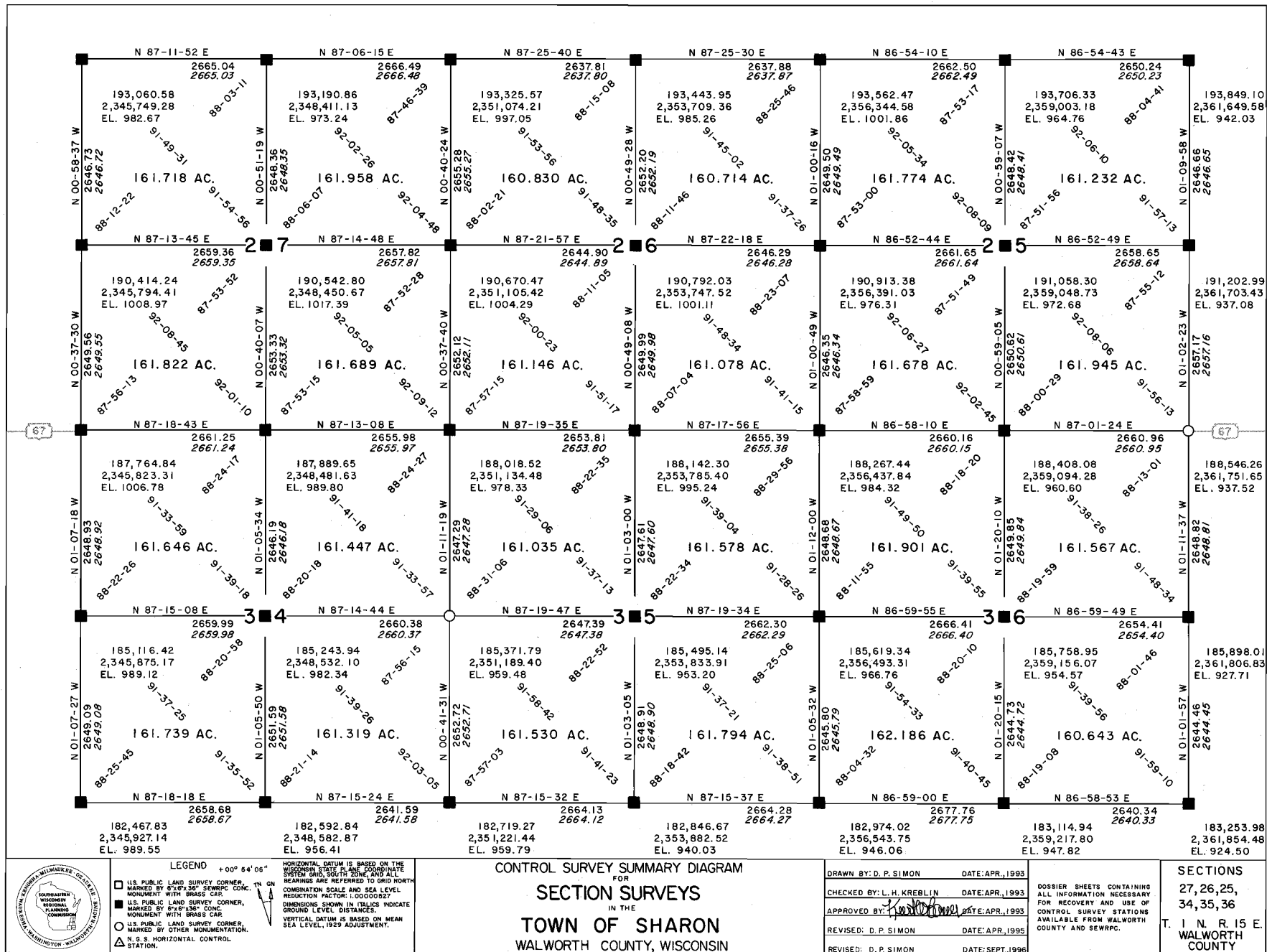
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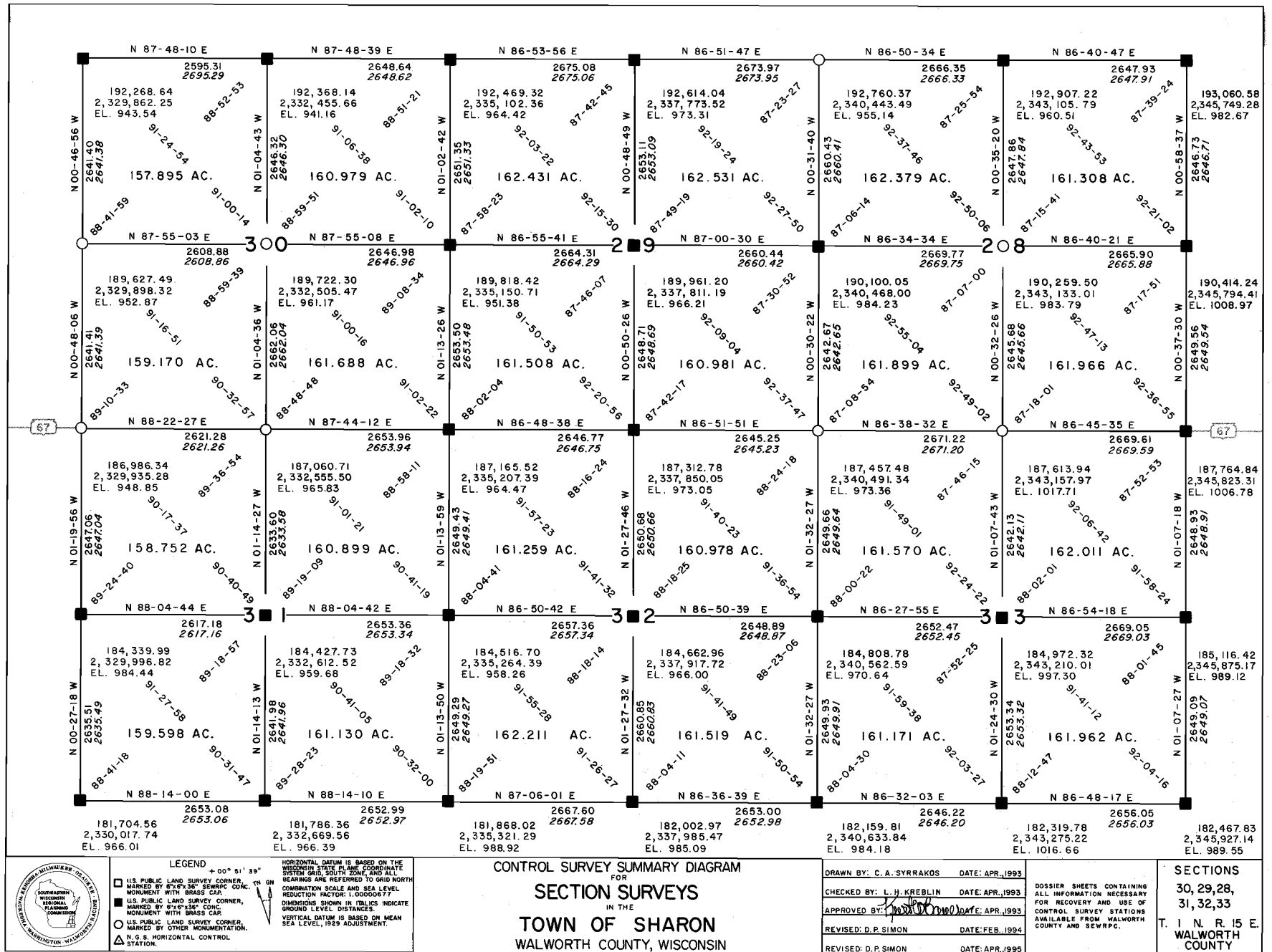


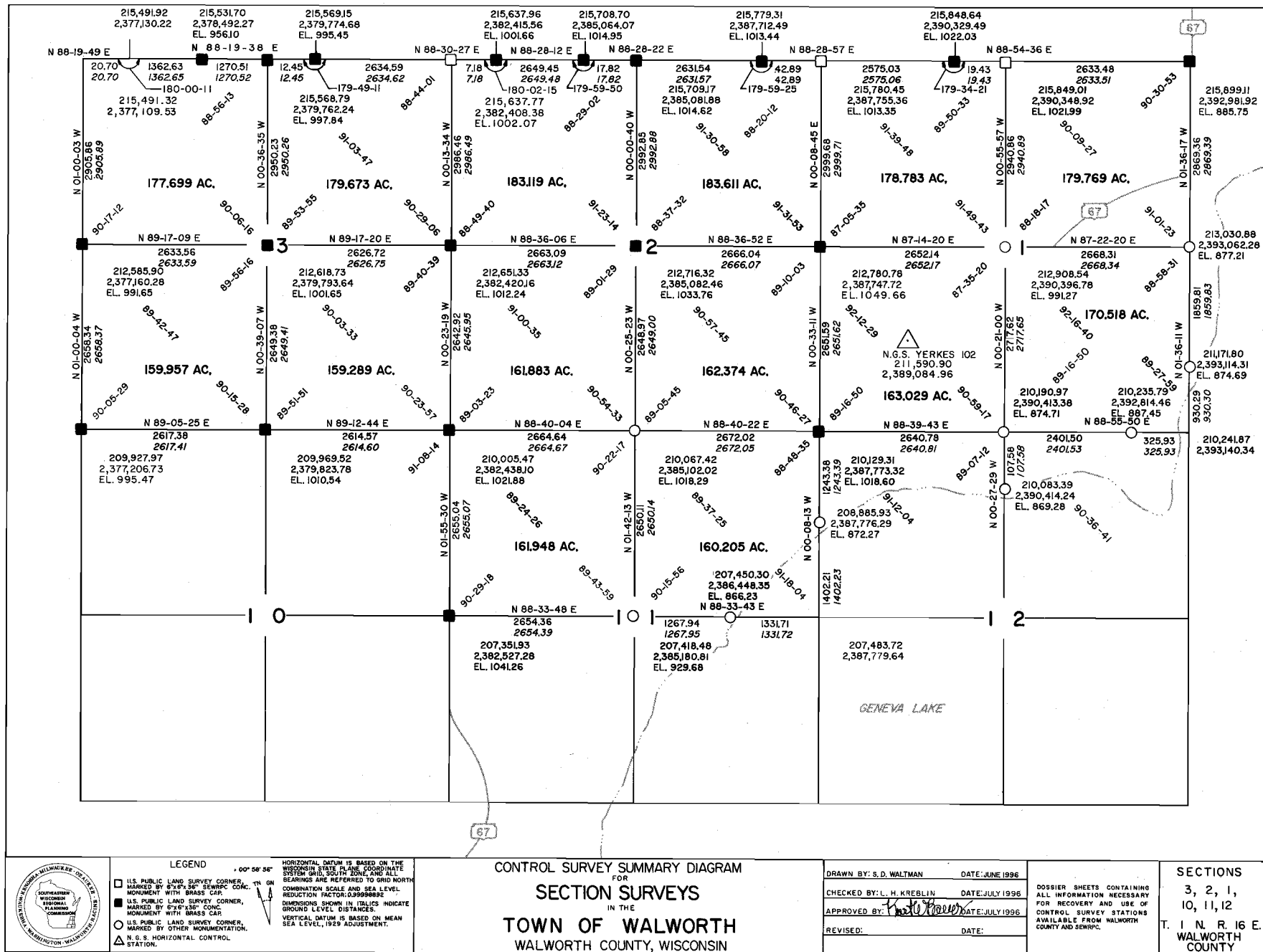


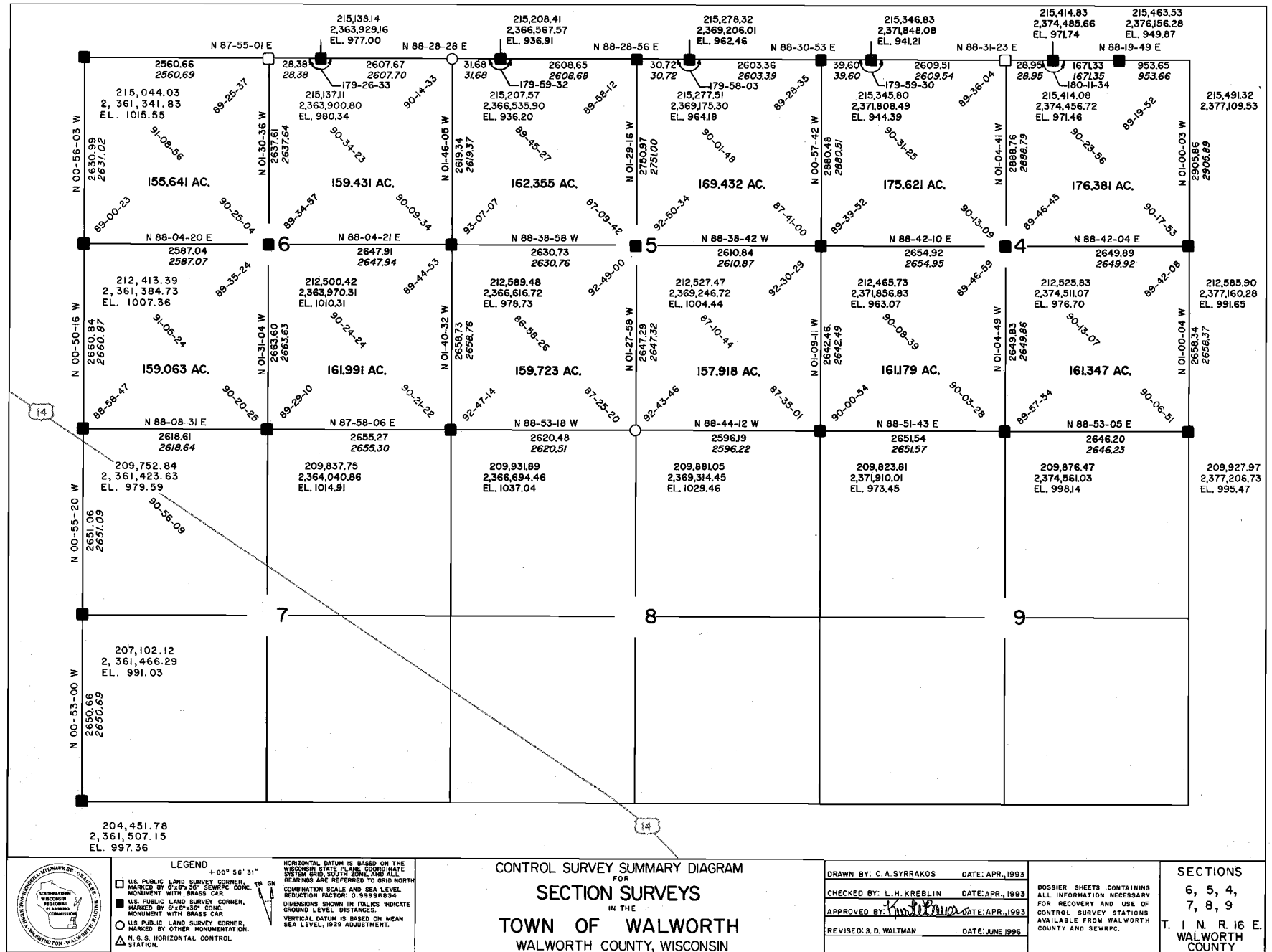


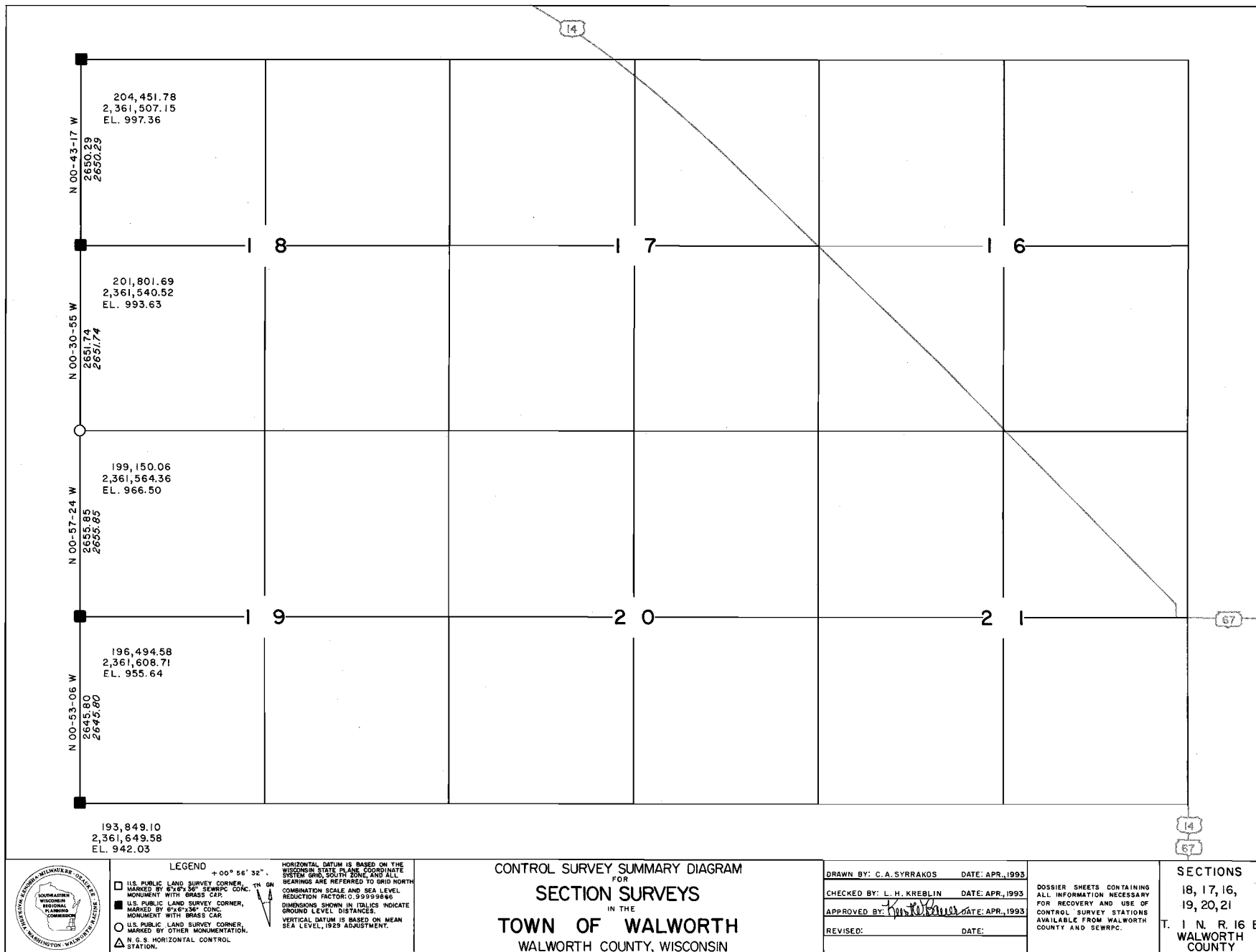


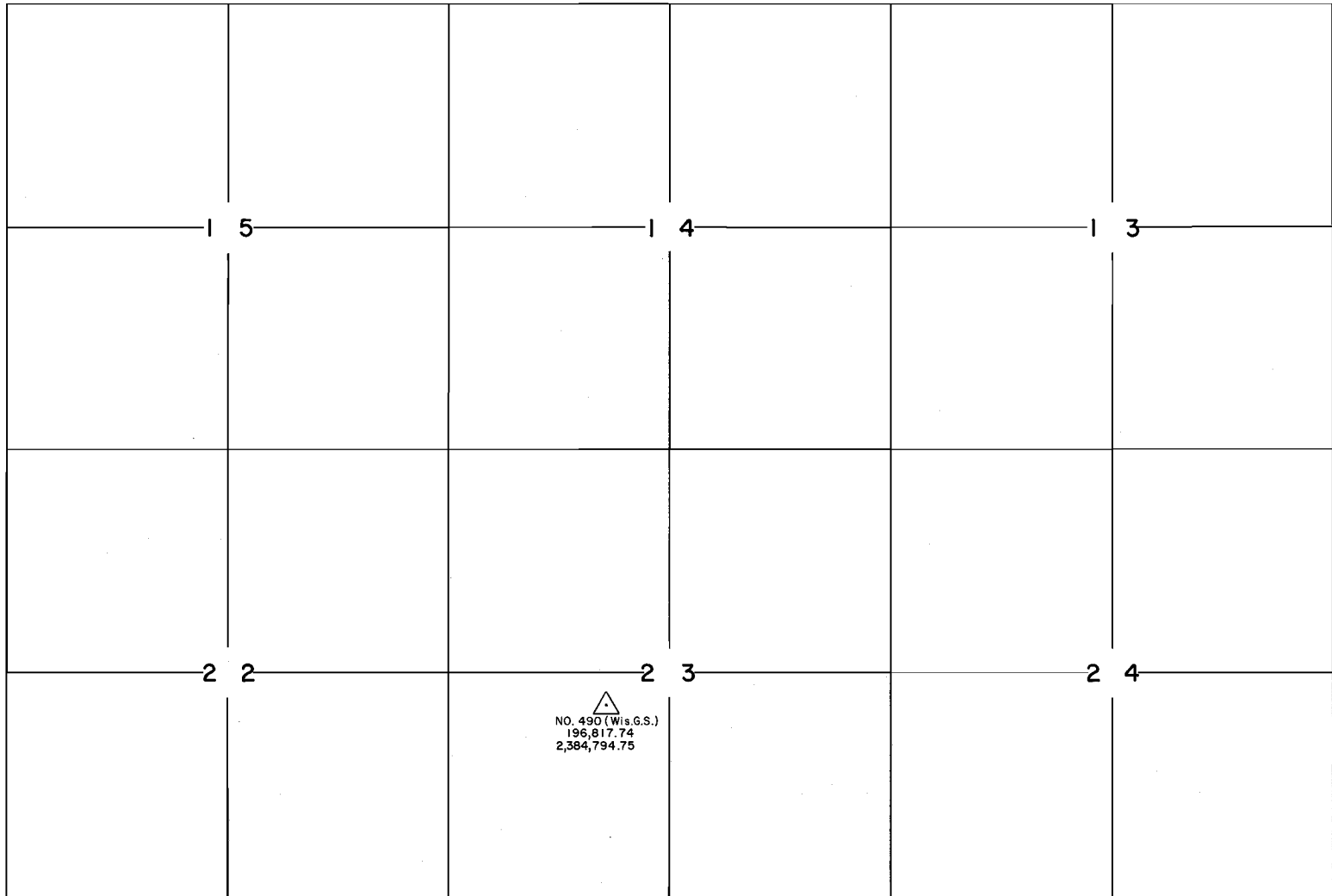




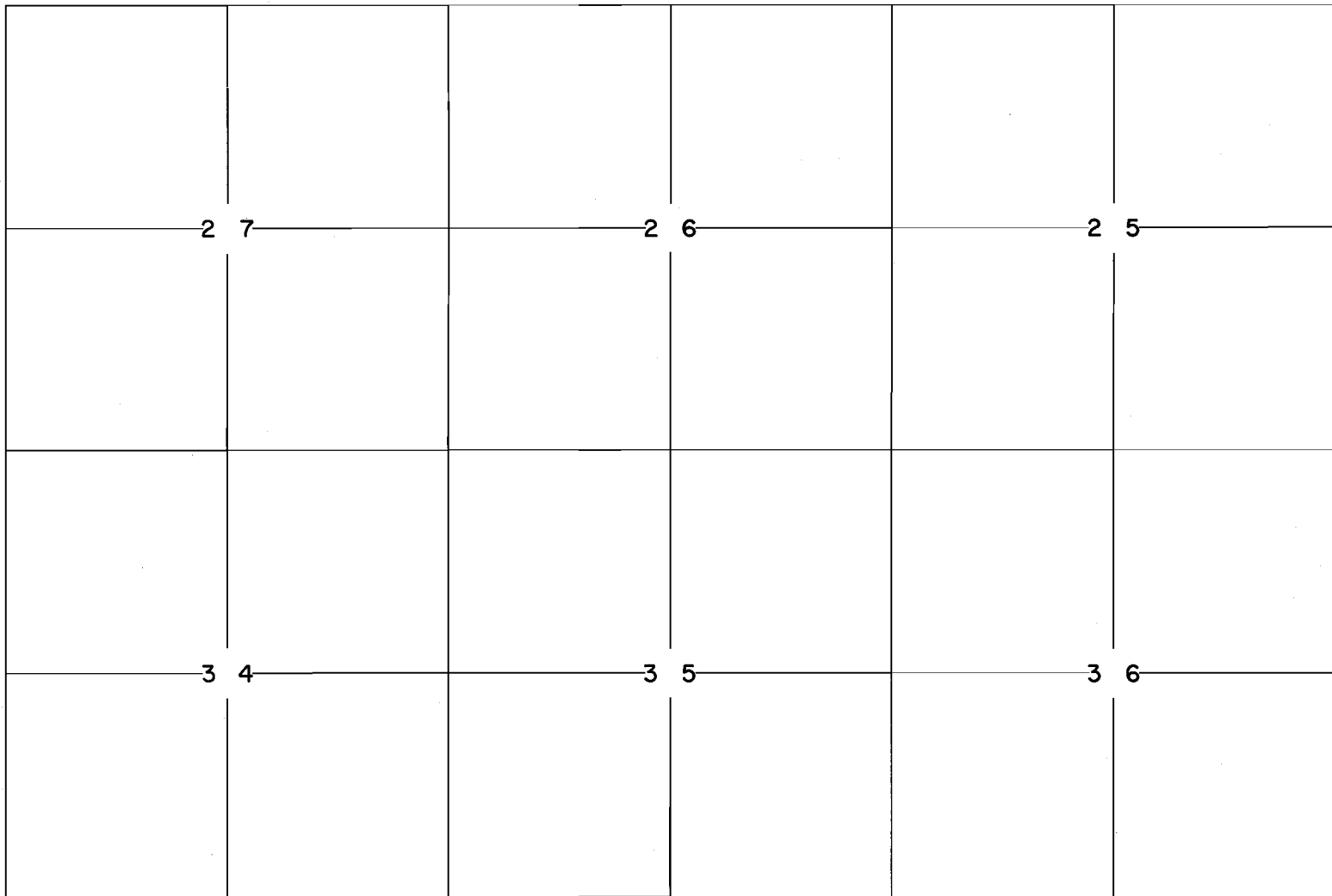




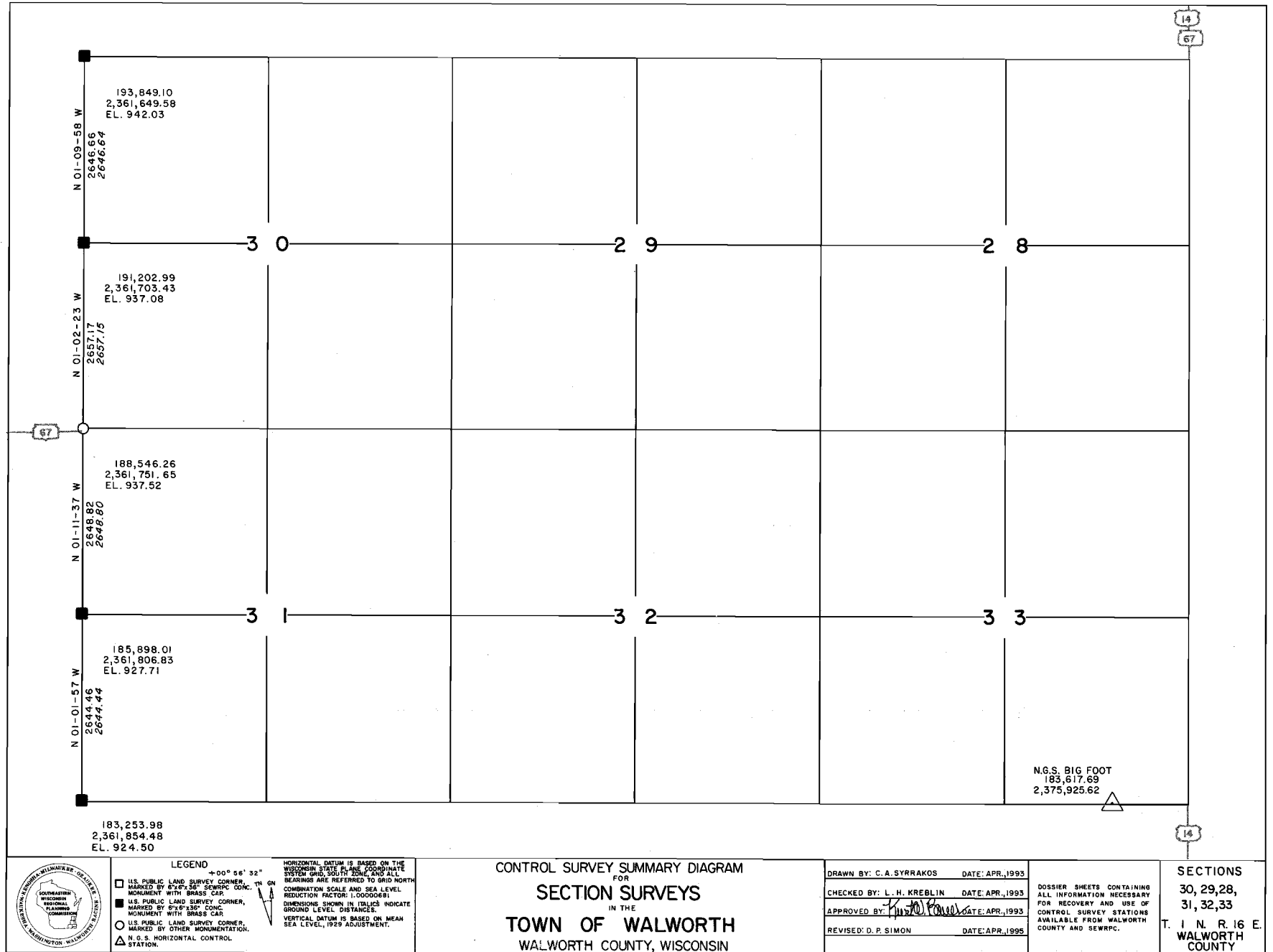


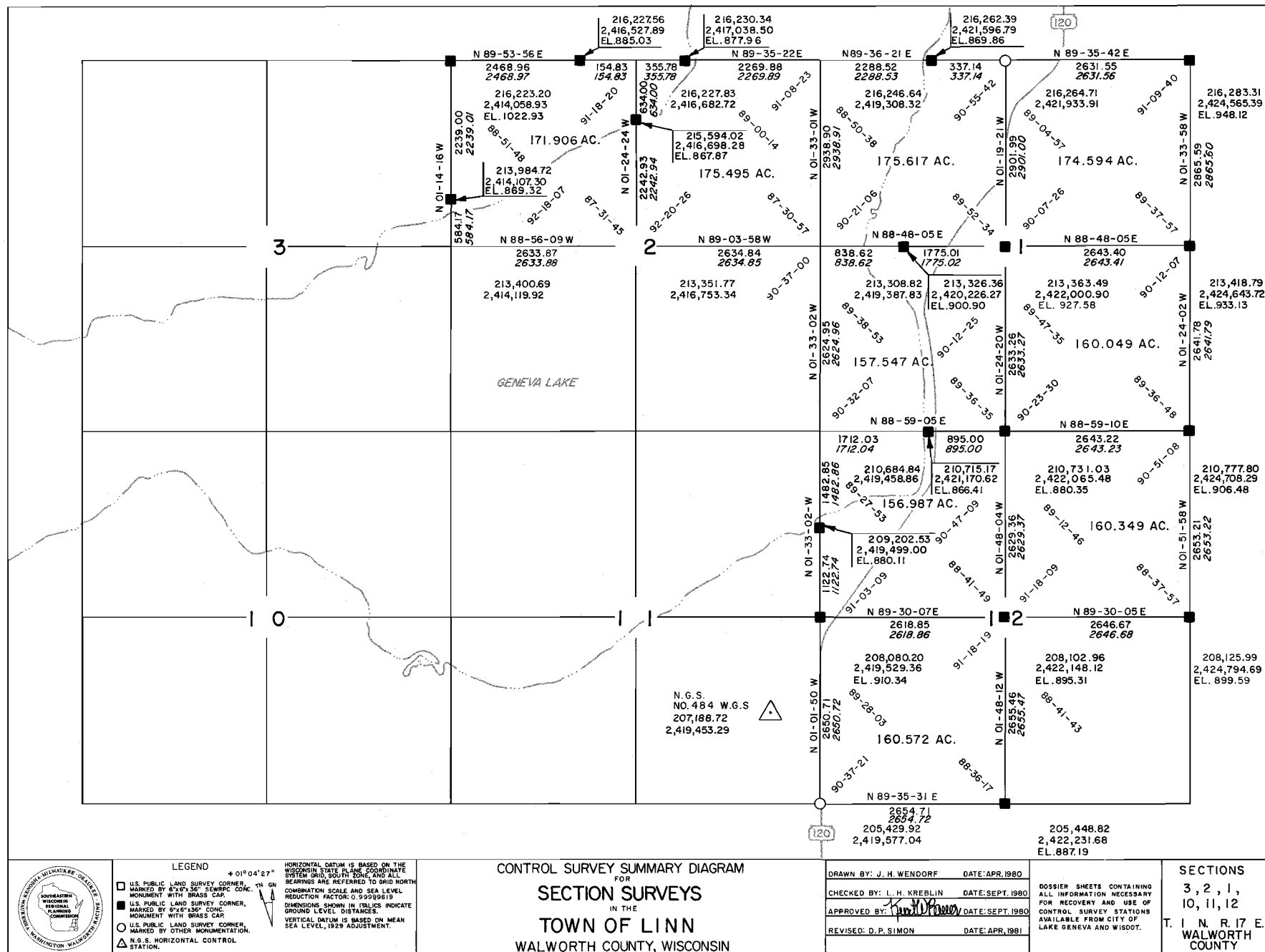


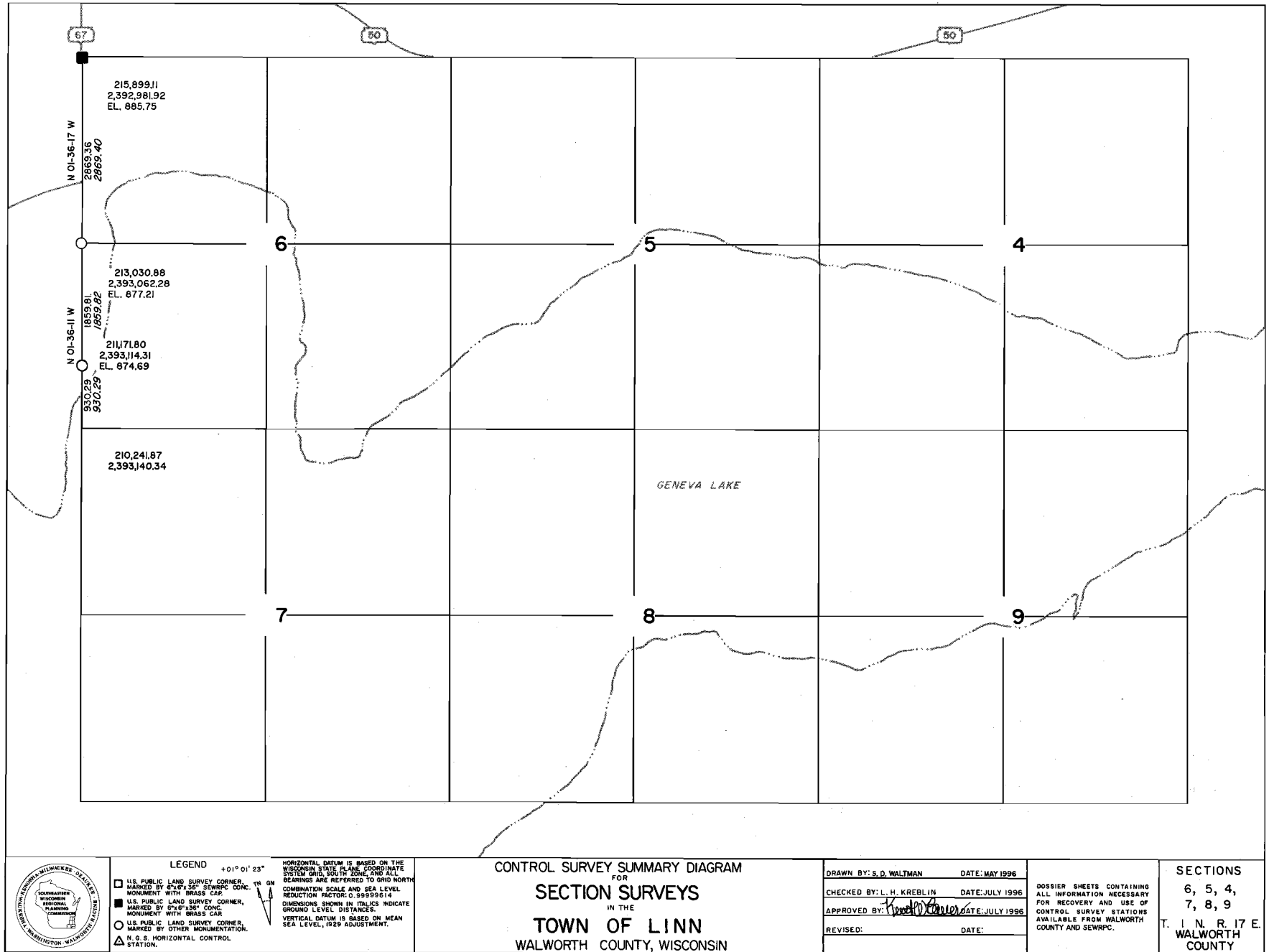
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			CHECKED BY: _____ DATE: _____			
			APPROVED BY: _____ DATE: _____			
			REVISED: _____ DATE: _____			

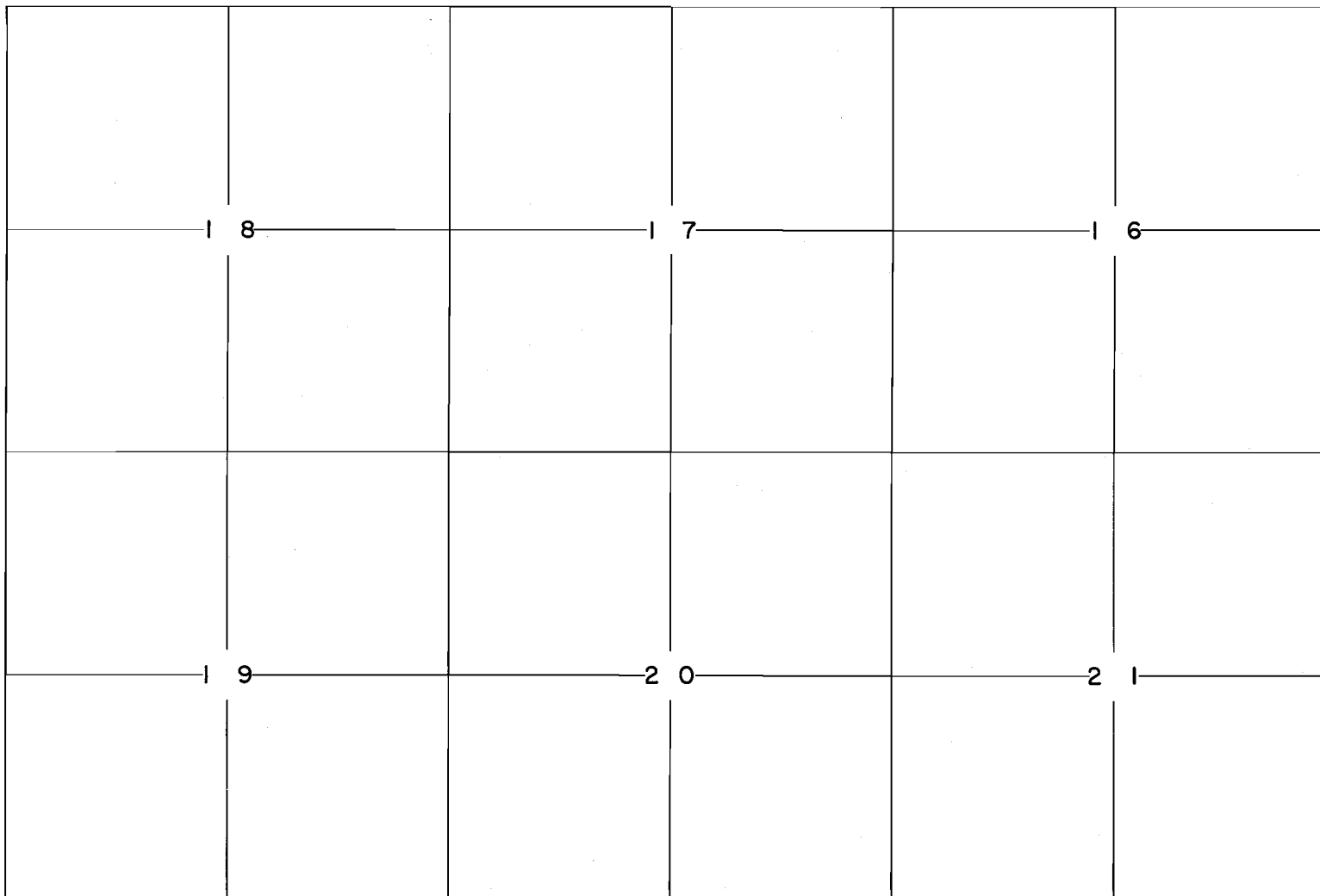


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					CHECKED BY: _____ DATE: _____		
					APPROVED BY: _____ DATE: _____		
					REVISED: _____ DATE: _____		









LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6" 36" S.W. COR. CONC.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6" 36" CONC. MONUMENT WITH BRASS CAP
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N. G. S. HORIZONTAL CONTROL STATION.

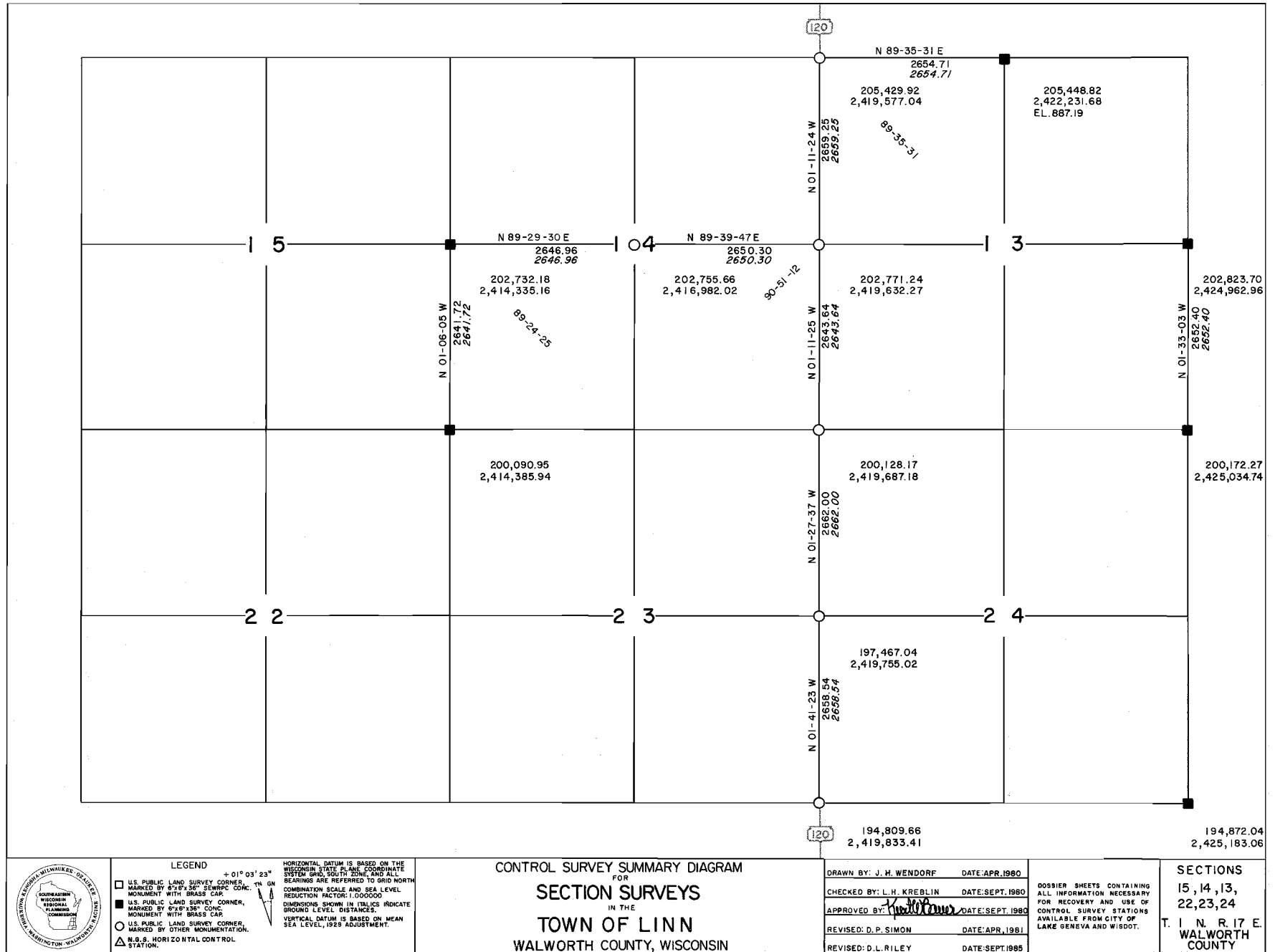
HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM AND SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF LINN WALWORTH COUNTY, WISCONSIN

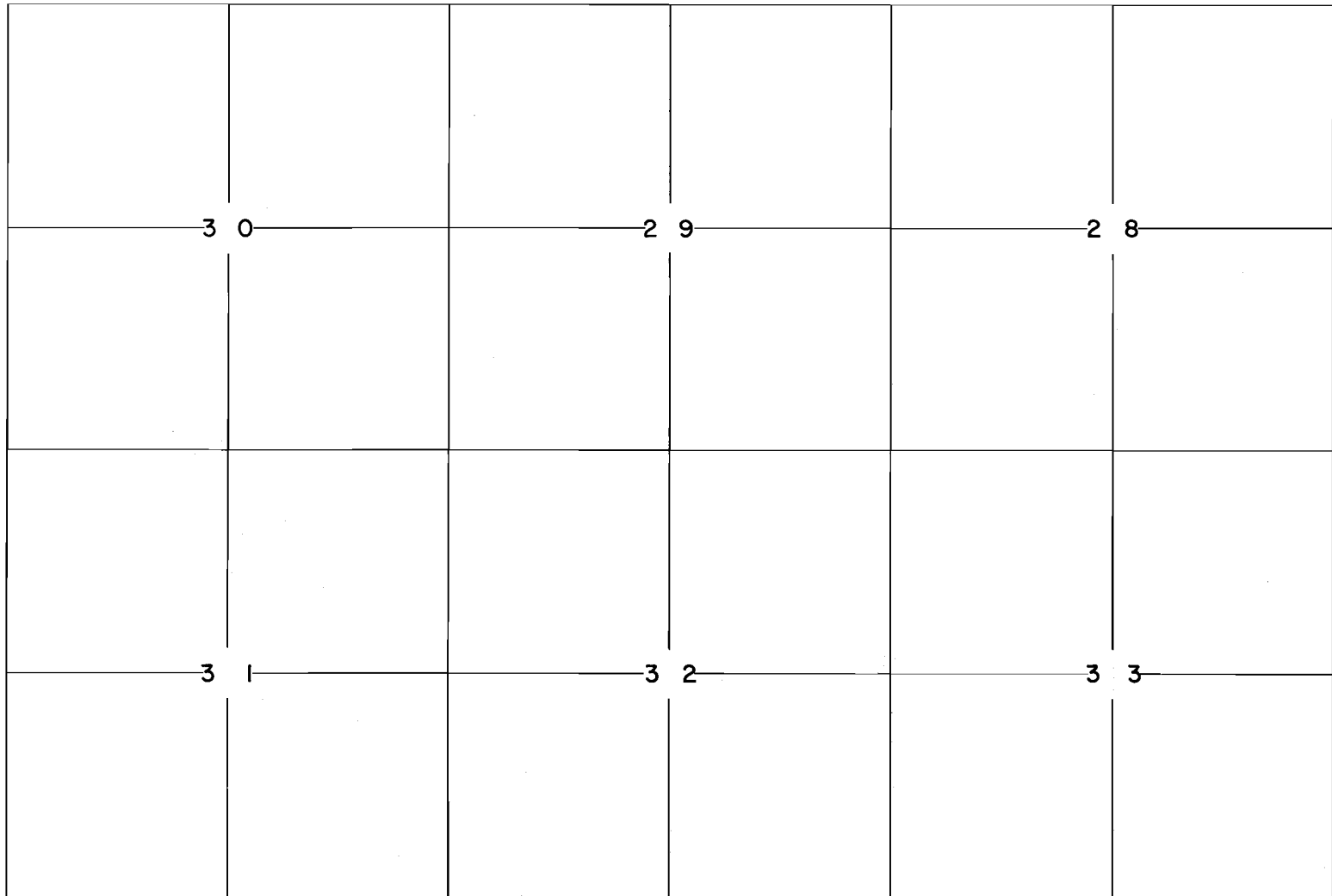
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DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS
18, 17, 16,
19, 20, 21
T. 1 N. R. 17 E.
WALWORTH
COUNTY







LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"x8"x36" SEWPC CONC. MONUMENT WITH BRASS CAP.
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x8"x36" CONC. MONUMENT WITH BRASS CAP.
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
☐ N.G.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.
 COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR.
 DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.
 VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM

SECTION SURVEYS

IN THE
TOWN OF LINN
 WALWORTH COUNTY, WISCONSIN

DRAWN BY: _____ DATE: _____

CHECKED BY: _____ DATE: _____

APPROVED BY: _____ DATE: _____

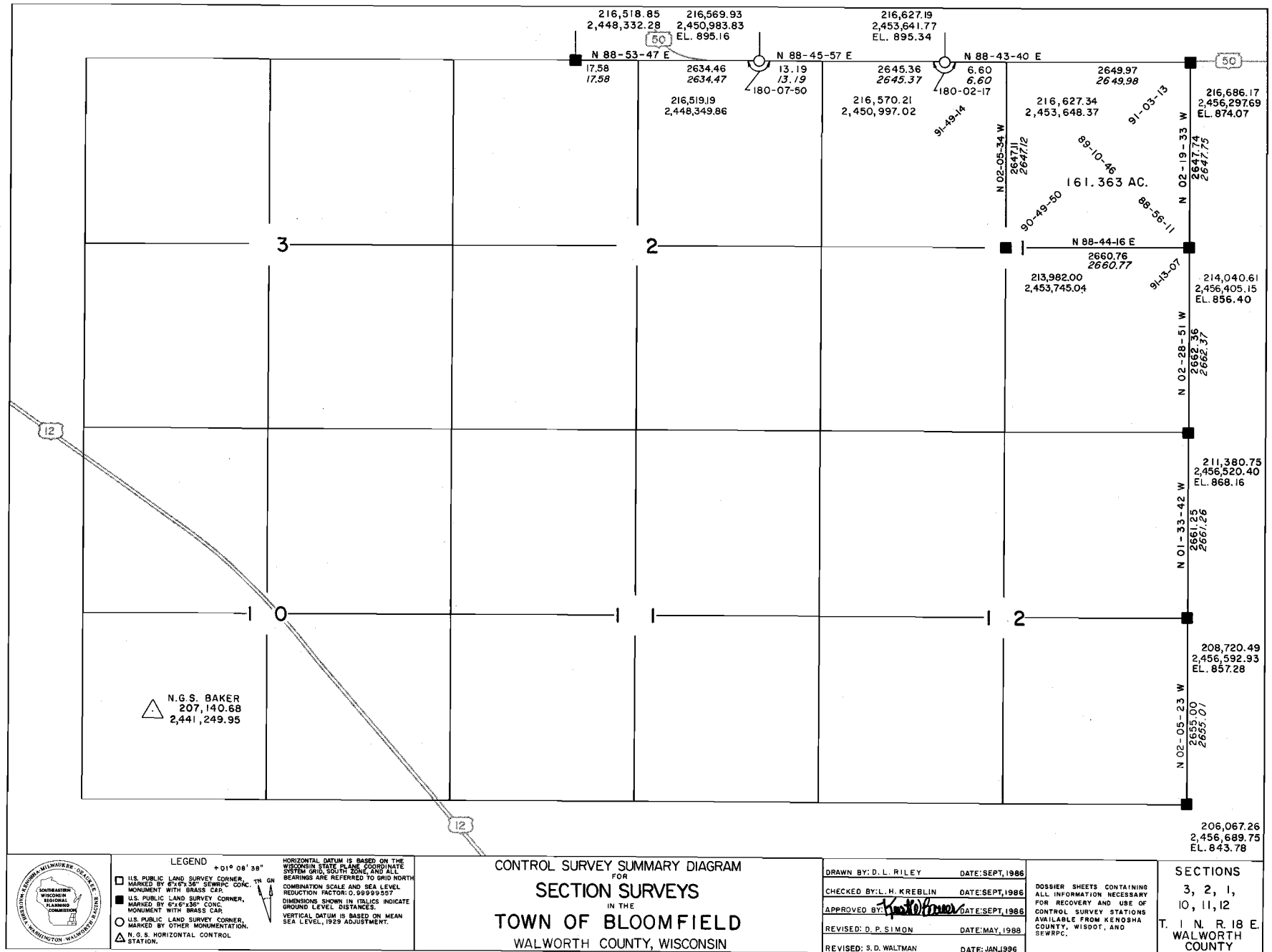
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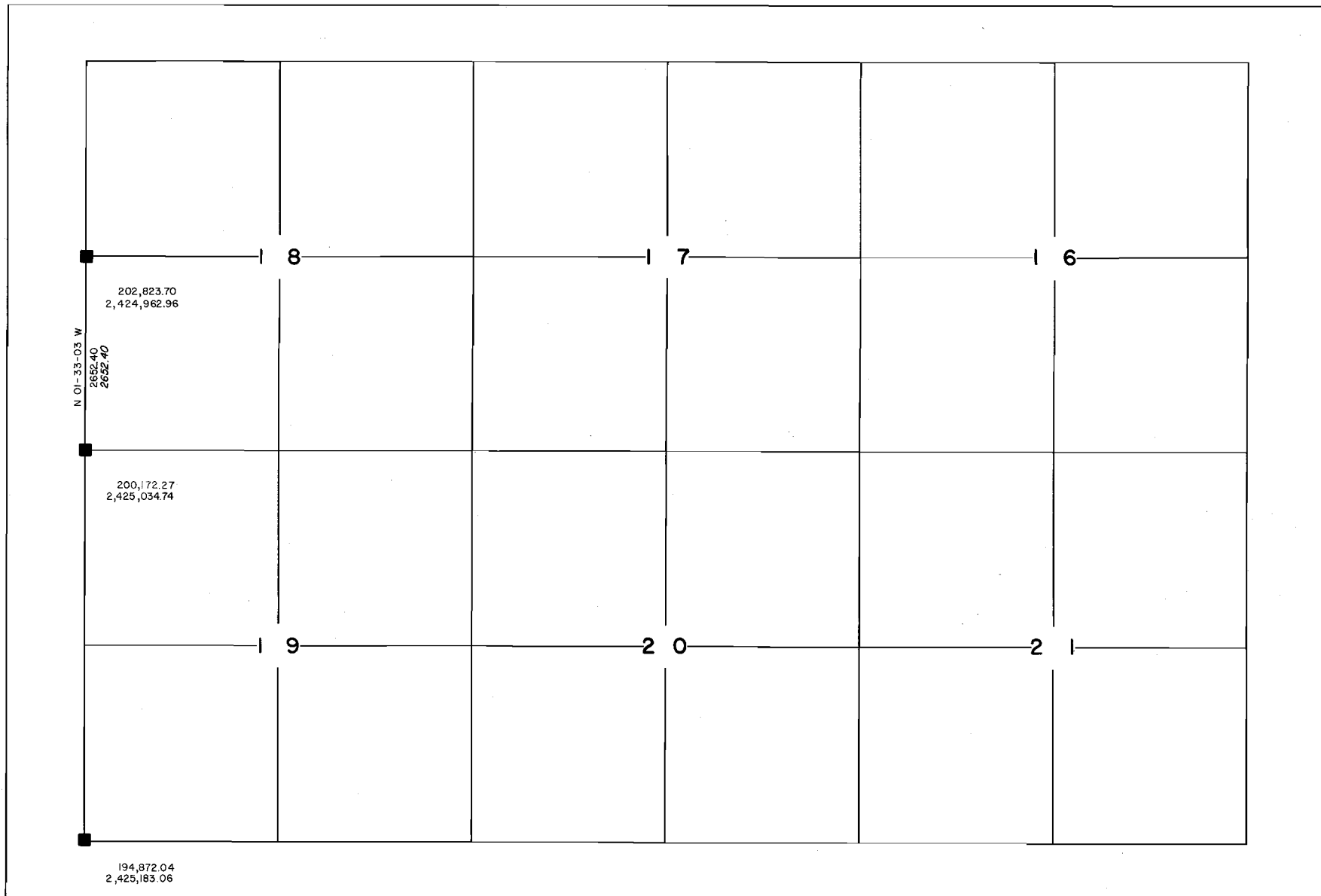
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS

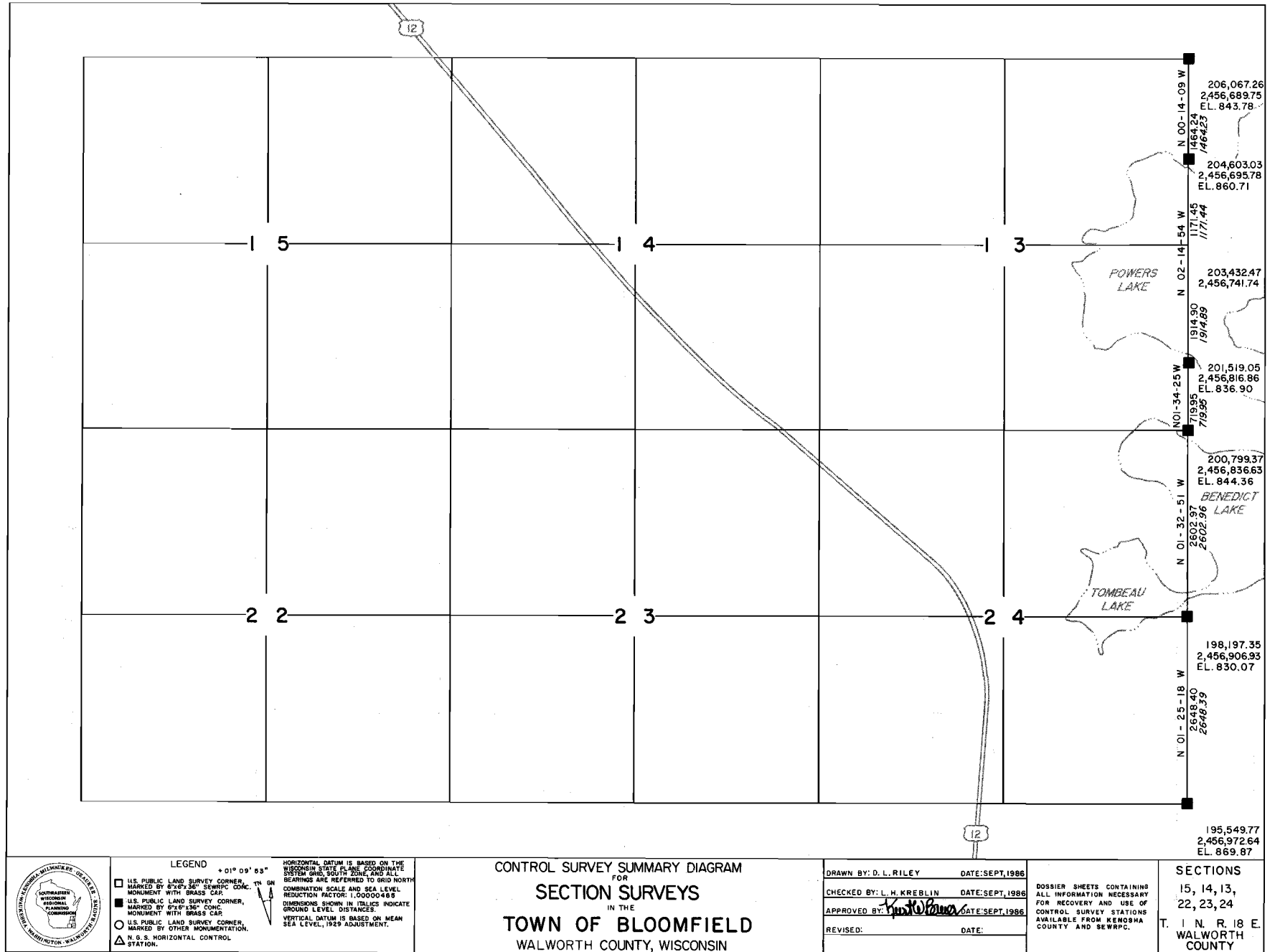
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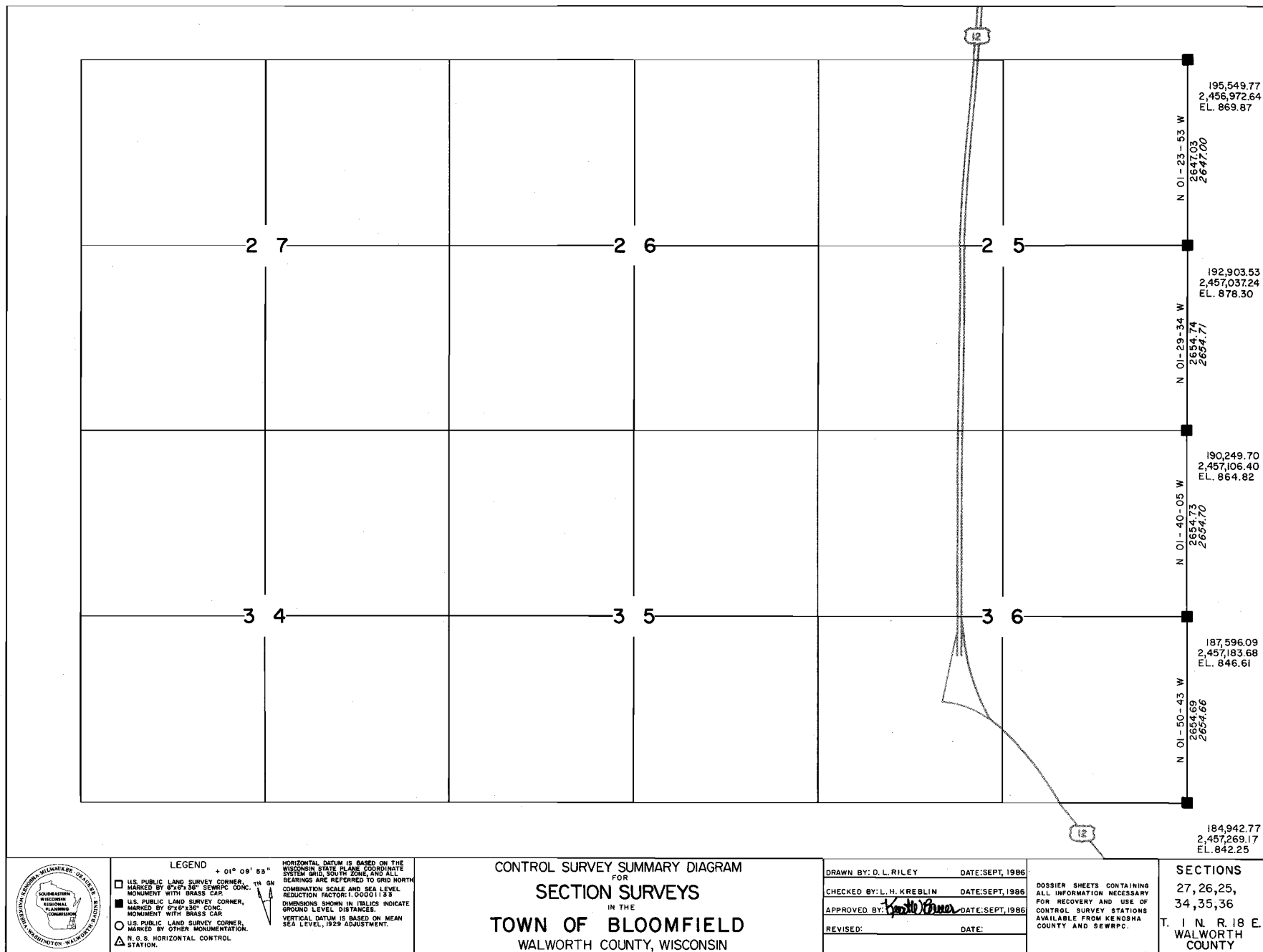
T. 1 N. R. 17 E.
 WALWORTH COUNTY

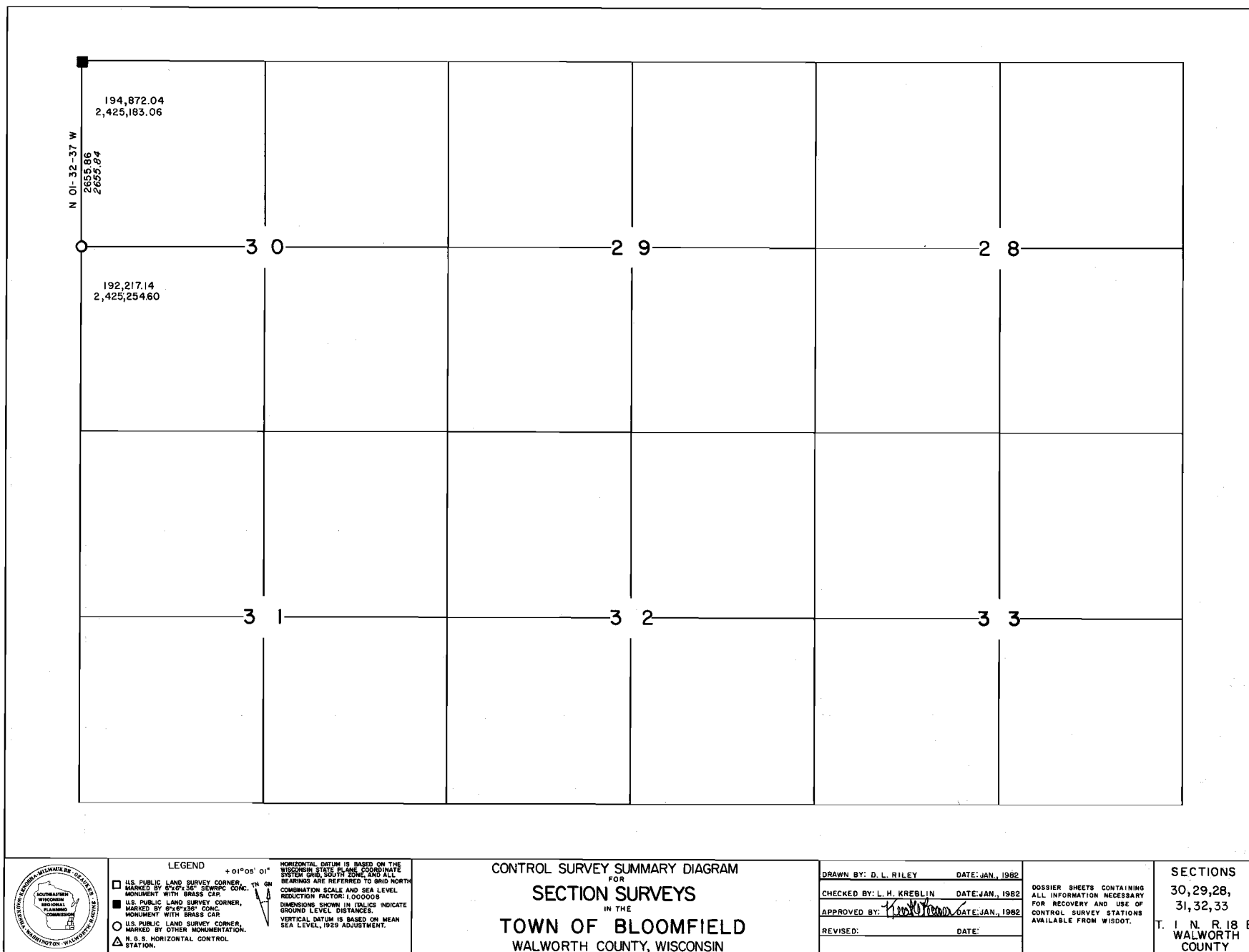


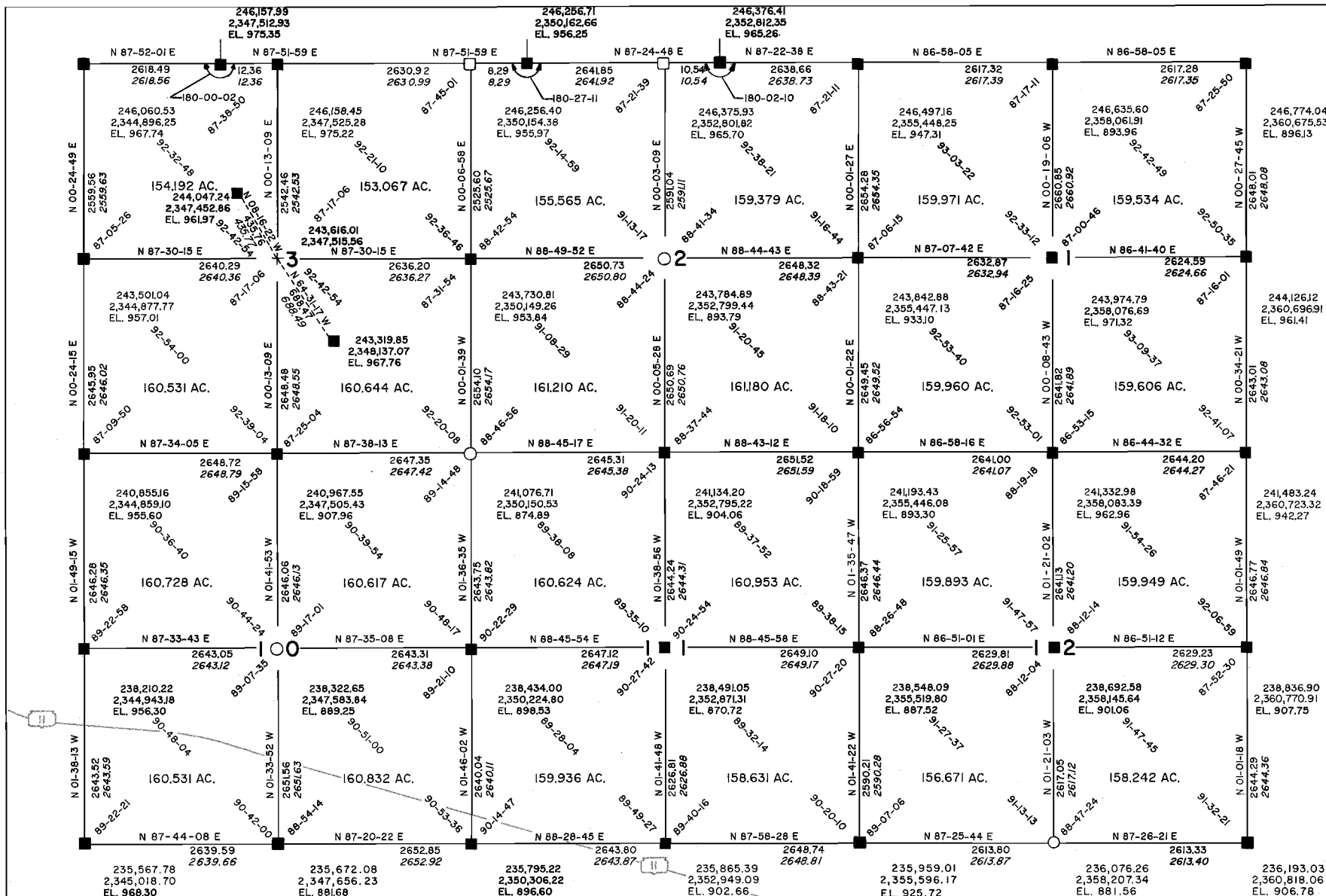


	LEGEND +01° 05' 01" TN GN <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONCRETE MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONCRETE MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.	HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL. REDUCTION FACTOR: 1.000001. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.	CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF BLOOMFIELD WALWORTH COUNTY, WISCONSIN		DRAWN BY: D. L. RILEY DATE: JAN., 1982 CHECKED BY: L. H. KREBLIN DATE: JAN., 1982 APPROVED BY: <i>[Signature]</i> DATE: JAN., 1982 REVISED: DATE:	DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WISDOT.	SECTIONS 18, 17, 16, 19, 20, 21 T. 1 N. R. 18 E. WALWORTH COUNTY
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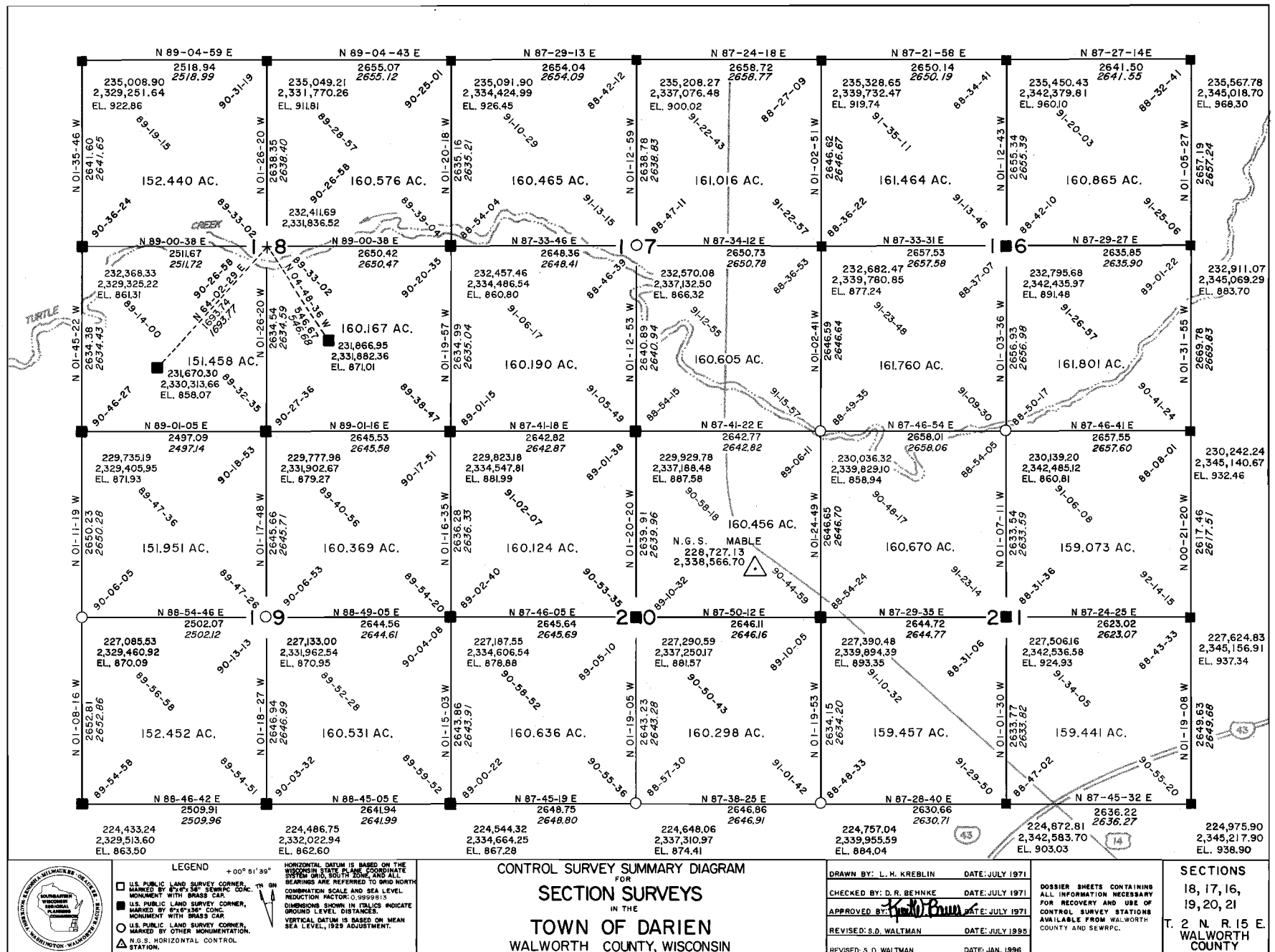


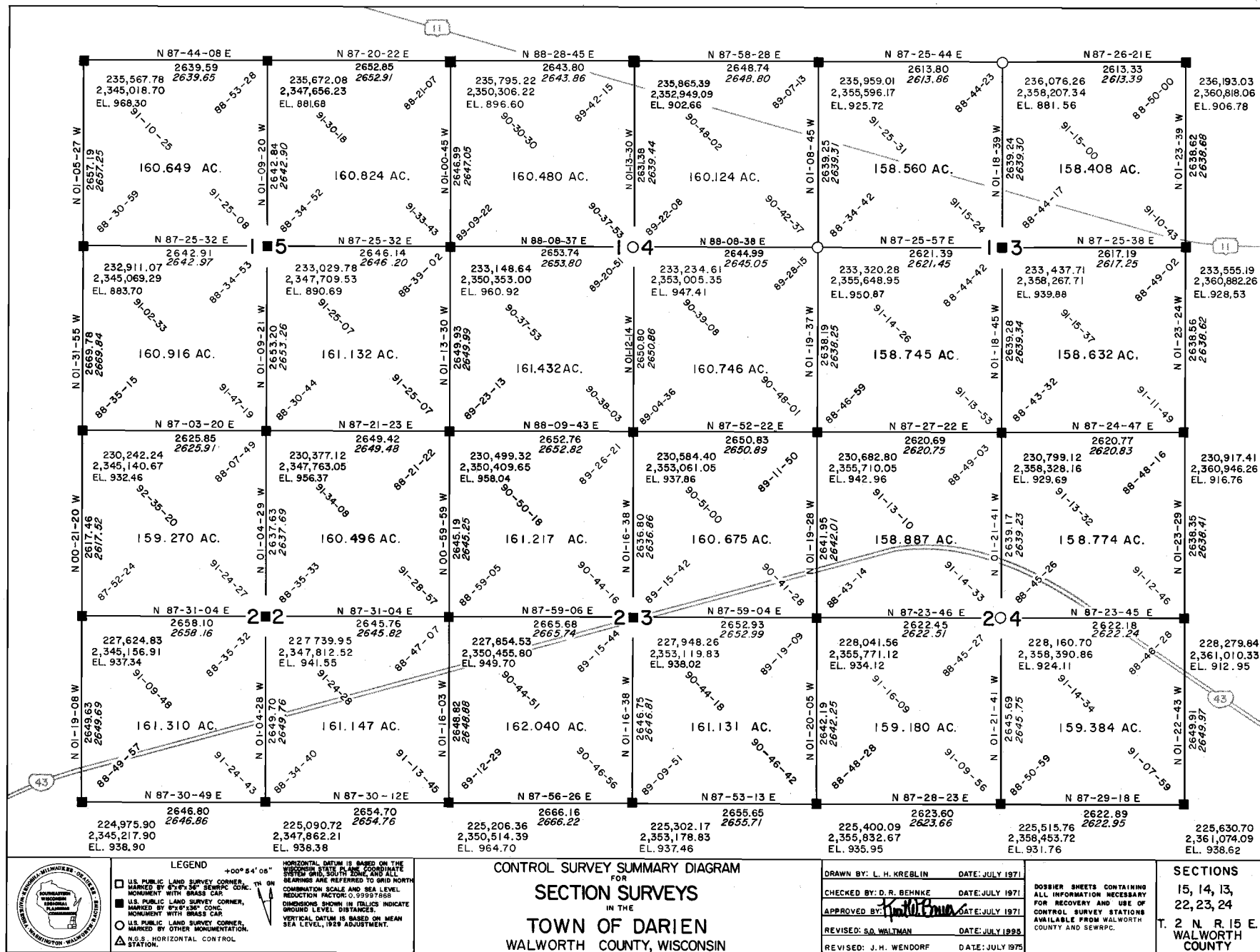


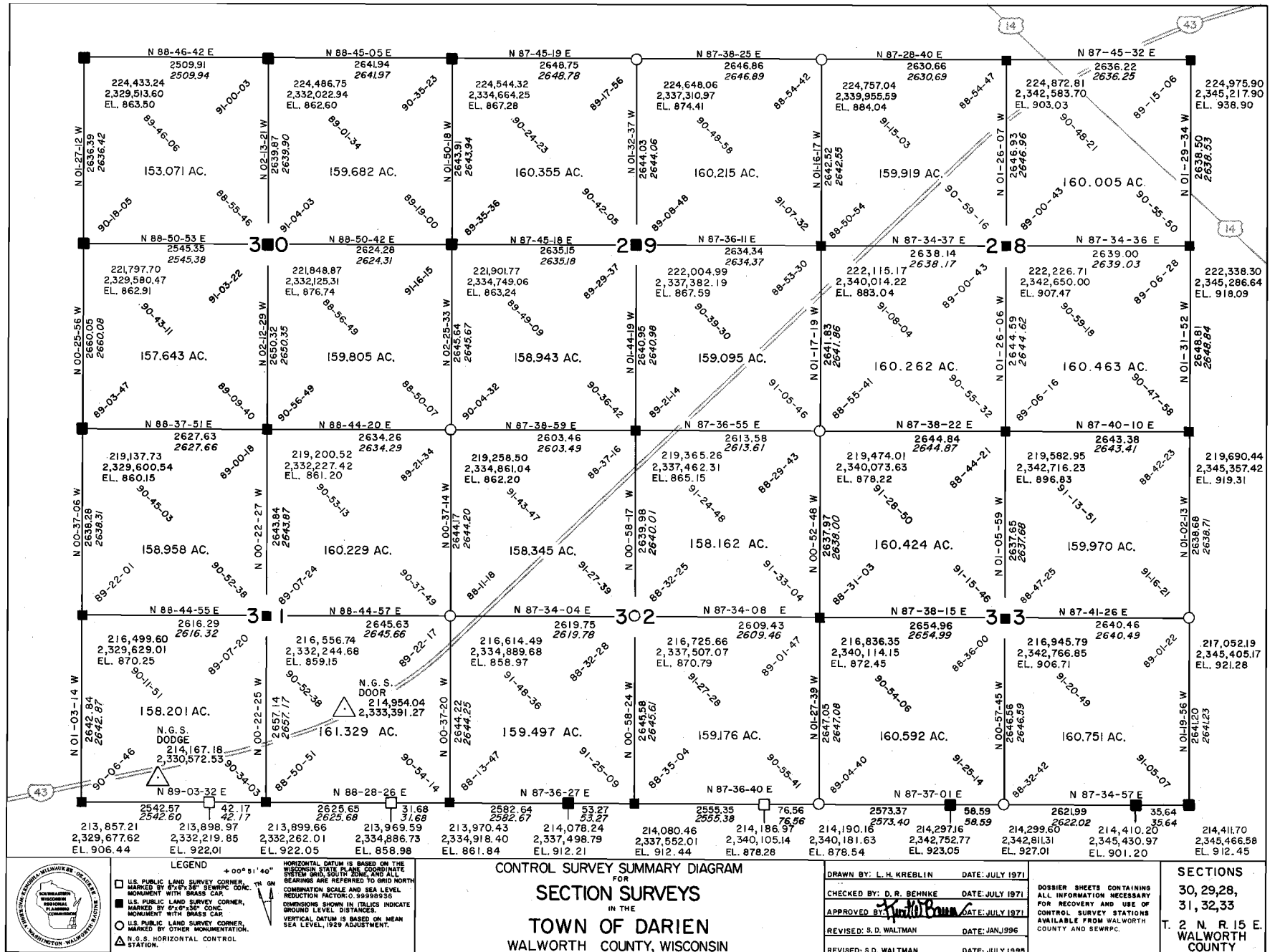


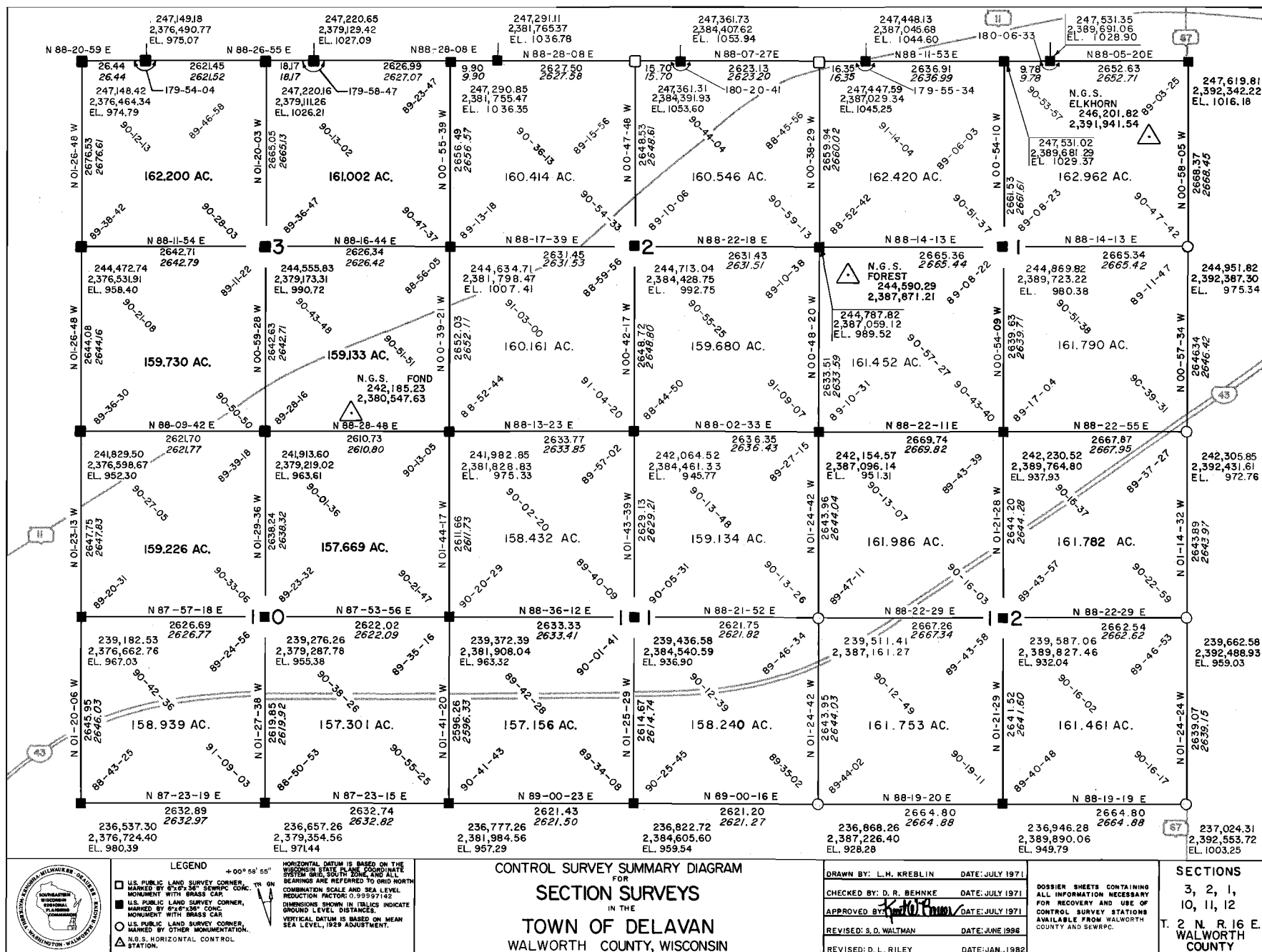


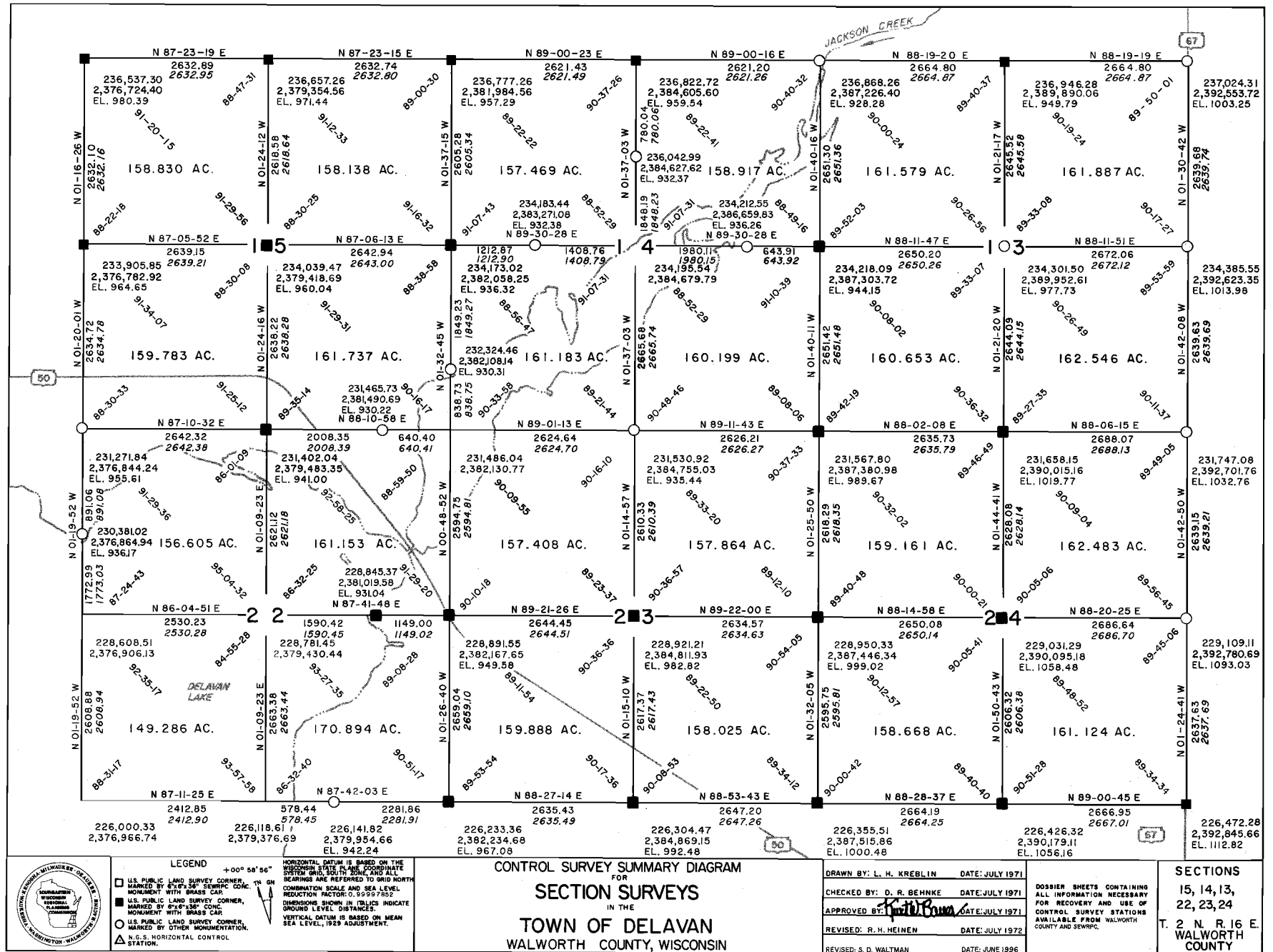
	<p>LEGEND</p> <p>U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"X 6" BRASS CAP.</p> <p>U.S. PUBLIC LAND SURVEY CORNER MARKED BY 6"X 6" BRASS CAP. MONUMENT WITH BRASS CAP.</p> <p>U.S. PUBLIC LAND SURVEY CORNER MARKED BY OTHER MONUMENTATION.</p> <p>STATION.</p>	<p>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.</p> <p>COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99997367.</p> <p>DIMENSIONS SHOWN IN FEET INDICATE GROUND LEVEL DISTANCES.</p> <p>VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</p> <p>CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF DARIEN WALWORTH COUNTY, WISCONSIN</p>	<p>DRAWN BY: D. L. RILEY DATE: SEPT, 1988</p> <p>CHECKED BY: L. H. KREBLIN DATE: SEPT, 1988</p> <p>APPROVED BY: <i>[Signature]</i> DATE: SEPT, 1988</p> <p>REVISED: S. D. WALTMAN DATE: JUNE 1996</p> <p>REVISED: S. D. WALTMAN DATE: JULY, 1995</p>	<p>DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WALWORTH COUNTY AND SEWIC.</p> <p>SECTIONS</p> <p>3, 2, 1, 10, 11, 12</p> <p>T. 2 N. R. 15 E. WALWORTH COUNTY</p>
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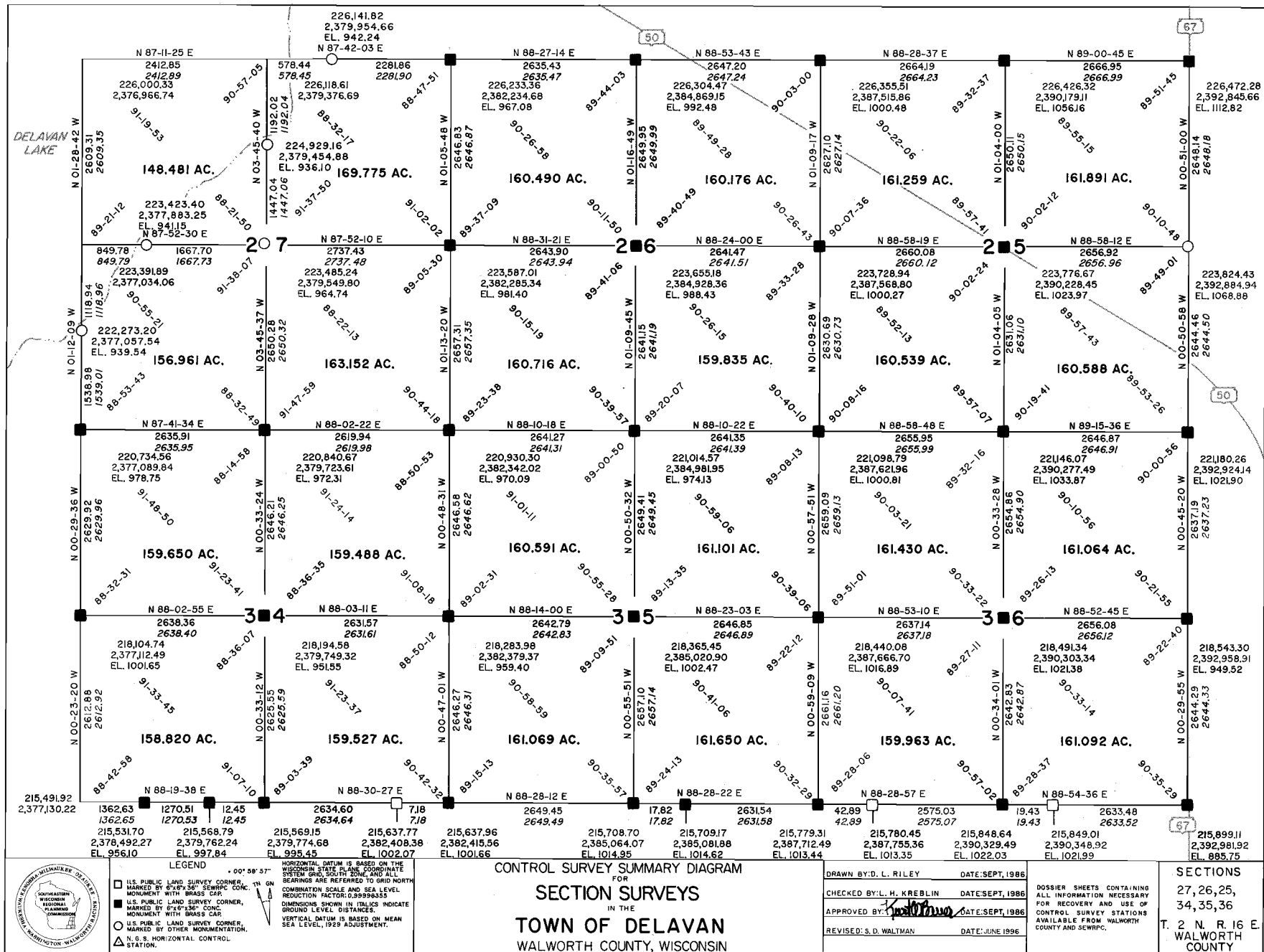


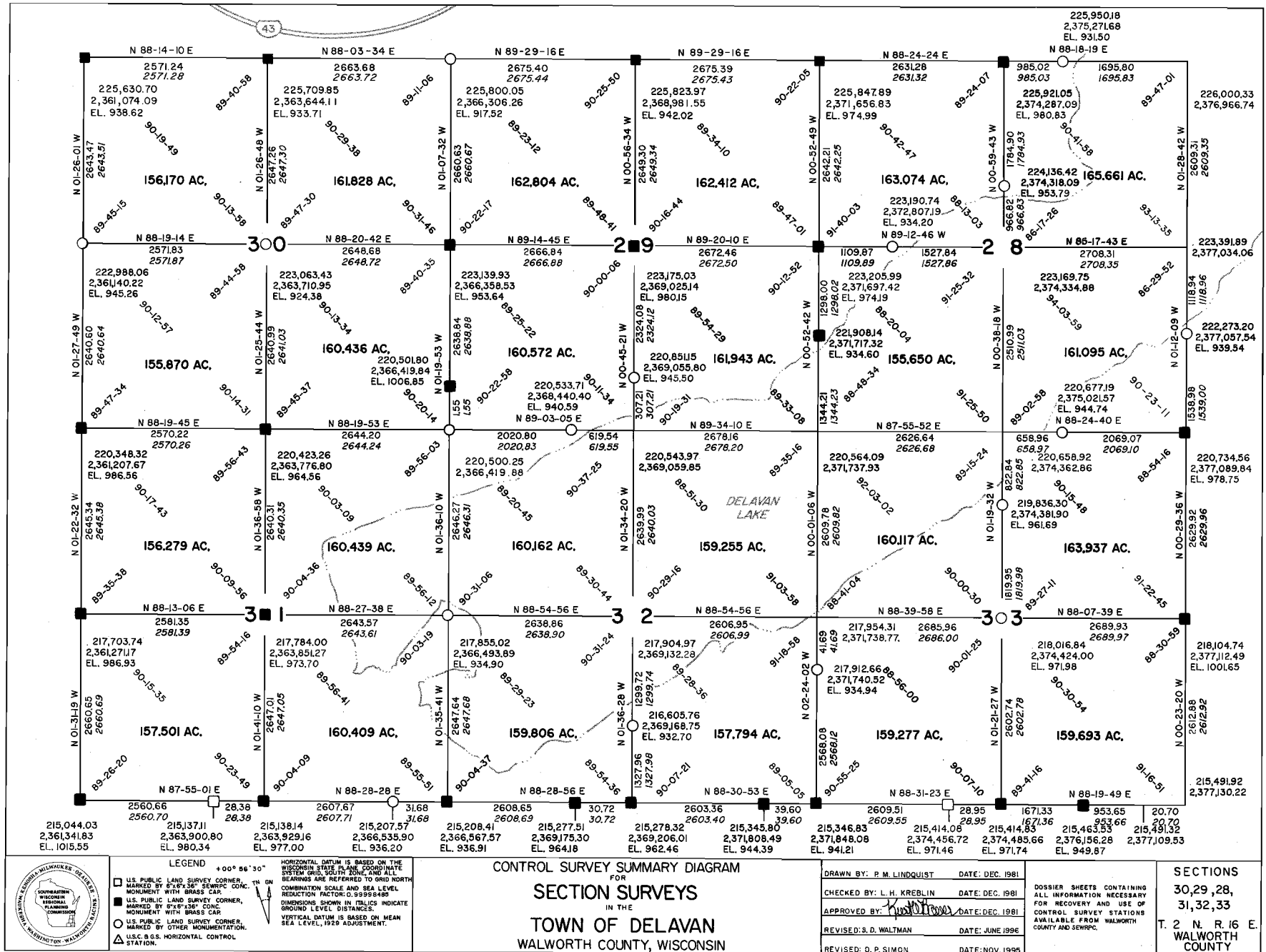


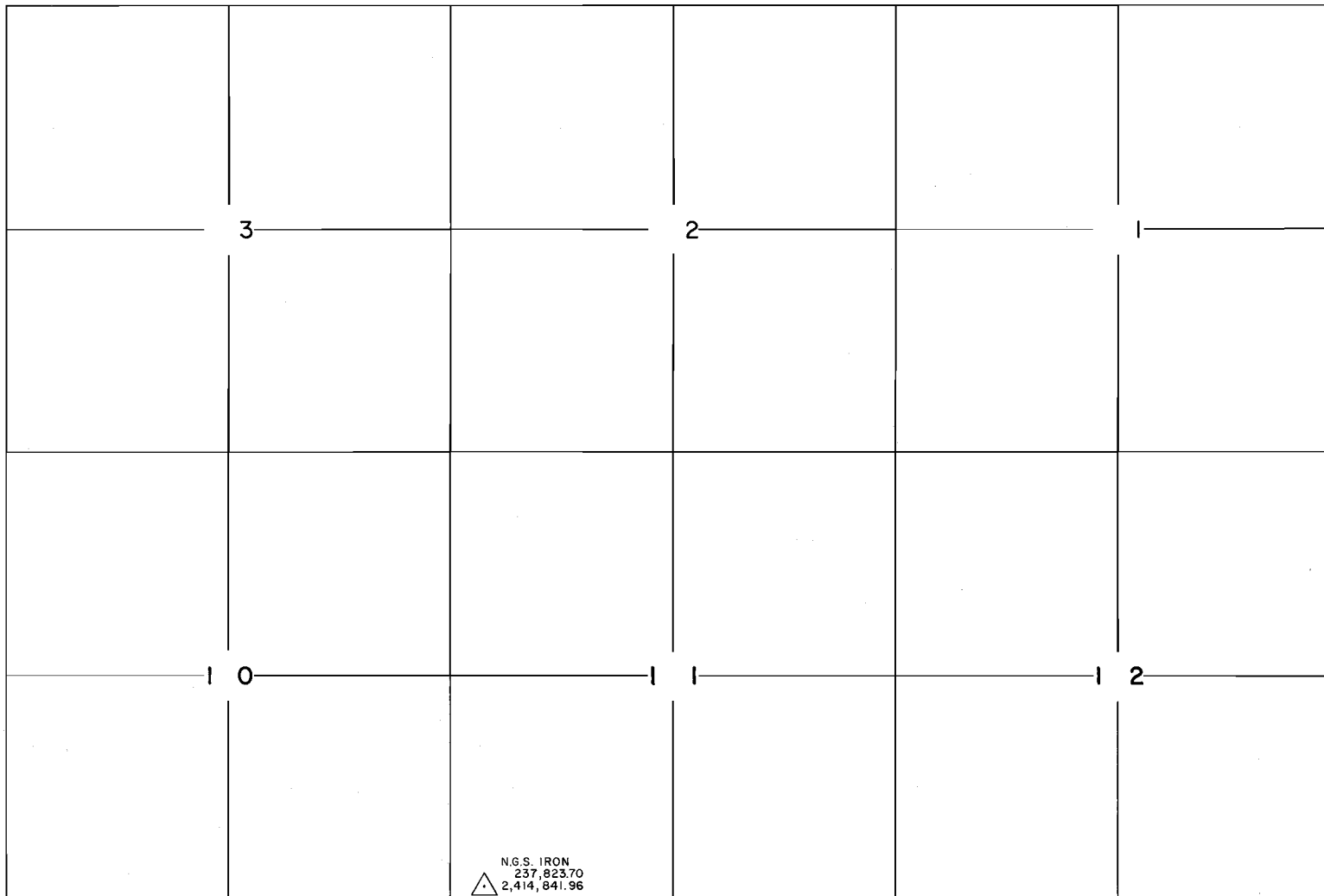












LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEWRPC CONC. MONUMENT WITH BRASS CAP
- ☒ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION
- ☐ N. S. S. HORIZONTAL CONTROL STATION

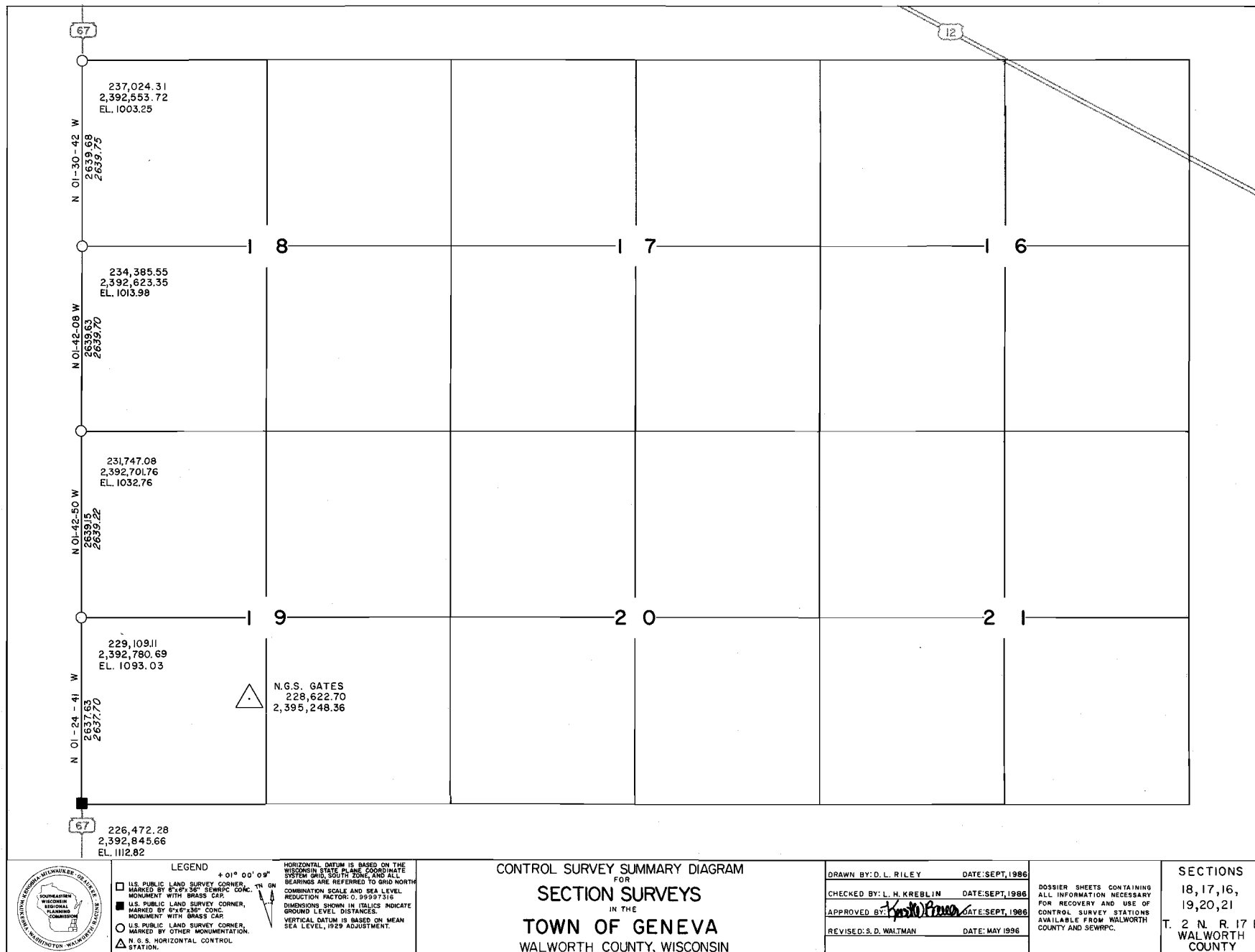
HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH
COMBINATION SCALE AND SEA LEVEL
REDUCTION FACTOR:
DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.
VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

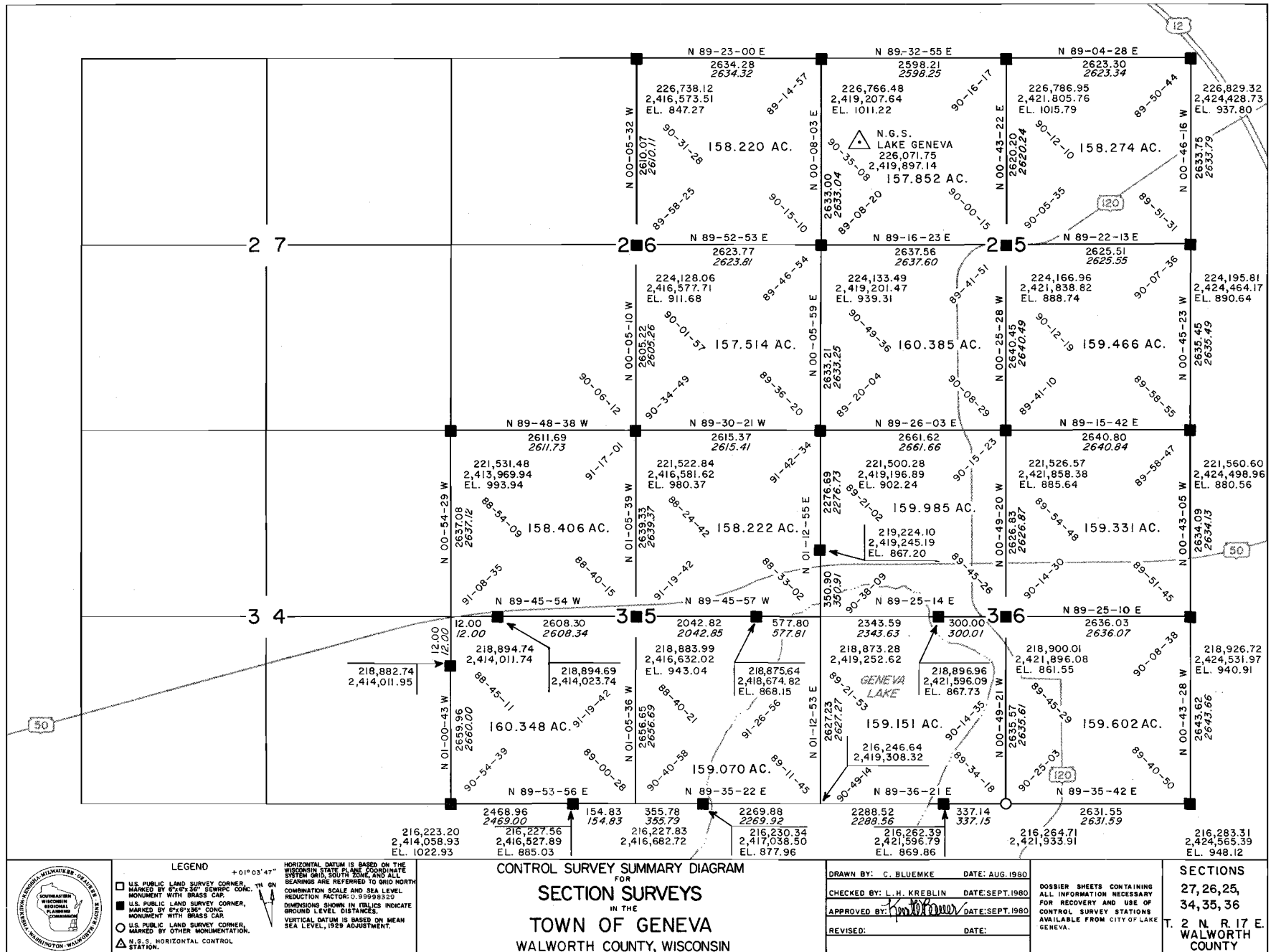
CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF GENEVA WALWORTH COUNTY, WISCONSIN

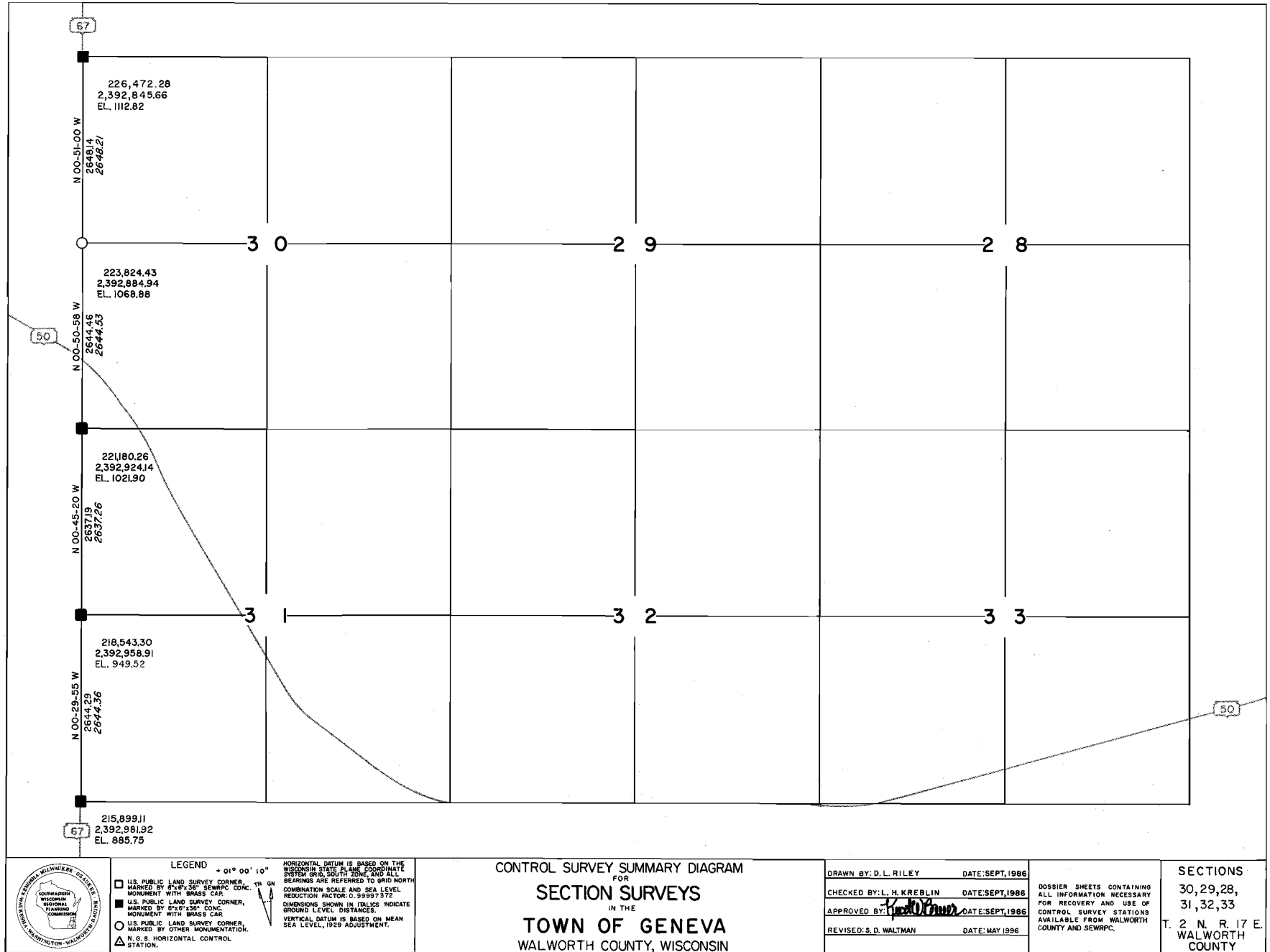
DRAWN BY: K. HALL	DATE: SEPT. 1991
CHECKED BY:	DATE:
APPROVED BY:	DATE:
REVISED:	DATE:

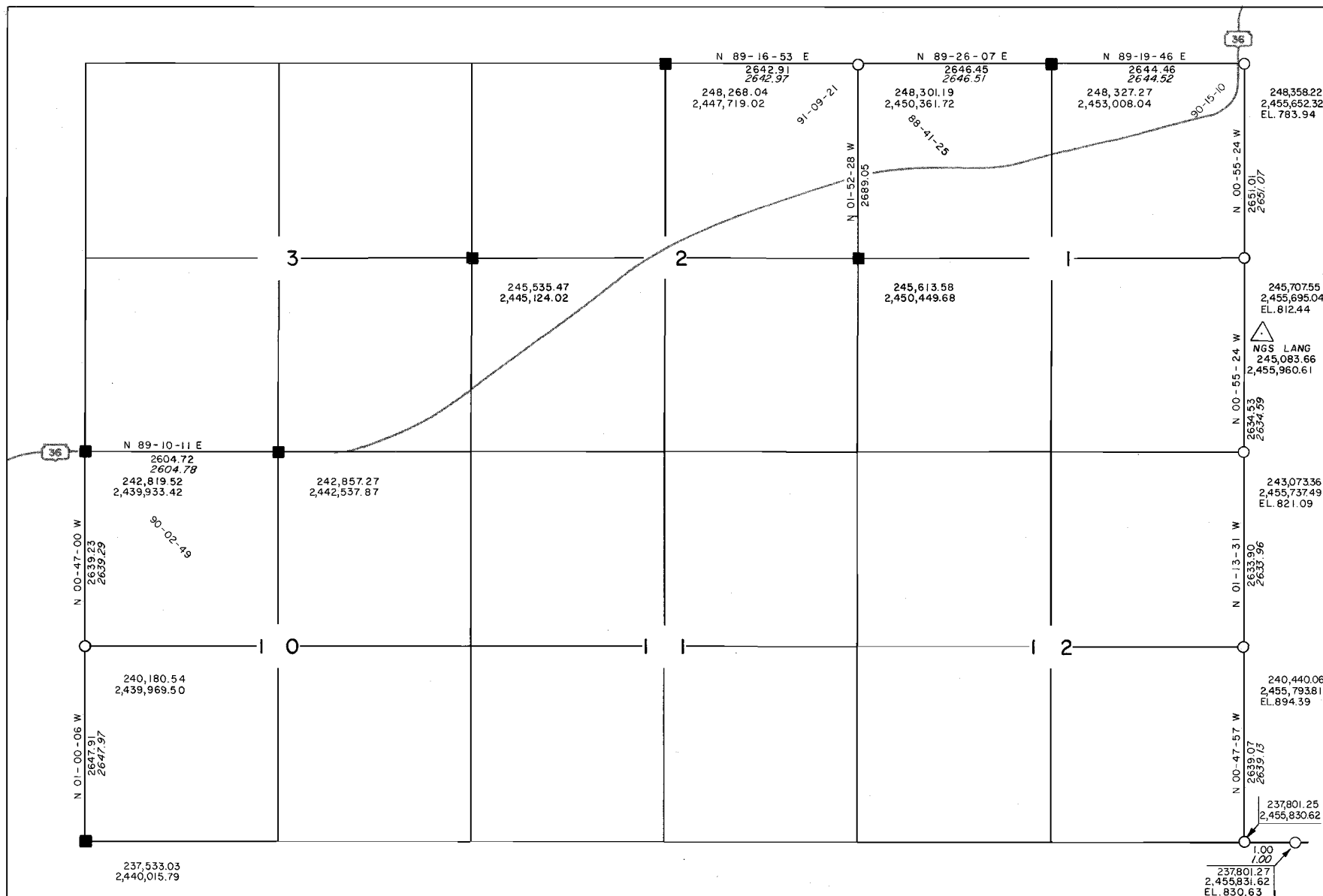
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

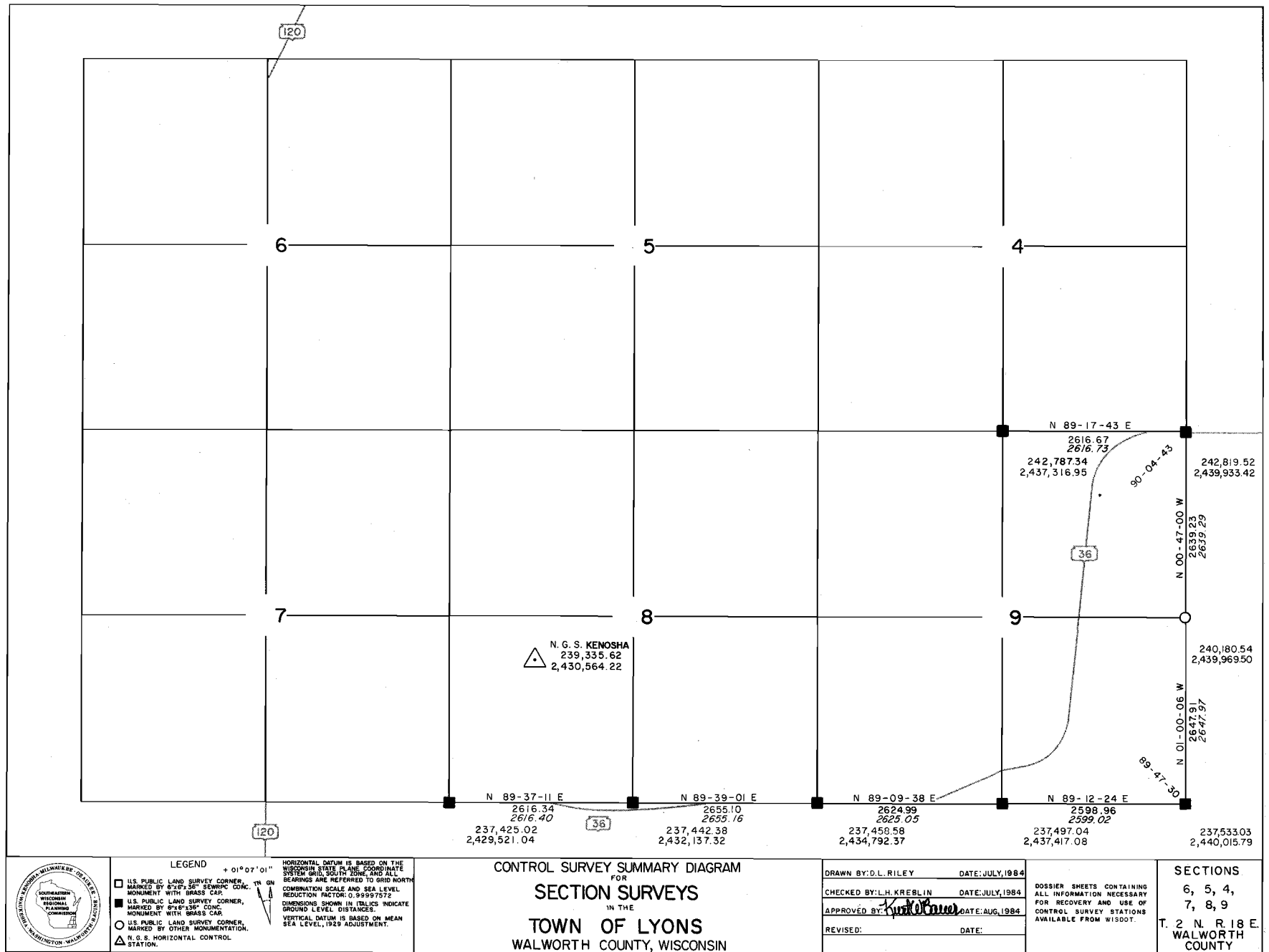
SECTIONS
3, 2, 1,
10, 11, 12
T. 2 N. R. 17 E.
WALWORTH
COUNTY

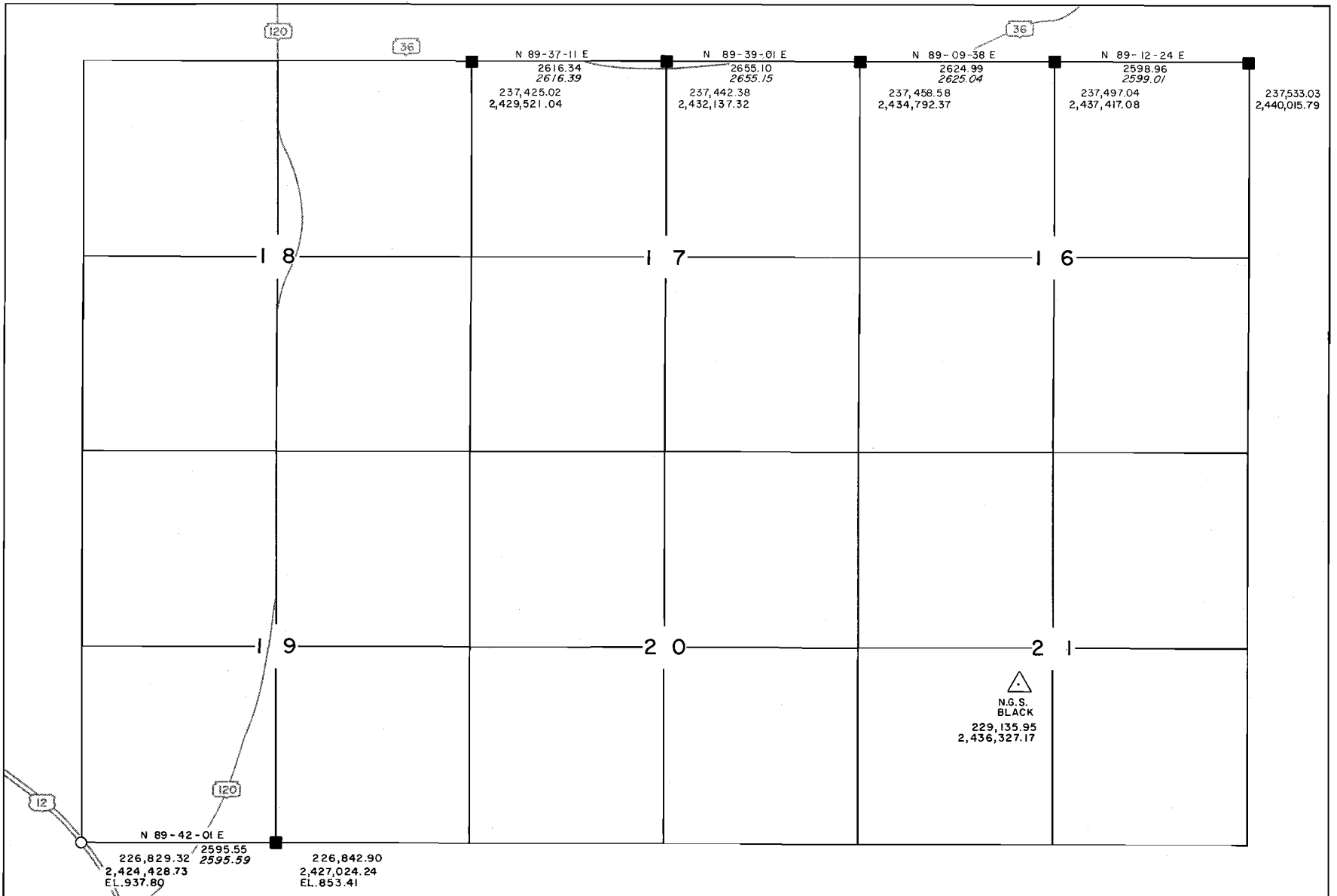




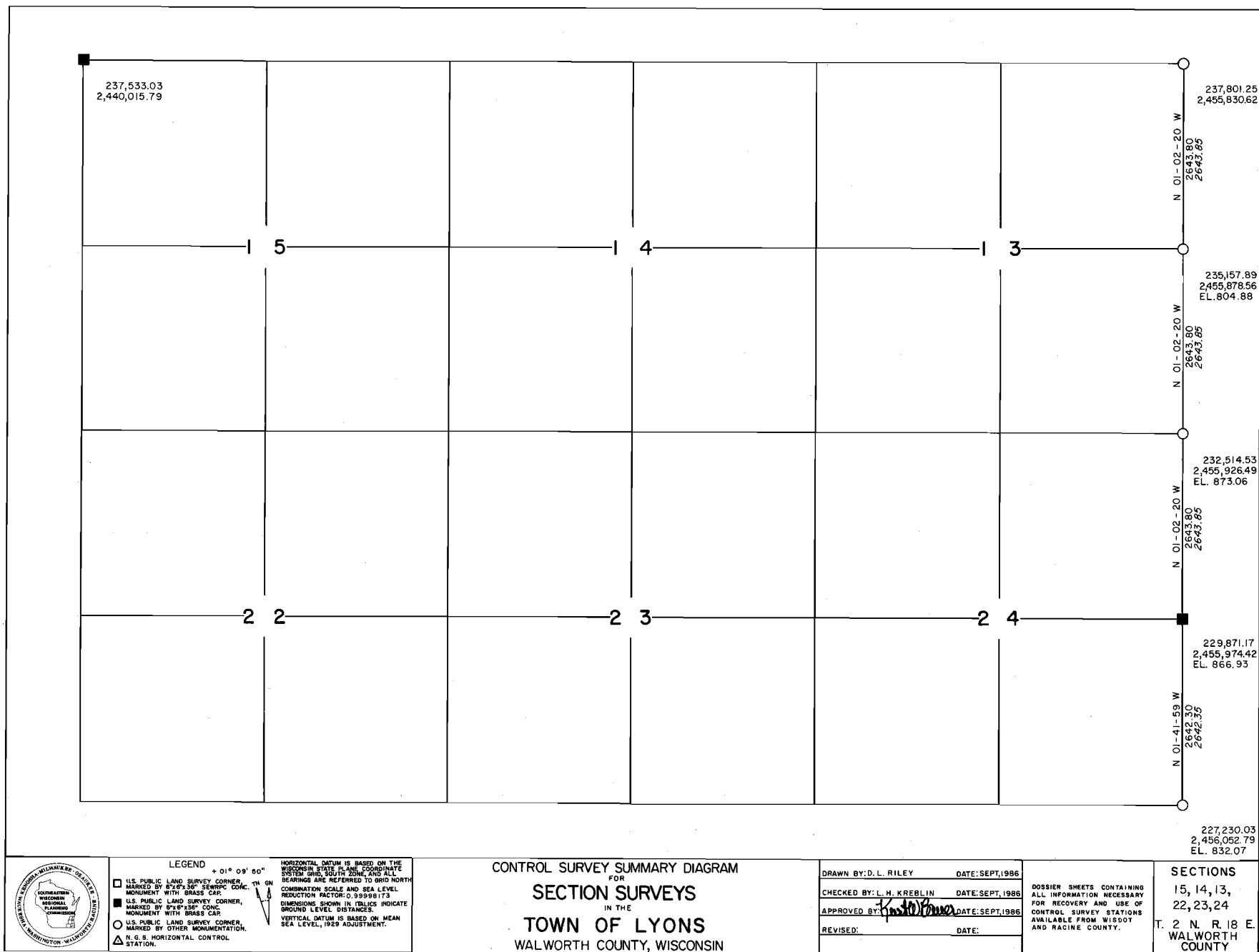


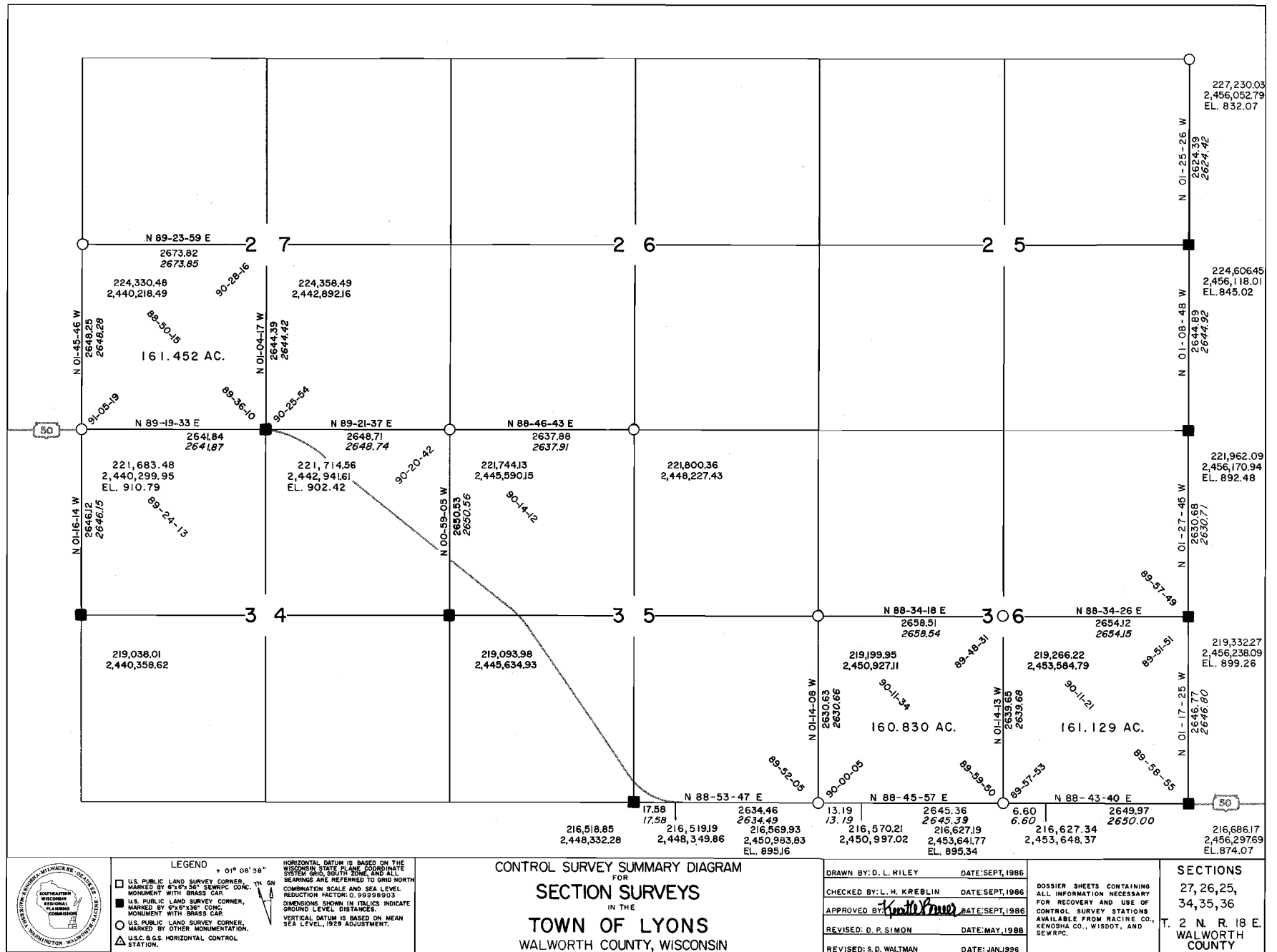


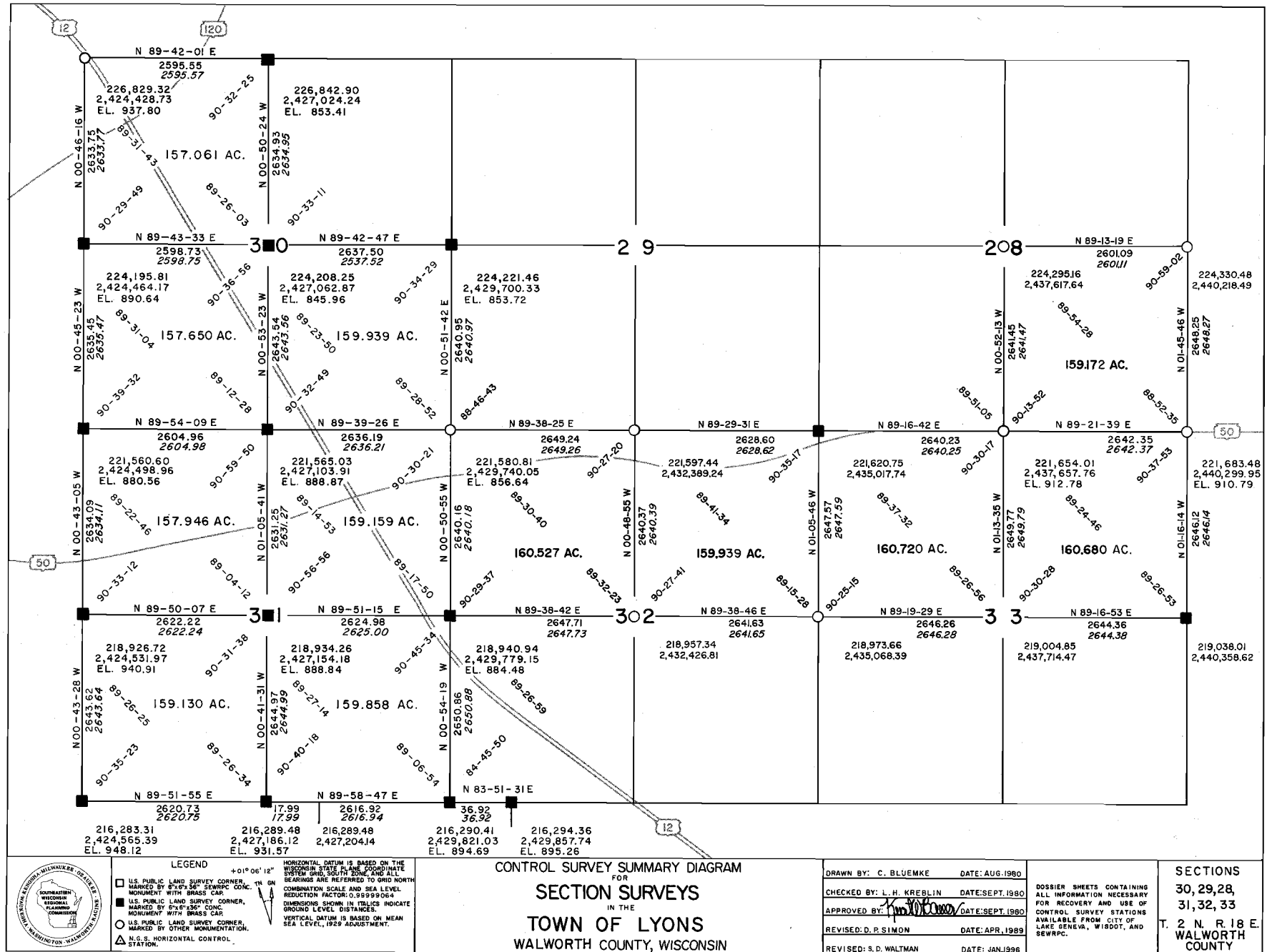





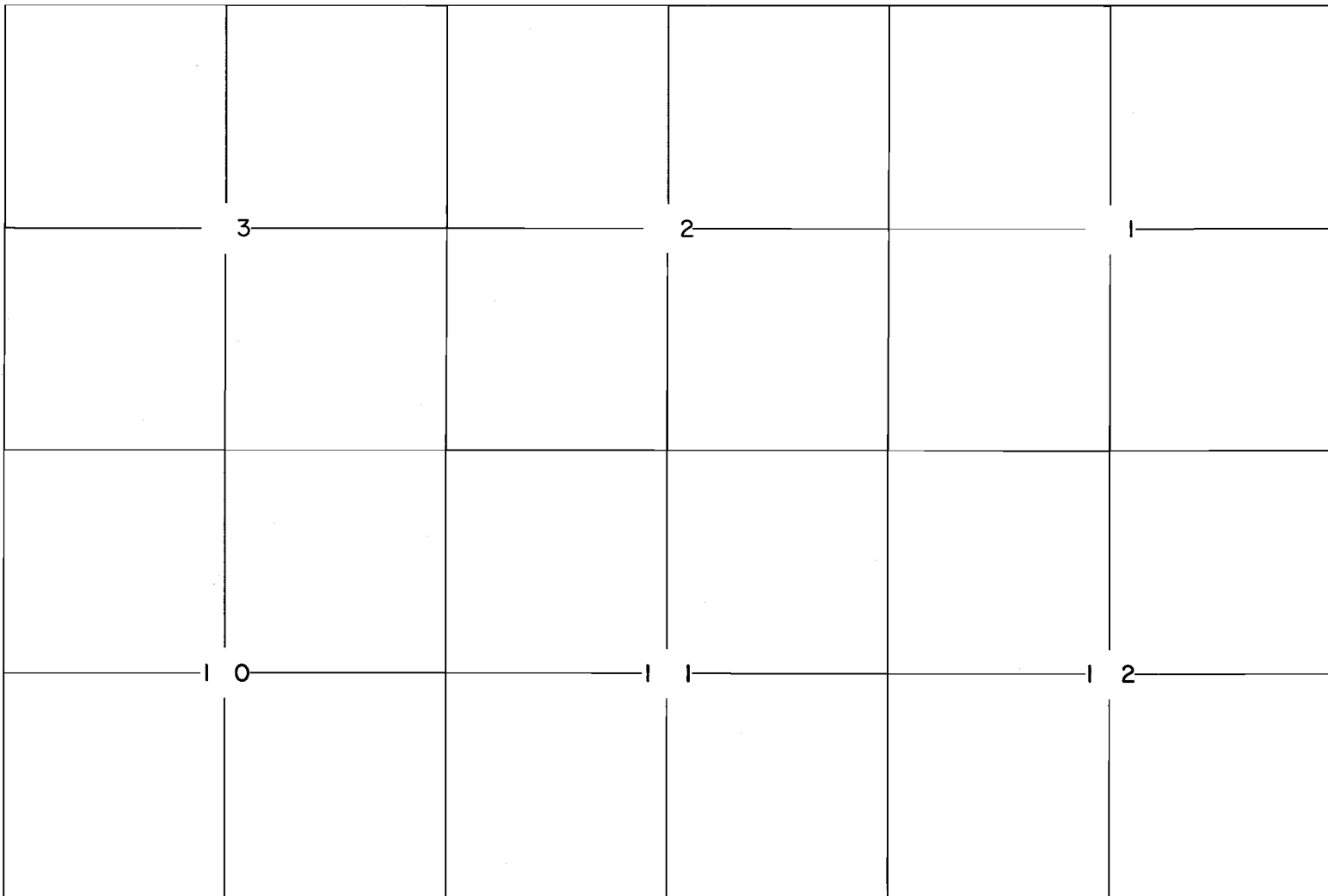
	LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 5"X8"X36" DEWOP CONC. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 5"X8"X36" CONC. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.	HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, 1983, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99998012. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.	CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF LYONS WALWORTH COUNTY, WISCONSIN		DRAWN BY: C. BLUEMKE DATE: AUG. 1980 CHECKED BY: L. H. KREBLIN DATE: SEPT. 1980 APPROVED BY: DATE: SEPT. 1980 REVISED: D. L. RILEY DATE: JULY, 1984	DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM CITY OF LAKE GENEVA AND WISDOT.	SECTIONS 18, 17, 16, 19, 20, 21 T. 2 N. R. 18 E. WALWORTH COUNTY
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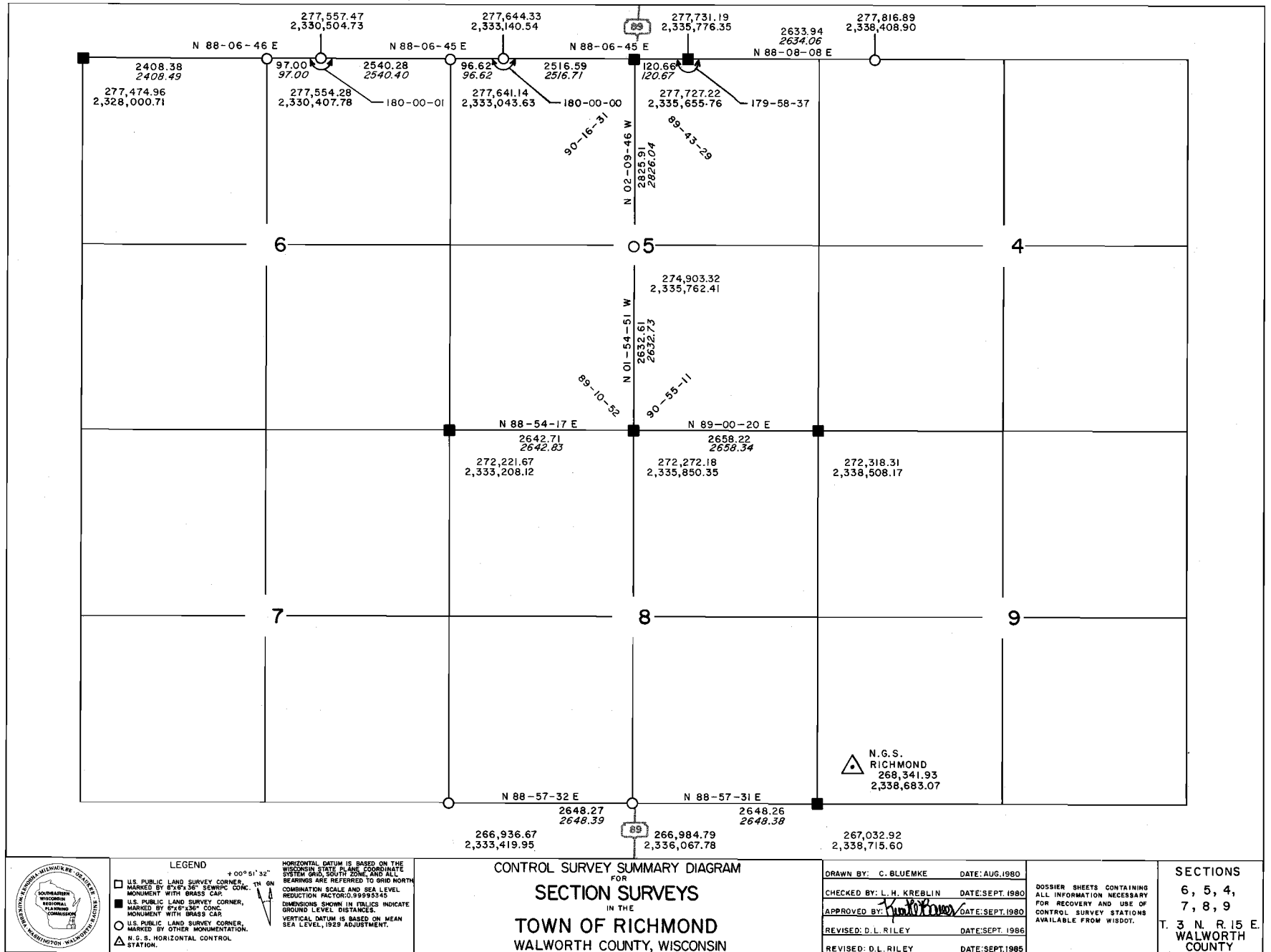


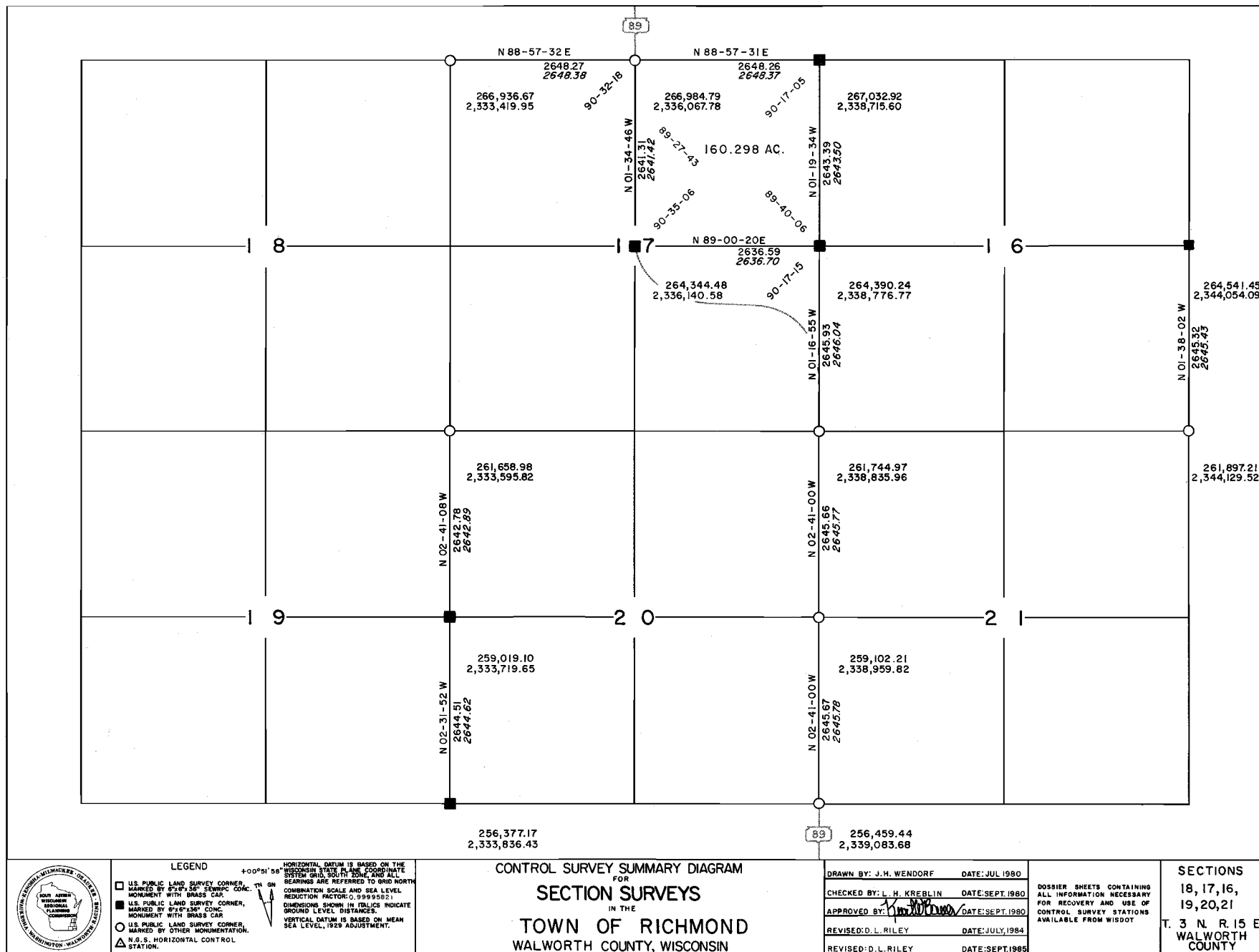


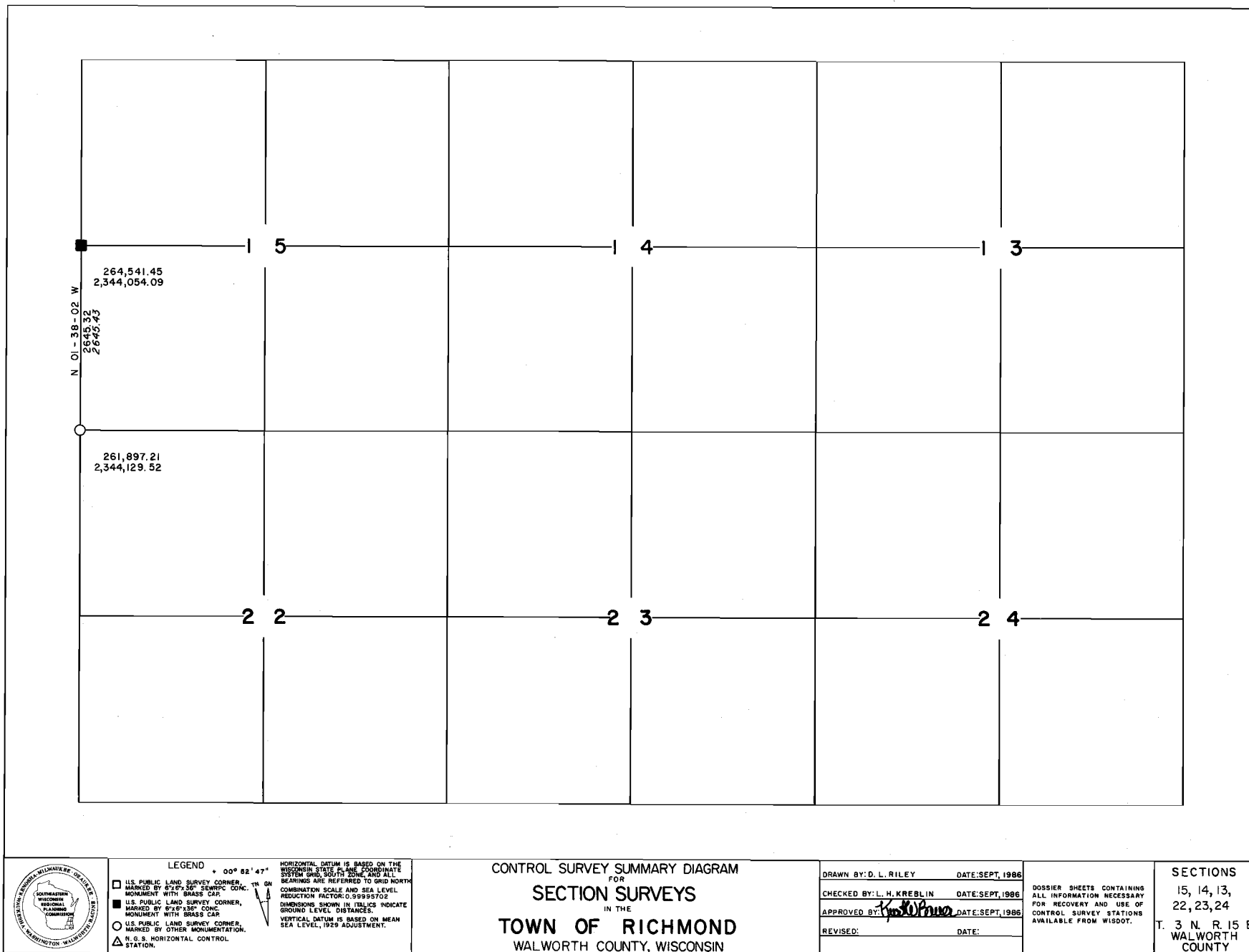


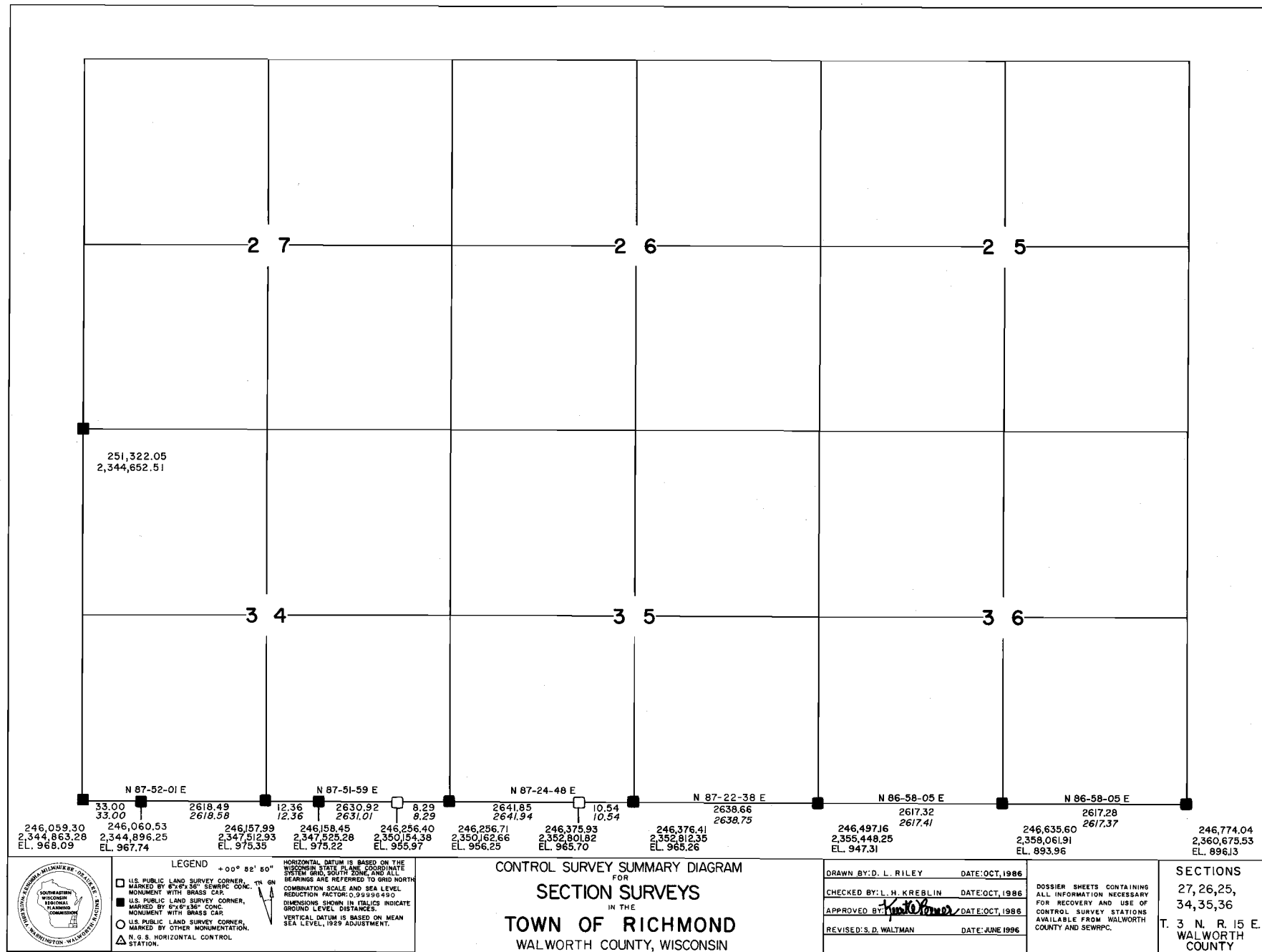
		LEGEND		HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.		CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF RICHMOND WALWORTH COUNTY, WISCONSIN		DRAWN BY: _____ DATE: _____		DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM T. 3 N. R. 15 E. WALWORTH COUNTY
		□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x3/4" S.W.I.P.C. CONC. MONUMENT WITH BRASS CAP. ■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x3/4" CONC. MONUMENT WITH BRASS CAP. ○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. ▲ N. G. S. HORIZONTAL CONTROL STATION.				CHECKED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____ REVISED: _____ DATE: _____				

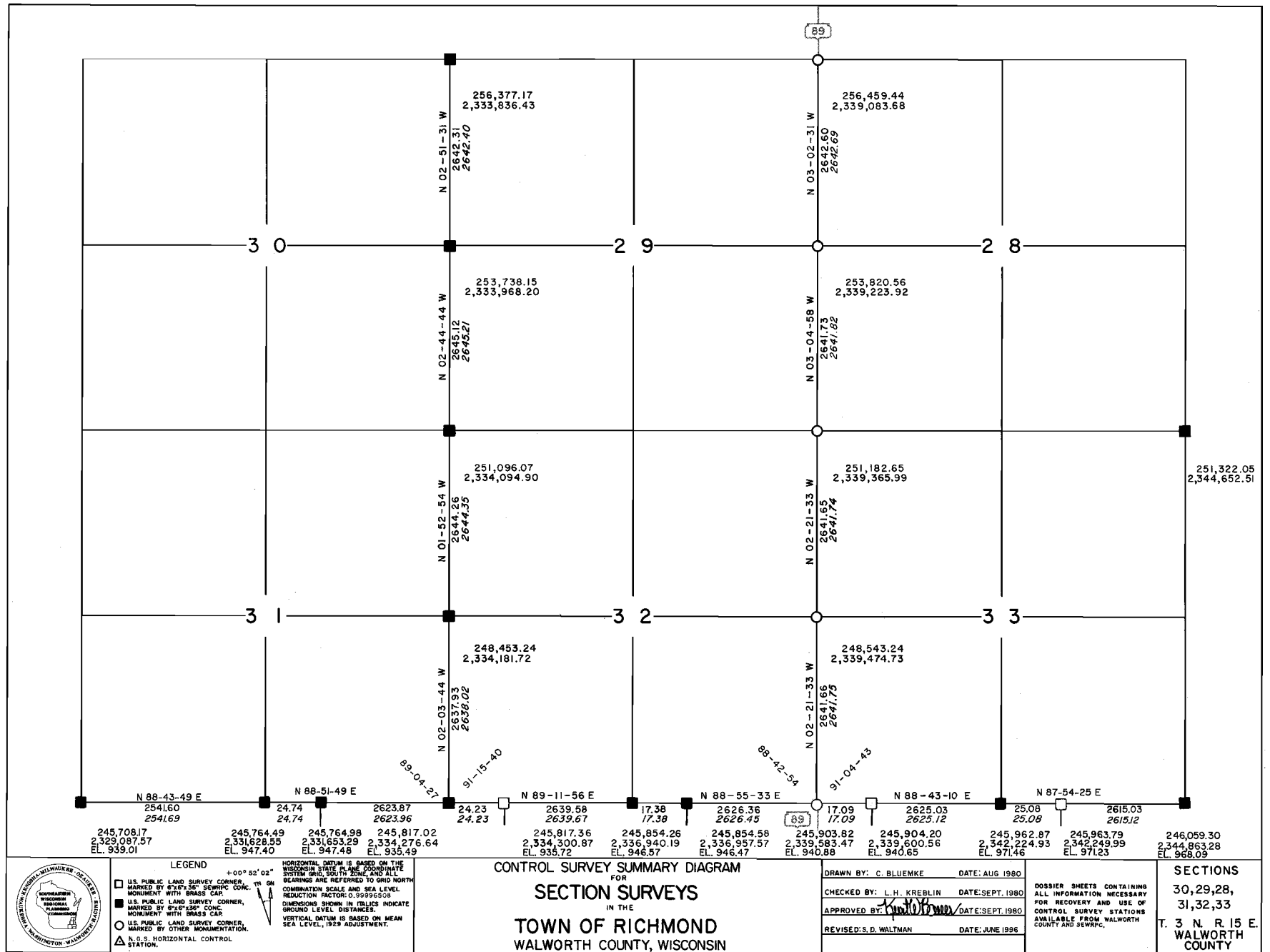


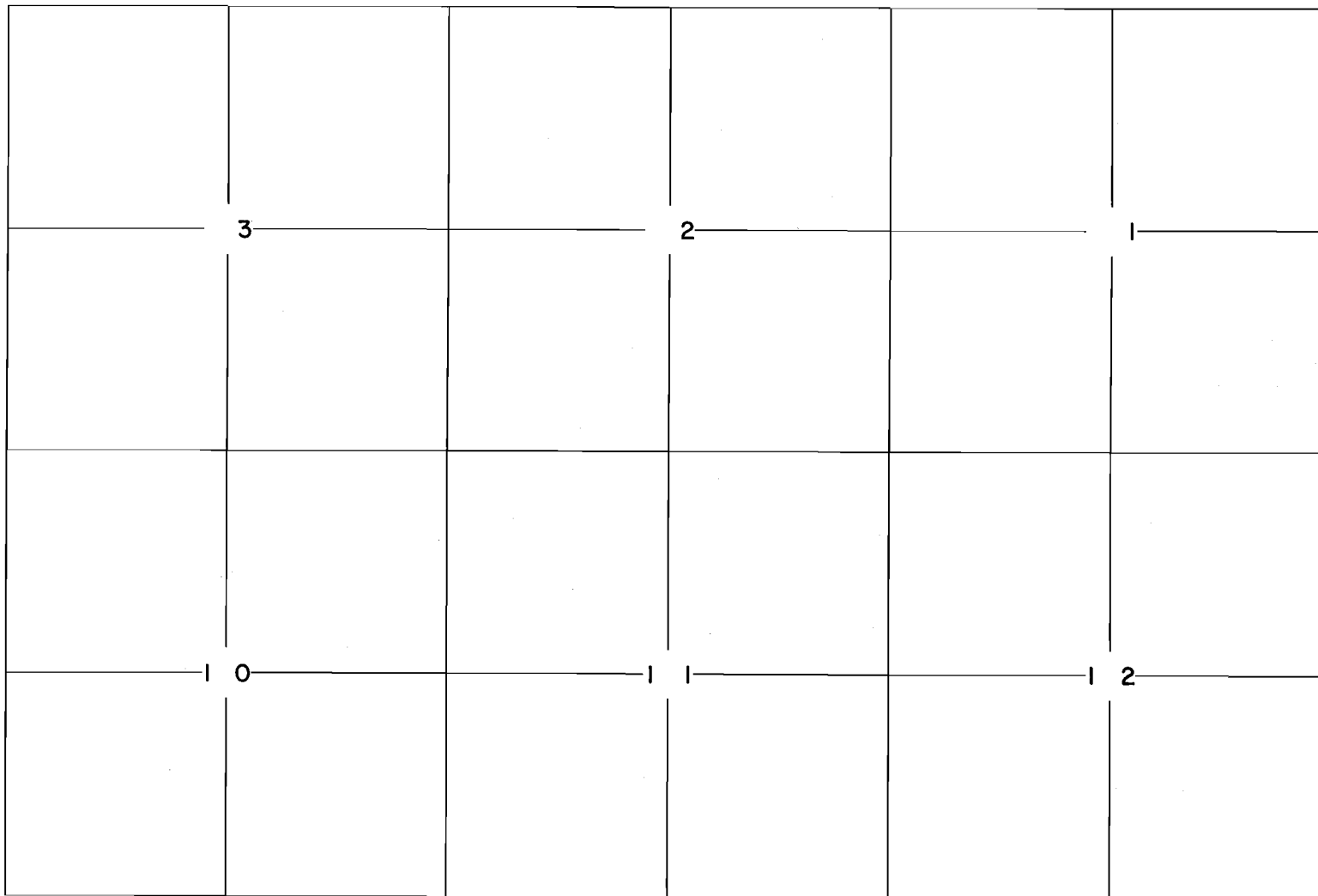












LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N.G.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM 600 SOUTH ZONE AND ALL BEARINGS ARE REFERRED TO GRID NORTH COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR:
DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.
VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF SUGAR CREEK WALWORTH COUNTY, WISCONSIN

DRAWN BY:

DATE:

CHECKED BY:

DATE:

APPROVED BY:

DATE:

REVISED:


DATE:

DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS

3, 2, 1,
10, 11, 12


T. 3 N. R. 16 E.
WALWORTH COUNTY

		LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" SET SQUARE CONC. MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.		<small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</small>		CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF SUGAR CREEK WALWORTH COUNTY, WISCONSIN		DRAWN BY: _____ DATE: _____ CHECKED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____ REVISED: _____ DATE: _____		DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM		SECTIONS 6, 5, 4, 7, 8, 9 T. 3 N. R. 16 E. WALWORTH COUNTY	

6

5

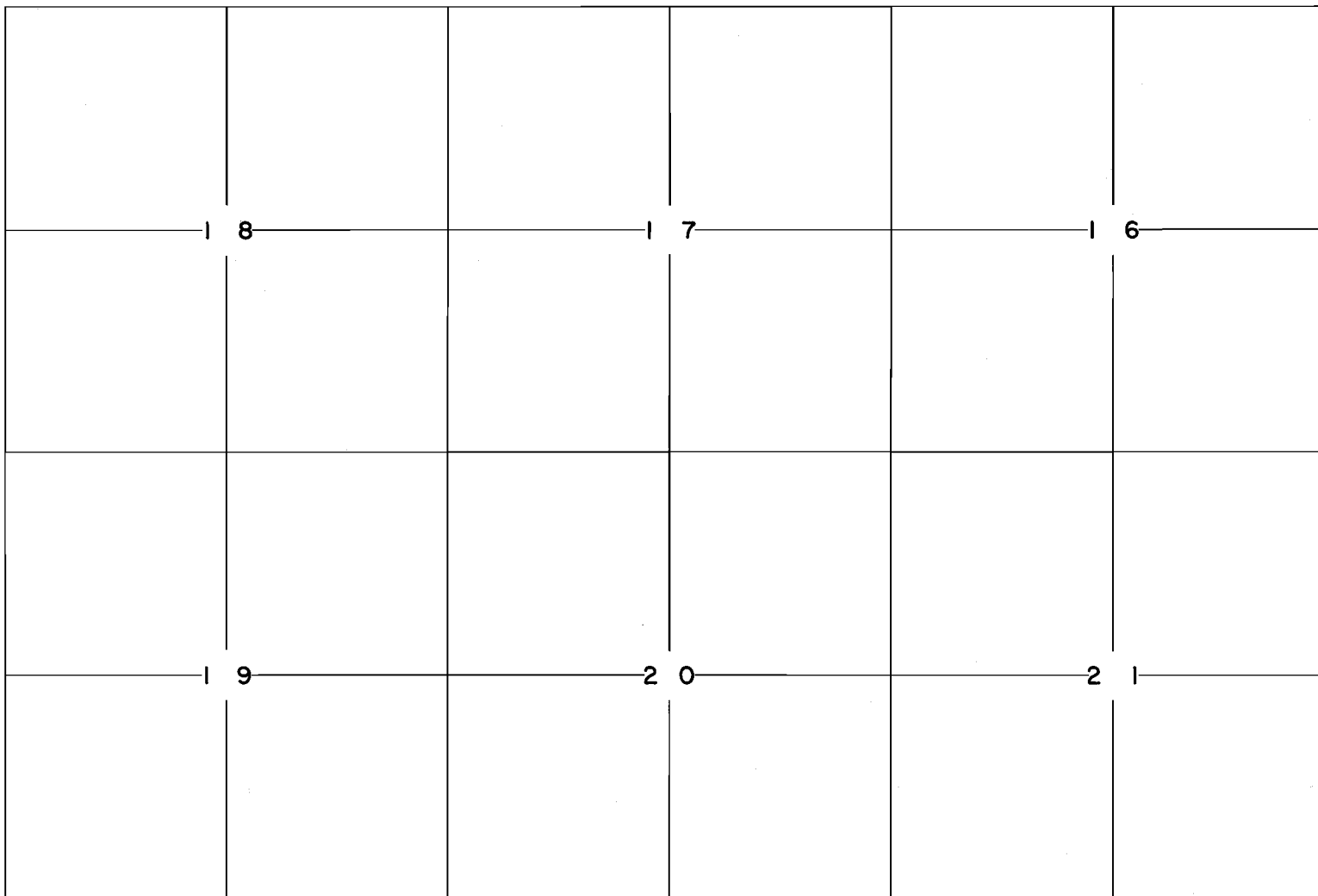
4


 N.G.S. MILLARD
 278,429.30
 2,369,895.27

7

8

9



LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x8"x36" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x8"x36" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N. S. HORIZONTAL CONTROL STATION.

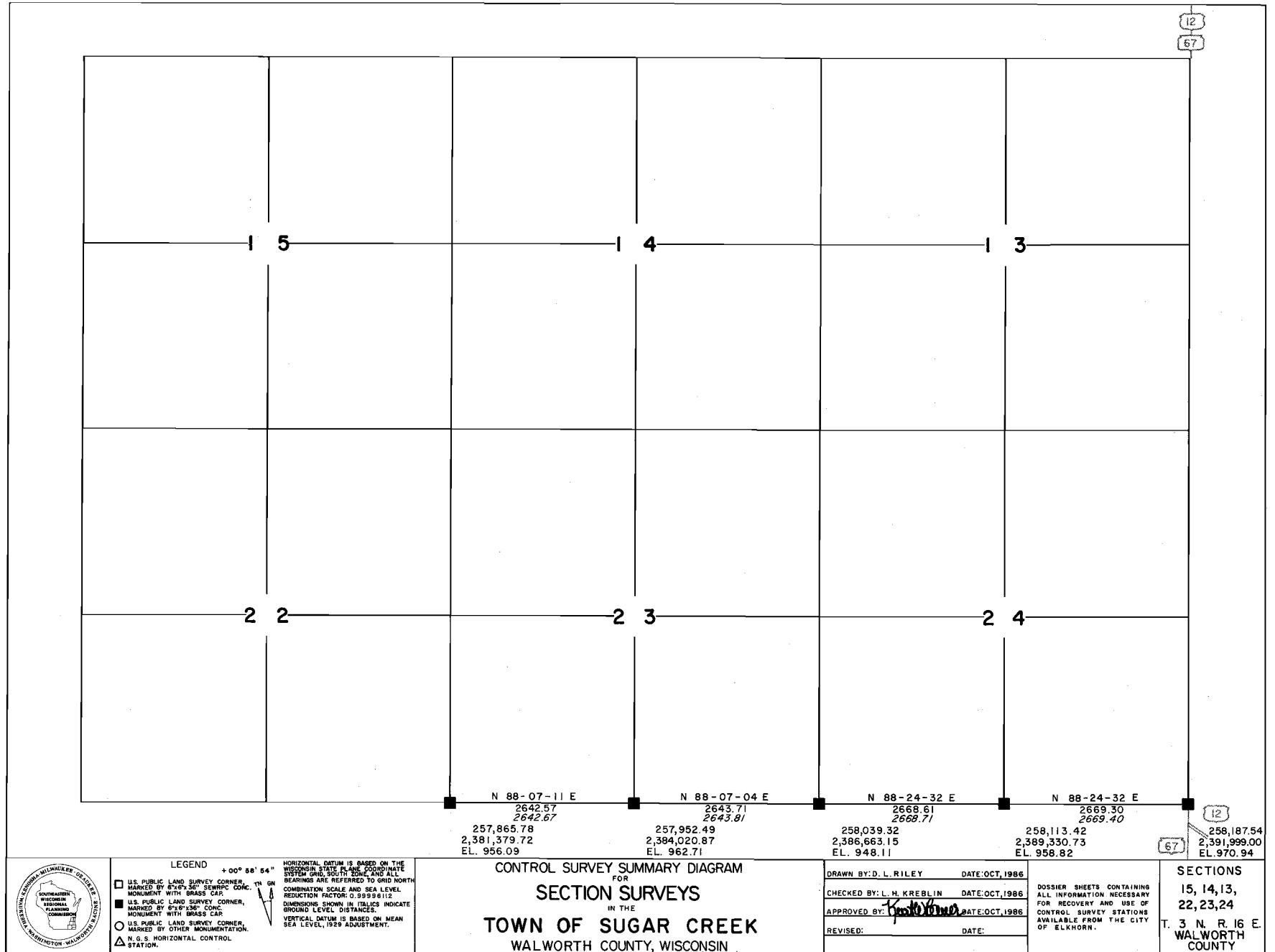
HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, SAID SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL. REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

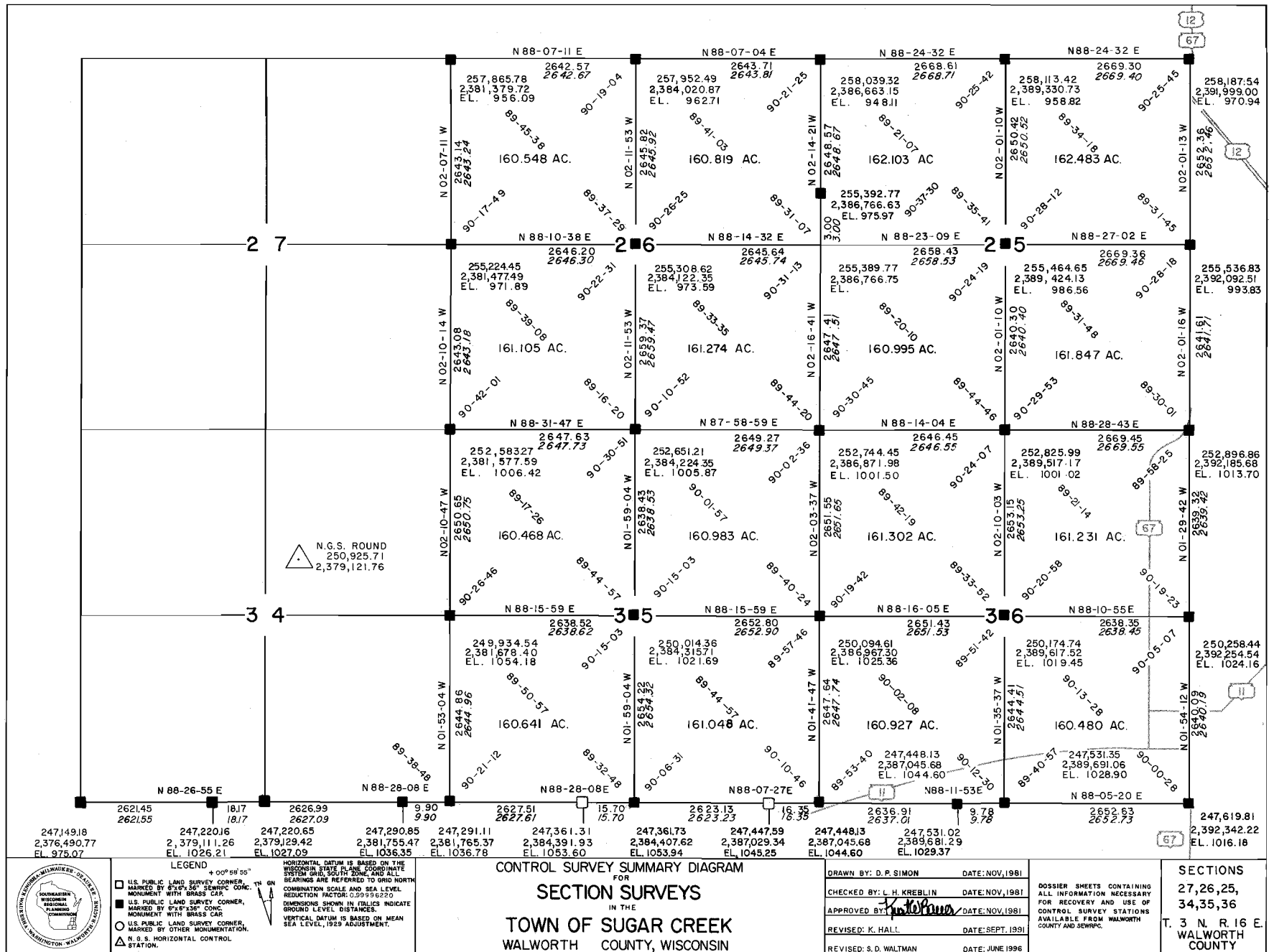
CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF SUGAR CREEK WALWORTH COUNTY, WISCONSIN

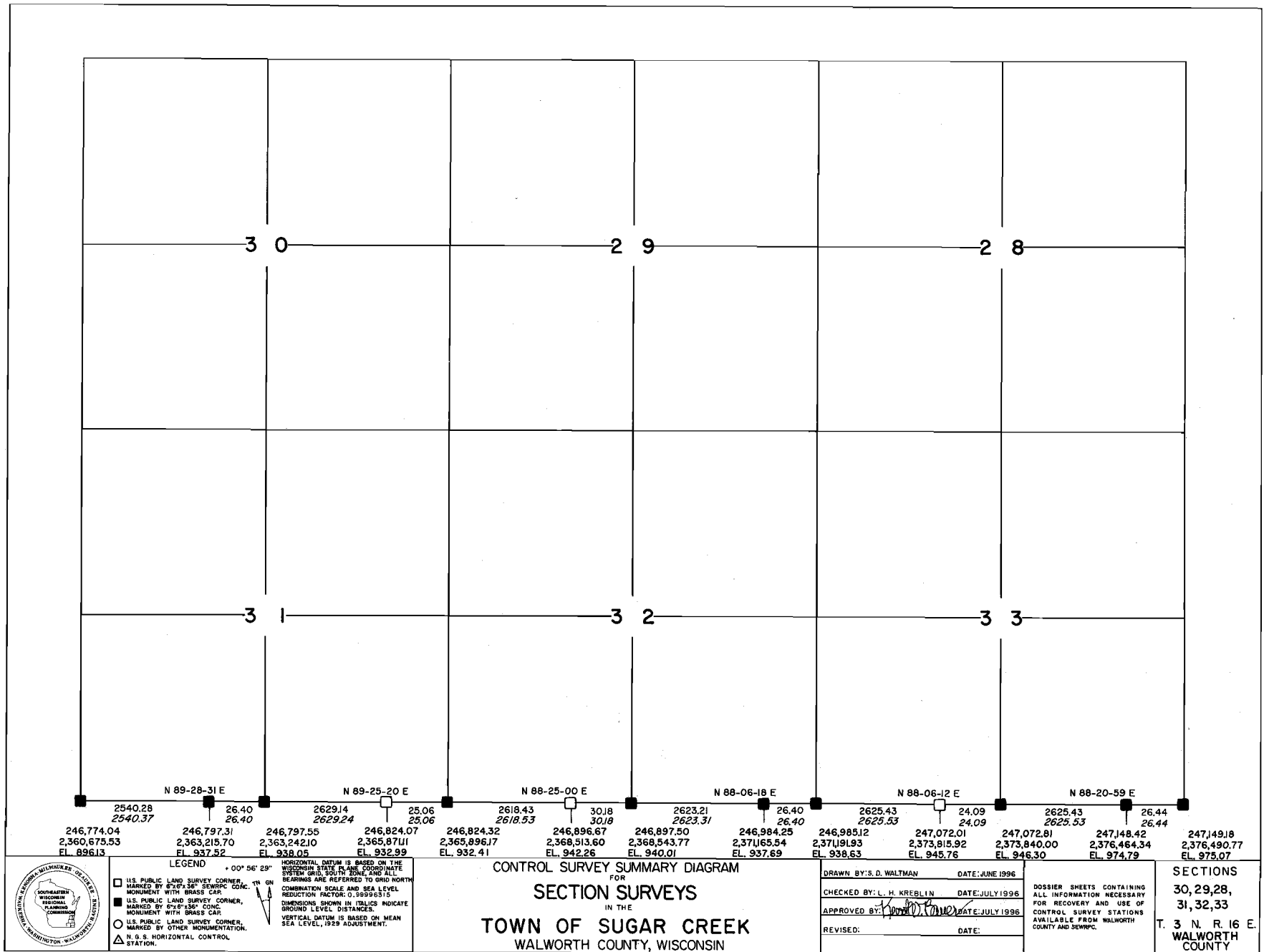
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REVISED:	DATE:

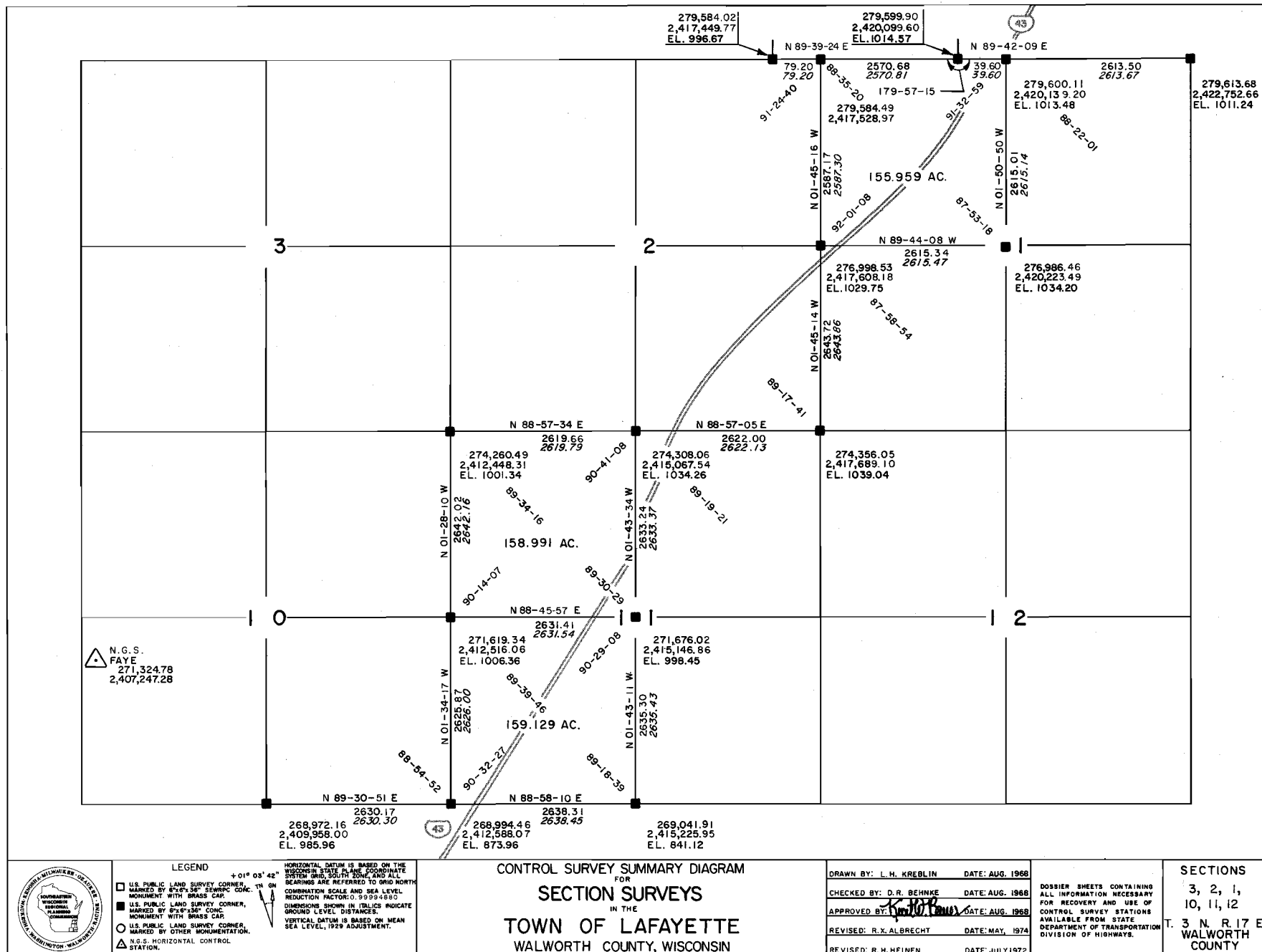
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS
18, 17, 16,
19, 20, 21
T. 3 N. R. 16 E.
WALWORTH
COUNTY

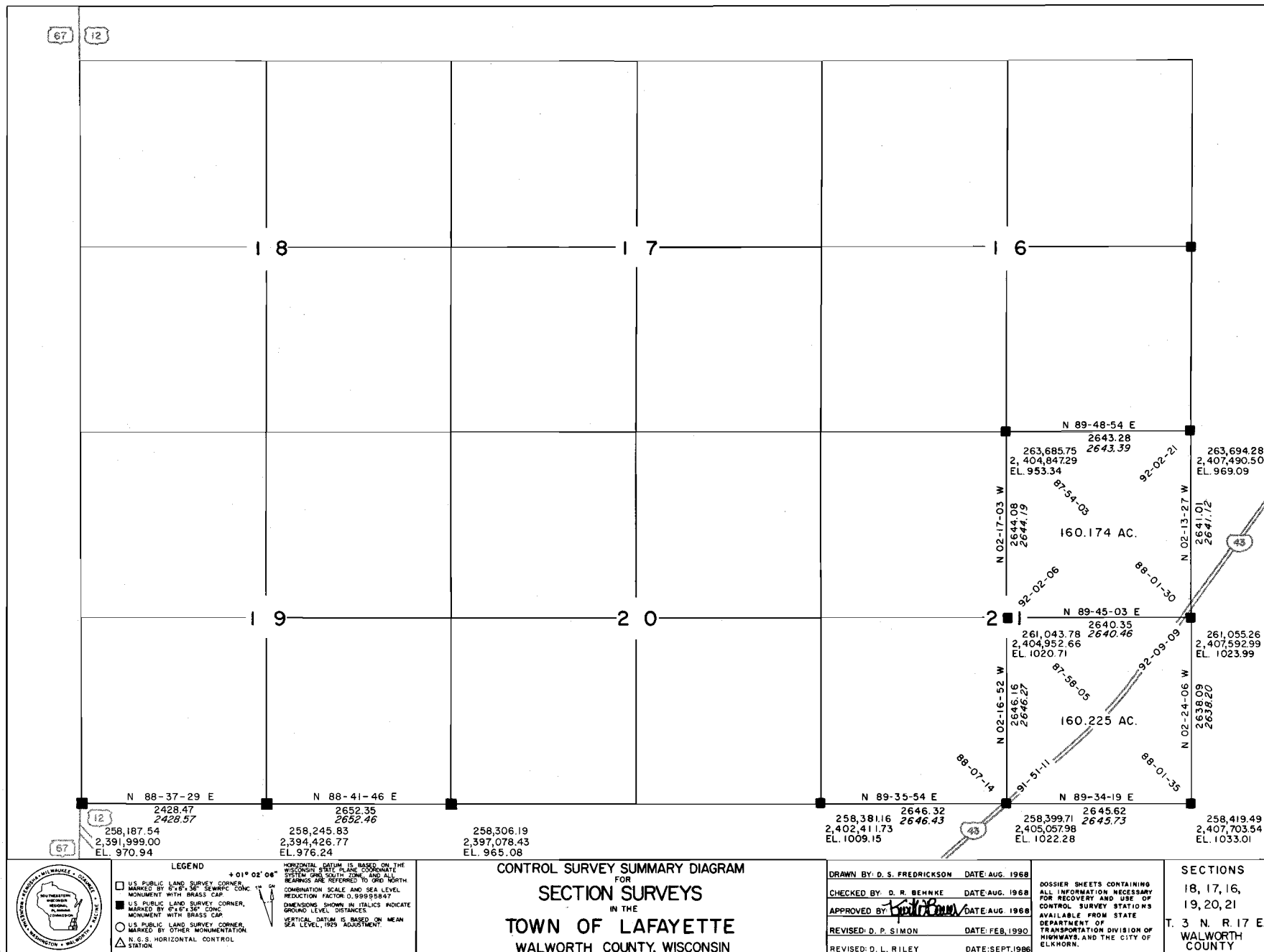


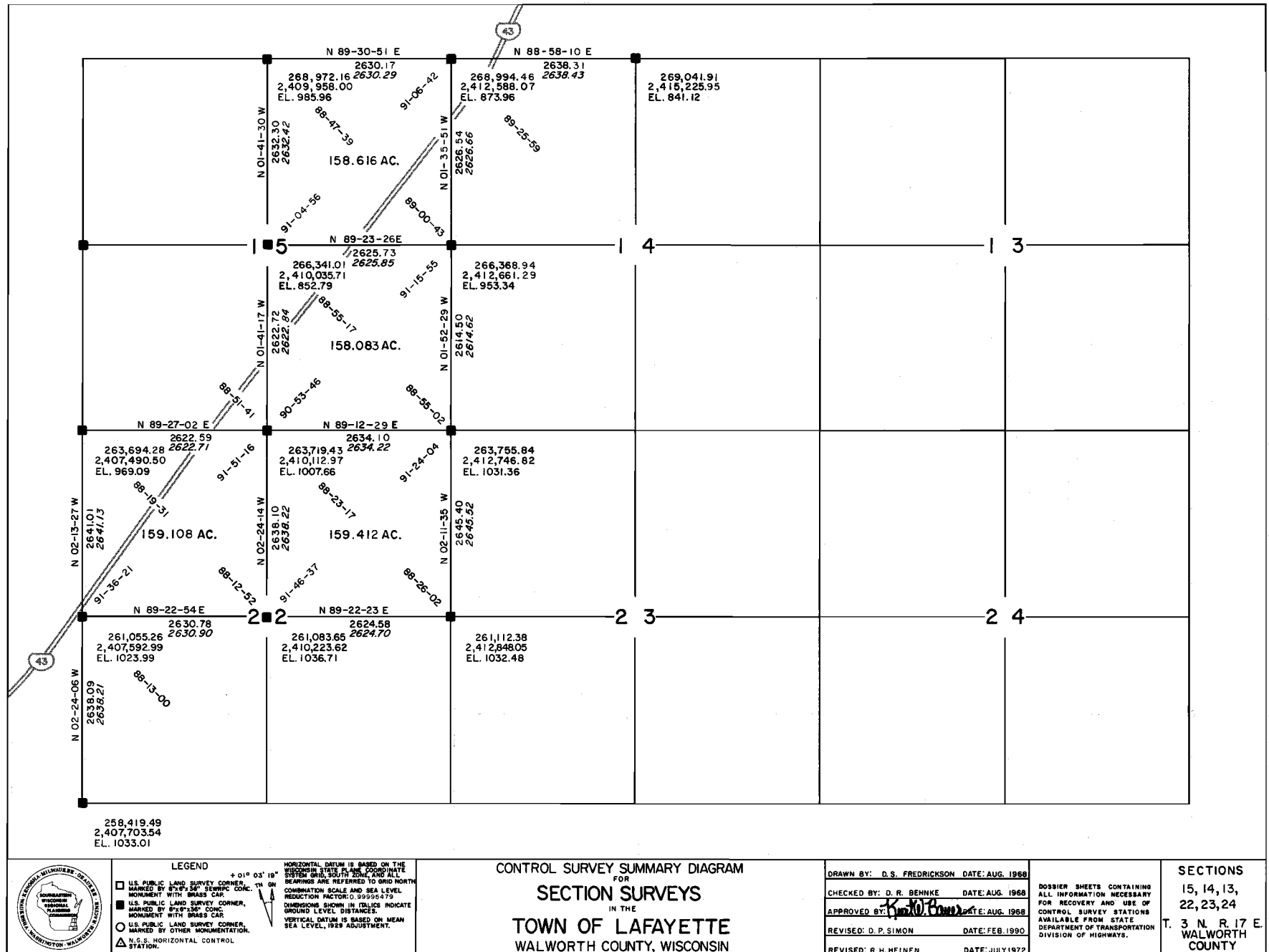


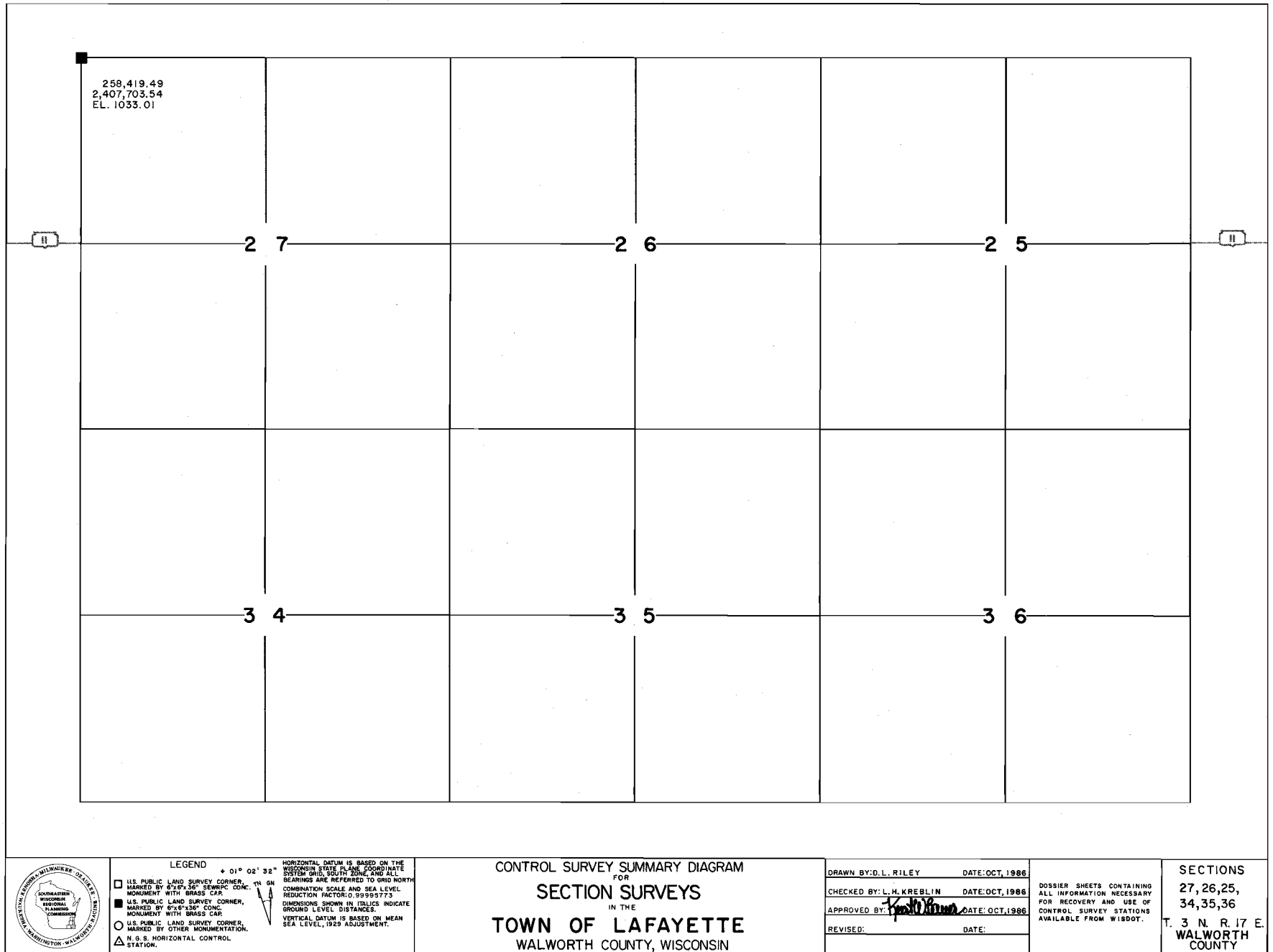


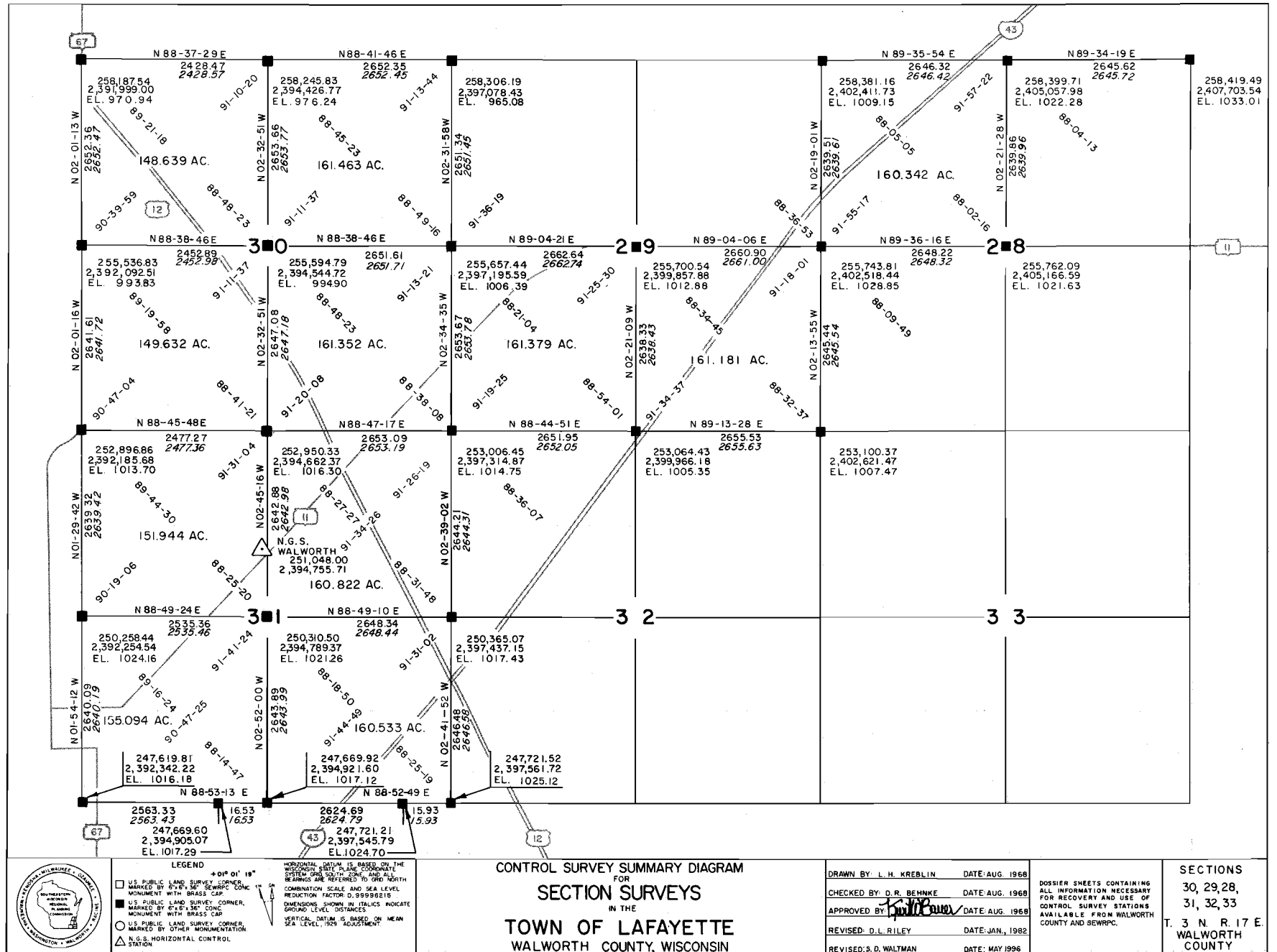


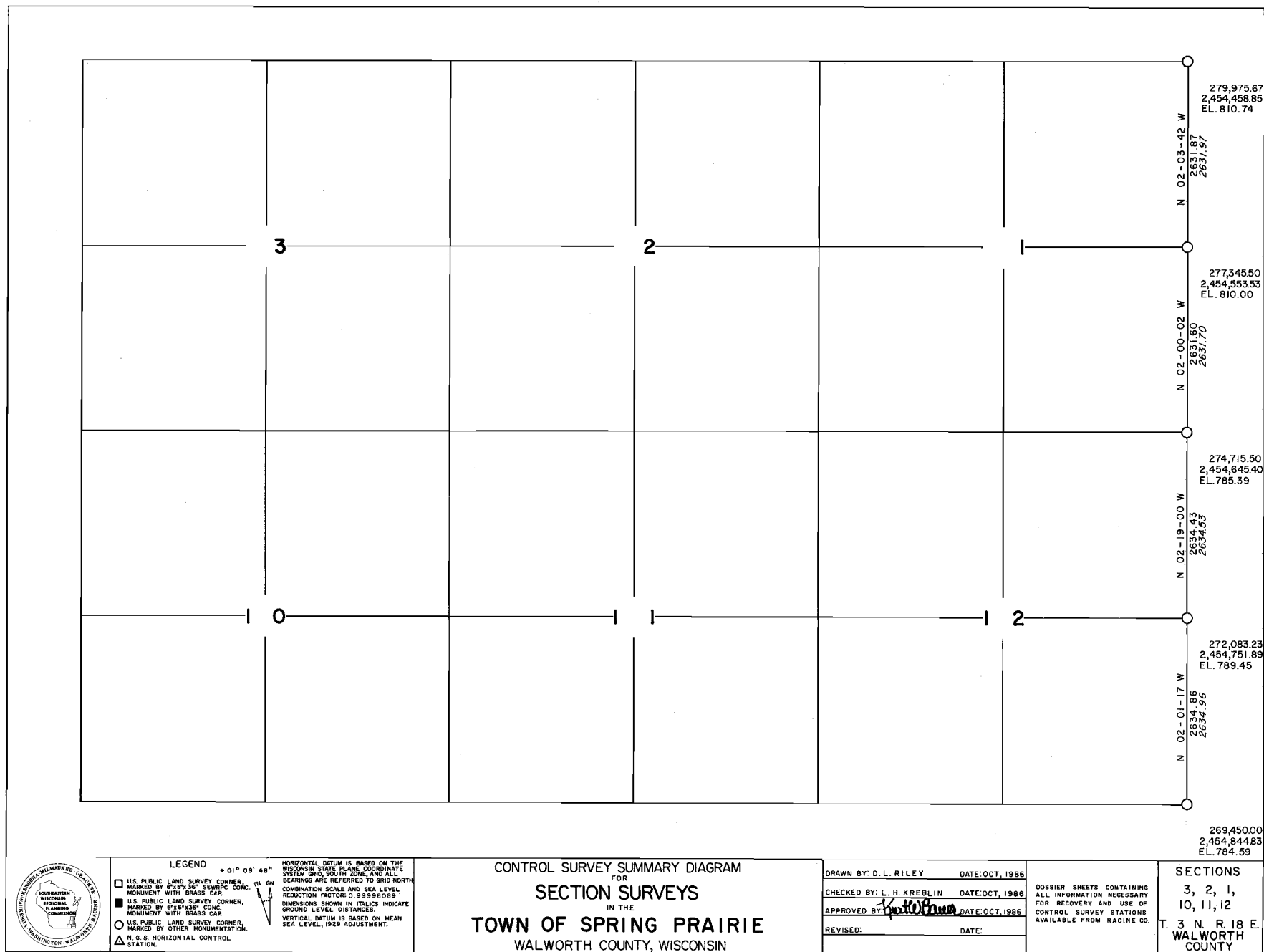
N.G.S. FAYE 271,324.78 2,407,247.28																			
<table border="0" style="width: 100%;"> <tr> <td style="width: 15%; vertical-align: top;"> </td> <td style="width: 35%; vertical-align: top;"> LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SOWPC CONC. MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N. G. S. HORIZONTAL CONTROL STATION. </td> <td style="width: 30%; vertical-align: top;"> <small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1928 ADJUSTMENT.</small> </td> <td style="width: 20%; vertical-align: top; text-align: center;"> CONTROL SURVEY SUMMARY DIAGRAM <small>FOR</small> SECTION SURVEYS <small>IN THE</small> TOWN OF LAFAYETTE WALWORTH COUNTY, WISCONSIN </td> <td style="width: 15%; vertical-align: top;"> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">DRAWN BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">CHECKED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">APPROVED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">REVISED:</td> <td style="padding: 2px;">DATE:</td> </tr> </table> </td> <td style="width: 15%; vertical-align: top;"> SECTIONS 6, 5, 4, 7, 8, 9 T. 3 N. R. 17 E. WALWORTH COUNTY </td> </tr> </table>							LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SOWPC CONC. MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N. G. S. HORIZONTAL CONTROL STATION.	<small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1928 ADJUSTMENT.</small>	CONTROL SURVEY SUMMARY DIAGRAM <small>FOR</small> SECTION SURVEYS <small>IN THE</small> TOWN OF LAFAYETTE WALWORTH COUNTY, WISCONSIN	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">DRAWN BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">CHECKED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">APPROVED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">REVISED:</td> <td style="padding: 2px;">DATE:</td> </tr> </table>	DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:	SECTIONS 6, 5, 4, 7, 8, 9 T. 3 N. R. 17 E. WALWORTH COUNTY
	LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SOWPC CONC. MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N. G. S. HORIZONTAL CONTROL STATION.	<small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1928 ADJUSTMENT.</small>	CONTROL SURVEY SUMMARY DIAGRAM <small>FOR</small> SECTION SURVEYS <small>IN THE</small> TOWN OF LAFAYETTE WALWORTH COUNTY, WISCONSIN	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">DRAWN BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">CHECKED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">APPROVED BY:</td> <td style="padding: 2px;">DATE:</td> </tr> <tr> <td style="padding: 2px;">REVISED:</td> <td style="padding: 2px;">DATE:</td> </tr> </table>	DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:	SECTIONS 6, 5, 4, 7, 8, 9 T. 3 N. R. 17 E. WALWORTH COUNTY						
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CHECKED BY:	DATE:																		
APPROVED BY:	DATE:																		
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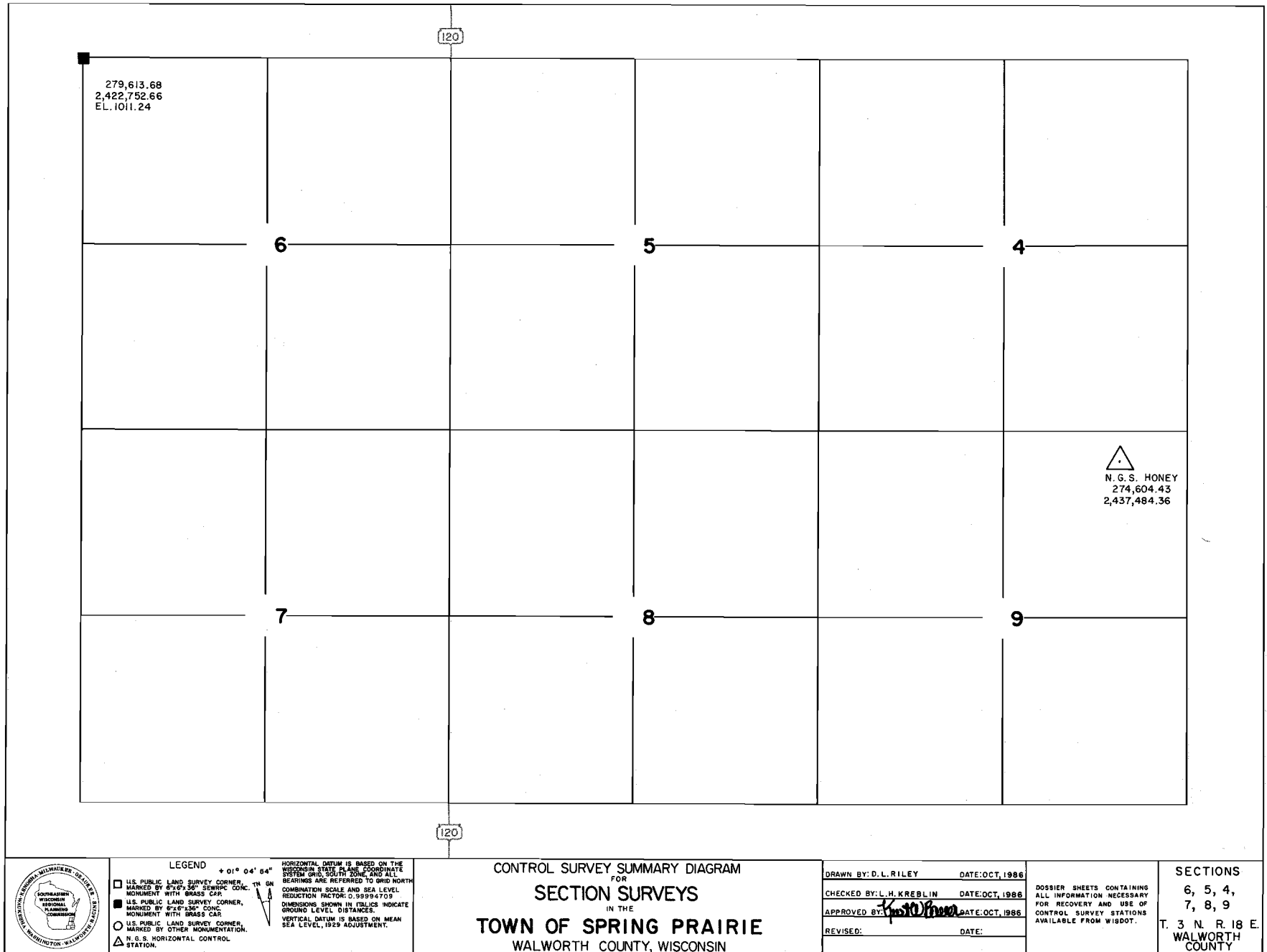




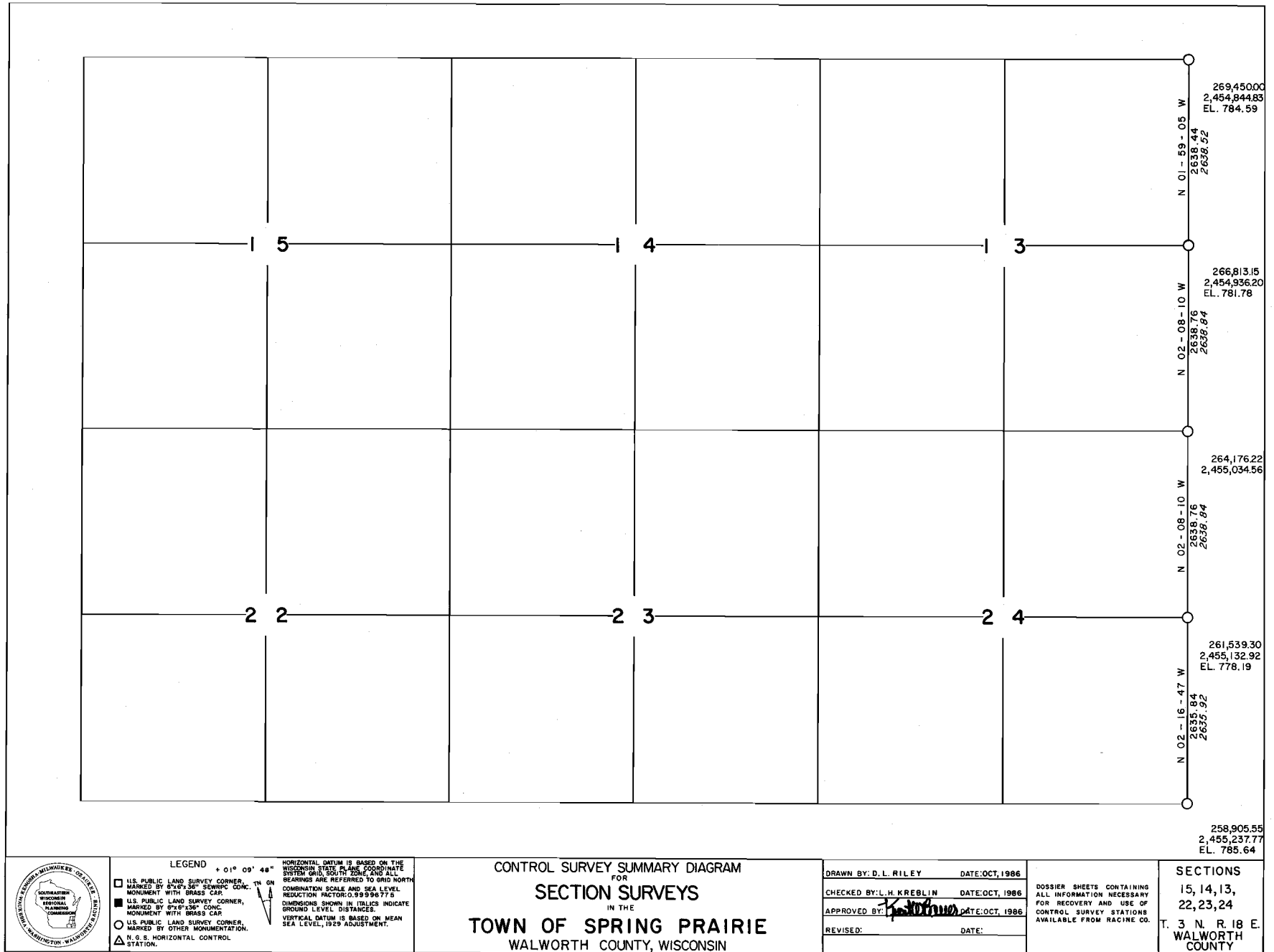


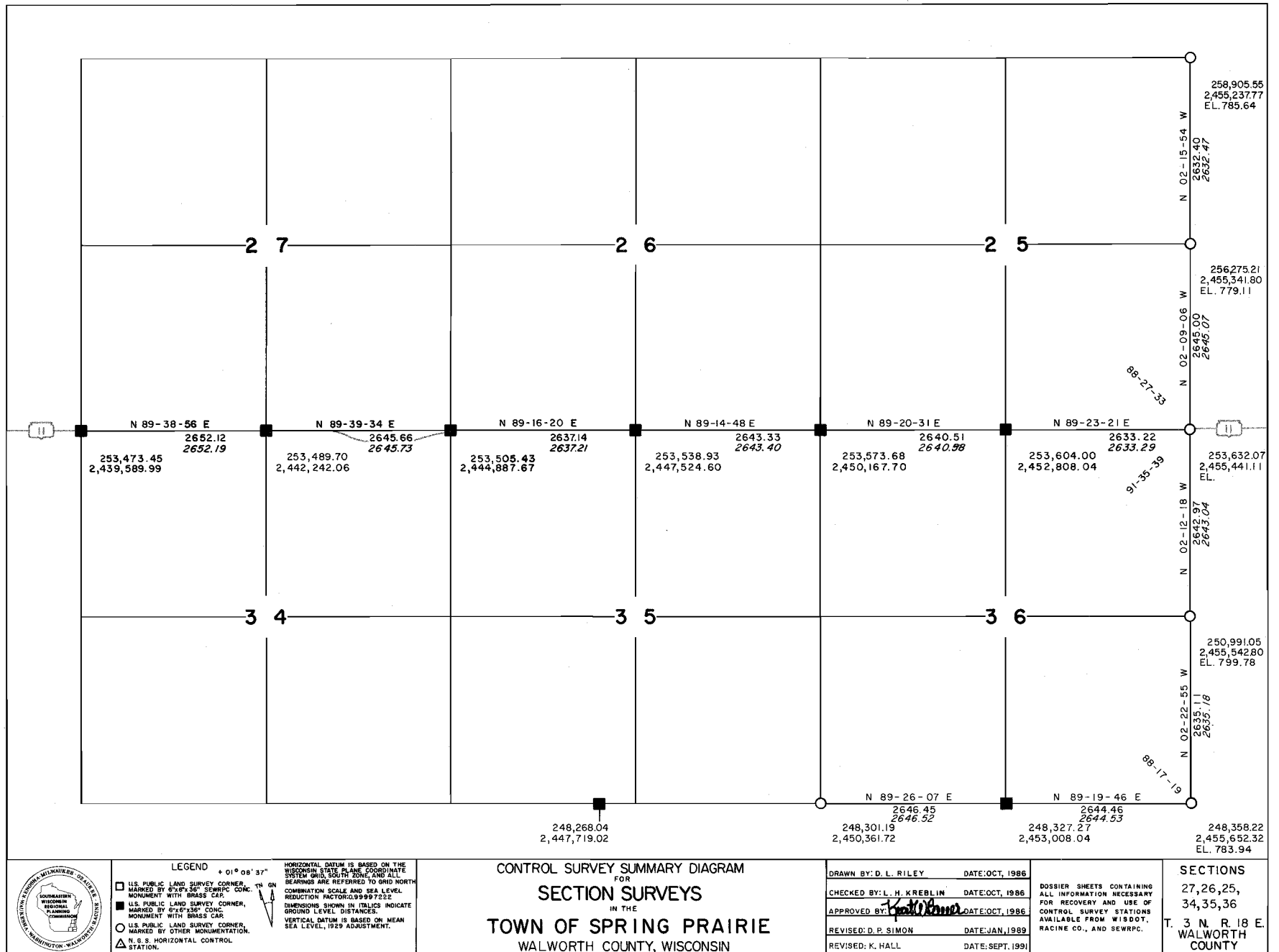


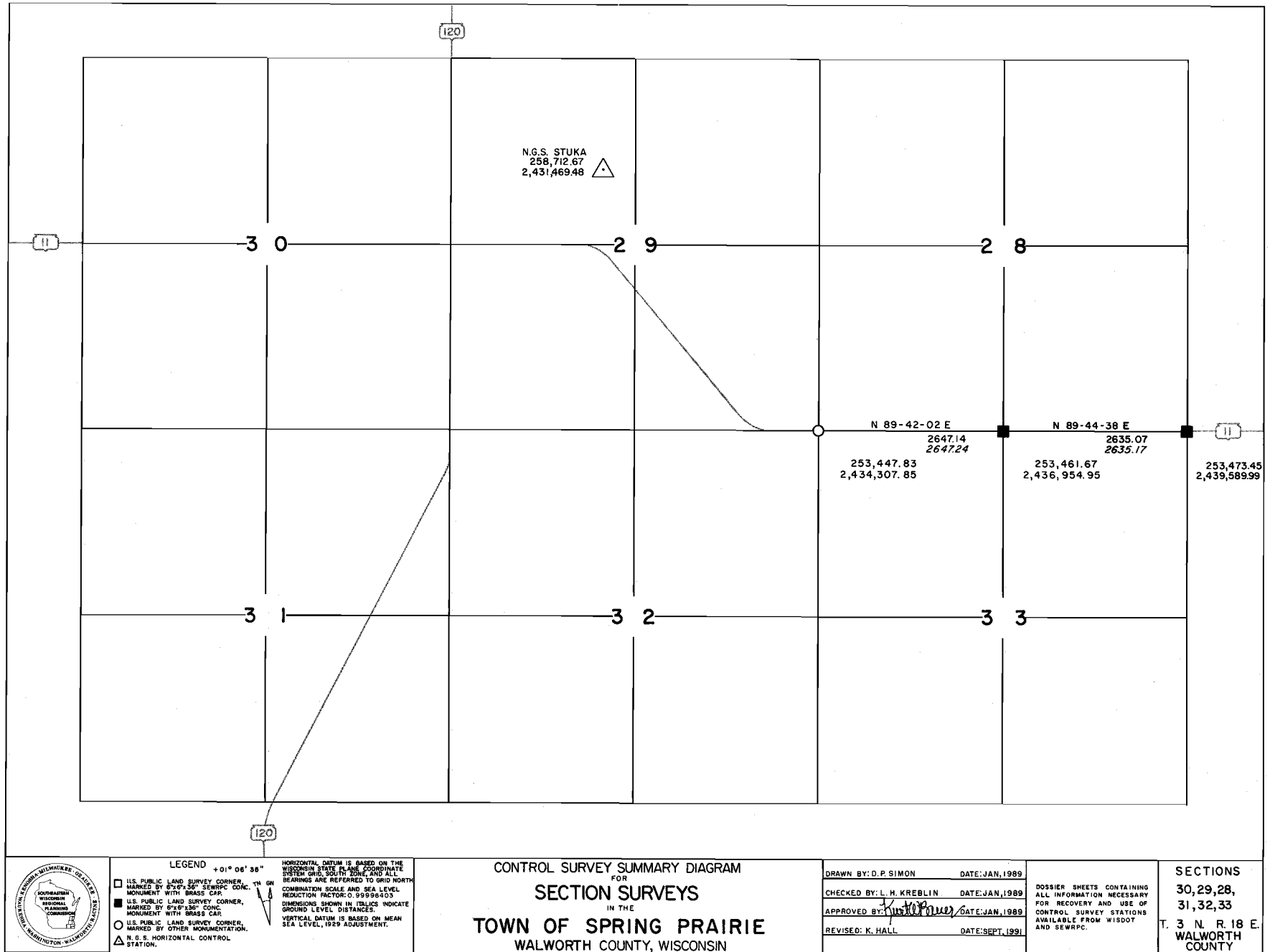


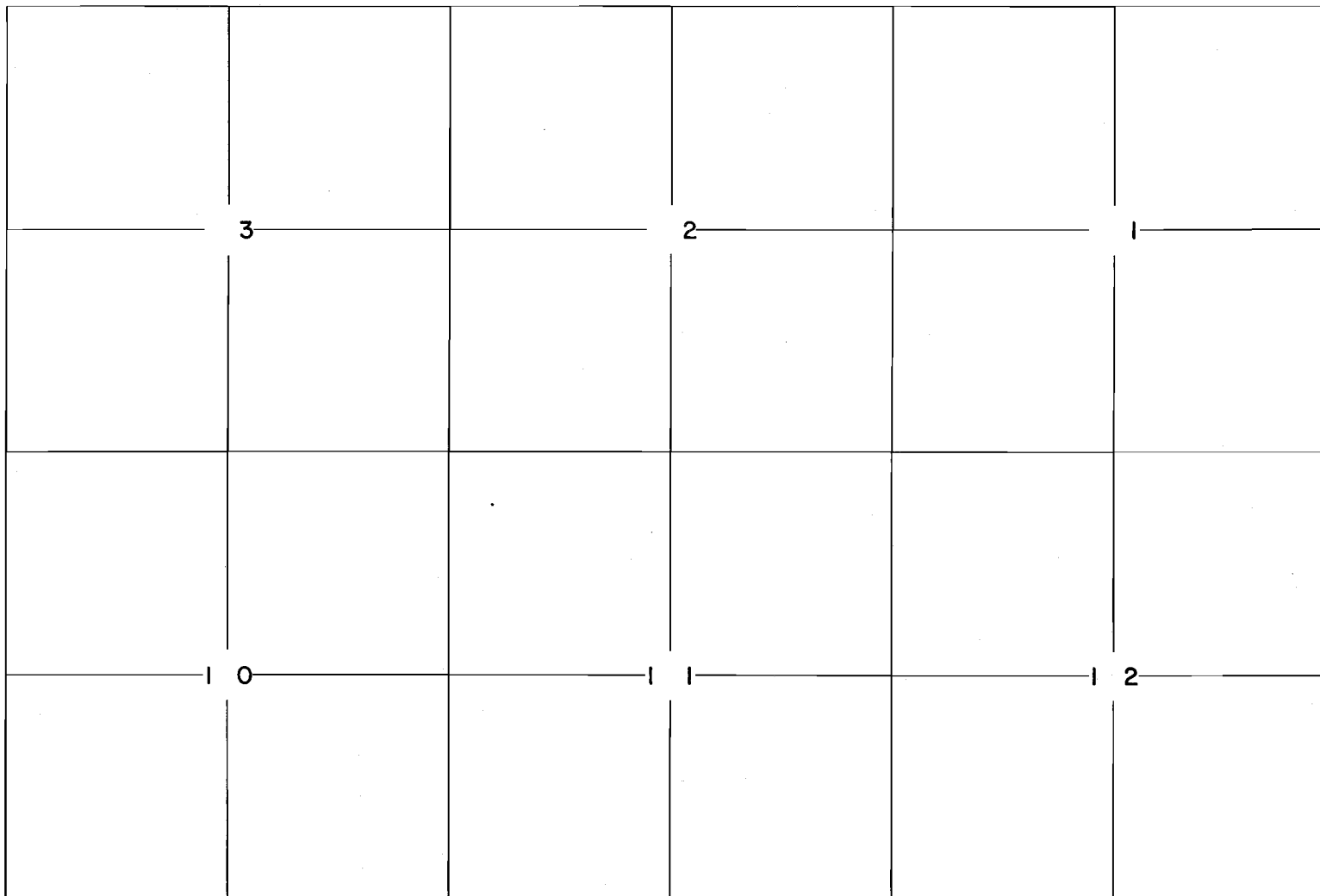



	LEGEND		<small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</small>		CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF SPRING PRAIRIE WALWORTH COUNTY, WISCONSIN				<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">DRAWN BY:</td> <td style="width: 50%;">DATE:</td> </tr> <tr> <td>CHECKED BY:</td> <td>DATE:</td> </tr> <tr> <td>APPROVED BY:</td> <td>DATE:</td> </tr> <tr> <td>REVISED:</td> <td>DATE:</td> </tr> </table>		DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:	SECTIONS 18, 17, 16, 19, 20, 21 T. 3 N. R. 18 E. WALWORTH COUNTY	
	DRAWN BY:	DATE:																		
CHECKED BY:	DATE:																			
APPROVED BY:	DATE:																			
REVISED:	DATE:																			
<input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x4"x36" CONCRETE MONUMENT WITH BRASS CAP. <input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.								DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM												

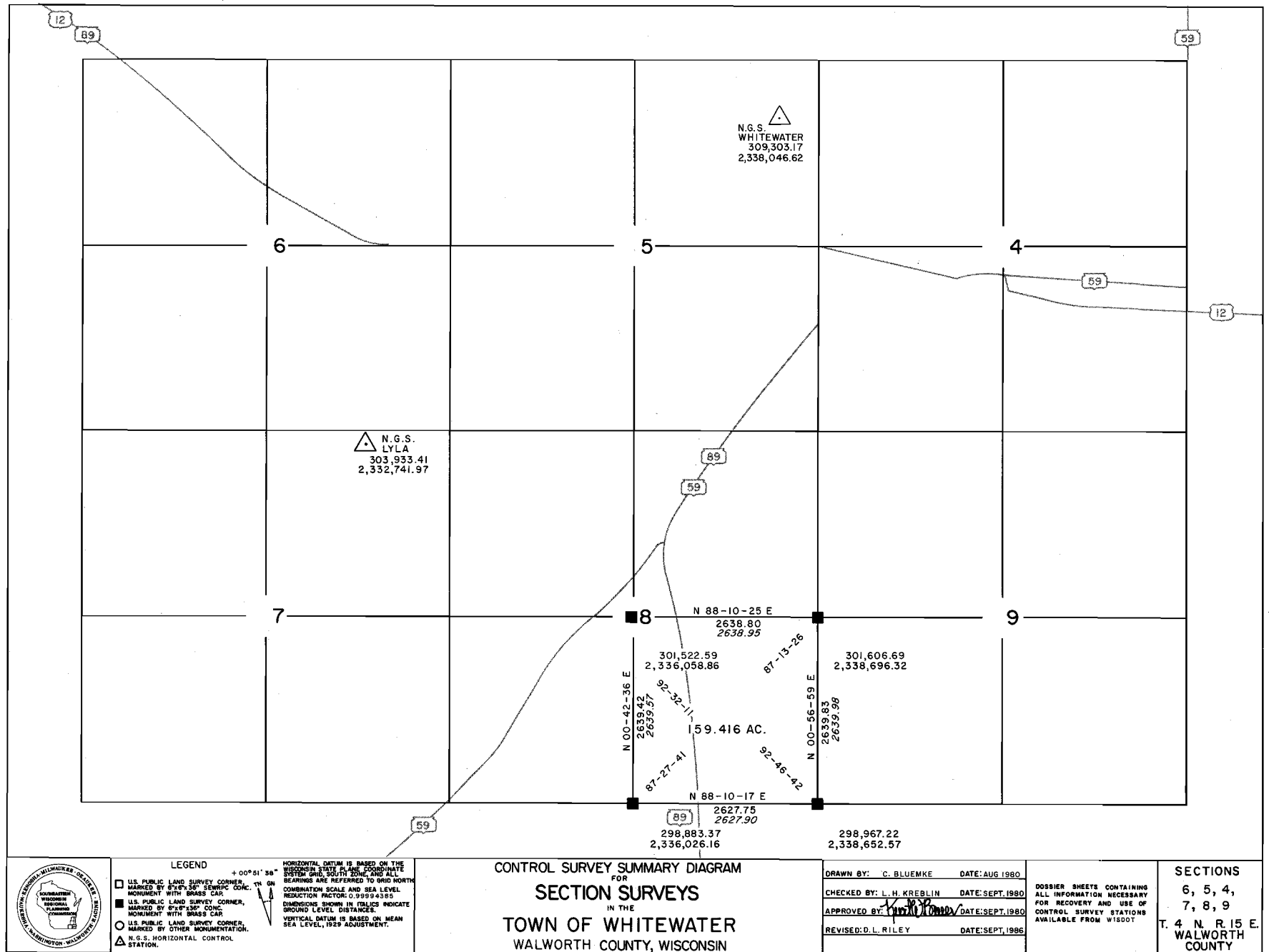




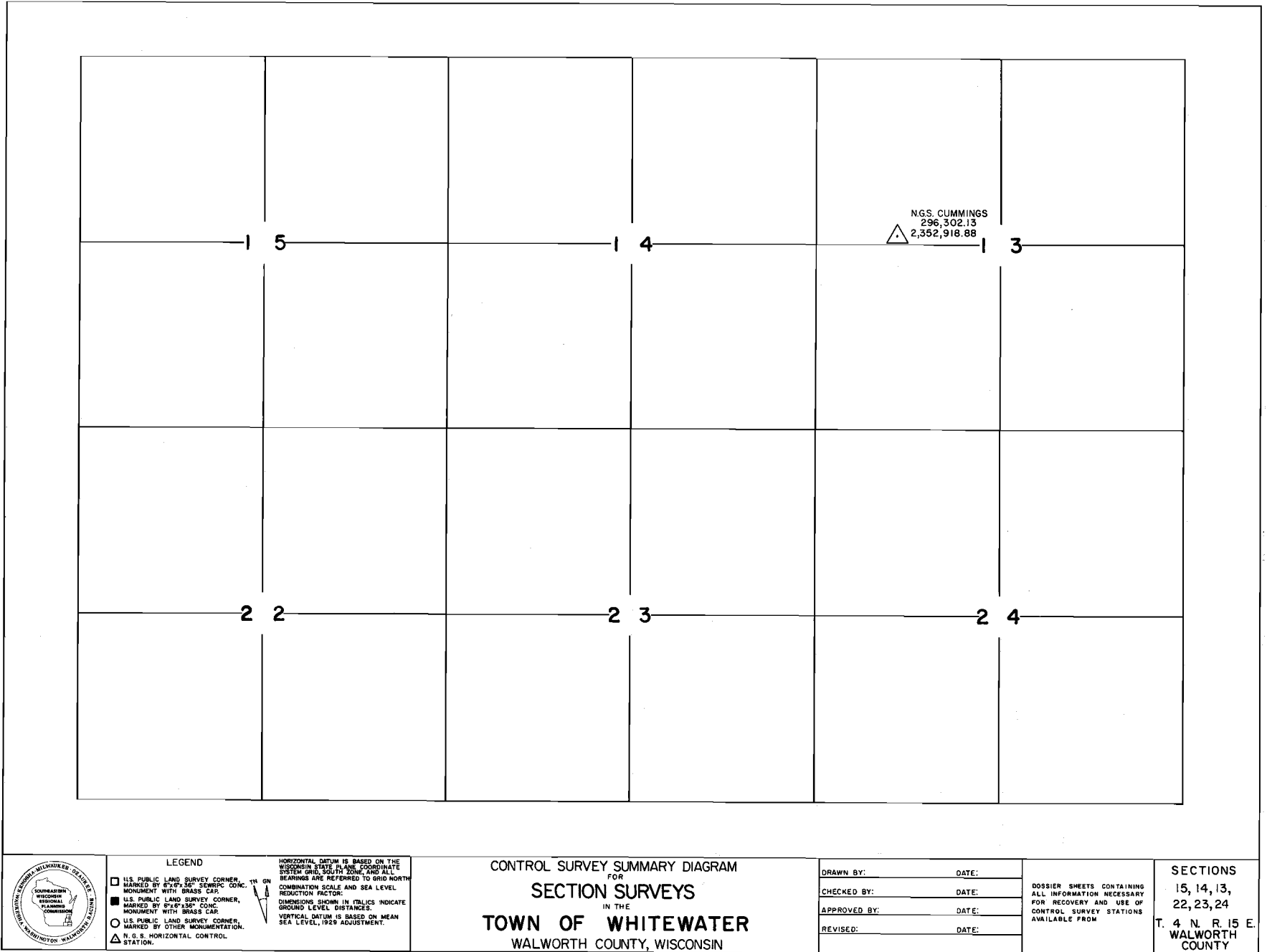


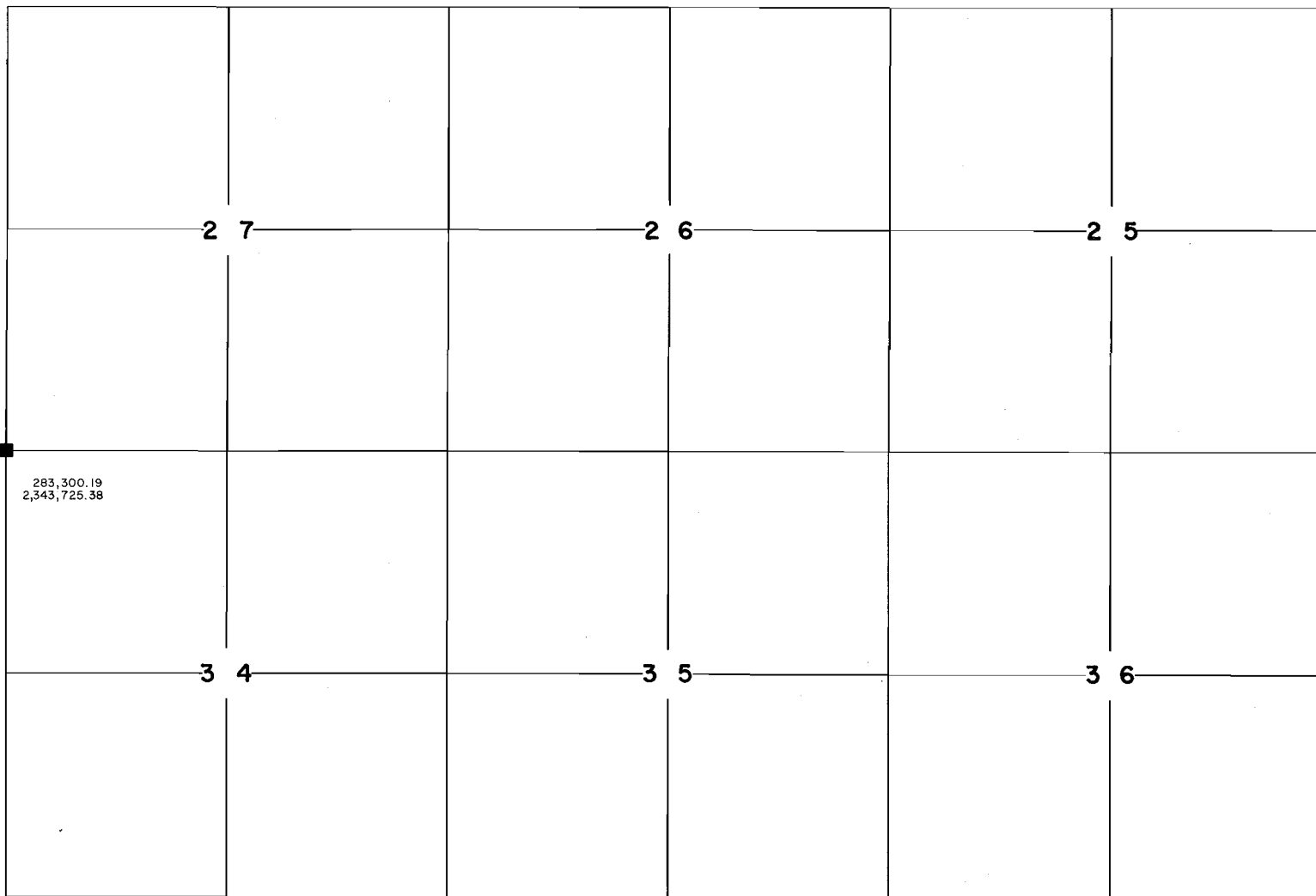


	LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" S.W.P.C. CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N.G.S. HORIZONTAL CONTROL STATION.	<small>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</small>	CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF WHITEWATER WALWORTH COUNTY, WISCONSIN		DRAWN BY: _____ DATE: _____	DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM	SECTIONS 3, 2, 1, 10, 11, 12 T. 4 N. R. 15 E. WALWORTH COUNTY
					CHECKED BY: _____ DATE: _____		
					APPROVED BY: _____ DATE: _____		
					REVISED: _____ DATE: _____		









LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONCRETE MONUMENT WITH BRASS CAP.
- ☒ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONCRETE MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N. G. S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99995024. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF WHITEWATER WALWORTH COUNTY, WISCONSIN

DRAWN BY: D. L. RILEY DATE: OCT, 1986

CHECKED BY: L. H. KREBLIN DATE: OCT, 1986

APPROVED BY: *[Signature]* DATE: OCT, 1986

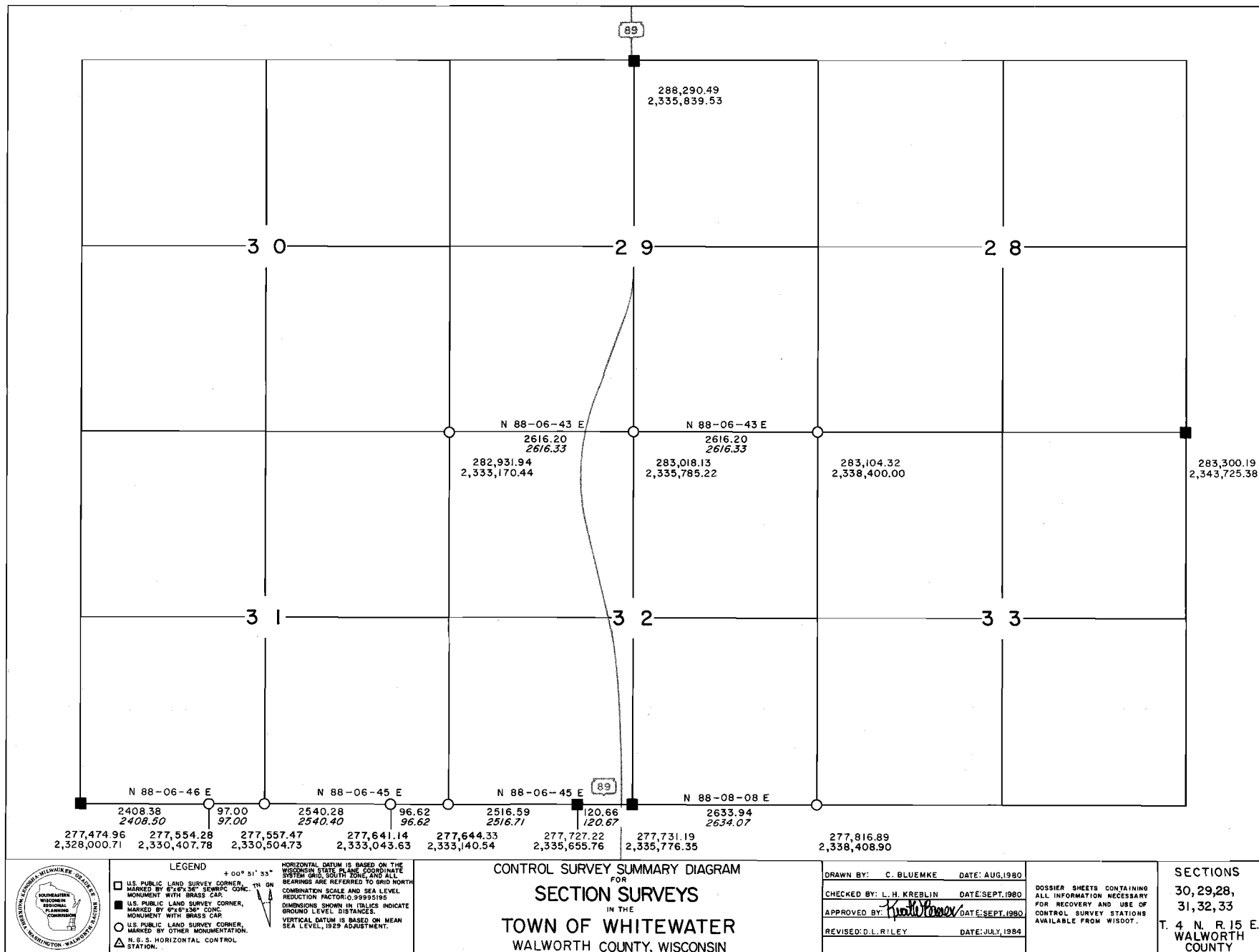
REVISED: DATE:


DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WISDOT.

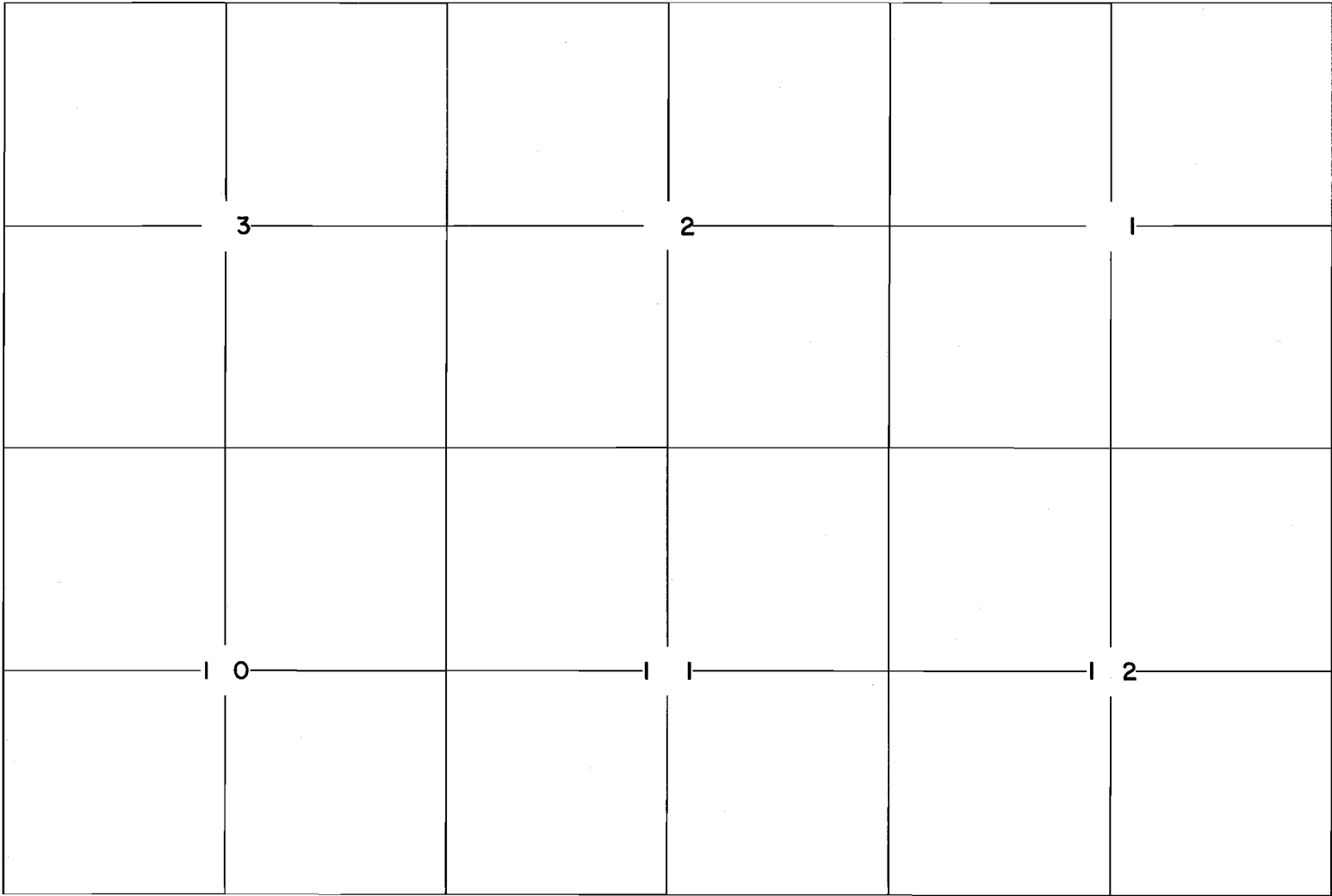
SECTIONS

27, 26, 25,
34, 35, 36

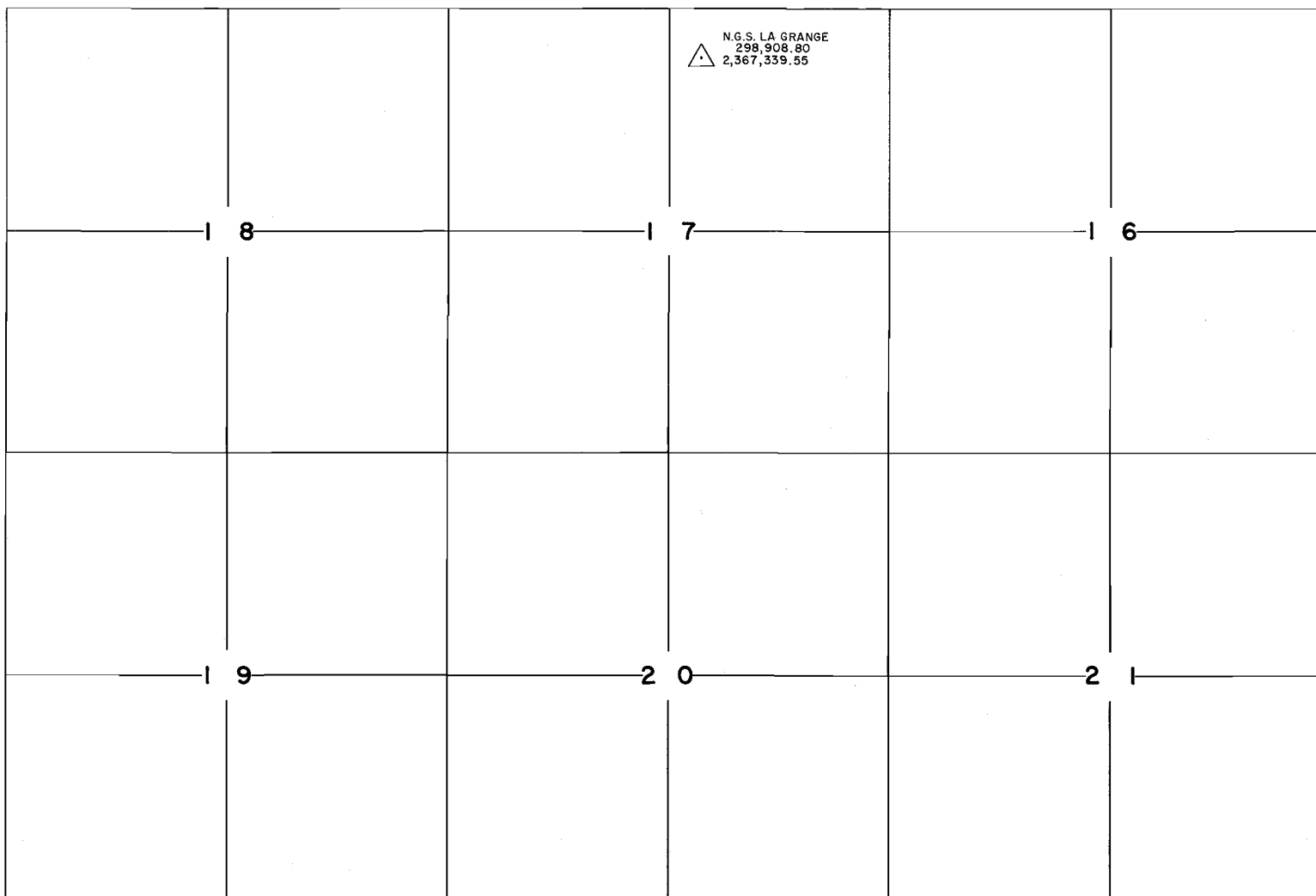
T. 4 N. R. 15 E.
WALWORTH
COUNTY



		LEGEND		HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.		CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF LA GRANGE WALWORTH COUNTY, WISCONSIN				DRAWN BY: _____ DATE: _____		DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM	SECTIONS 3, 2, 1, 10, 11, 12 T. 4 N. R. 16 E. WALWORTH COUNTY
		□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" SODIUM COAL. ■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONC. ○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. △ N.G.S. HORIZONTAL CONTROL STATION.				CHECKED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____ REVISED: _____ DATE: _____							



	<p>LEGEND</p> <p><input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SENSITIVE CONC. MONUMENT WITH BRASS CAP.</p> <p><input checked="" type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.</p> <p><input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.</p> <p><input type="checkbox"/> N. S. S. HORIZONTAL CONTROL STATION.</p>	<p>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.</p> <p>REDUCTION FACTOR:</p> <p>DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.</p> <p>VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</p>	<p>CONTROL SURVEY SUMMARY DIAGRAM</p> <p>SECTION SURVEYS</p> <p>IN THE</p> <p>TOWN OF LA GRANGE</p> <p>WALWORTH COUNTY, WISCONSIN</p>		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">DRAWN BY:</td> <td style="width: 50%;">DATE:</td> </tr> <tr> <td>CHECKED BY:</td> <td>DATE:</td> </tr> <tr> <td>APPROVED BY:</td> <td>DATE:</td> </tr> <tr> <td>REVISED:</td> <td>DATE:</td> </tr> </table>	DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:
DRAWN BY:	DATE:												
CHECKED BY:	DATE:												
APPROVED BY:	DATE:												
REVISED:	DATE:												
				<p>DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM</p>	<p>SECTIONS</p> <p>6, 5, 4, 7, 8, 9</p> <p>T. 4 N. R. 16 E. WALWORTH COUNTY</p>								



LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" SERRIP CONC. MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONC. MONUMENT WITH BRASS CAP
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION
- △ N. G. S. HORIZONTAL CONTROL STATION

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF LA GRANGE WALWORTH COUNTY, WISCONSIN

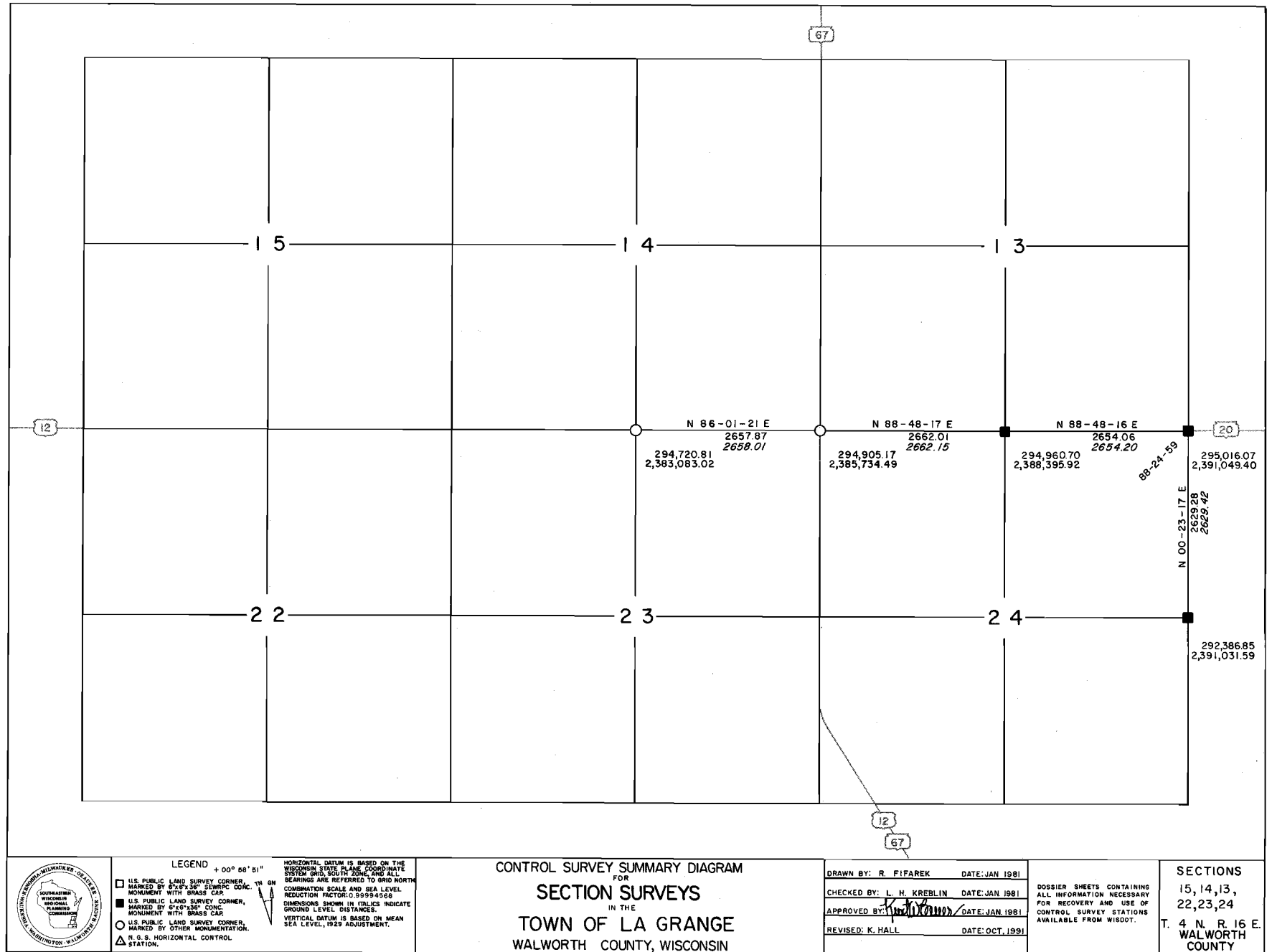
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CHECKED BY:	DATE:
APPROVED BY:	DATE:
REVISED:	DATE:

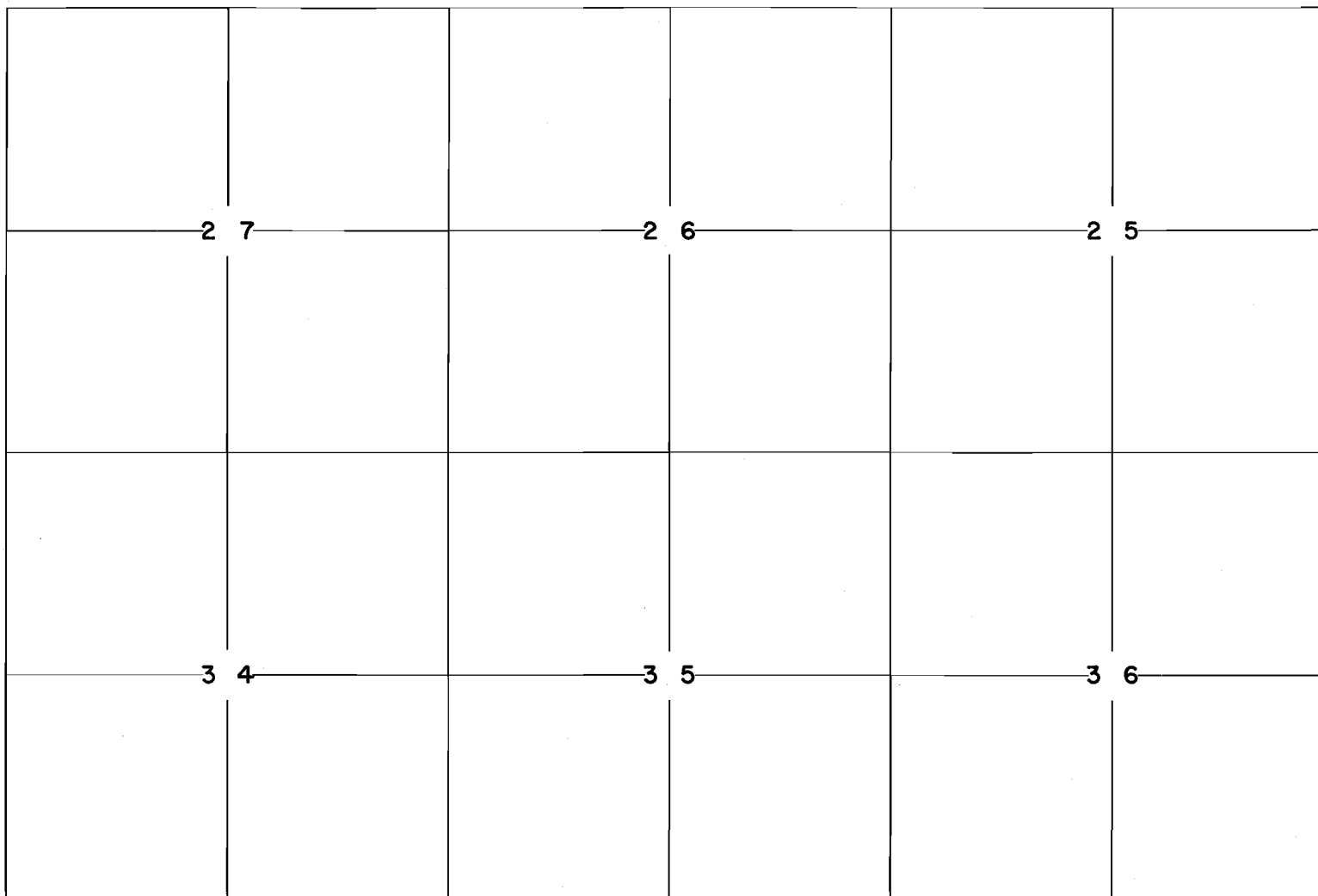
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS

18, 17, 16,
19, 20, 21

T. 4 N. R. 16 E.
WALWORTH
COUNTY





LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" SEWPC CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- △ T. & S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

REDUCTION FACTOR:
DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.


CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF LA GRANGE WALWORTH COUNTY, WISCONSIN

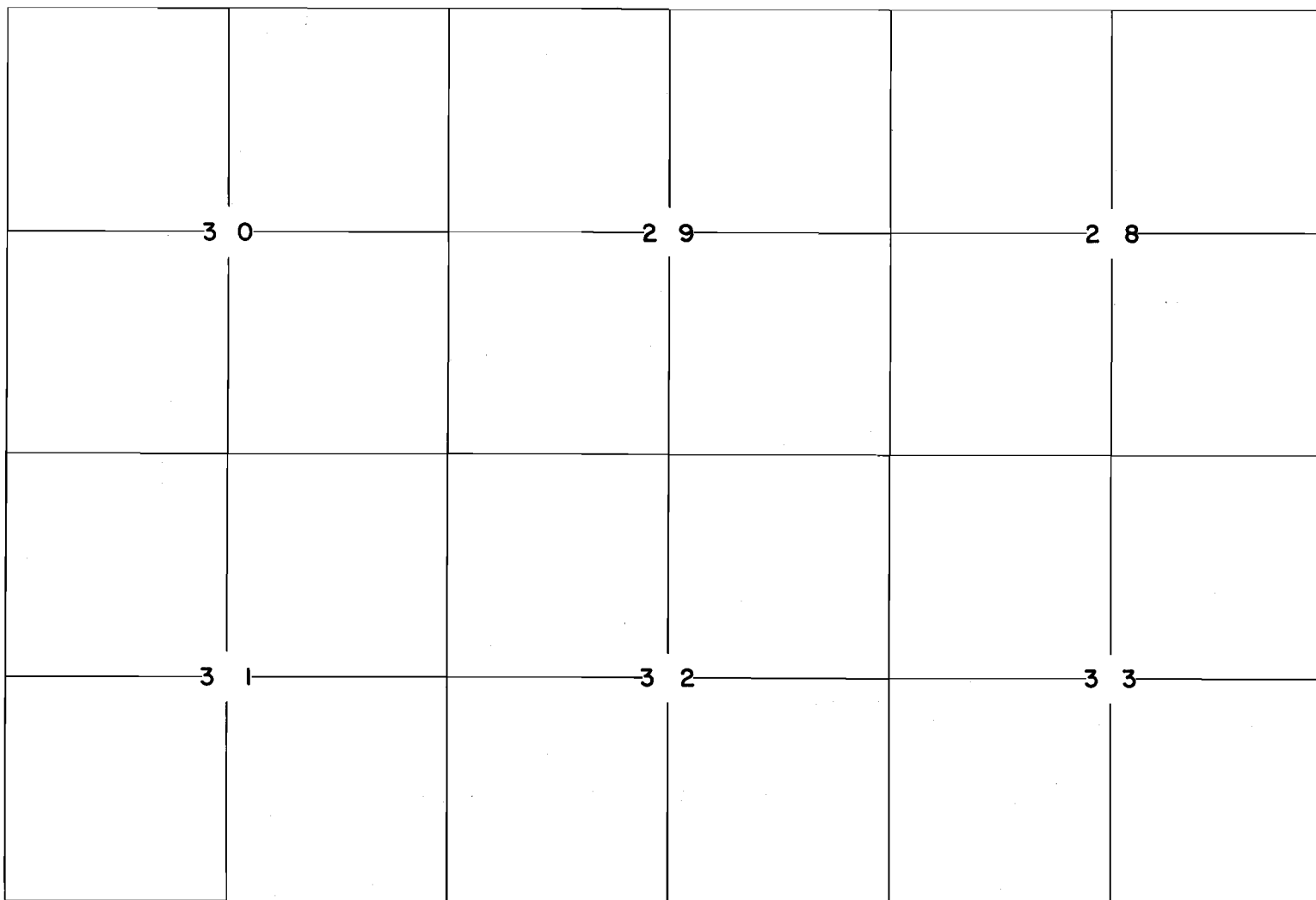
DRAWN BY:	DATE:
CHECKED BY:	DATE:
APPROVED BY:	DATE:
REVISED:	DATE:

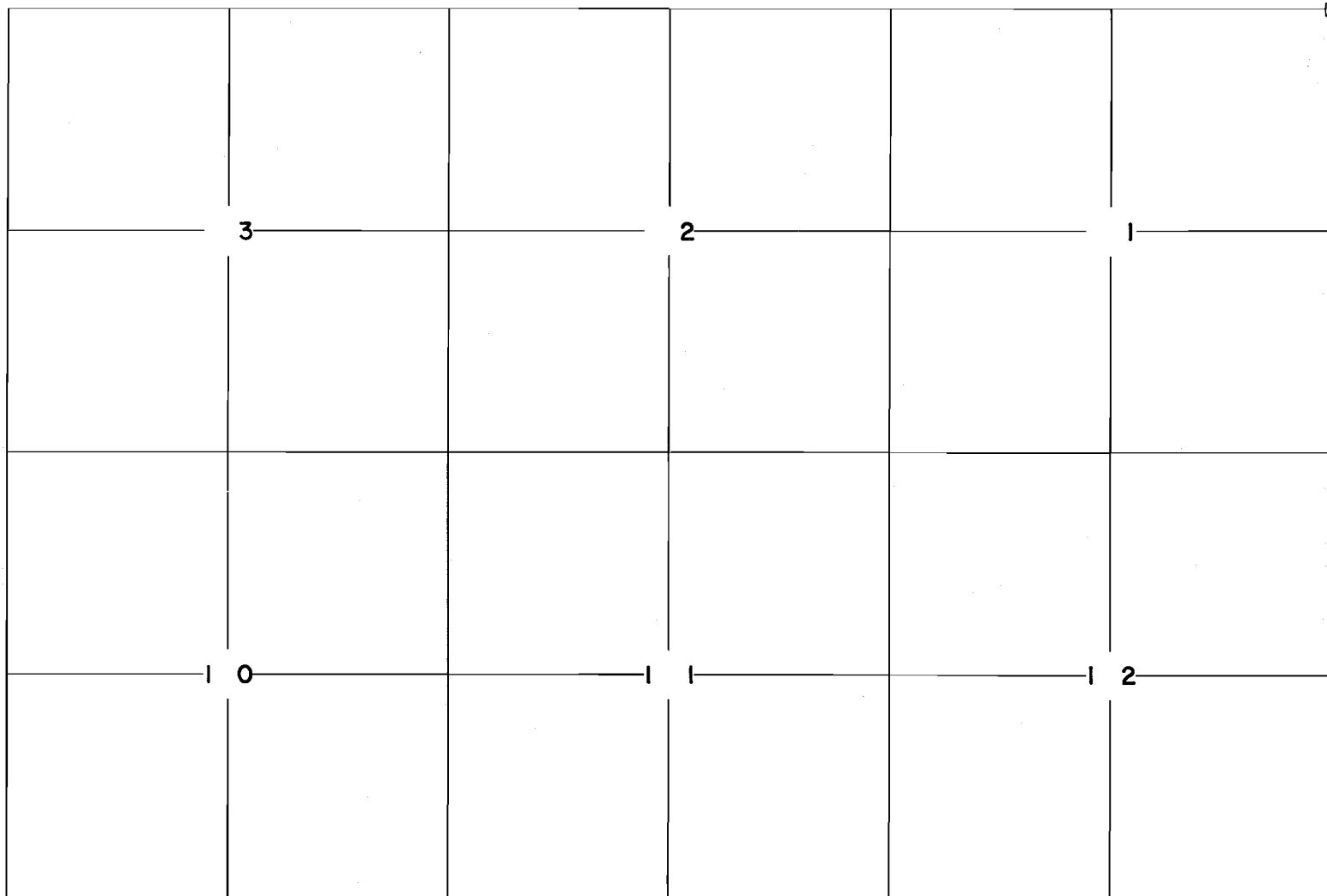
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

SECTIONS
27, 26, 25,
34, 35, 36

T. 4 N. R. 16 E.
WALWORTH
COUNTY

	<p>LEGEND</p> <p>□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONCRETE MONUMENT WITH BRASS CAP.</p> <p>■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x6" CONC. MONUMENT WITH BRASS CAP.</p> <p>○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.</p> <p>△ N. S. S. HORIZONTAL CONTROL STATION.</p>	<p>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM (GRID NORTH). ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</p>	<p>CONTROL SURVEY SUMMARY DIAGRAM</p> <p>FOR</p> <p>SECTION SURVEYS</p> <p>IN THE</p> <p>TOWN OF LA GRANGE</p> <p>WALWORTH COUNTY, WISCONSIN</p>	<p>DRAWN BY: _____ DATE: _____</p> <p>CHECKED BY: _____ DATE: _____</p> <p>APPROVED BY: _____ DATE: _____</p> <p>REVISED: _____ DATE: _____</p>	<p>DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM</p>	<p>SECTIONS</p> <p>30, 29, 28,</p> <p>31, 32, 33</p> <p>T. 4 N. R. 16 E.</p> <p>WALWORTH COUNTY</p>
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311,054.42
2,422,667.32
E.L. 840.63



LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" SEWRPC CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" CONC. MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N.G.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR 0.99984242. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF TROY WALWORTH COUNTY, WISCONSIN

DRAWN BY: D.P. SIMON DATE: MAY, 1995

CHECKED BY: L.H. KREBLIN DATE: MAY, 1995

APPROVED BY: *[Signature]* DATE: MAY, 1995

REVISED: DATE:

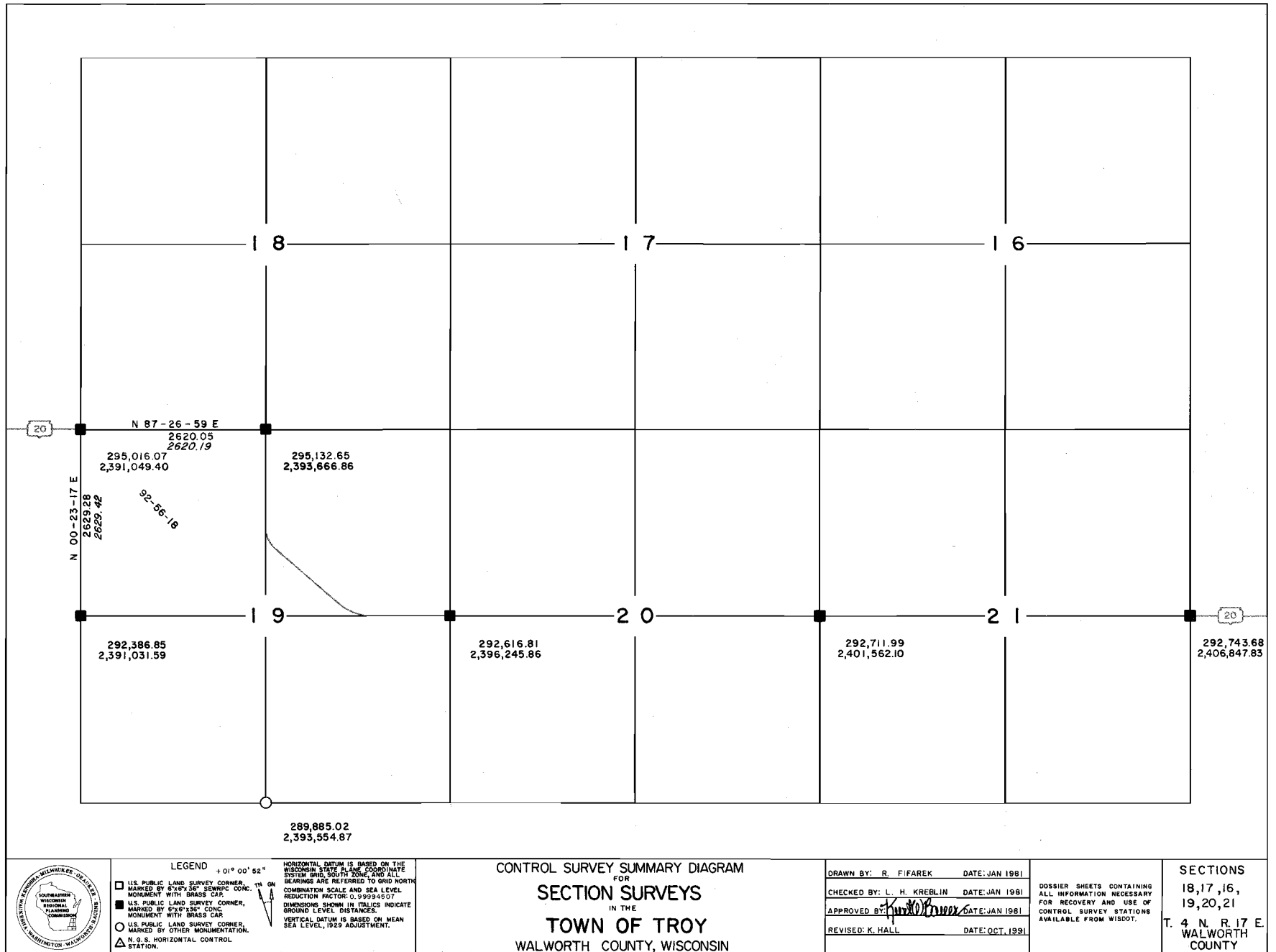
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WALWORTH CO. AND SEWRPC.

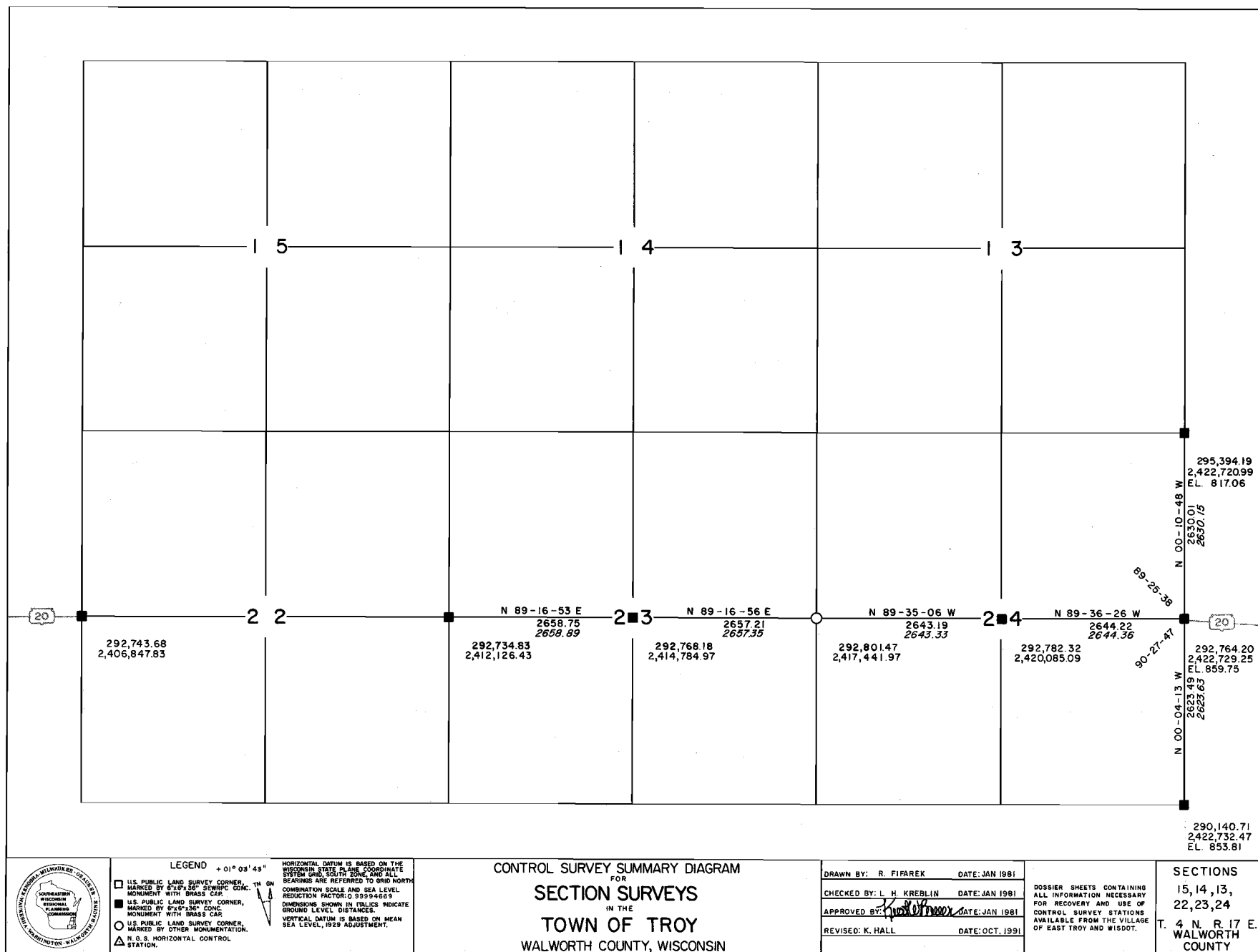
SECTIONS

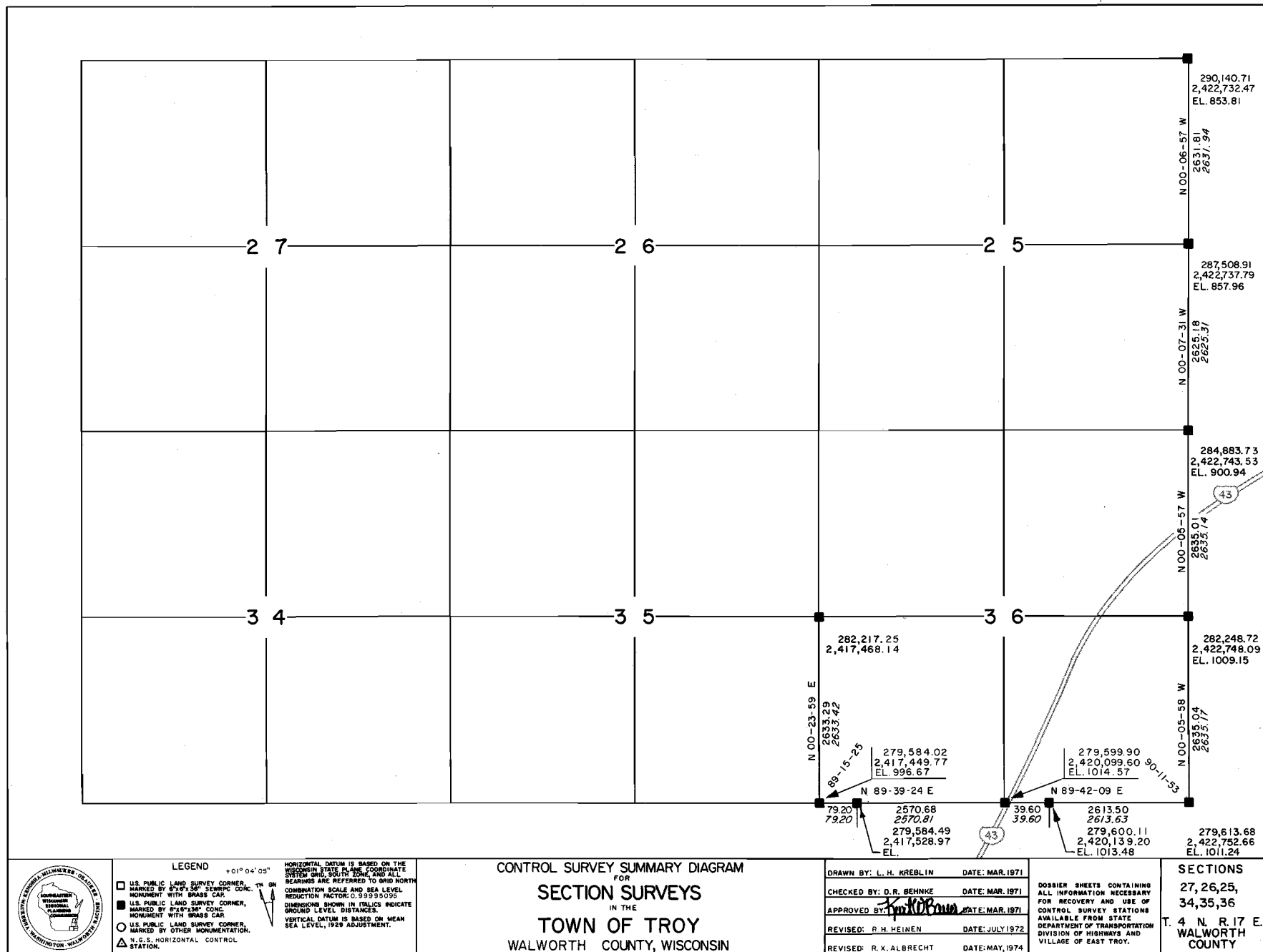
3, 2, 1,
10, 11, 12

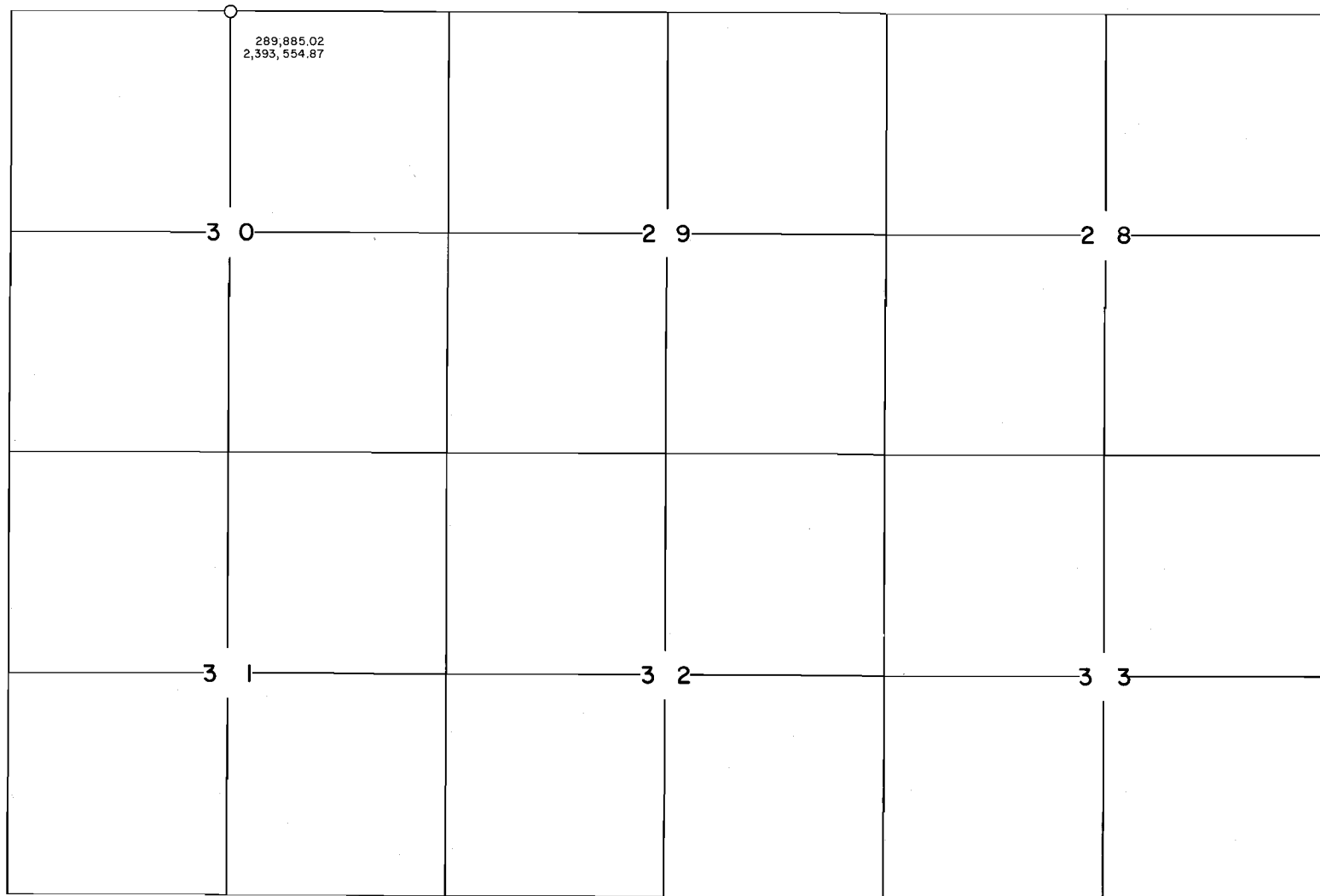
T. 4 N. R. 17 E.
WALWORTH
COUNTY

	<p>LEGEND</p> <p>□ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEMI-SP. CONC. MONUMENT WITH BRASS CAP.</p> <p>■ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.</p> <p>○ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.</p> <p>△ N. G. S. HORIZONTAL CONTROL STATION.</p>	<p>HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.</p> <p>COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR:</p> <p>DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.</p> <p>VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.</p>	<p>CONTROL SURVEY SUMMARY DIAGRAM</p> <p>FOR</p> <p>SECTION SURVEYS</p> <p>IN THE</p> <p>TOWN OF TROY</p> <p>WALWORTH COUNTY, WISCONSIN</p>	<p>DRAWN BY: _____ DATE: _____</p> <p>CHECKED BY: _____ DATE: _____</p> <p>APPROVED BY: _____ DATE: _____</p> <p>REVISED: _____ DATE: _____</p>	<p>DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM</p>	<p>SECTIONS</p> <p>6, 5, 4,</p> <p>7, 8, 9</p> <p>T. 4 N. R. 17 E.</p> <p>WALWORTH COUNTY</p>









LEGEND

+ 01° 00' 26"

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X6" SEWRPC CONC. MONUMENT WITH BRASS CAP
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X6" CONC. MONUMENT WITH BRASS CAP
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION
☐ N. S. S. HORIZONTAL CONTROL STATION

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL. REDUCTION FACTOR: 0.99994821. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF TROY
WALWORTH COUNTY, WISCONSIN

DRAWN BY: D. L. RILEY DATE: OCT, 1986

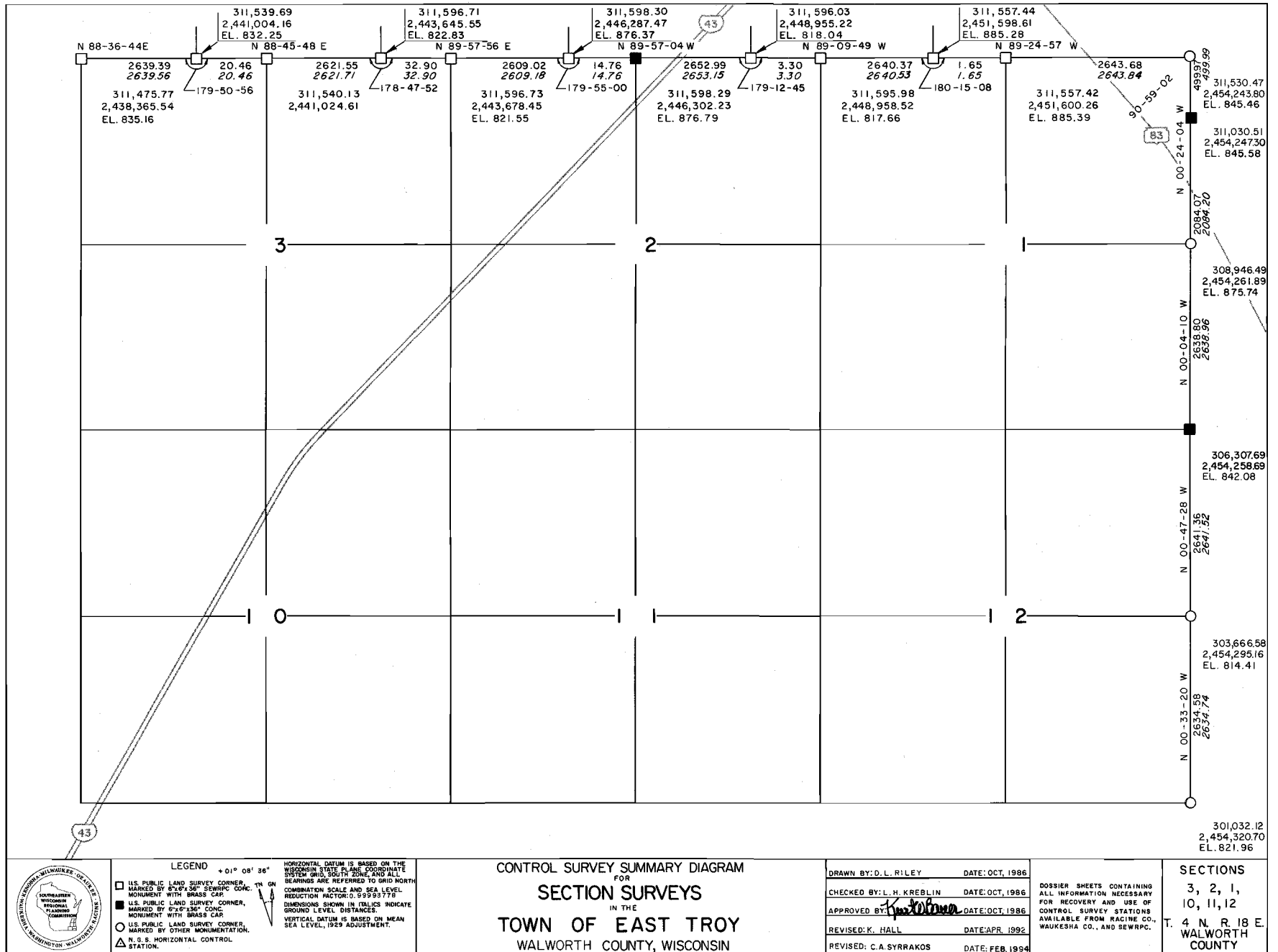
CHECKED BY: L. H. KREBLIN DATE: OCT, 1986

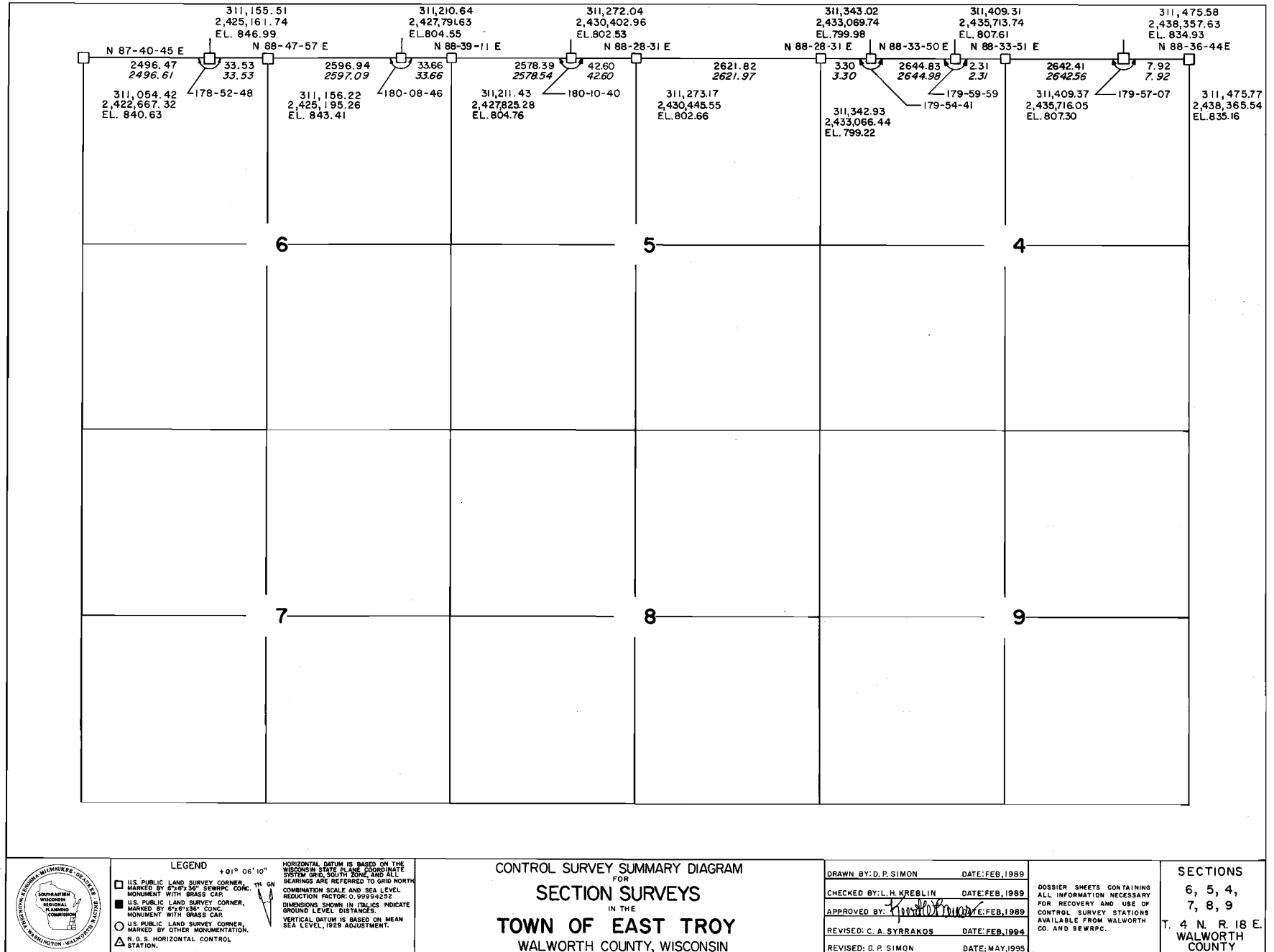
APPROVED BY: *[Signature]* DATE: OCT, 1986

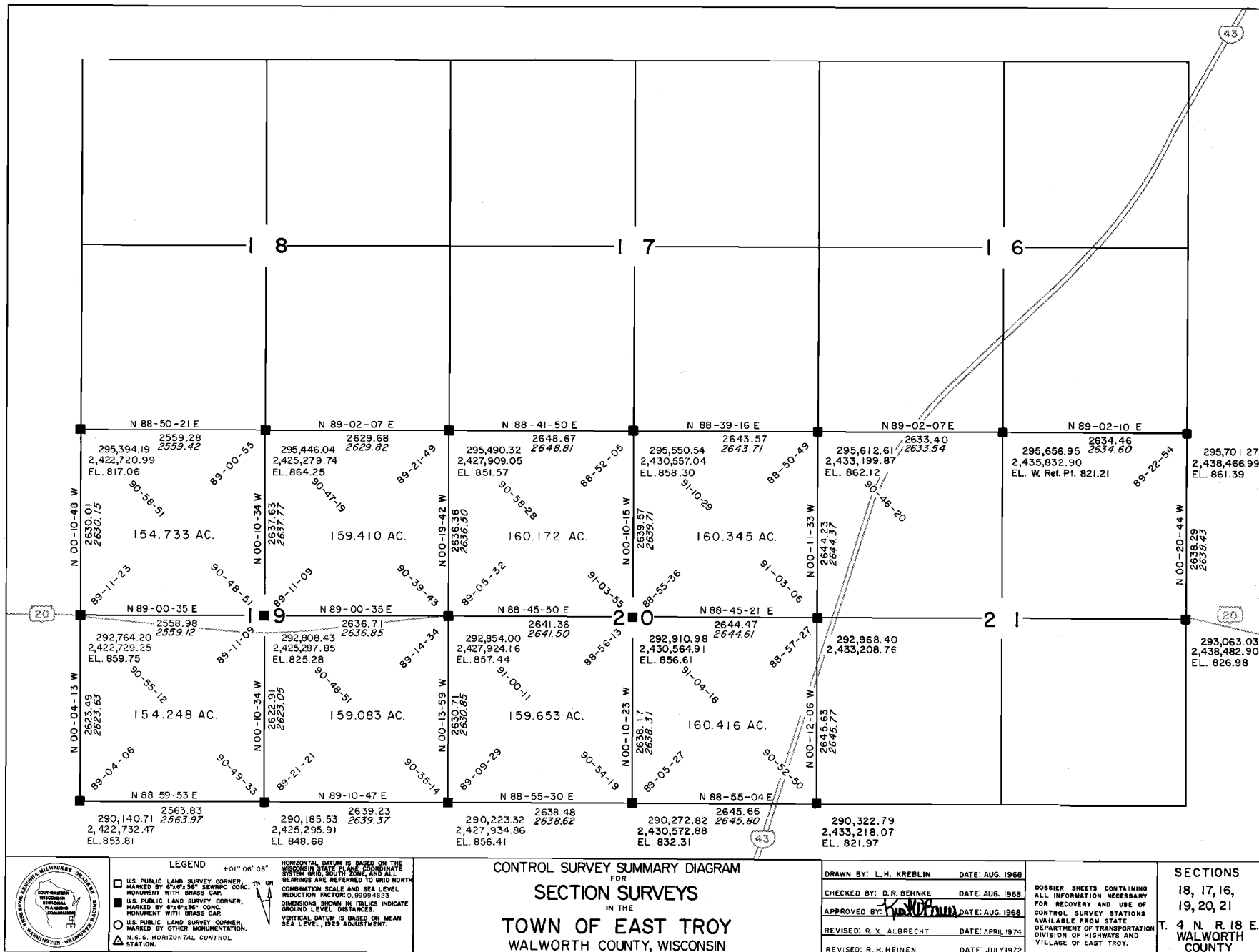
REVISED: DATE:

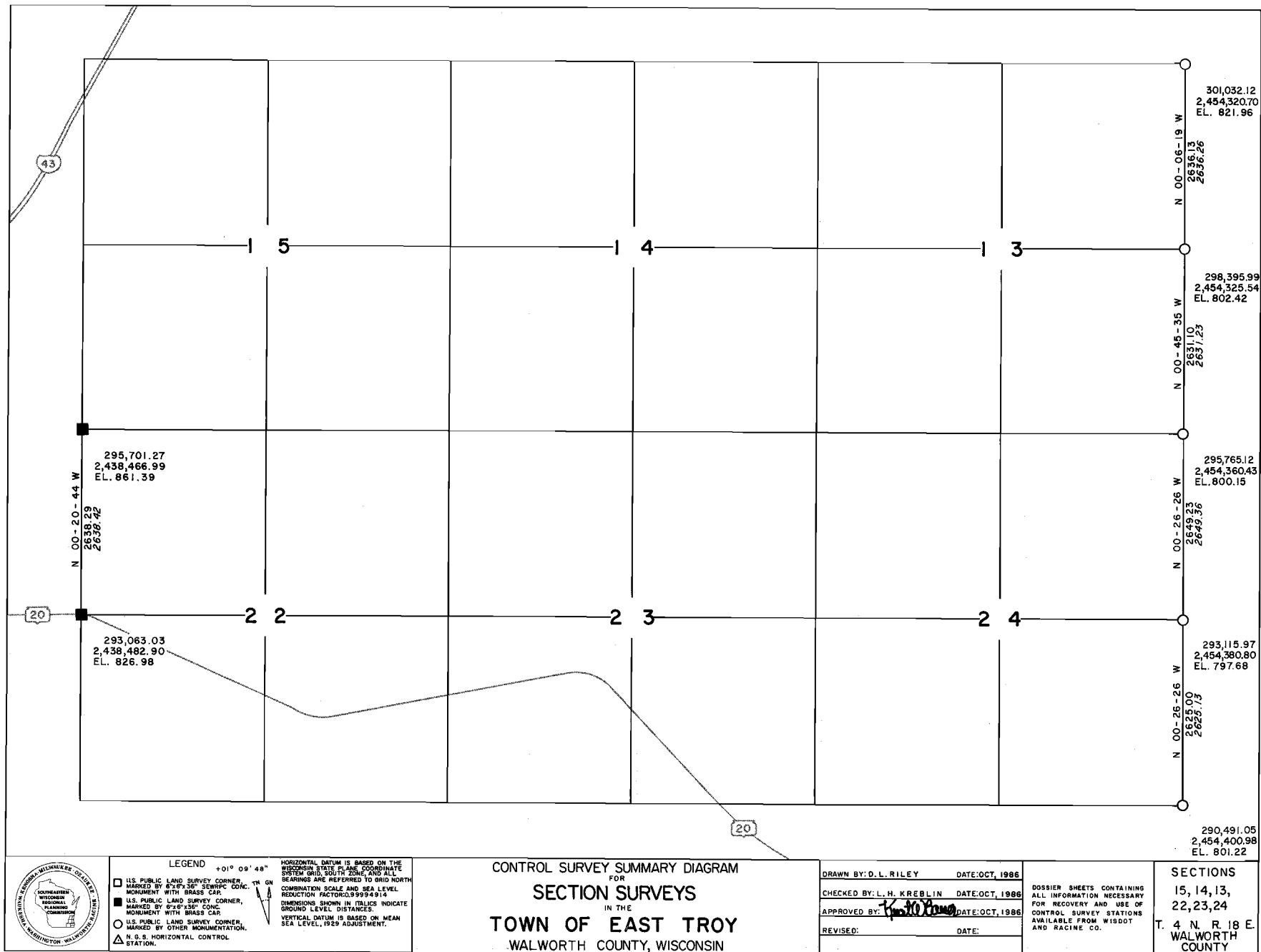
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WISDOT.

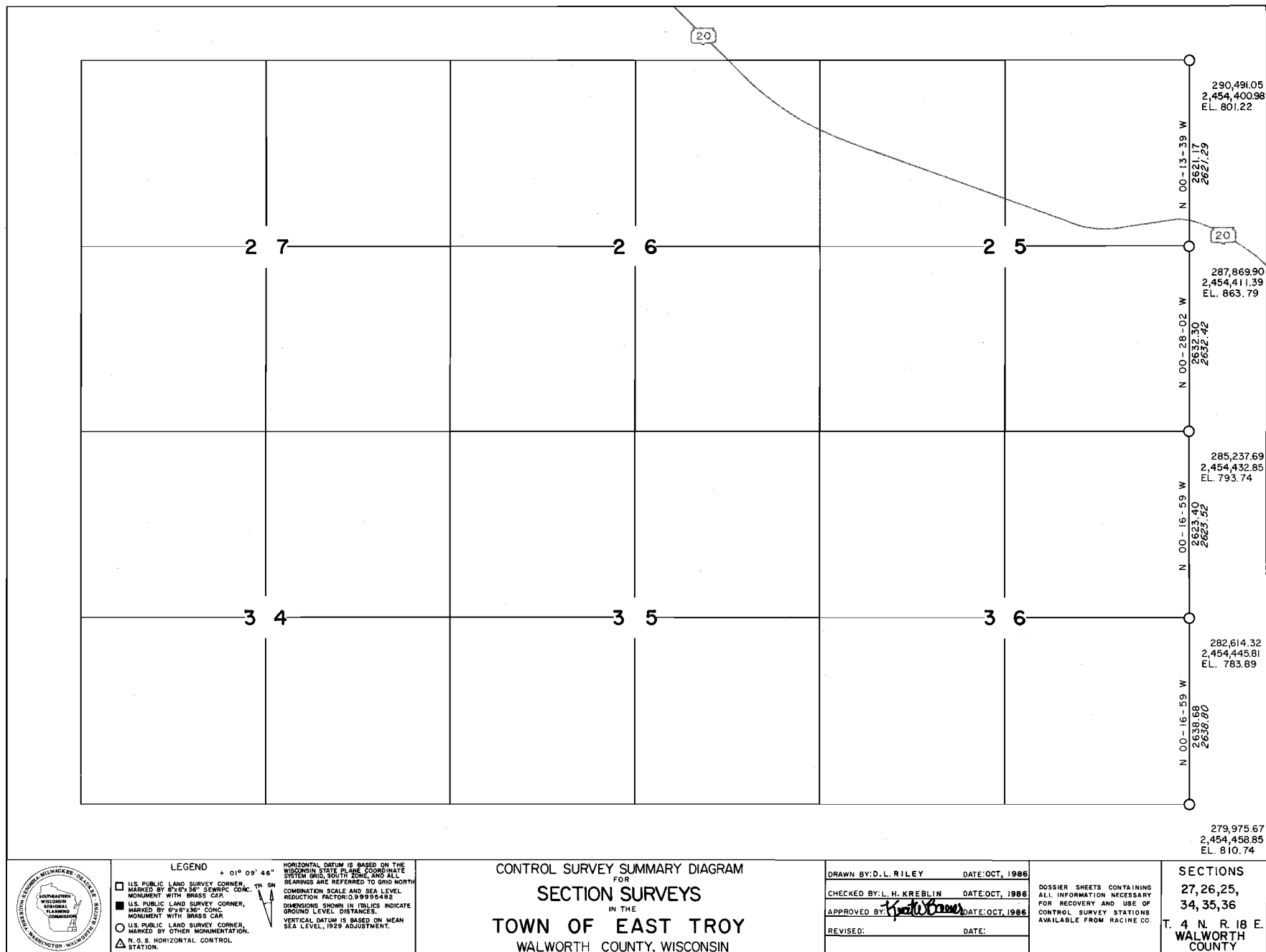
SECTIONS
30, 29, 28,
31, 32, 33
T. 4 N. R. 17 E.
WALWORTH COUNTY

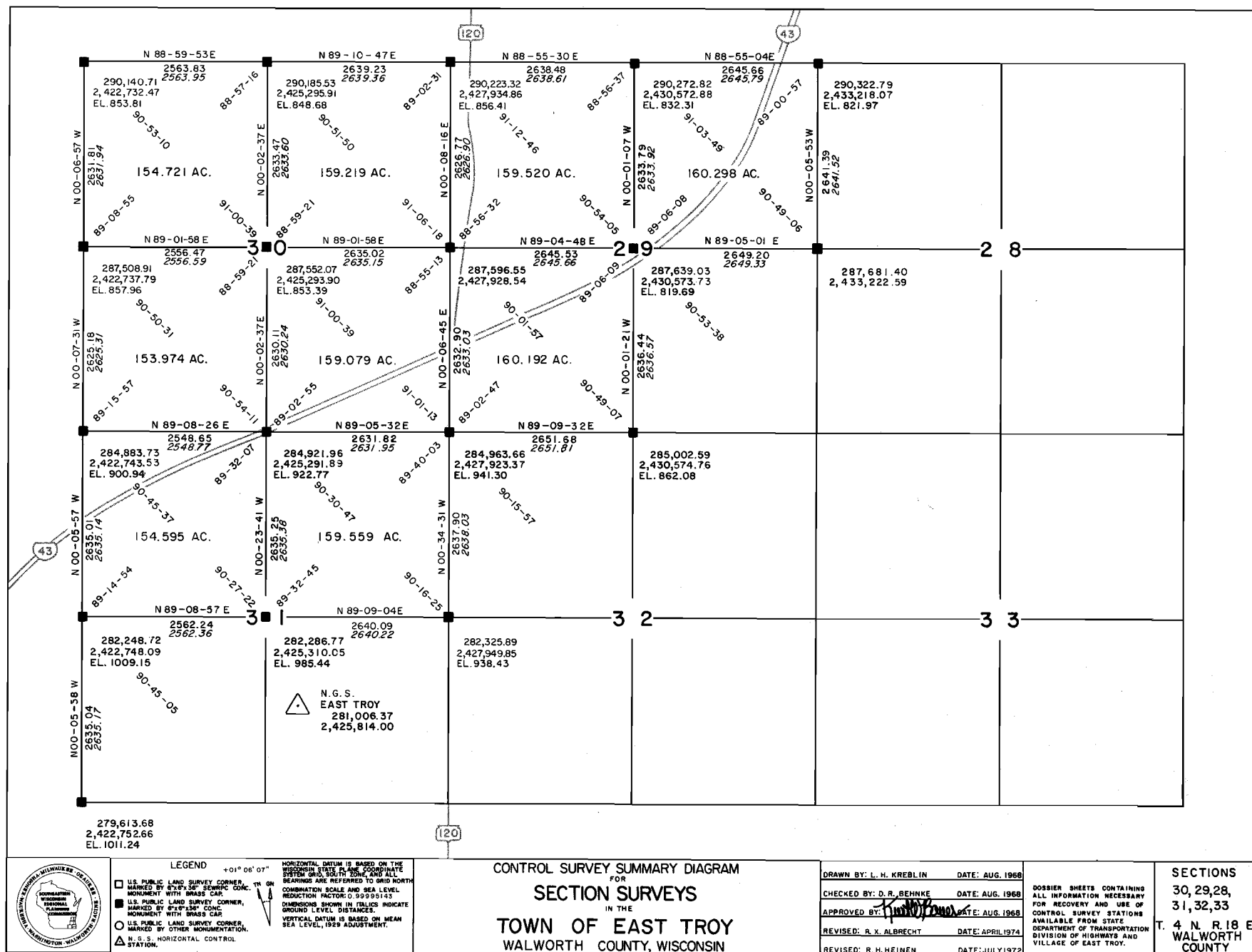




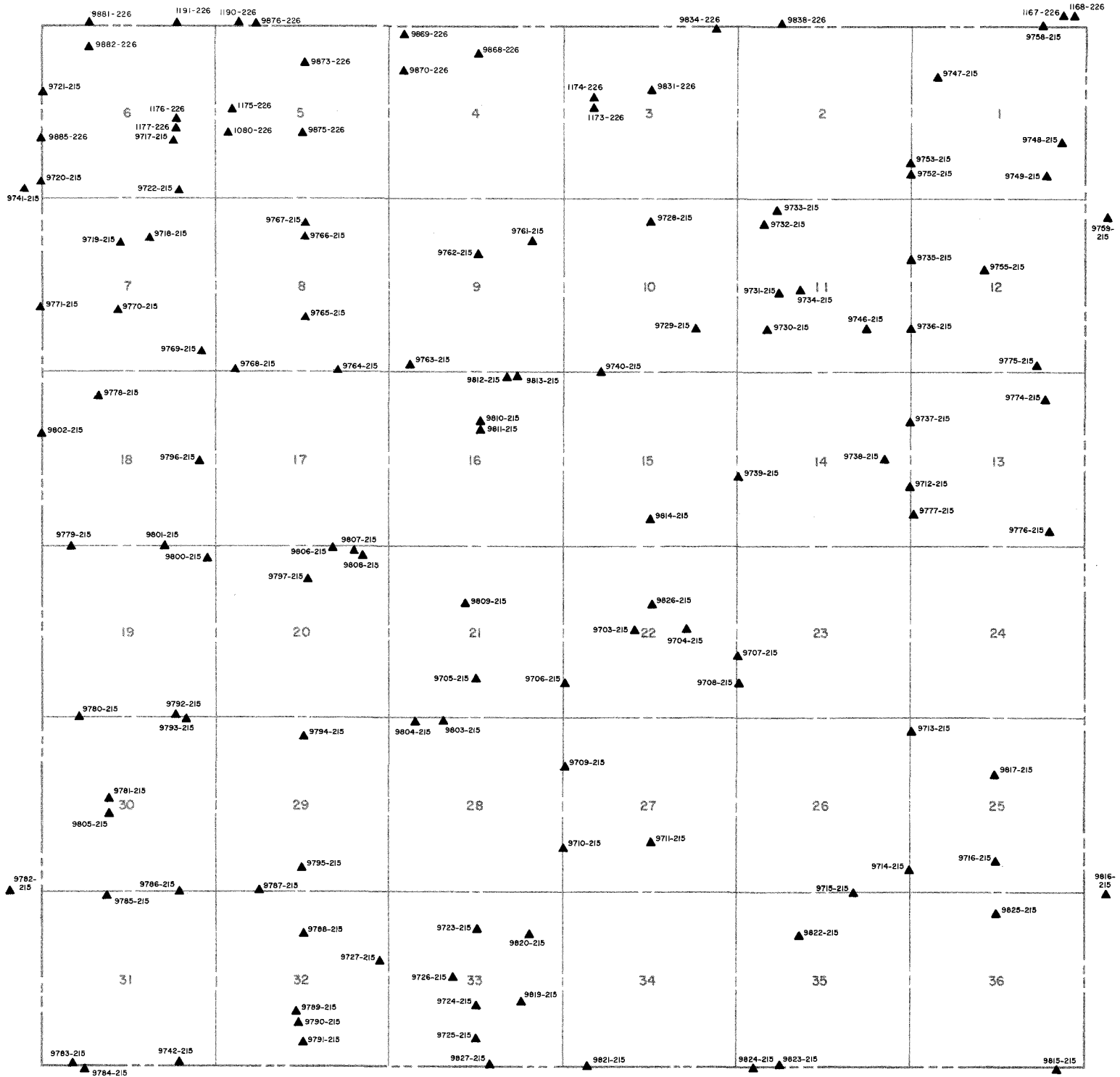




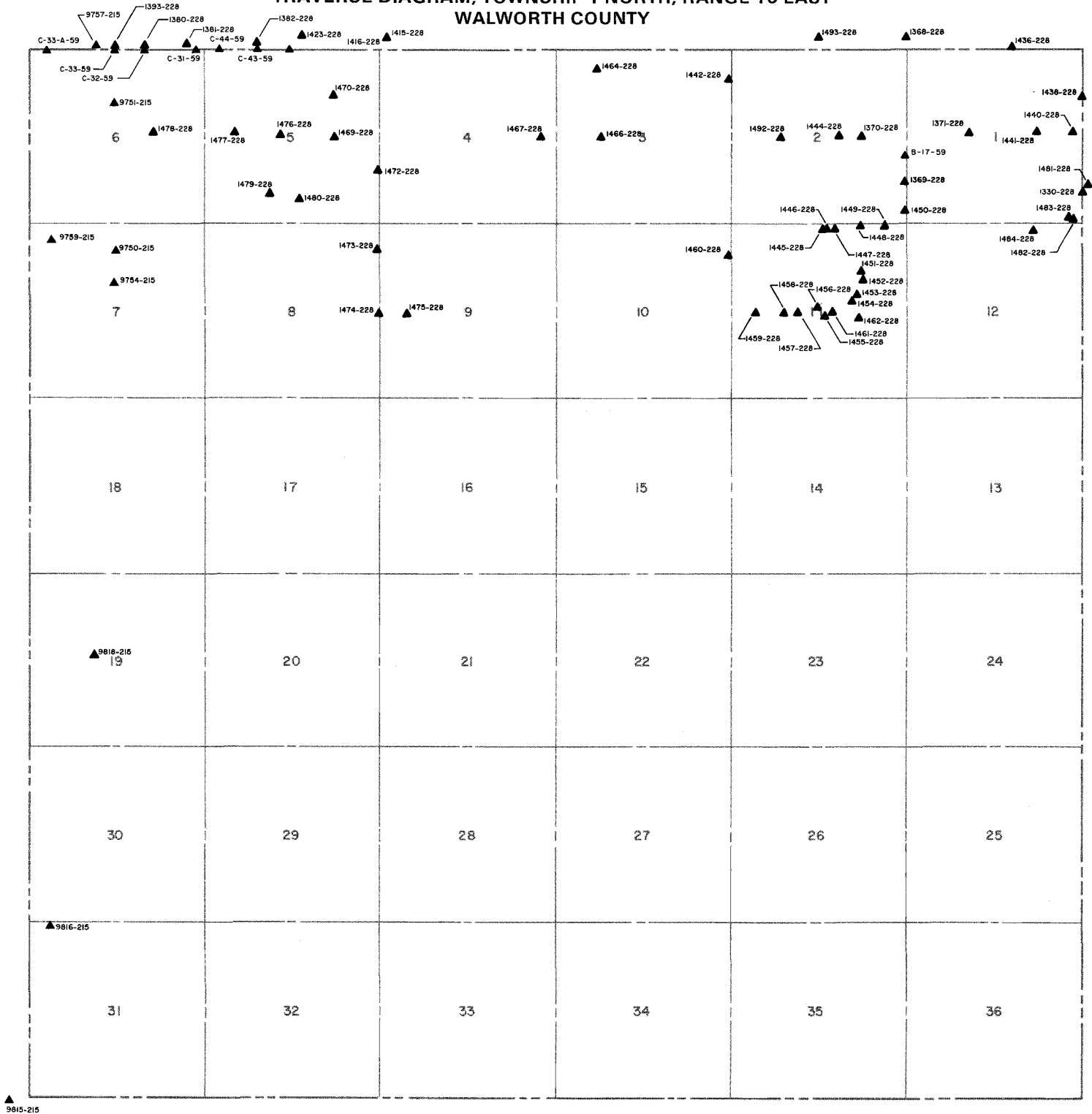




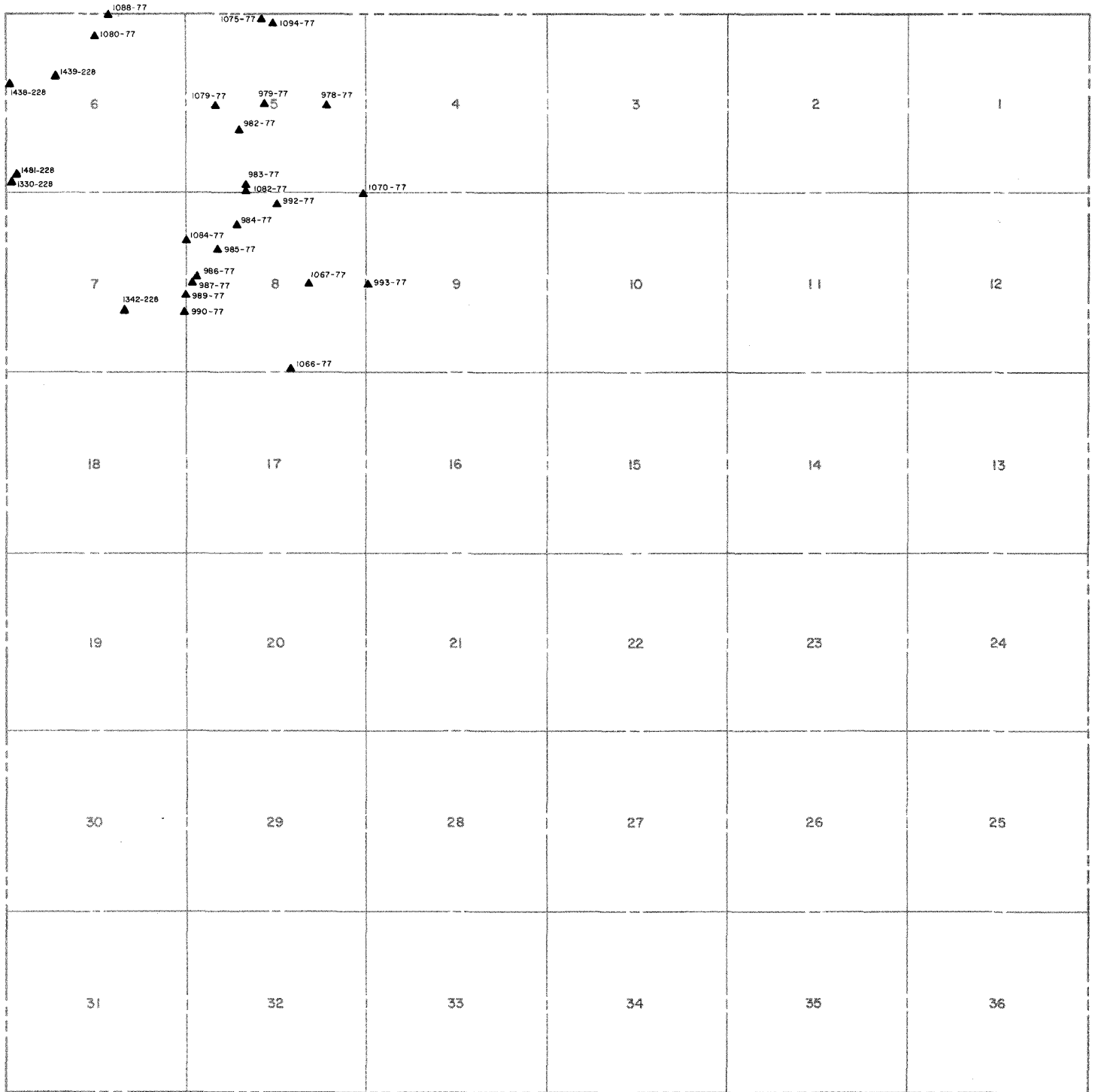
TRAVERSE DIAGRAM, TOWNSHIP 1 NORTH, RANGE 15 EAST
WALWORTH COUNTY



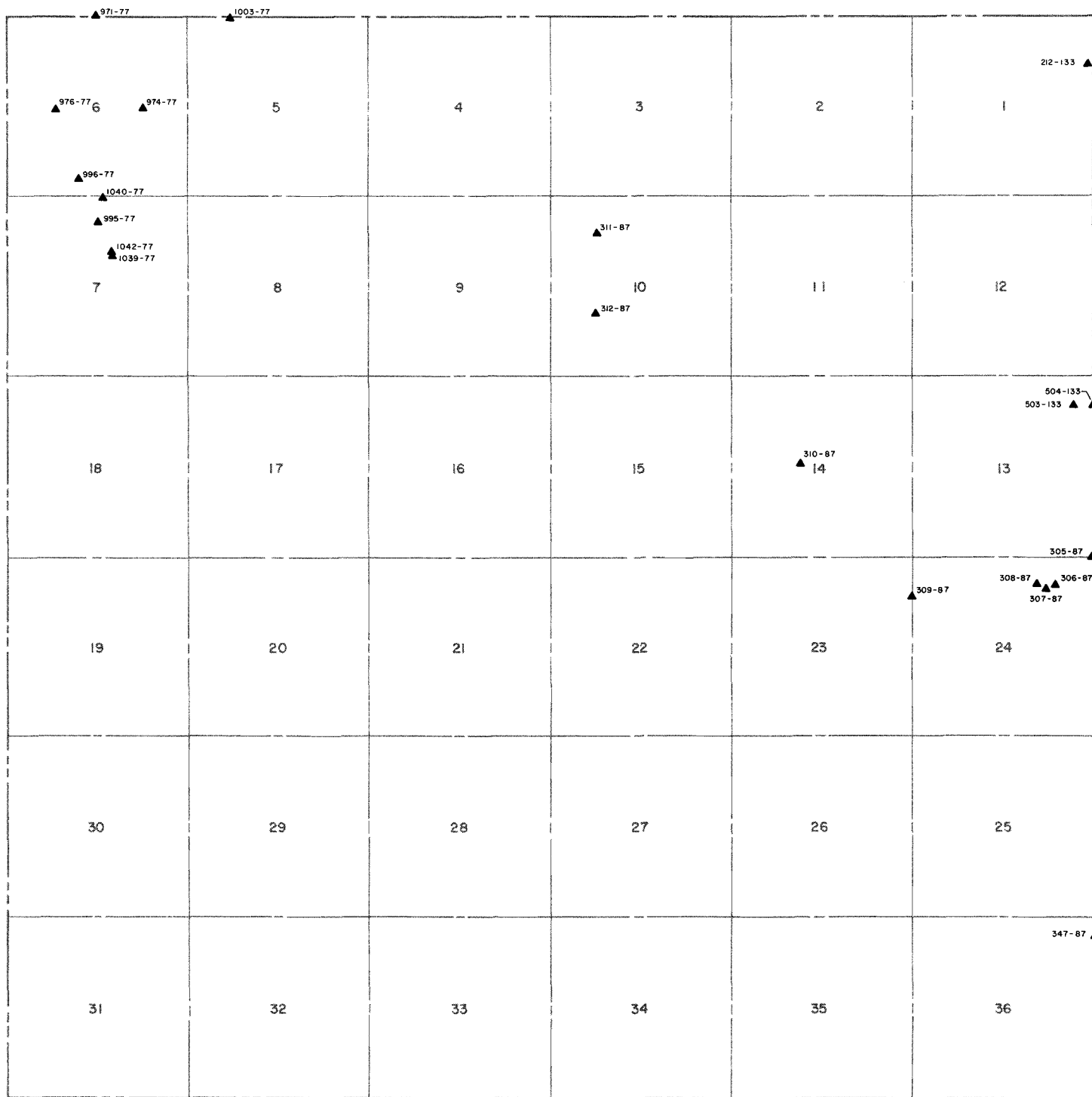
TRAVERSE DIAGRAM, TOWNSHIP 1 NORTH, RANGE 16 EAST WALWORTH COUNTY



**TRAVERSE DIAGRAM, TOWNSHIP 1 NORTH, RANGE 17 EAST
WALWORTH COUNTY**



TRAVERSE DIAGRAM, TOWNSHIP 1 NORTH, RANGE 18 EAST WALWORTH COUNTY



This map displays the 36-degree latitude zone in the North Atlantic, divided into a grid of 36 squares. Each square is numbered from 1 to 36. The map is populated with numerous data points, represented by triangles, many of which are labeled with alphanumeric codes. These labels often include a four-digit number followed by a hyphen and another number (e.g., 1113-226, 5301-27, 1085-226). Some points are labeled with '226' and others with '27'. The distribution of points is uneven, with some squares containing many points and others containing none. The map also shows some larger-scale features like coastlines and major shipping lanes.

This map displays the 36-degree latitude zone in the Pacific Ocean, divided into 36 squares. Each square is labeled with a number (1-36) and contains various alphanumeric codes representing data points. The map includes a coordinate grid with latitude and longitude markings. A legend in the top right corner identifies symbols for '1000 FATHOM DEPTH' (a triangle) and '1000 FATHOM DEPTH' (a circle).

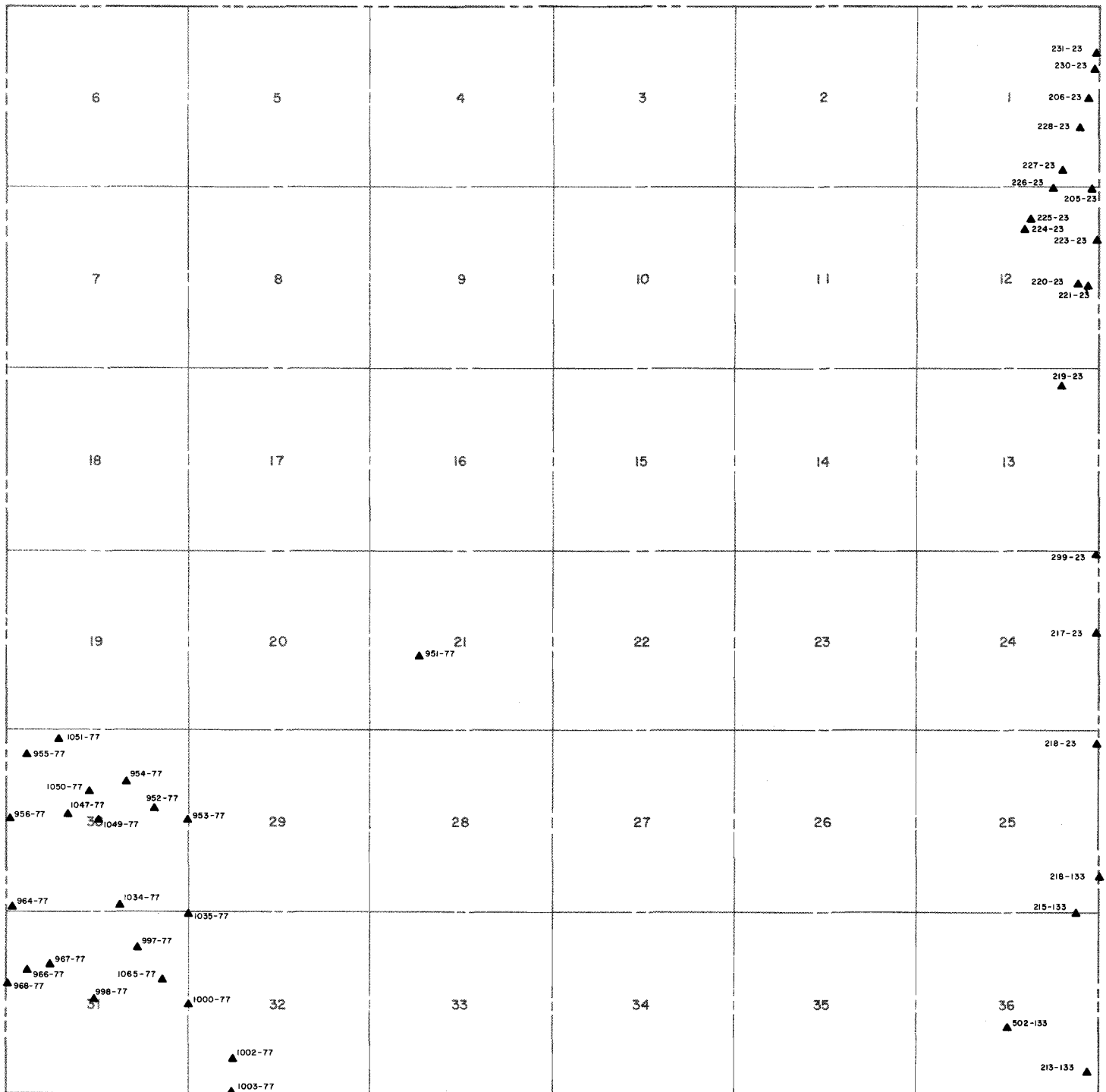
The map displays a 6x6 grid of cells, numbered 1 through 34. The grid is oriented with North at the top. The cells are numbered as follows:

- Row 1: 1, 2, 3, 4, 5, 6
- Row 2: 7, 8, 9, 10, 11, 12
- Row 3: 13, 14, 15, 16, 17, 18
- Row 4: 19, 20, 21, 22, 23, 24
- Row 5: 25, 26, 27, 28, 29, 30
- Row 6: 31, 32, 33, 34

Shipwreck locations are marked with triangles and alphanumeric codes. The locations are distributed across the grid, with a higher concentration in the lower right quadrant (cells 25-34). The codes include:

- 6313-27, 2039-27, 6321-27, 102-27, 2040-27, 101-27, 6322-27, 4886-114, 6317-27, 4889-114, 451-27, 4887-114, 18-27, 4889-114, 451-27, 101-59, 102-59, 1372-228, 1374-228, 1375-228, 1033-77, 1092-77, 1031-77, 1059-77, 1055-77, 1054-77, 1057-77, 961-77, 960-77, 962-77, 959-77, 958-77, 956-77, 1029-77, 1026-77, 1025-77, 1008-77, 1006-77, 1005-77, 1004-77, 986-77, 1073-77, 1074-77, 1076-77, 1078-77, 1090-77, 1011-77, 1012-77, 1015-77, 1016-77, 1018-77, 1019-77, 1020-77, 1021-77, 1023-77, 1043-77, 1045-77, 1009-77, 1111-77, 1013-77, 1087-77, 1088-77, 1086-77.

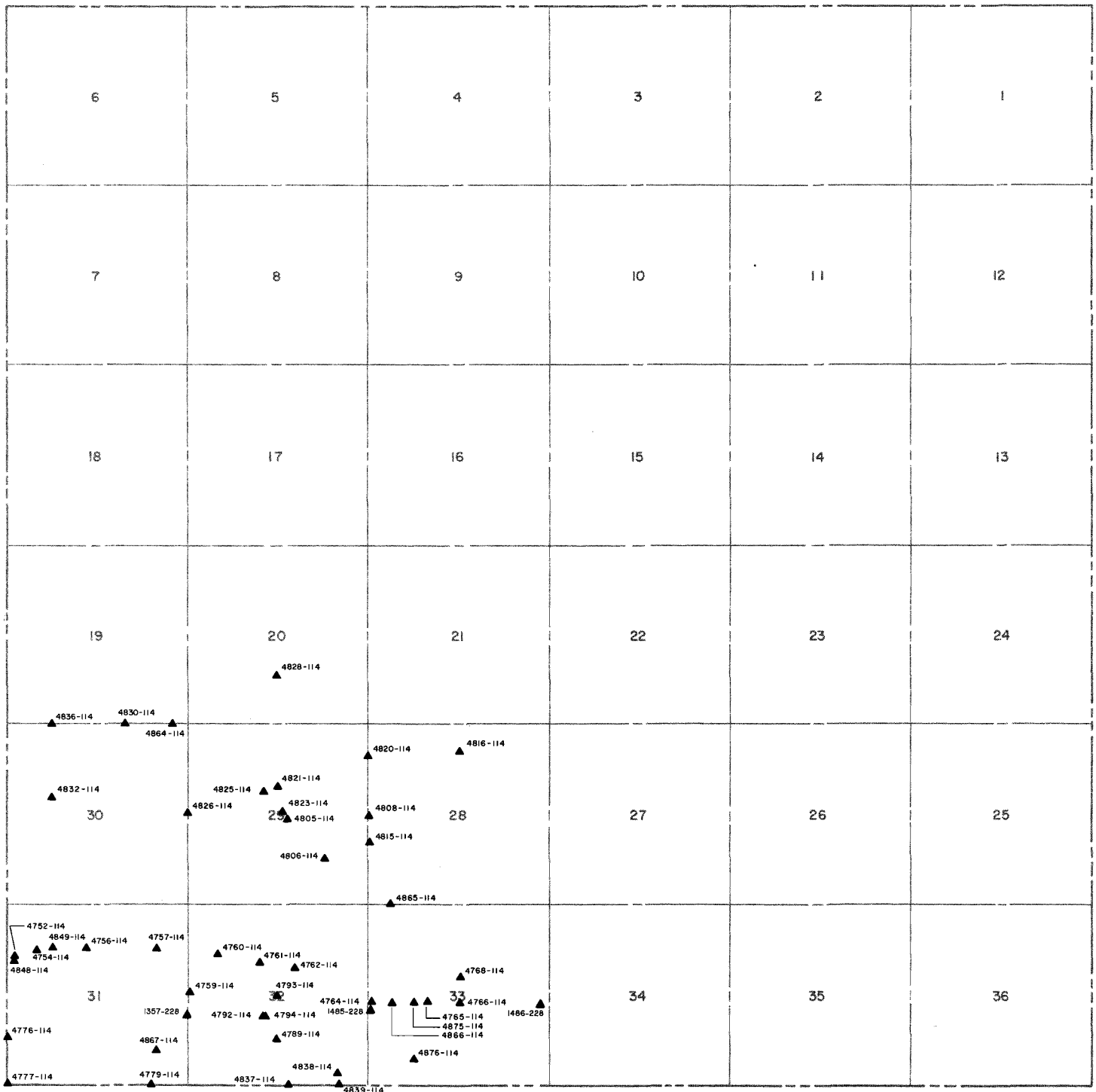
TRAVERSE DIAGRAM, TOWNSHIP 2 NORTH, RANGE 18 EAST WALWORTH COUNTY



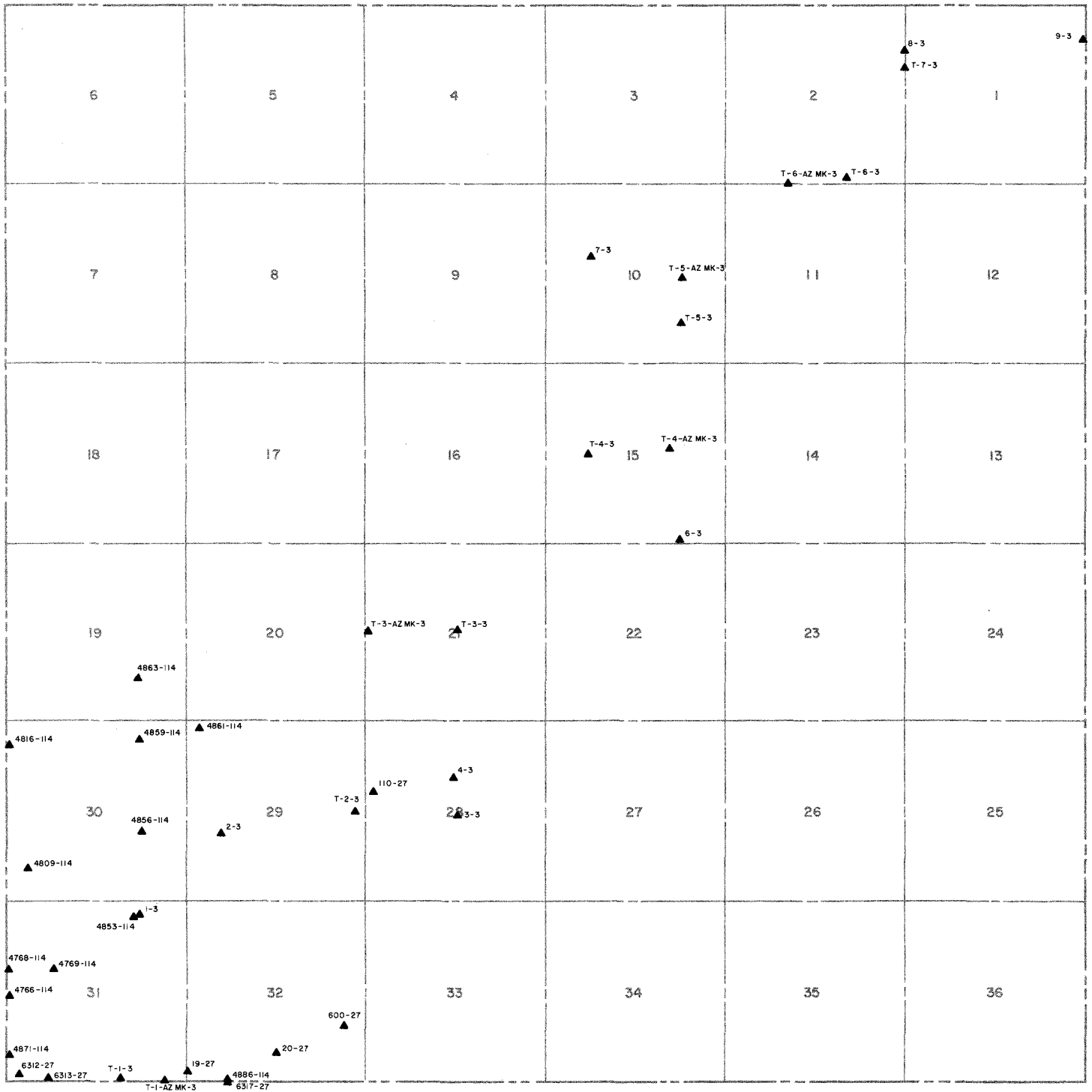
**TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 15 EAST
WALWORTH COUNTY**

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

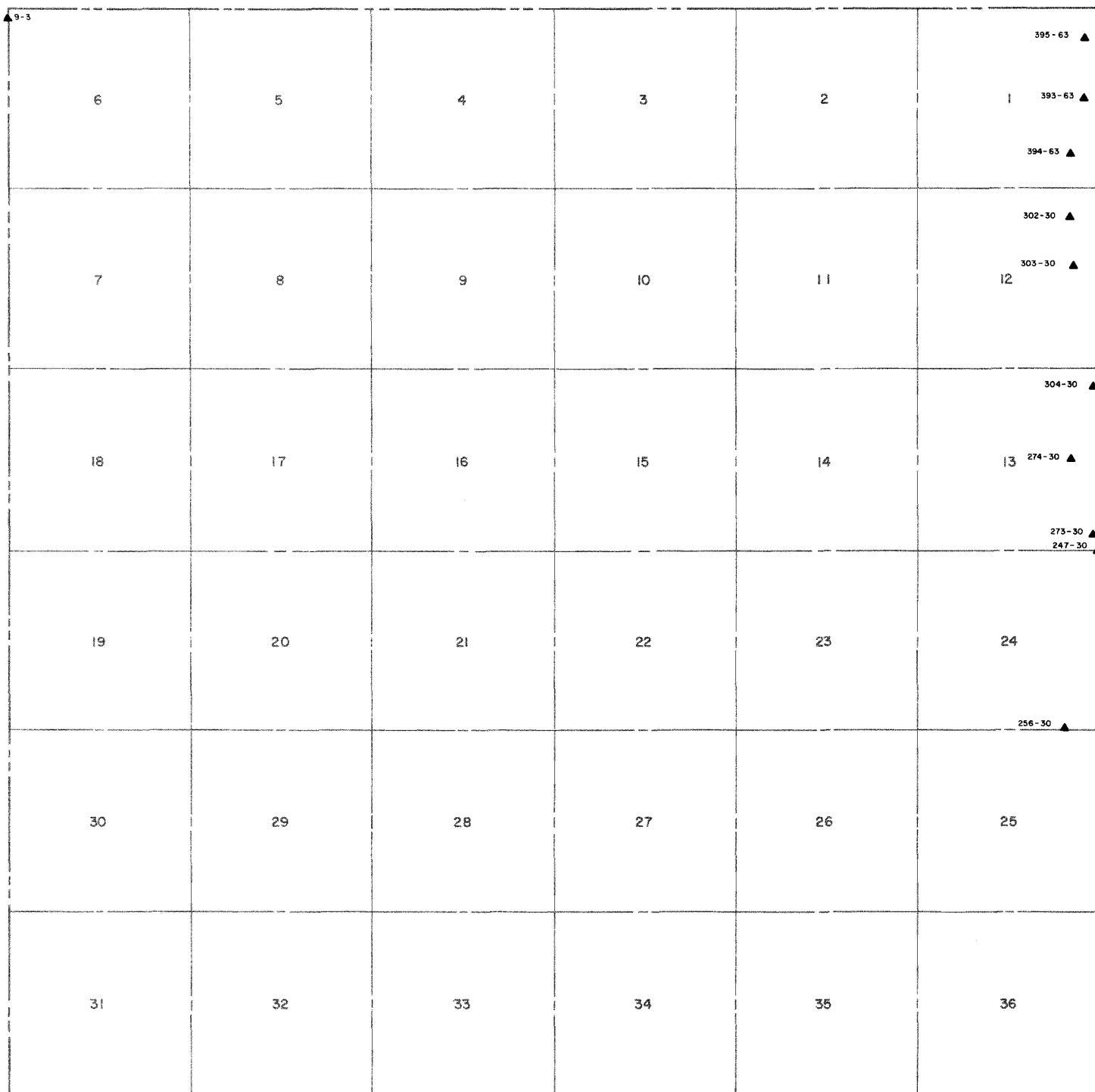
TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 16 EAST WALWORTH COUNTY



**TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 17 EAST
WALWORTH COUNTY**



TRAVERSE DIAGRAM, TOWNSHIP 3 NORTH, RANGE 18 EAST WALWORTH COUNTY



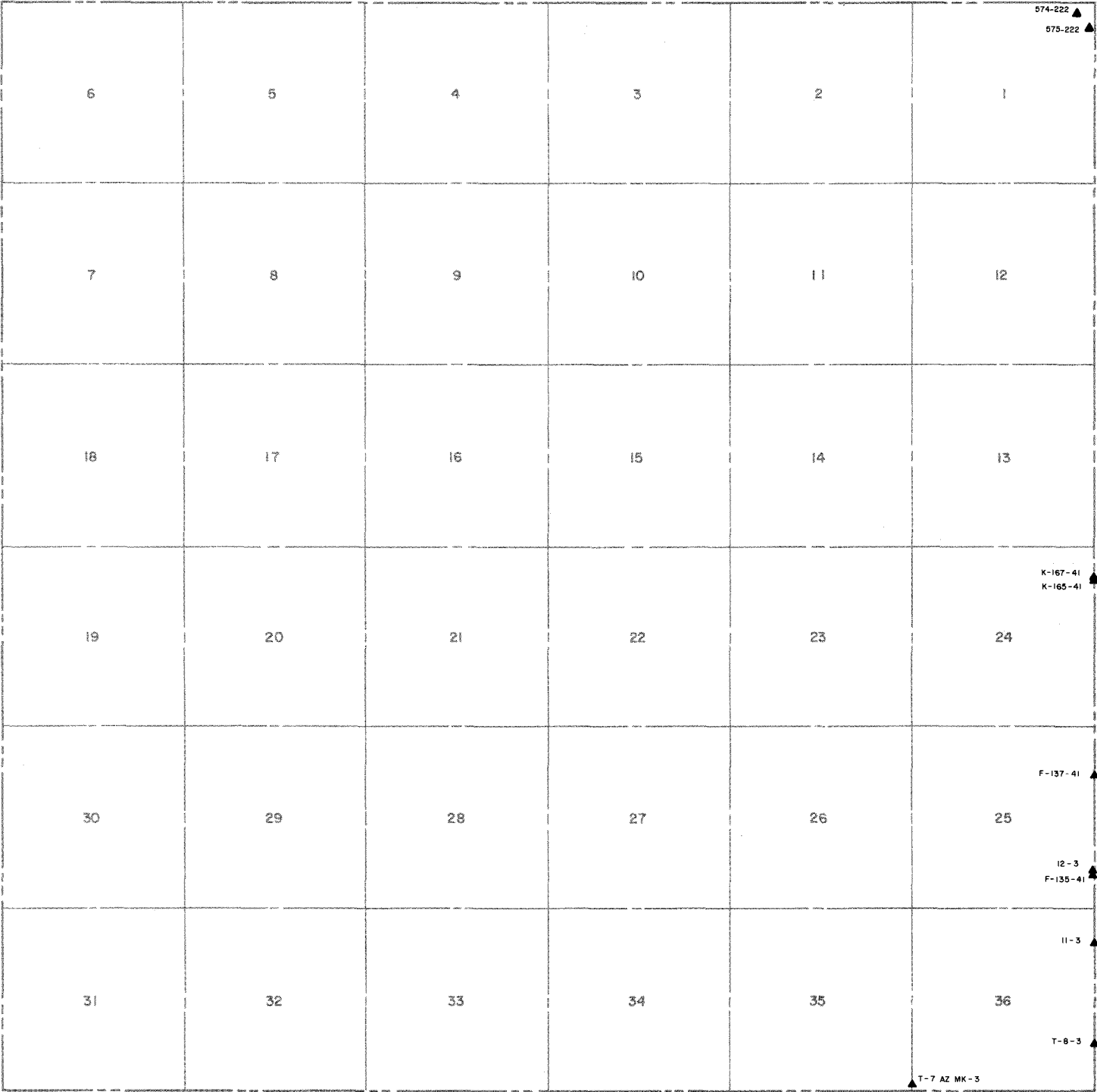
**TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 15 EAST
WALWORTH COUNTY**

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

**TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 16 EAST
WALWORTH COUNTY**

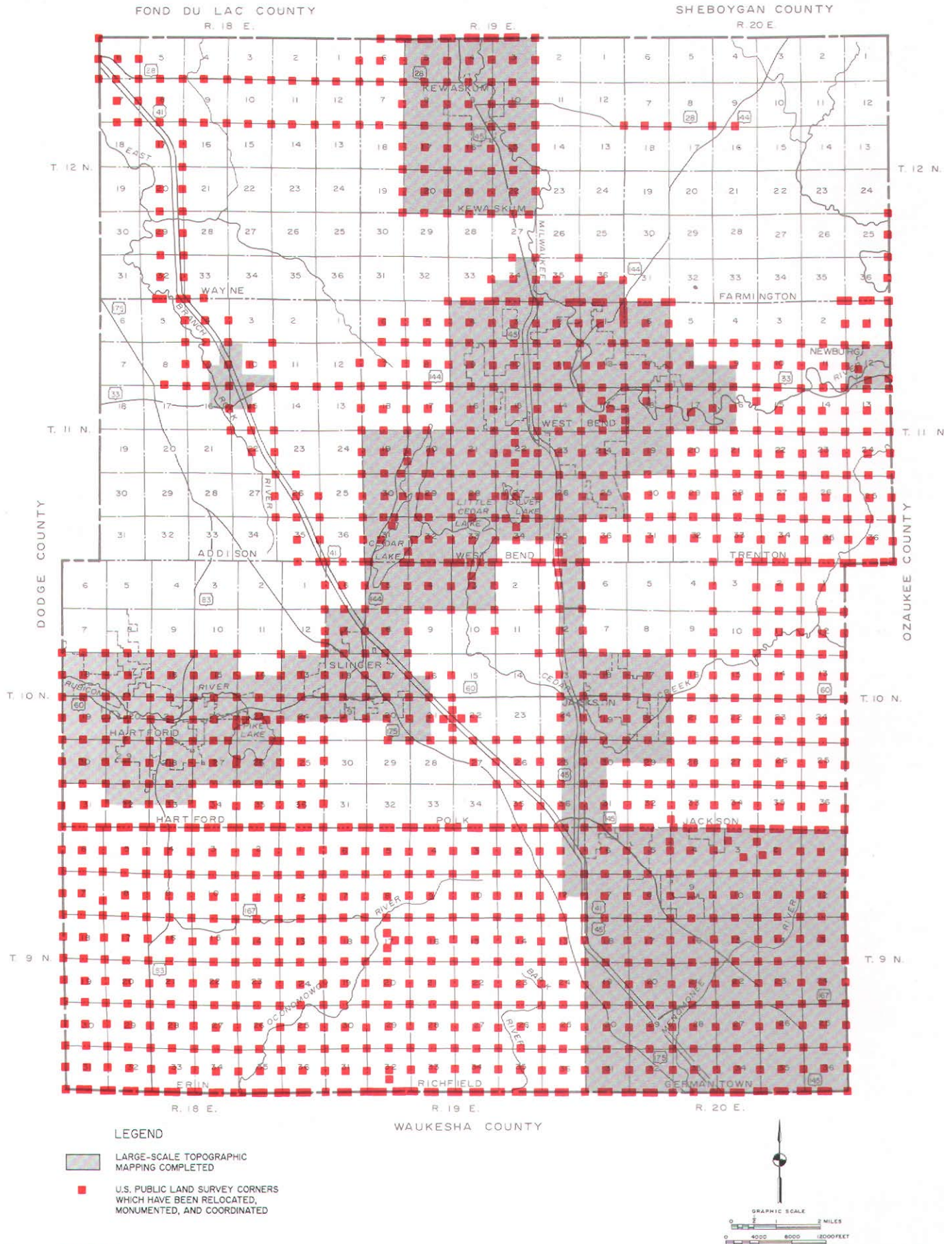
6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

TRAVERSE DIAGRAM, TOWNSHIP 4 NORTH, RANGE 17 EAST
WALWORTH COUNTY

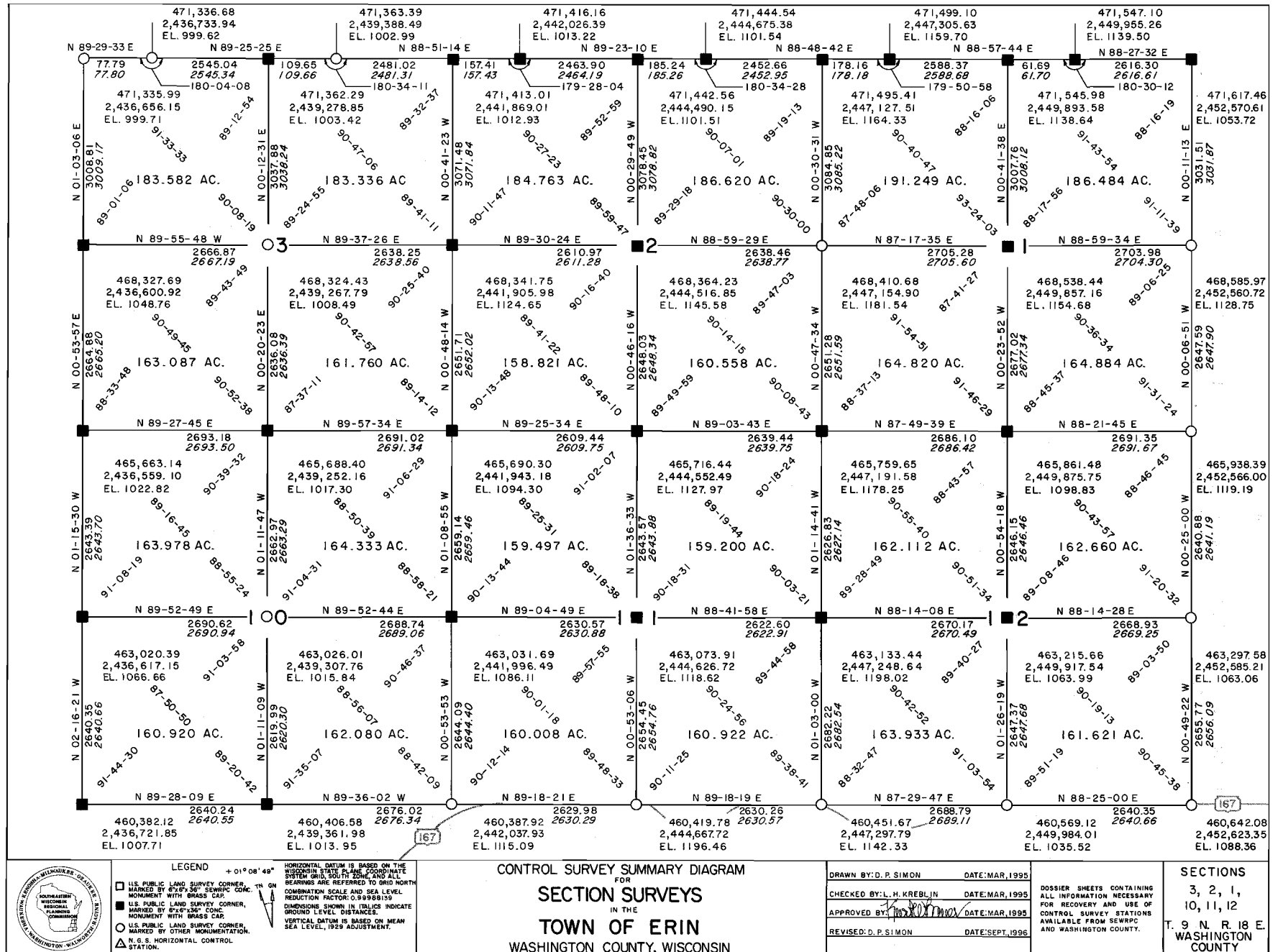


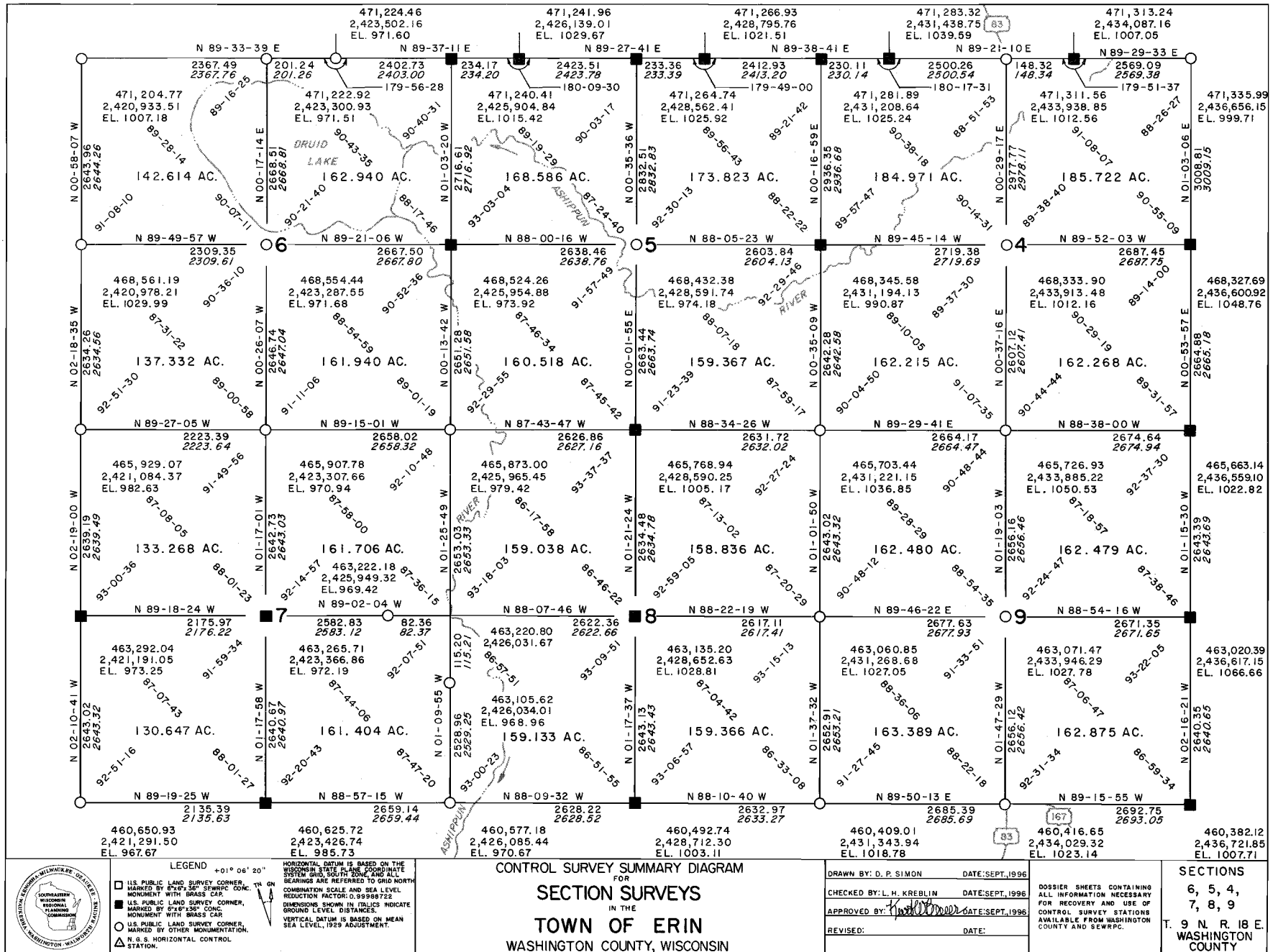
Map C-6

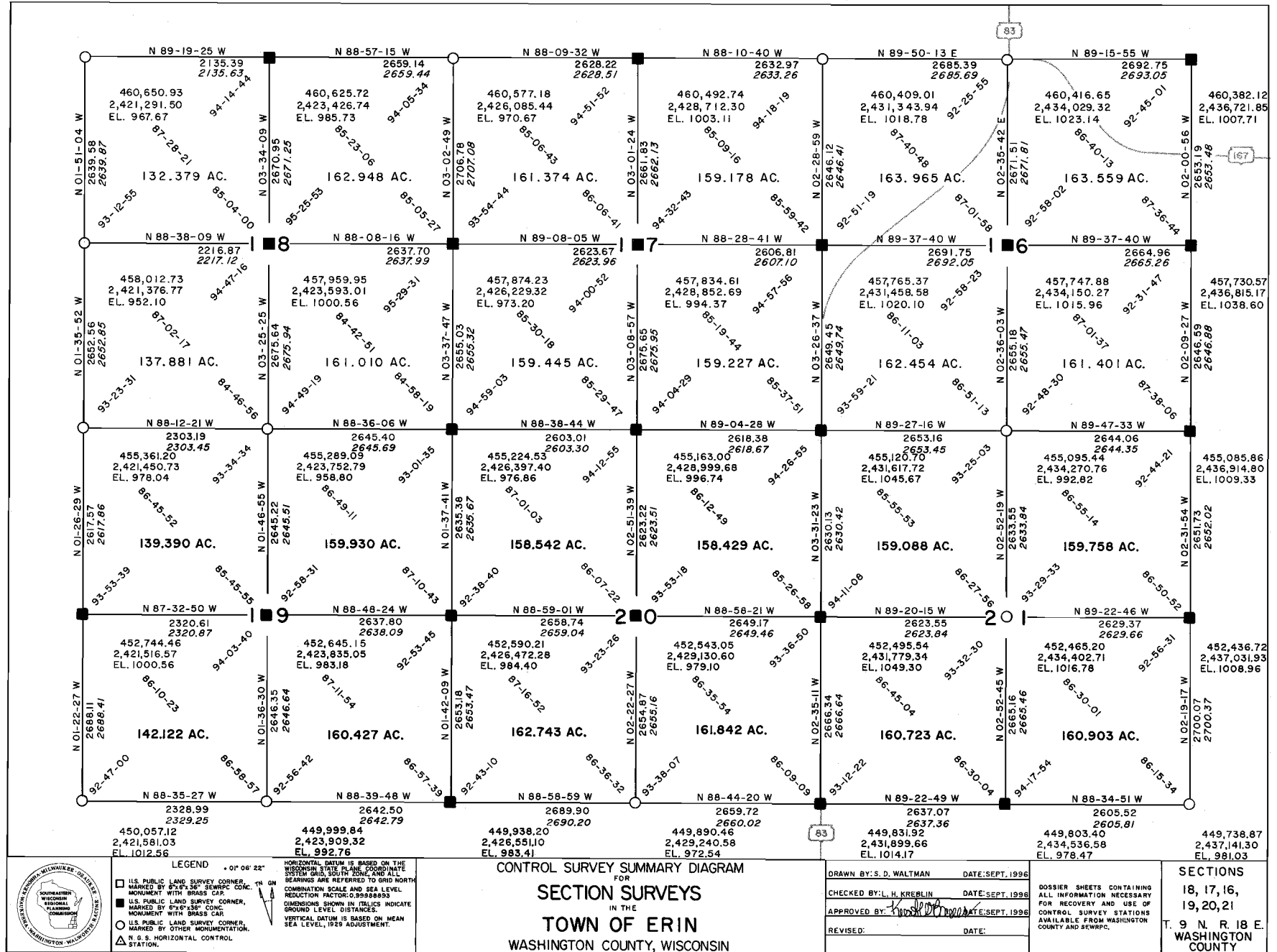
STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE RELOCATION, MONUMENTATION, AND COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS IN WASHINGTON COUNTY: SEPTEMBER 1996

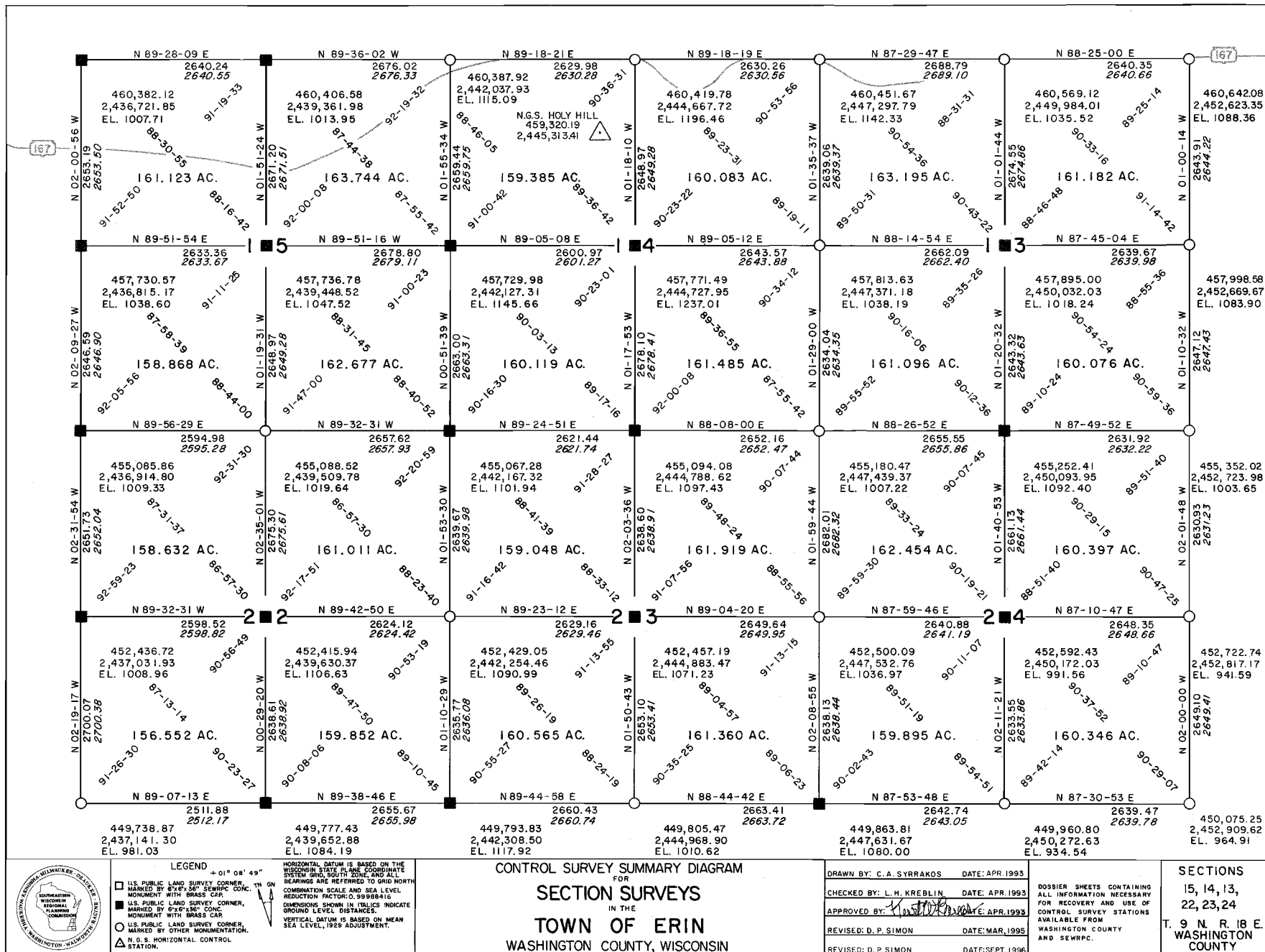


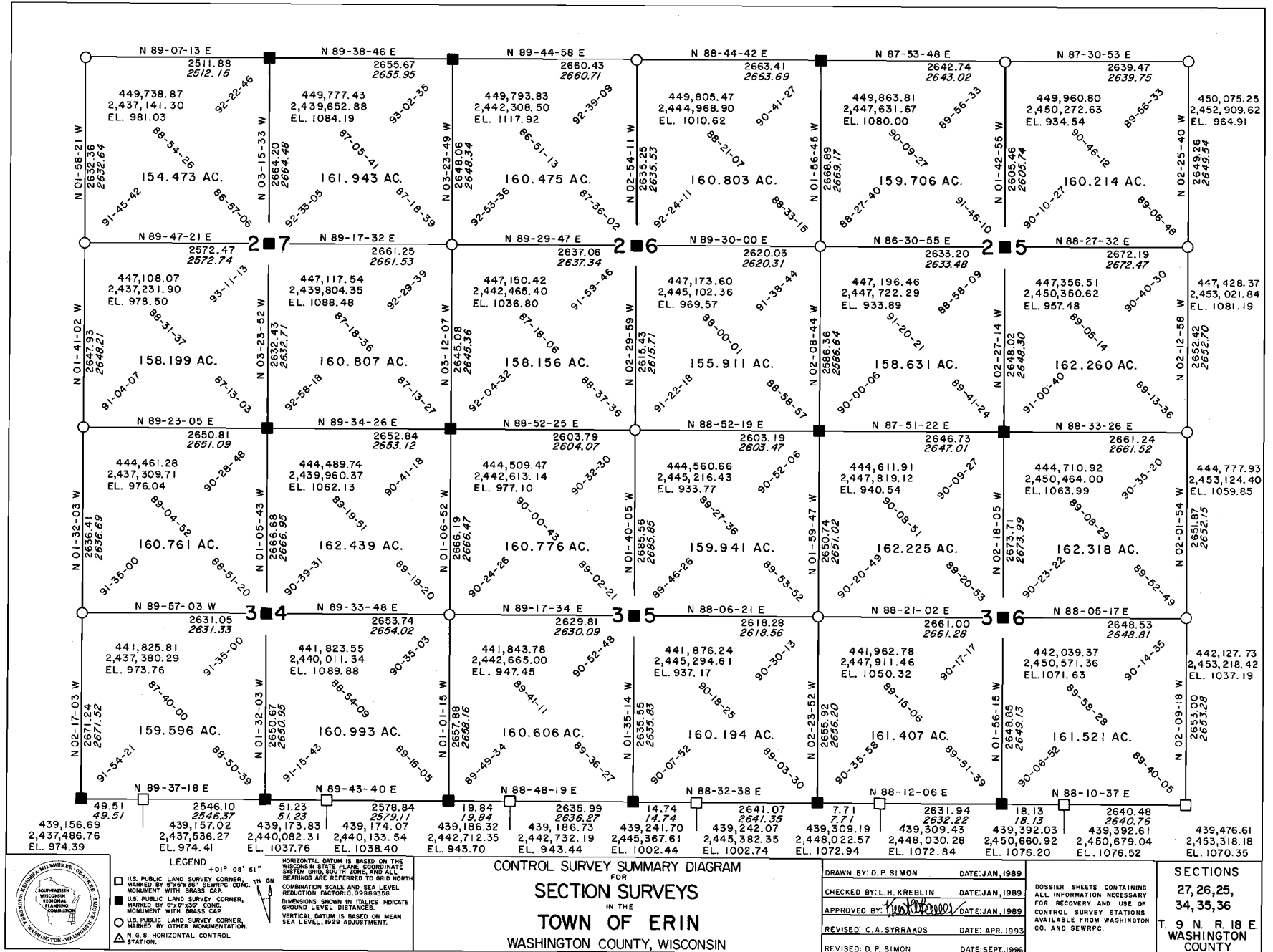
Source: SEWRPC.

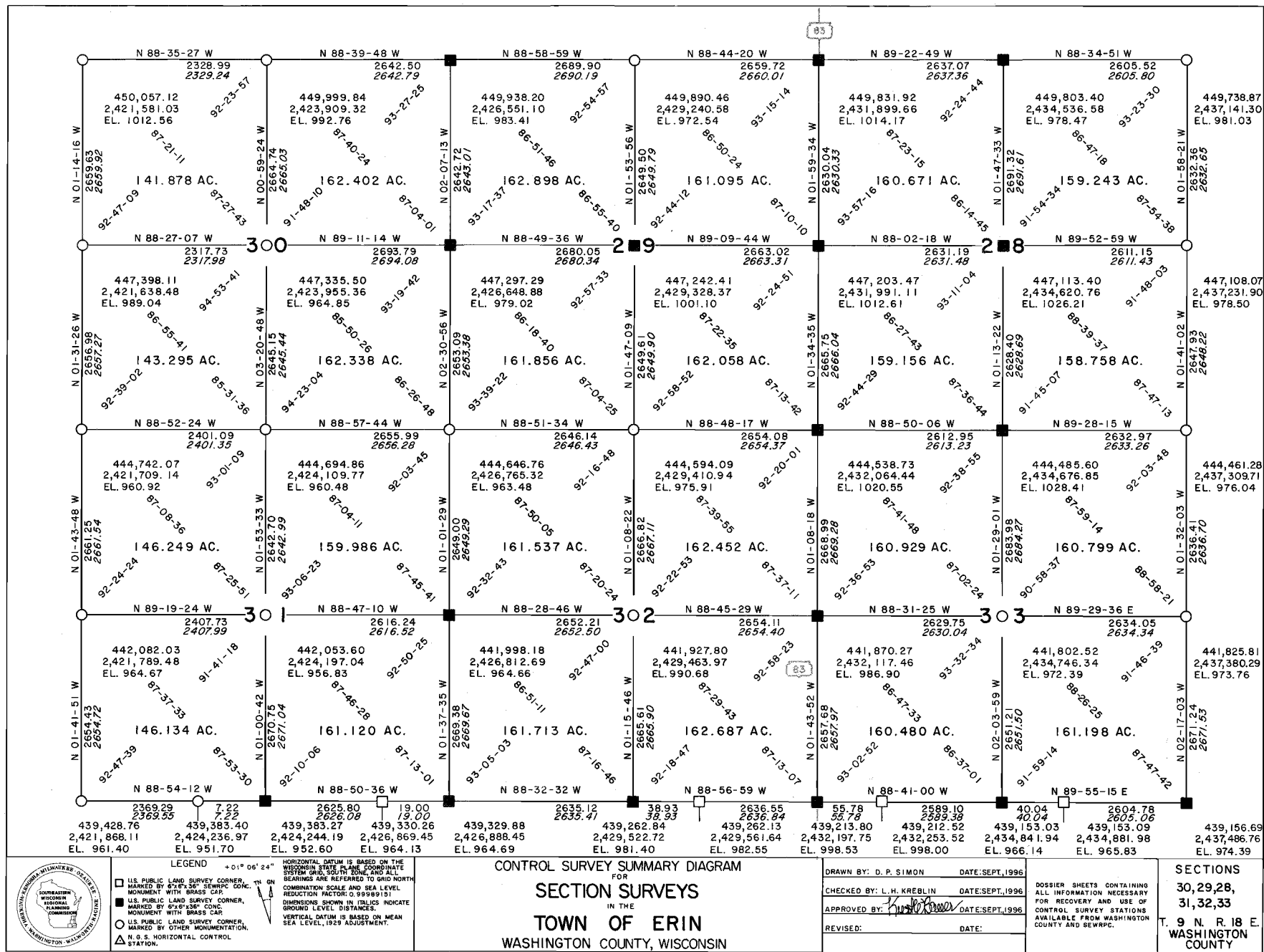


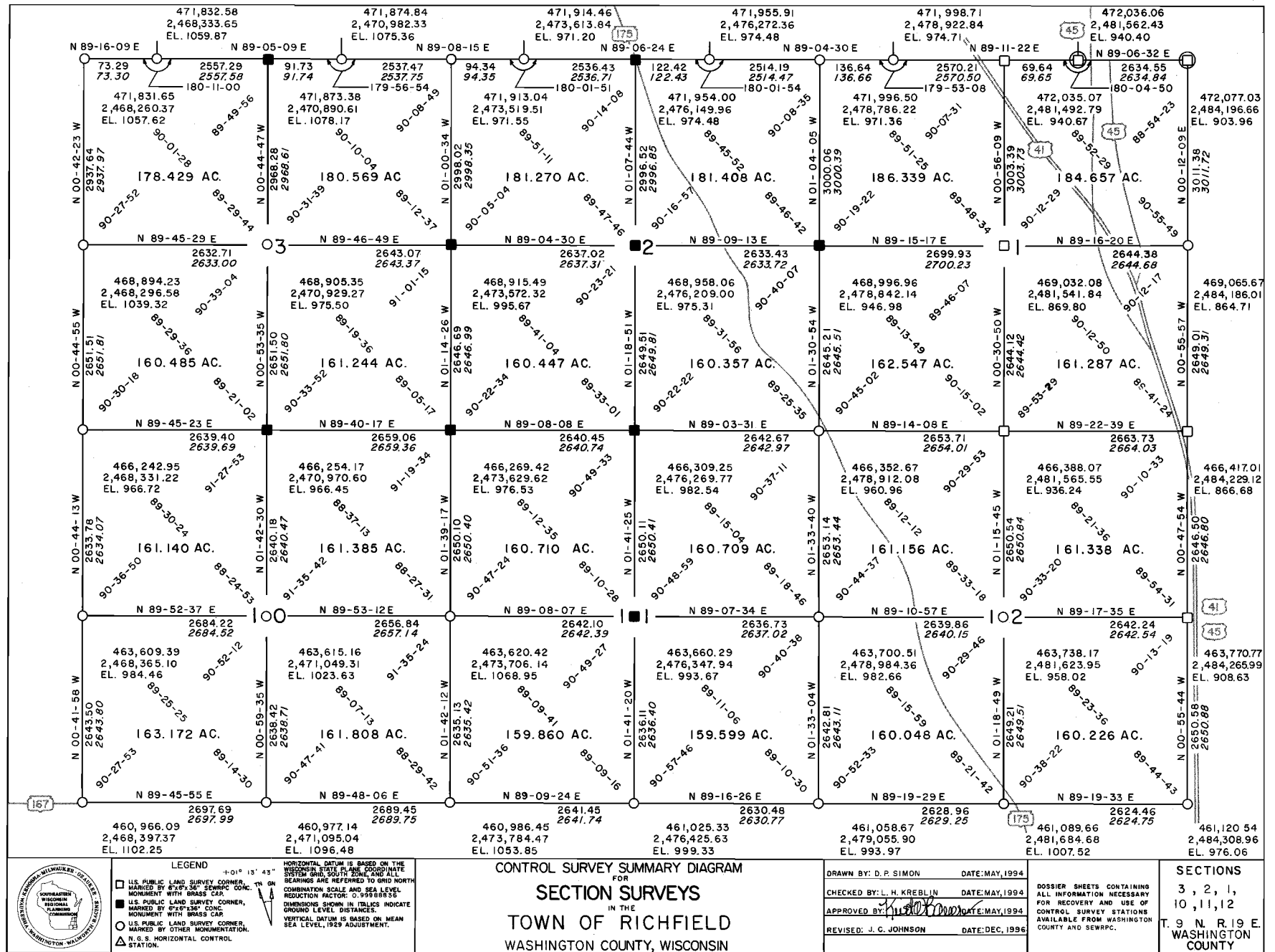


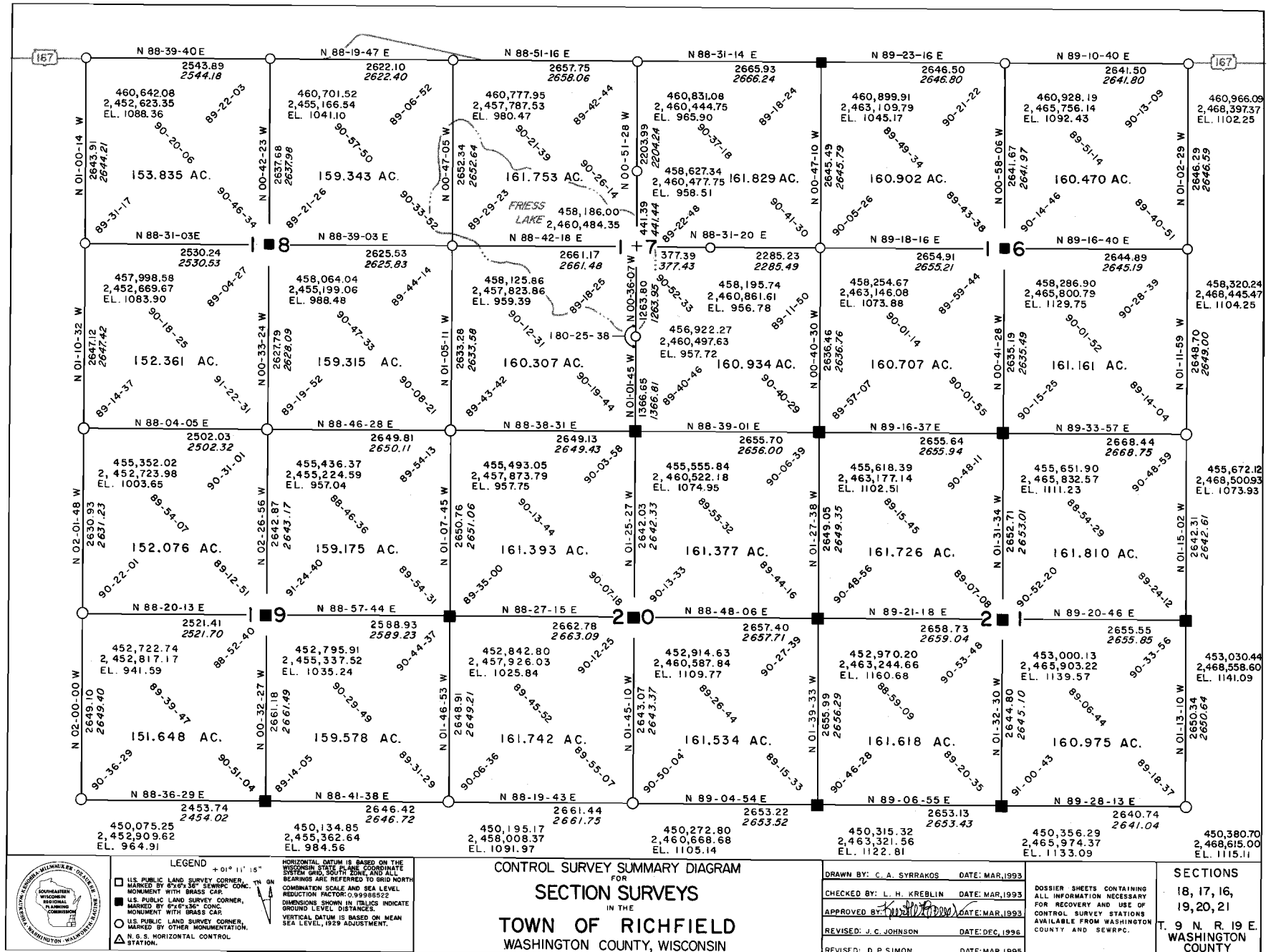


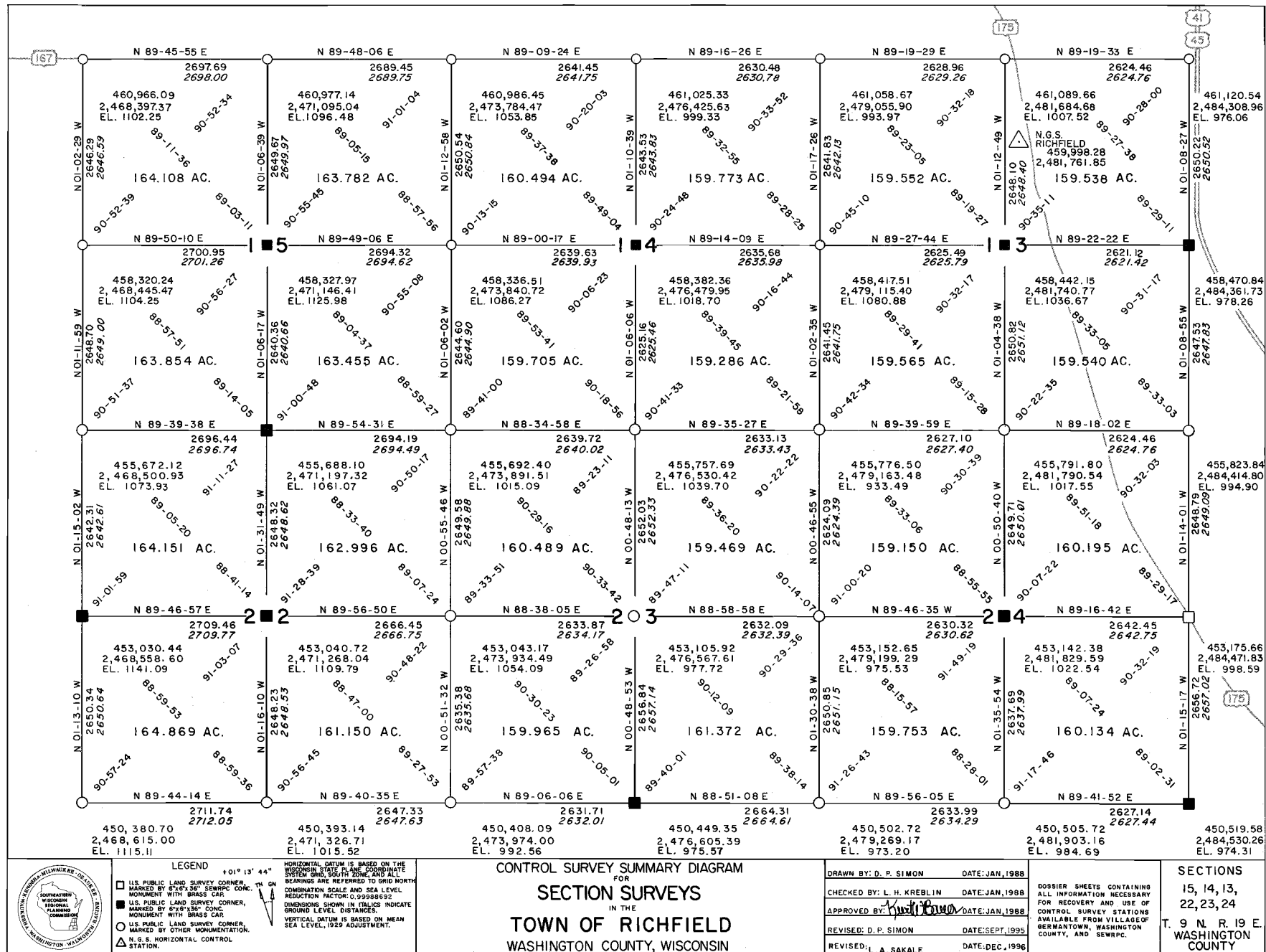


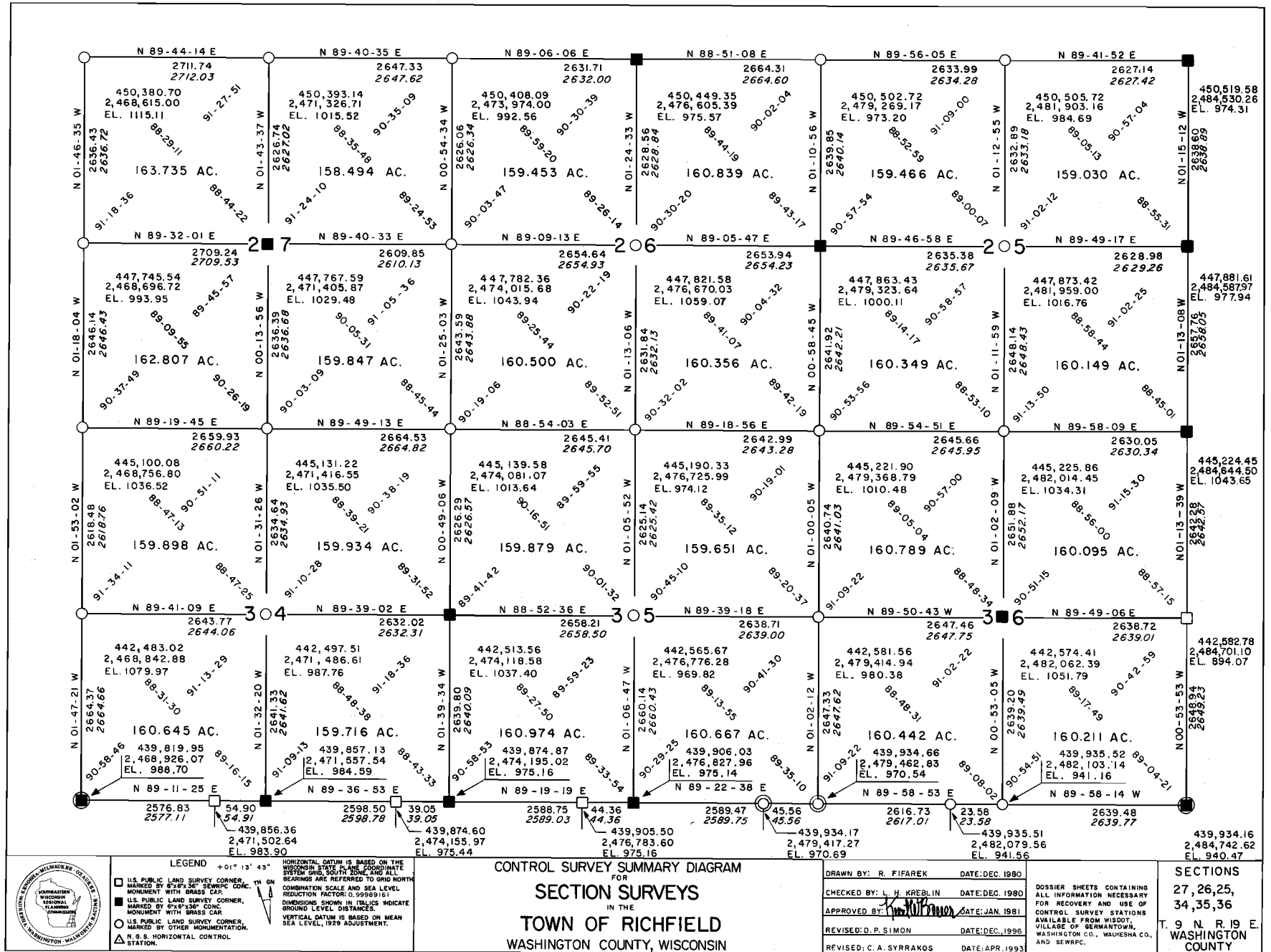


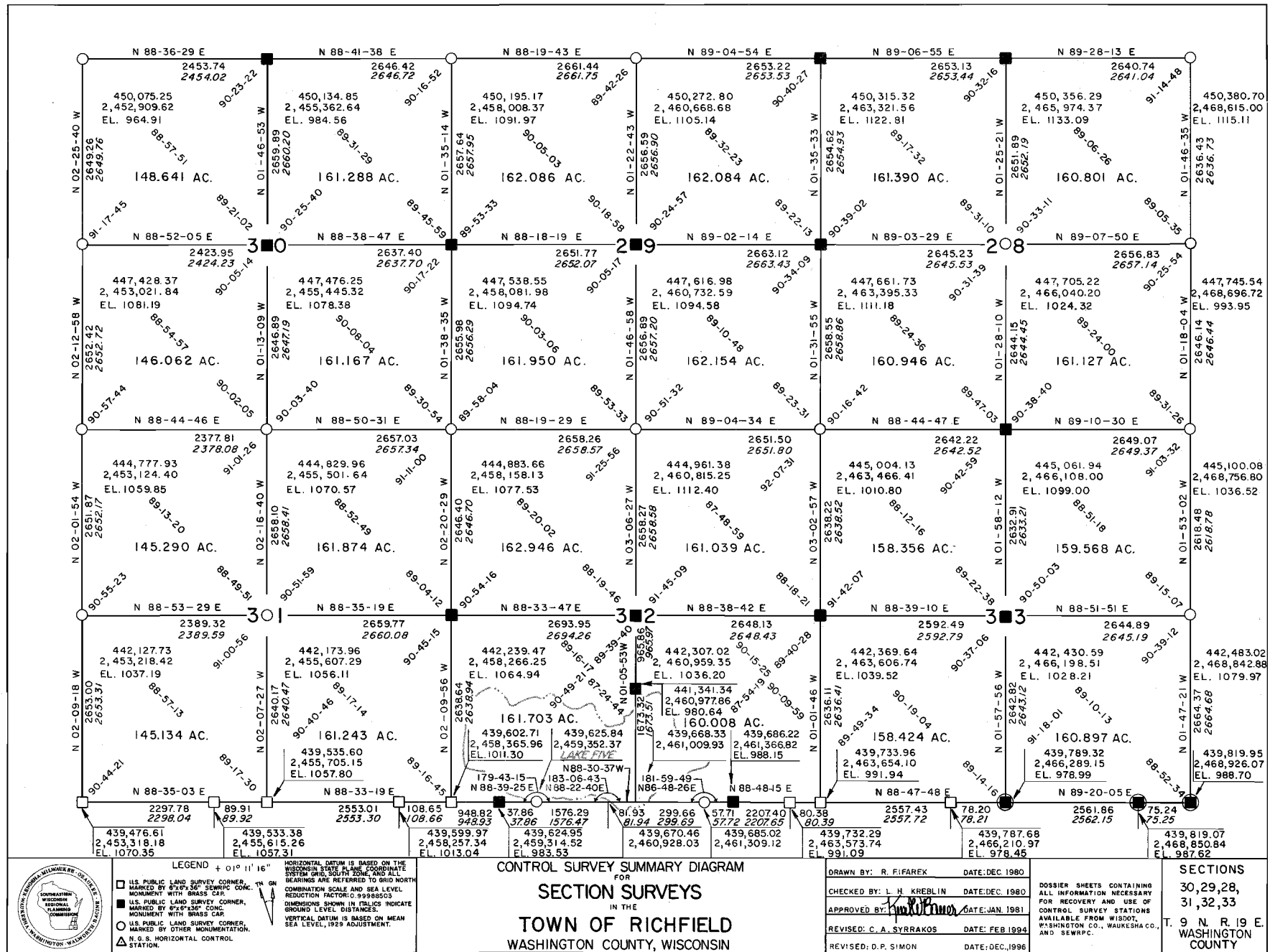




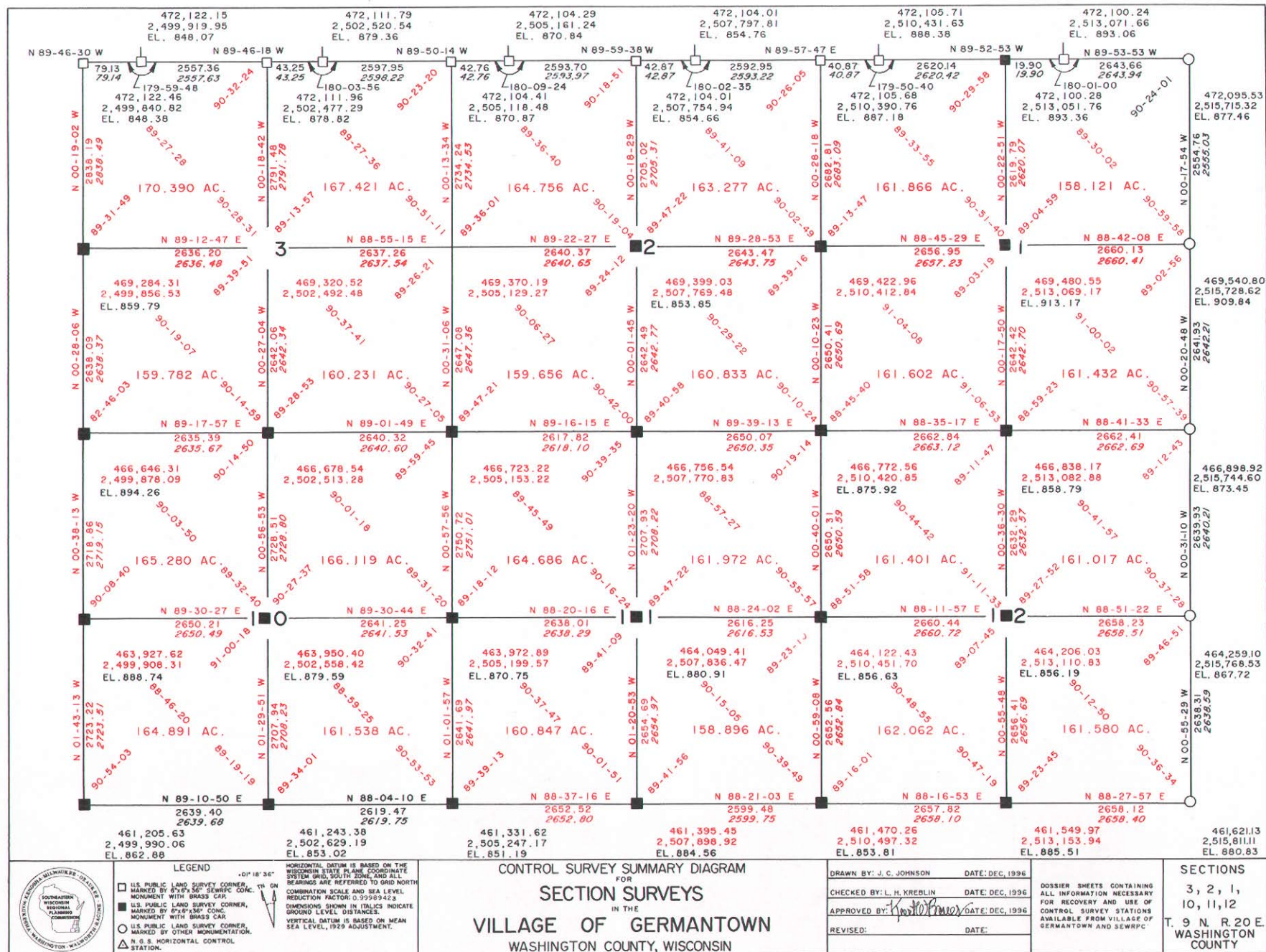


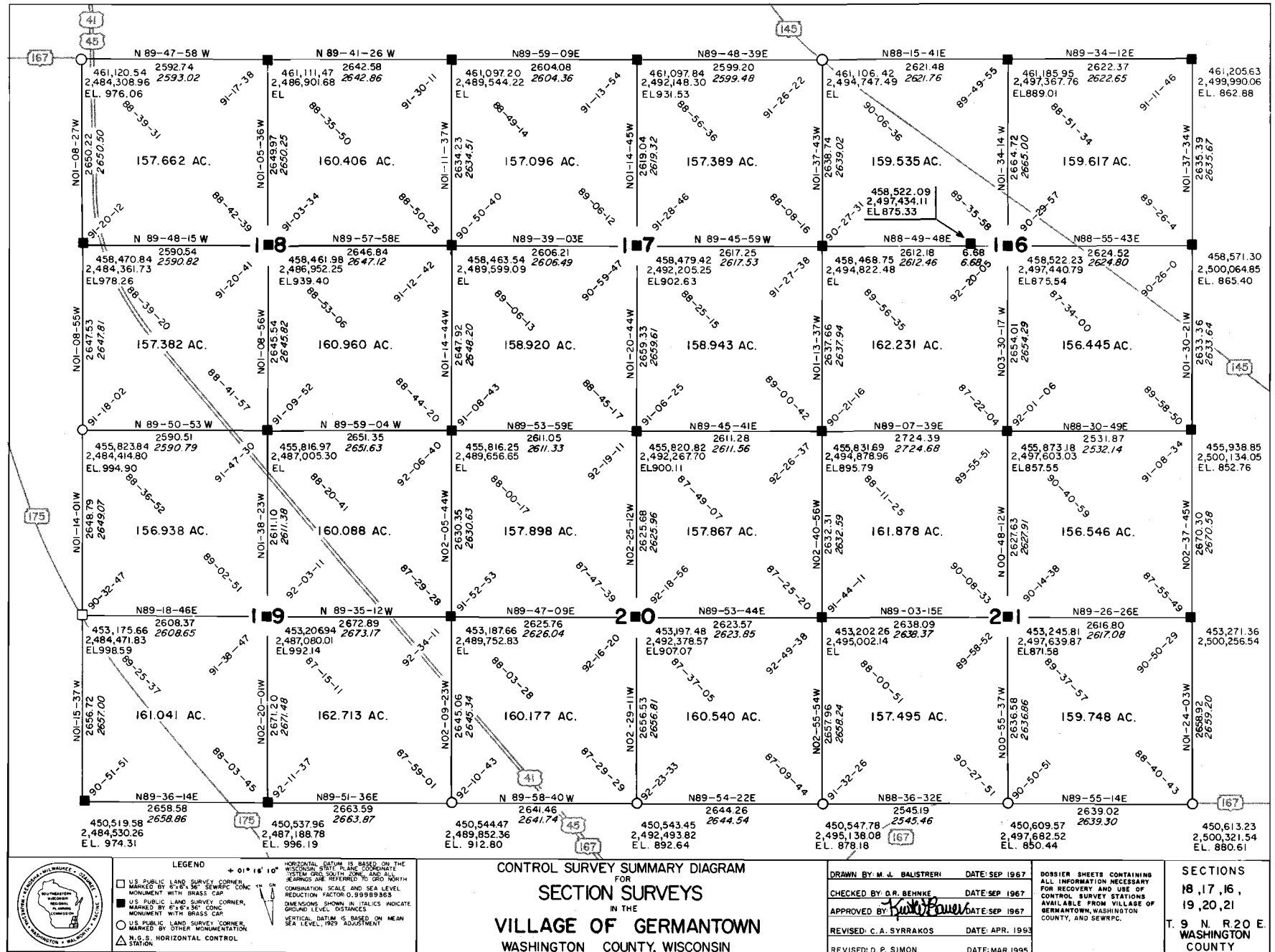




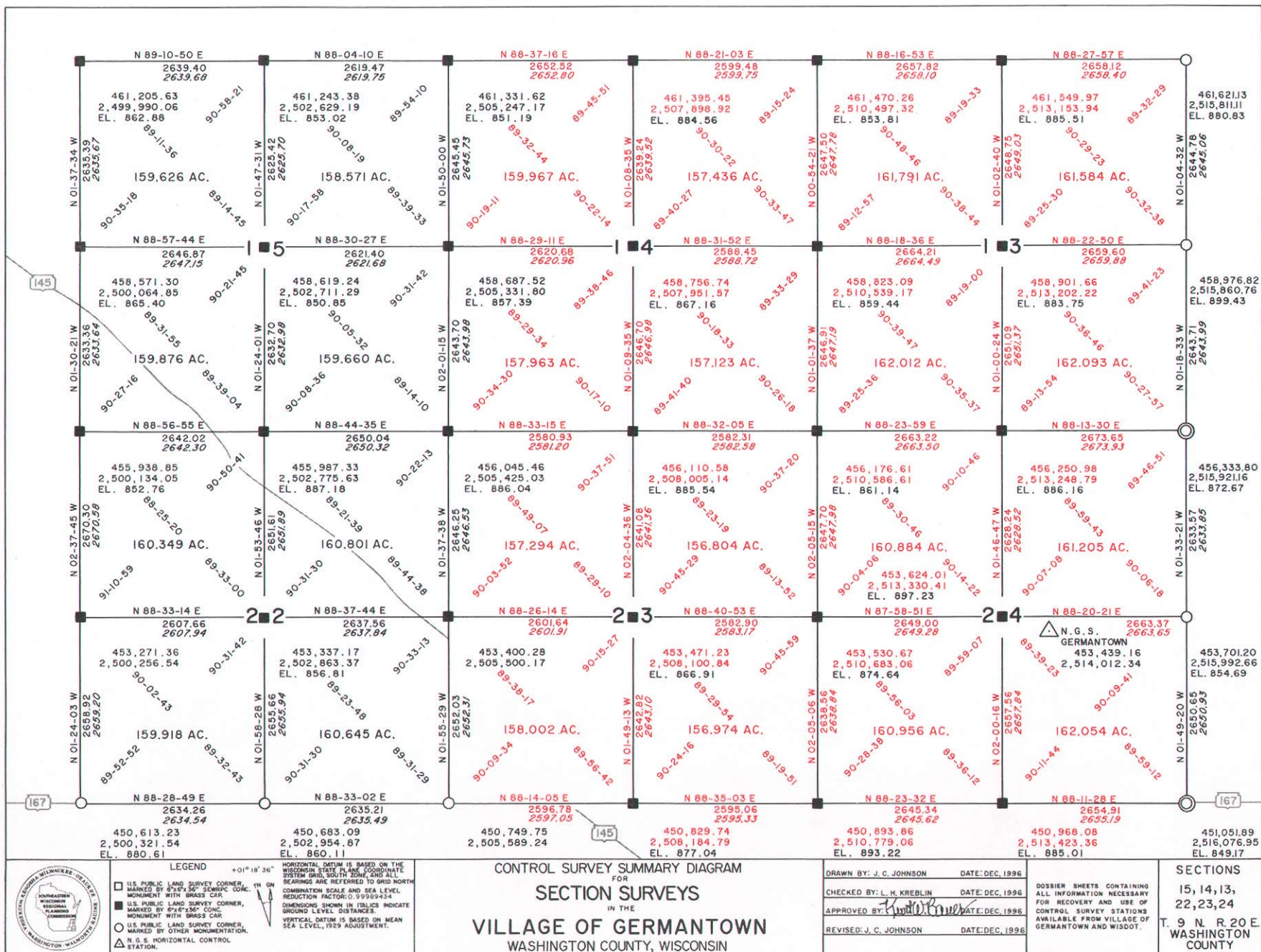


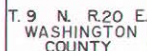
462

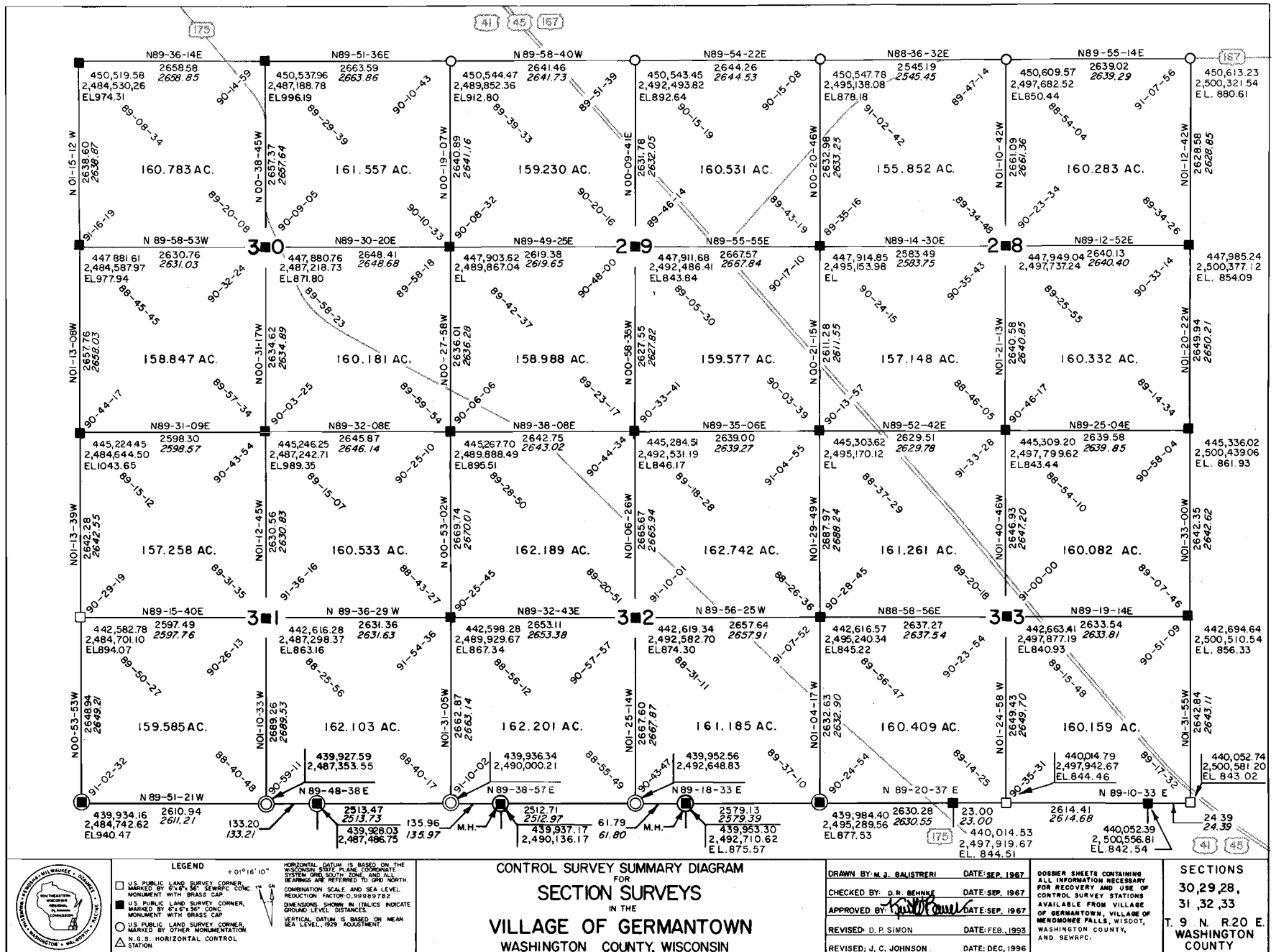


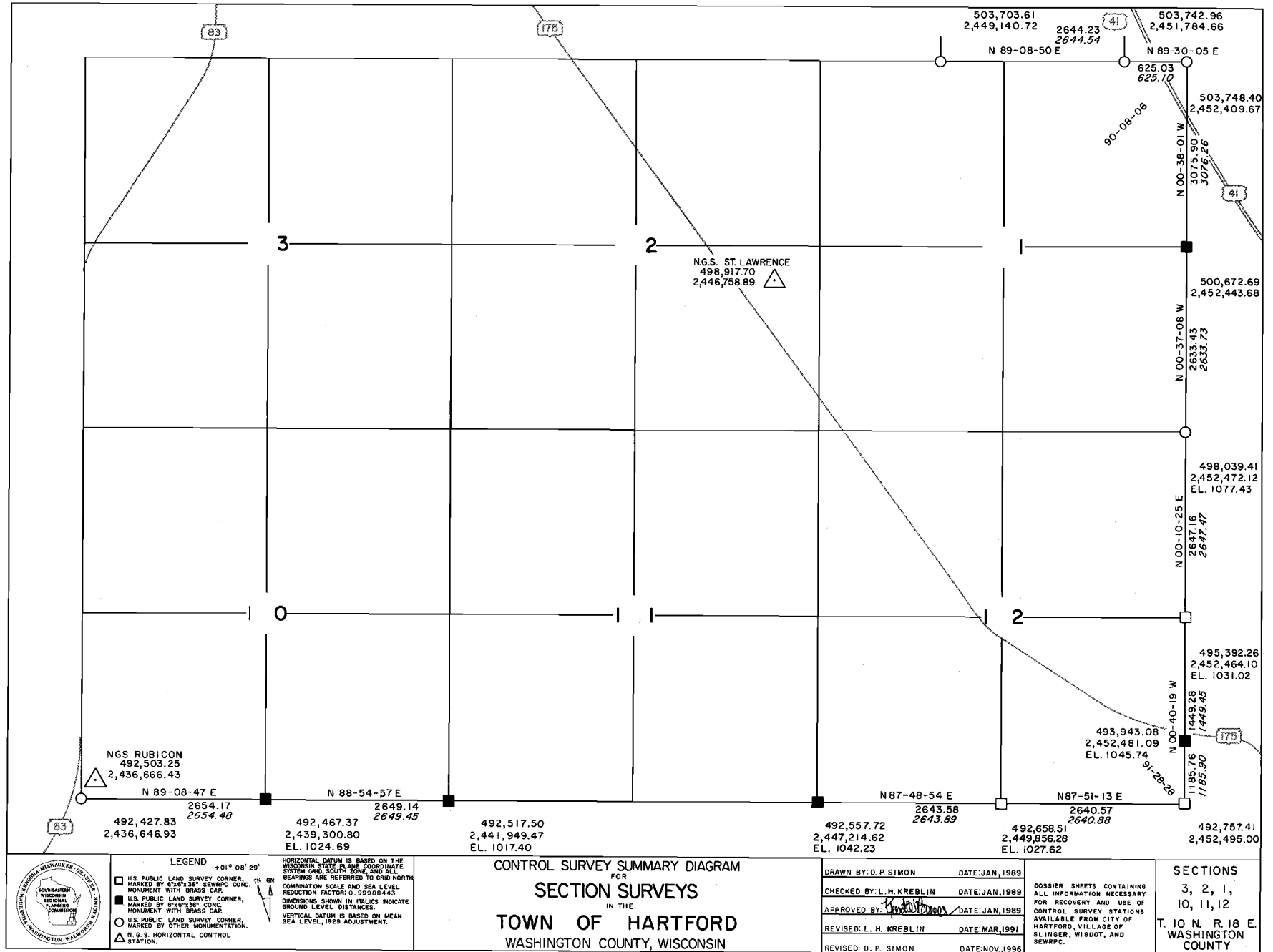


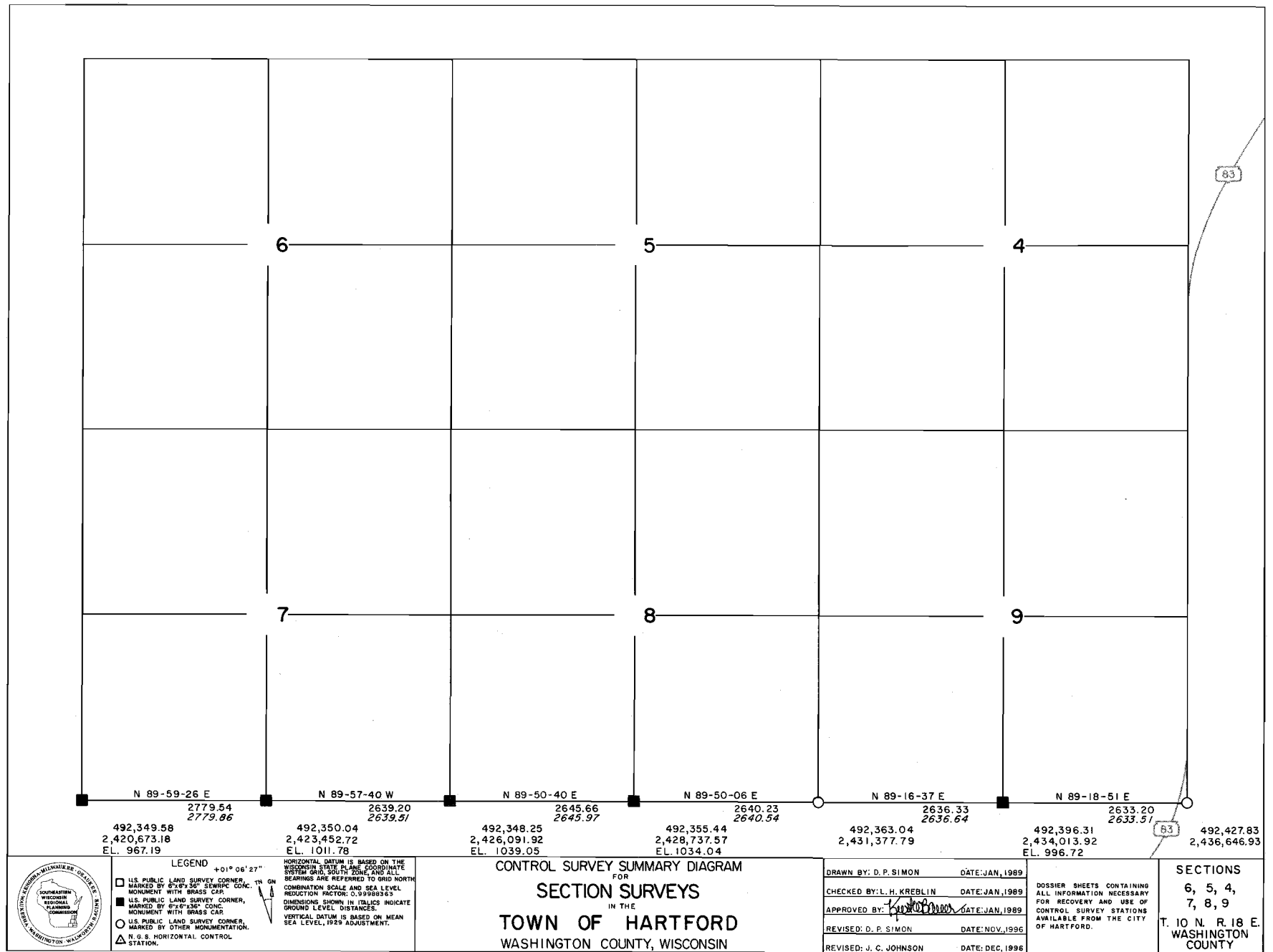
THE HORIZONTAL CONTROL SURVEY DATA SHOWN IN RED WERE DERIVED BY A READJUSTMENT OF PREVIOUSLY ADJUSTED DATA AND, AS SUCH, MAY NOT MEET THIRD ORDER, CLASS I ACCURACY. FIELD VERIFICATION OF THE DATA SHOWN IN RED MAY BE DESIRABLE, AND THE REQUIRED ADDITIONAL FIELD SURVEYS NECESSARY TO CORRECT ANY CONTROL SURVEY DEFICIENCIES ARE BEING SCHEDULED.

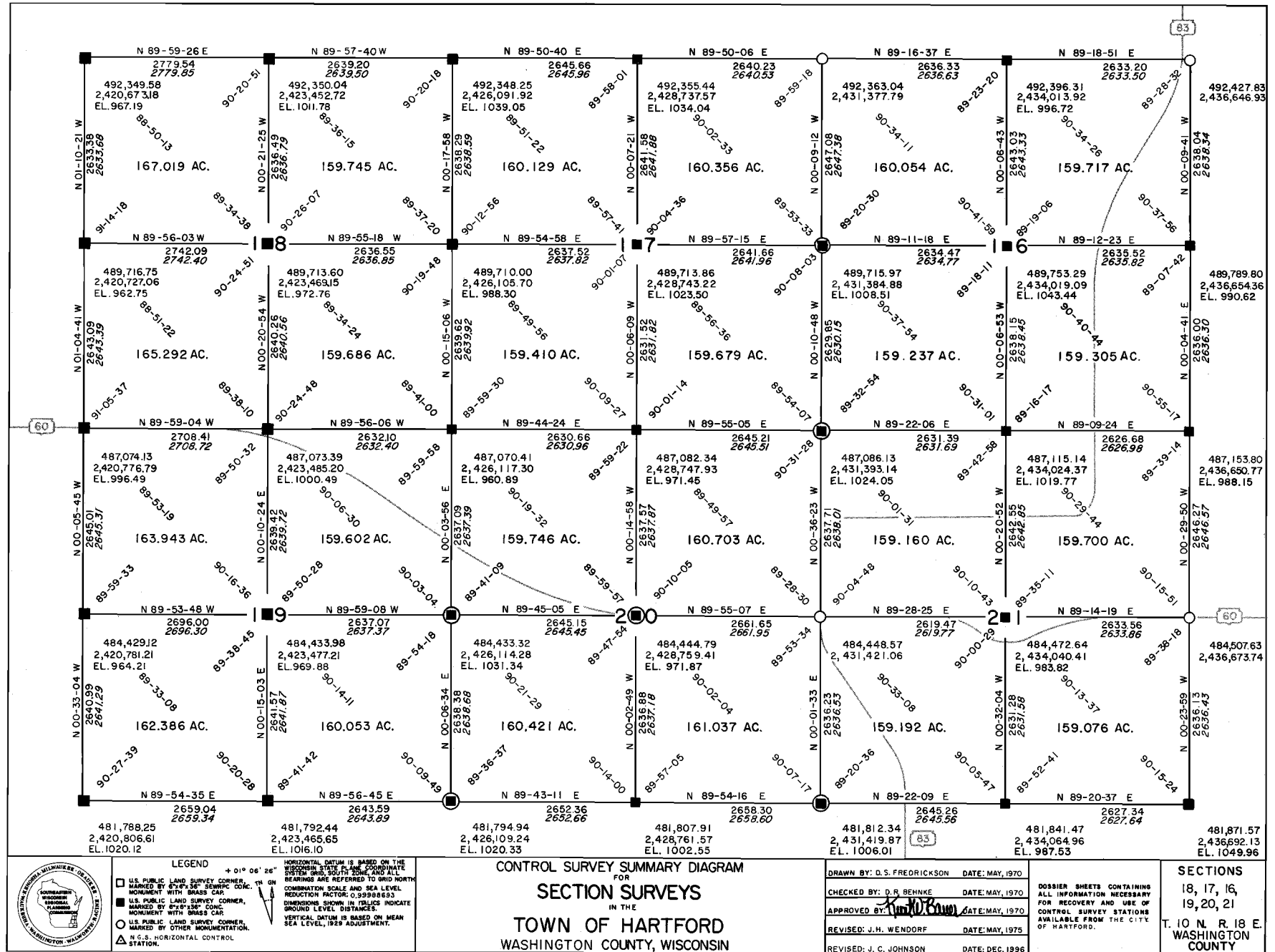


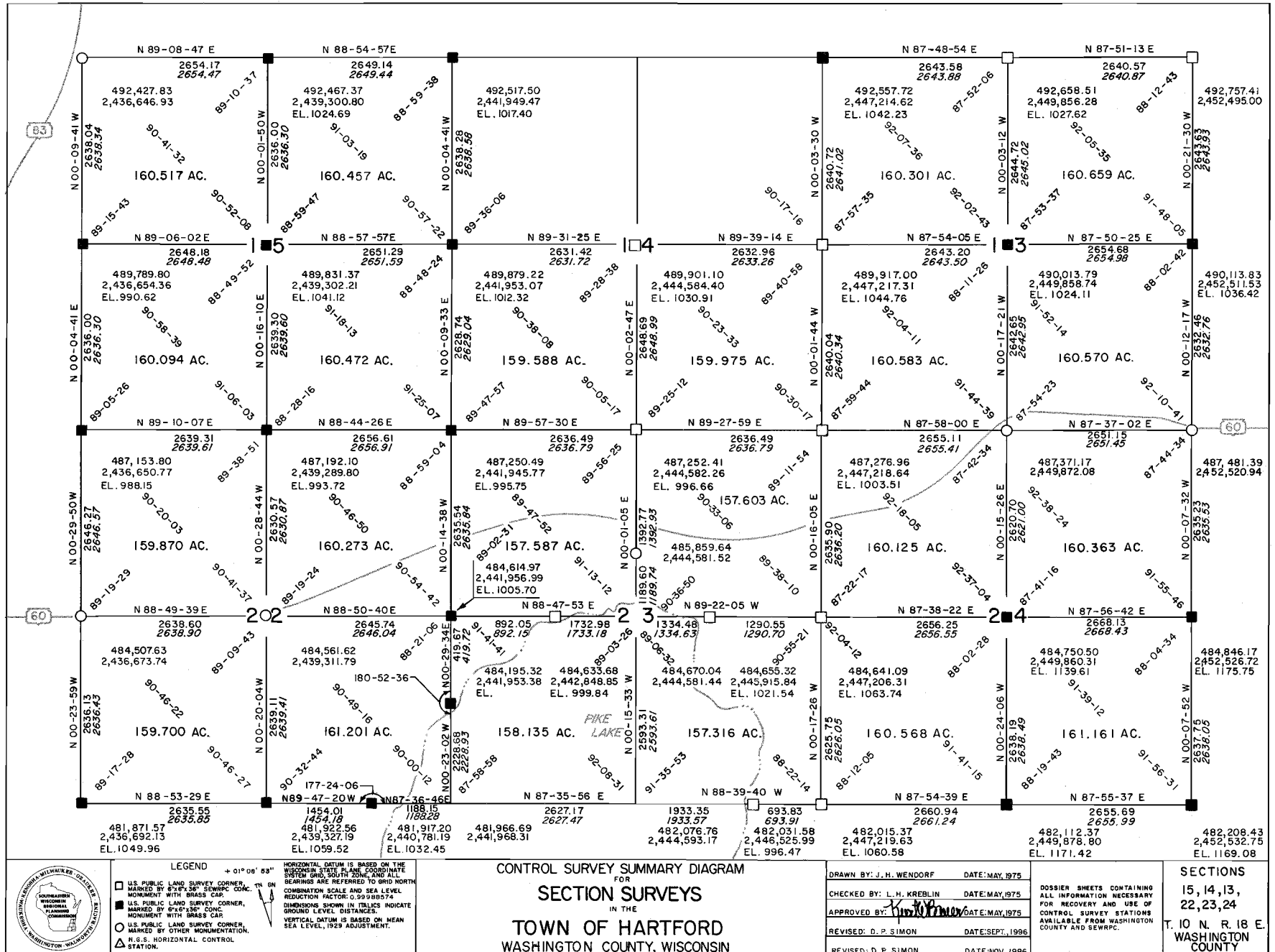


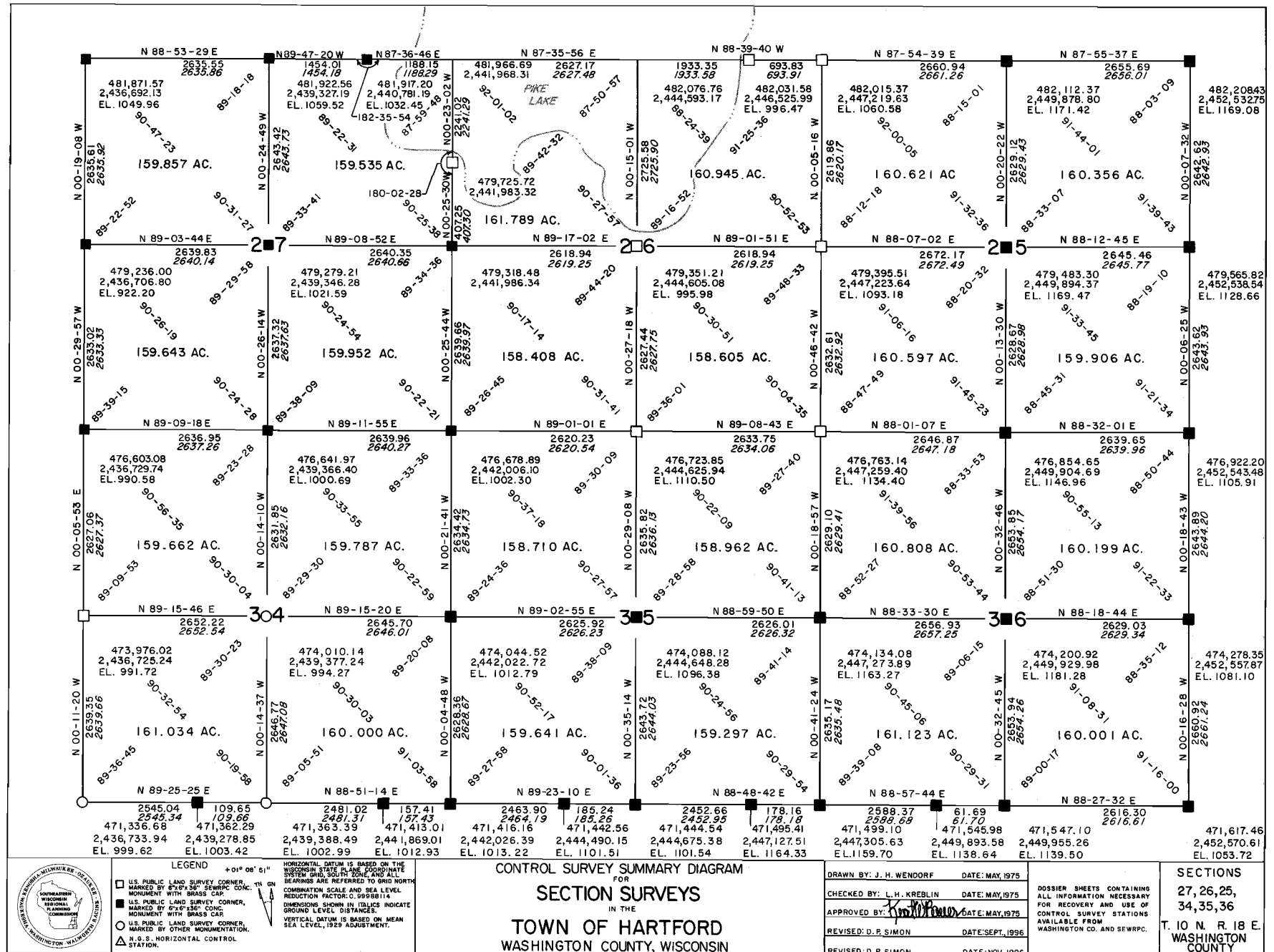


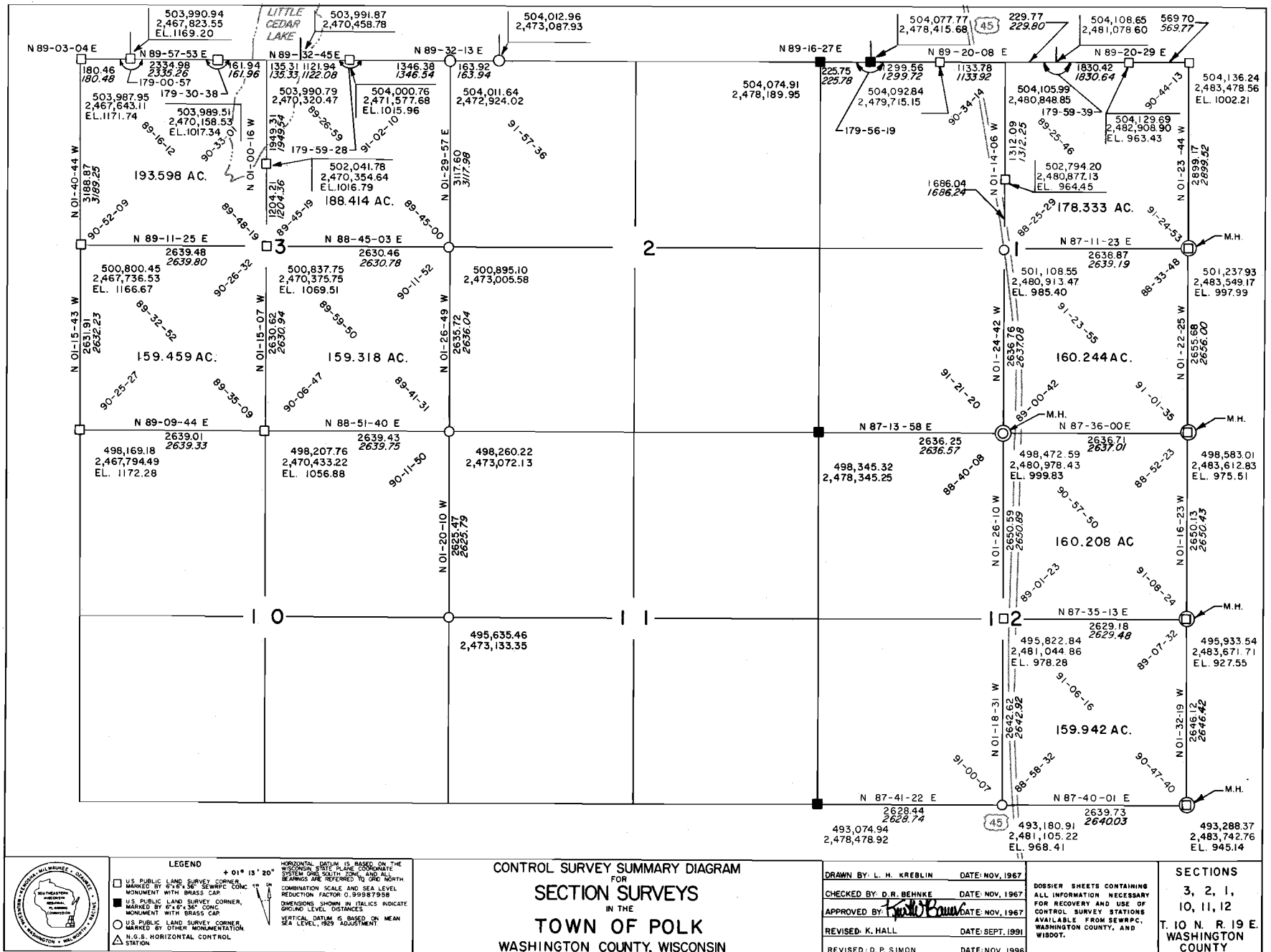


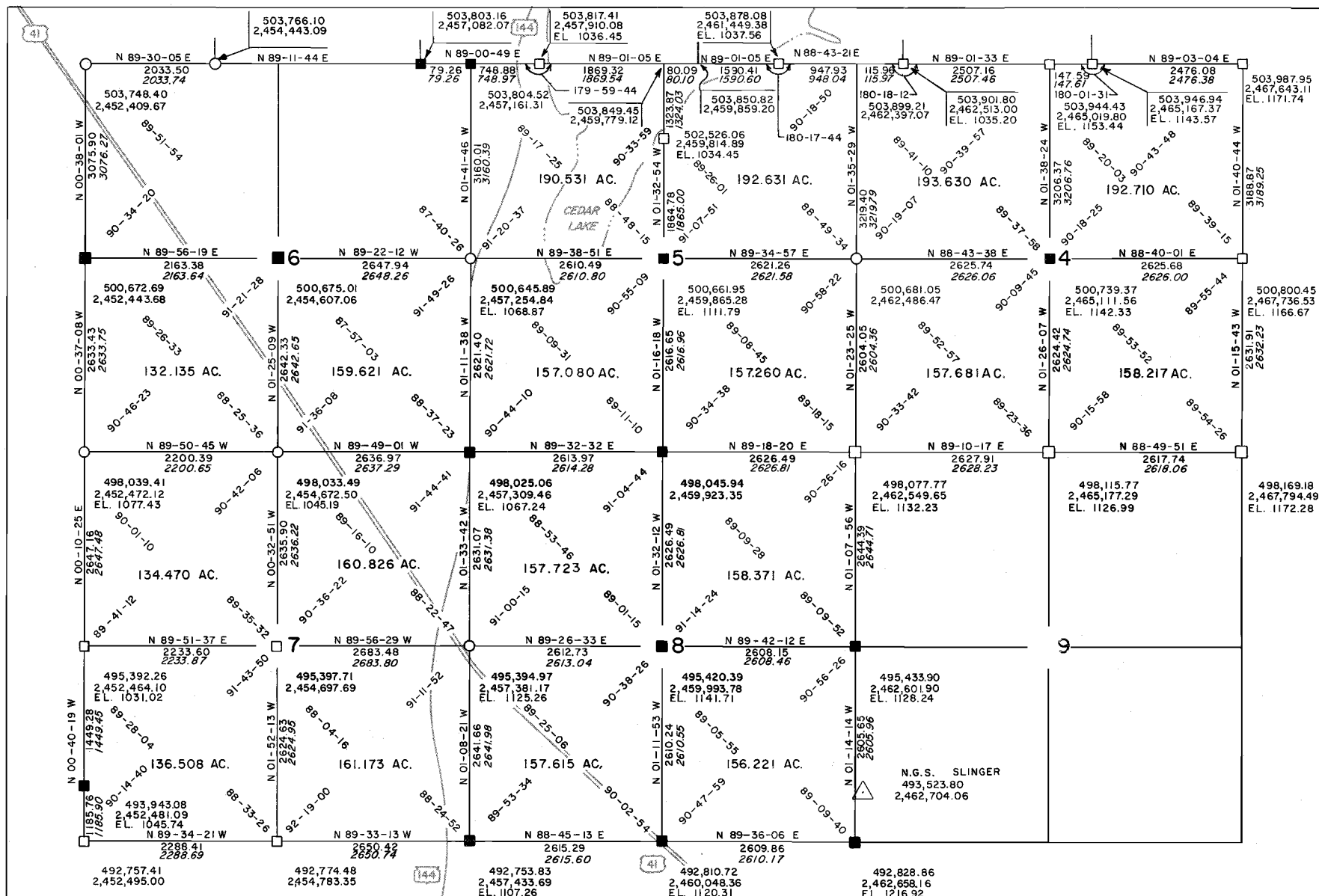












LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 8" x 8" x 1/2" CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 6" x 1/2" CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- N.G.S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, GRID, SOUTH ZONE, AND BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.9998796. DIMENSIONS SHOWN IN FEET INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

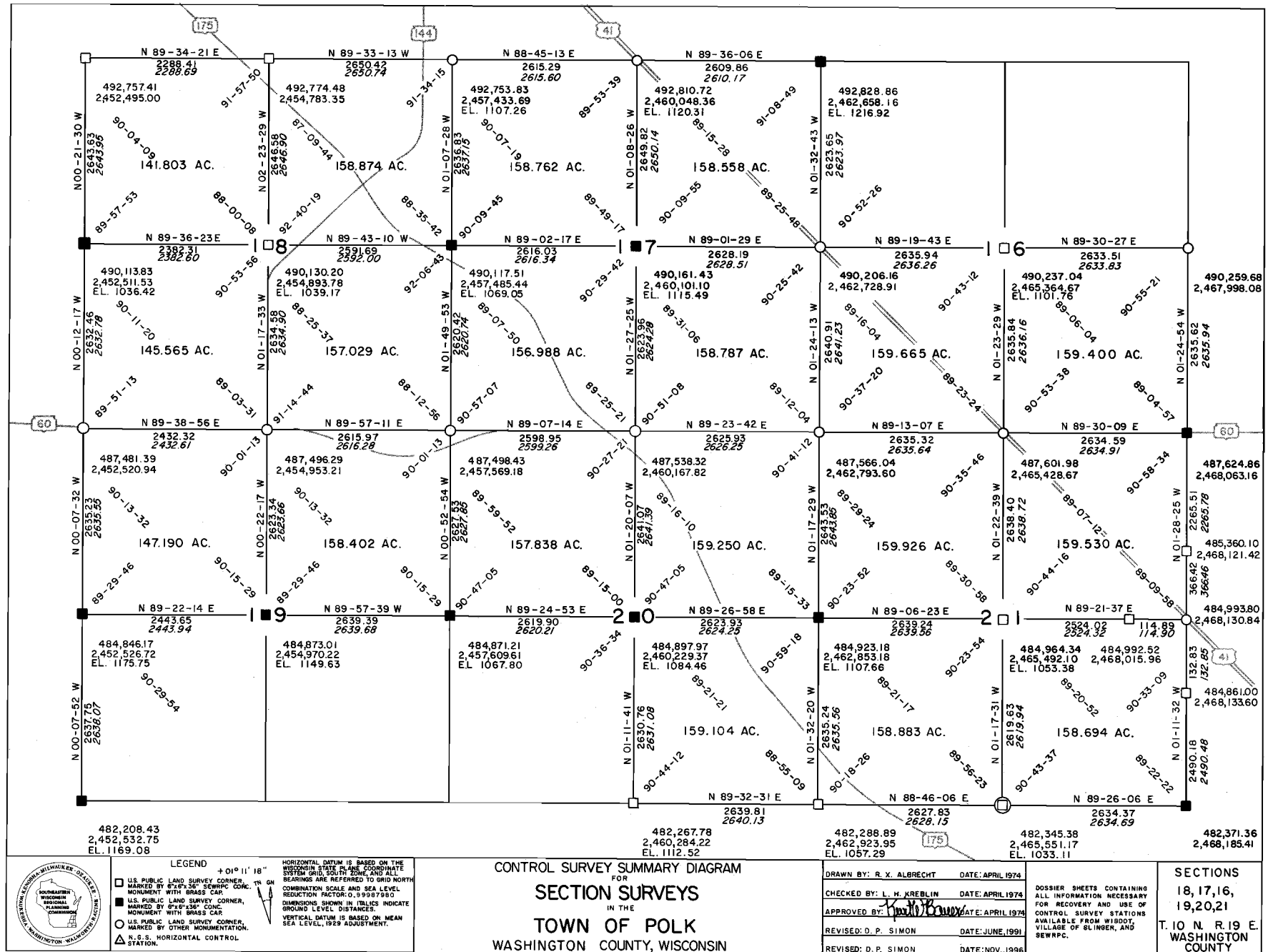
CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF POLK WASHINGTON COUNTY, WISCONSIN

DRAWN BY: R. X. ALBRECHT DATE: APRIL 1974
 CHECKED BY: L. M. KREBLIN DATE: APRIL 1974
 APPROVED BY: *[Signature]* DATE: APRIL 1974
 REVISED: L. H. KREBLIN DATE: MAR. 1991
 REVISED: D. P. SIMON DATE: NOV. 1996

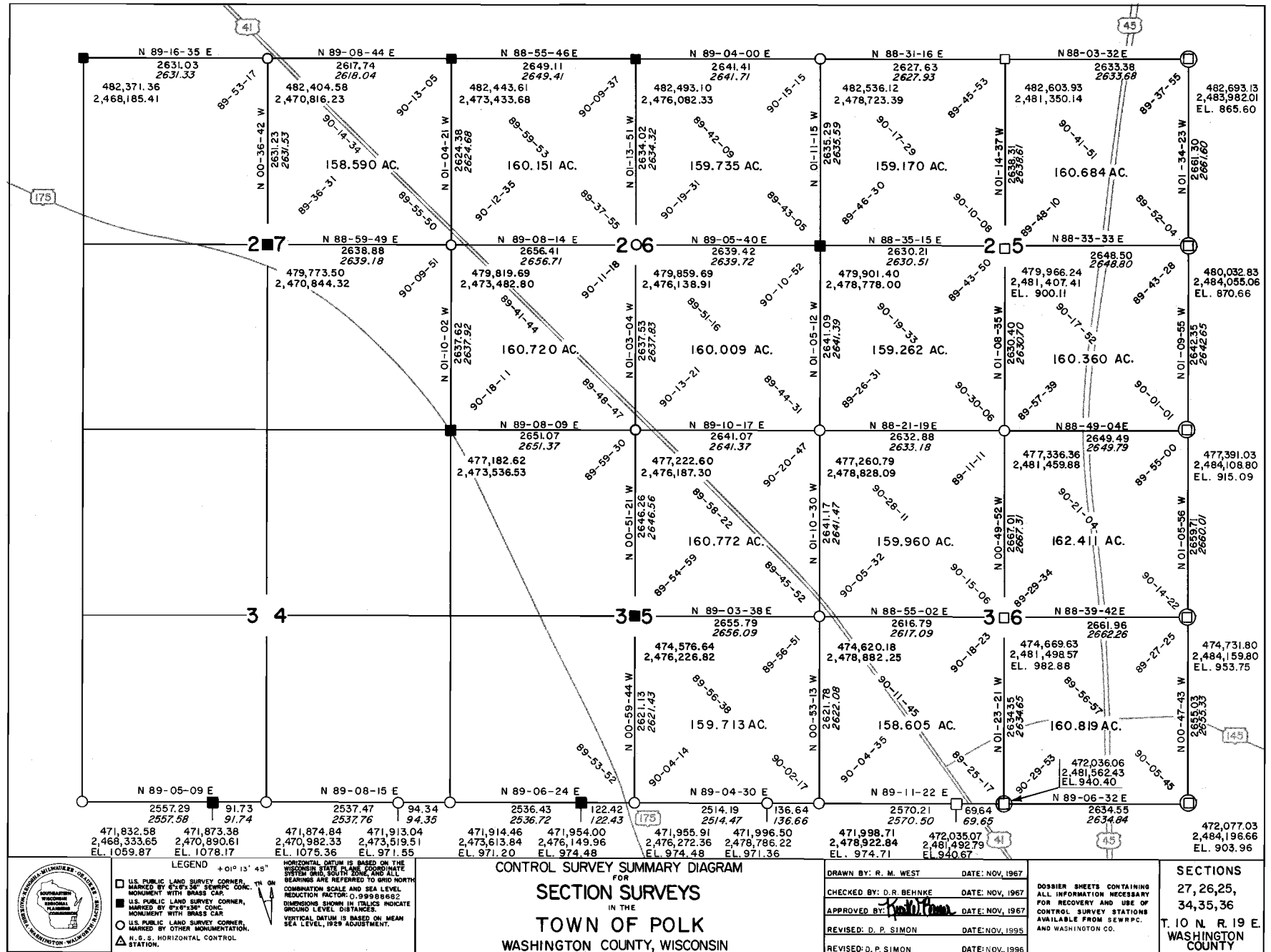
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM WISDOT, VILLAGE OF SLINGER, AND SEWRPC.

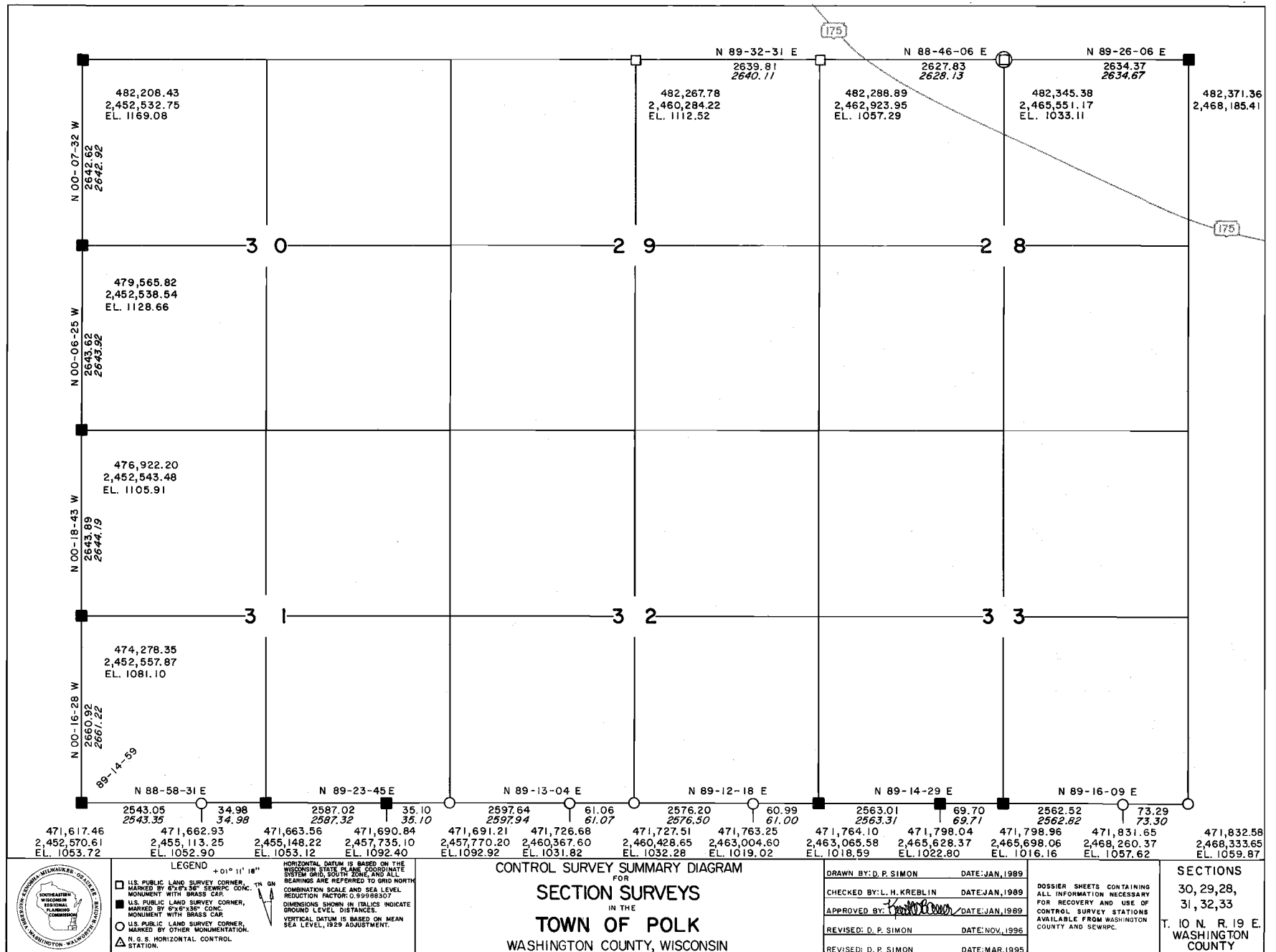
SECTIONS

6, 5, 4,
7, 8, 9
T. 10 N. R. 19 E.
WASHINGTON COUNTY

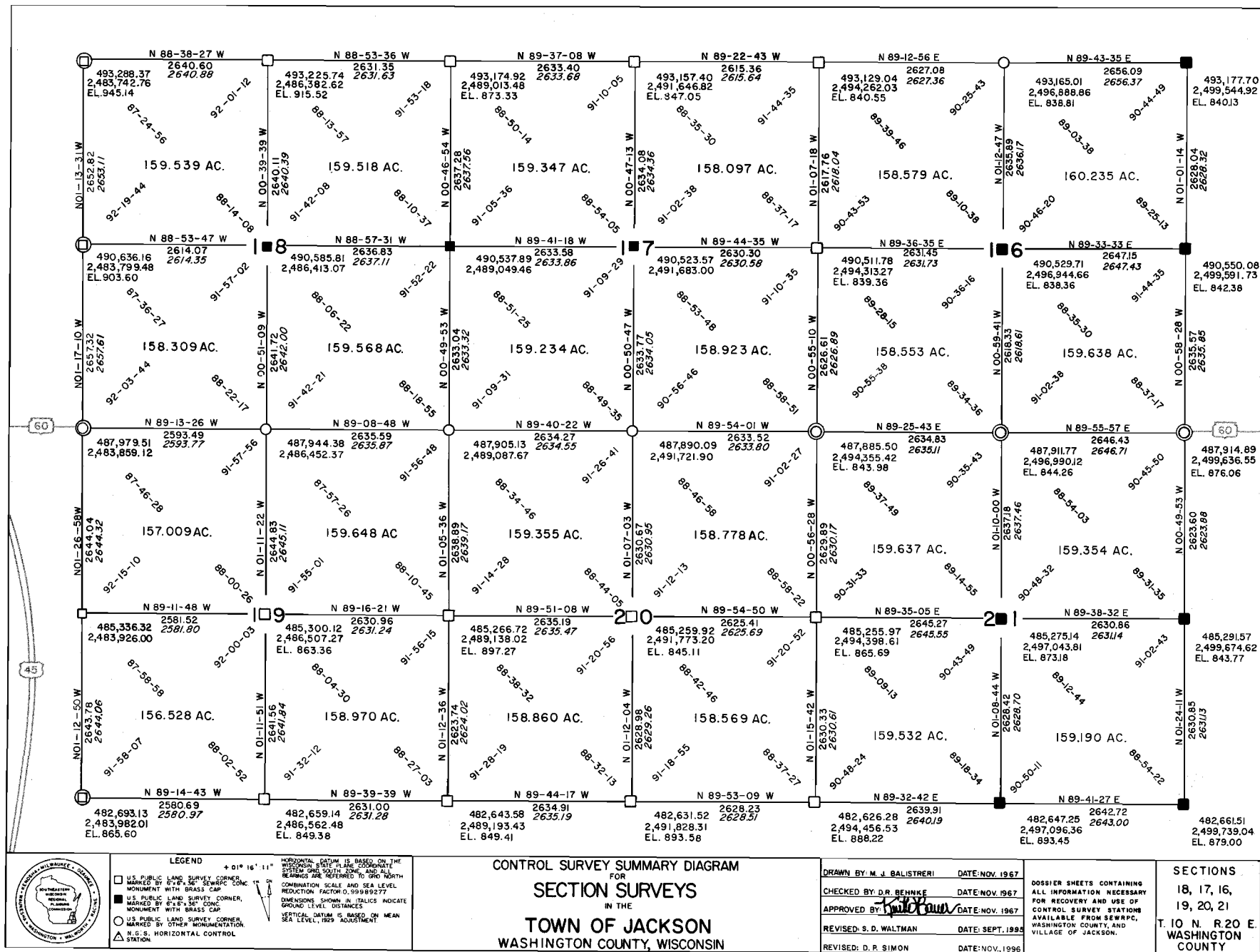


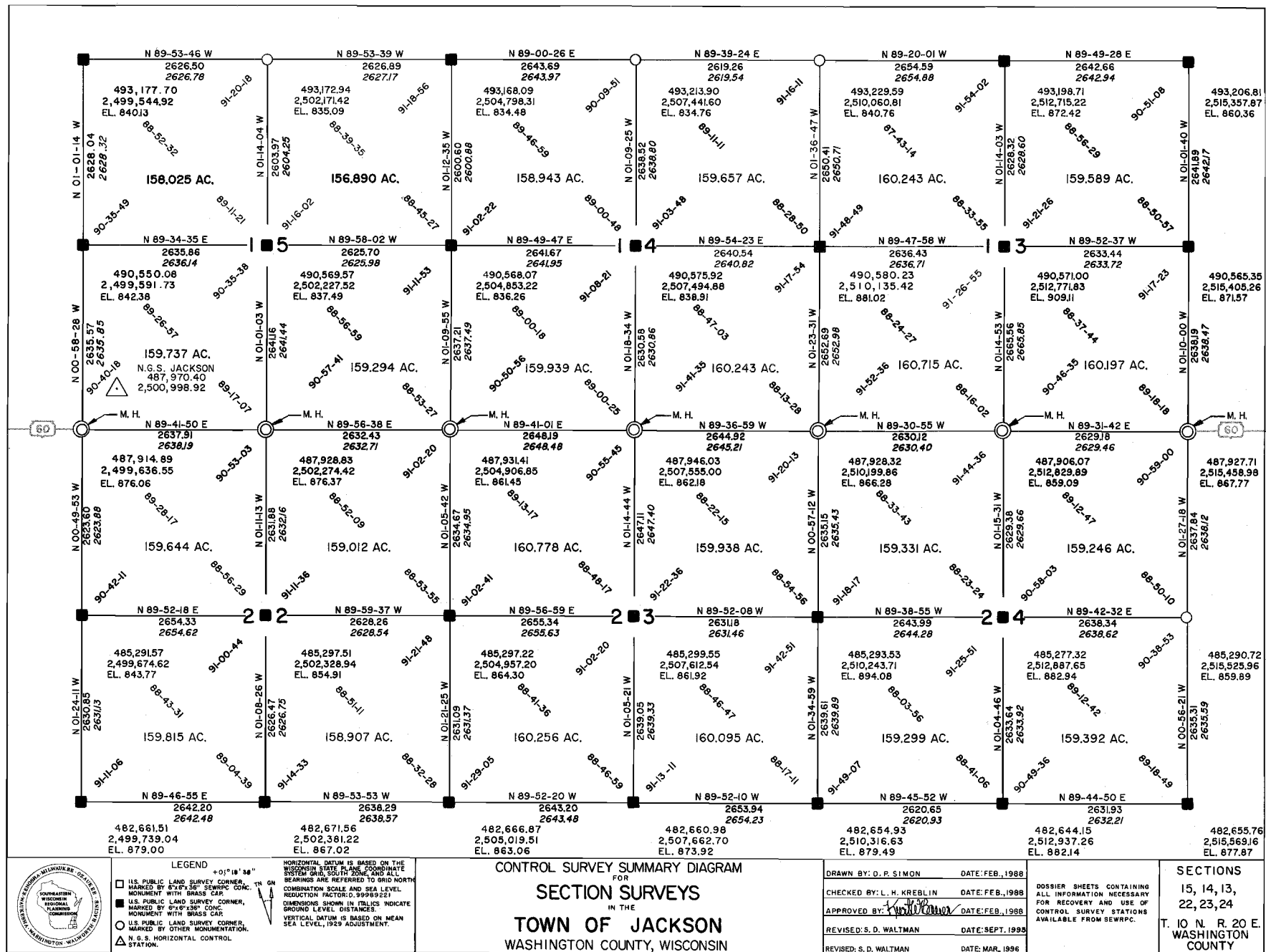


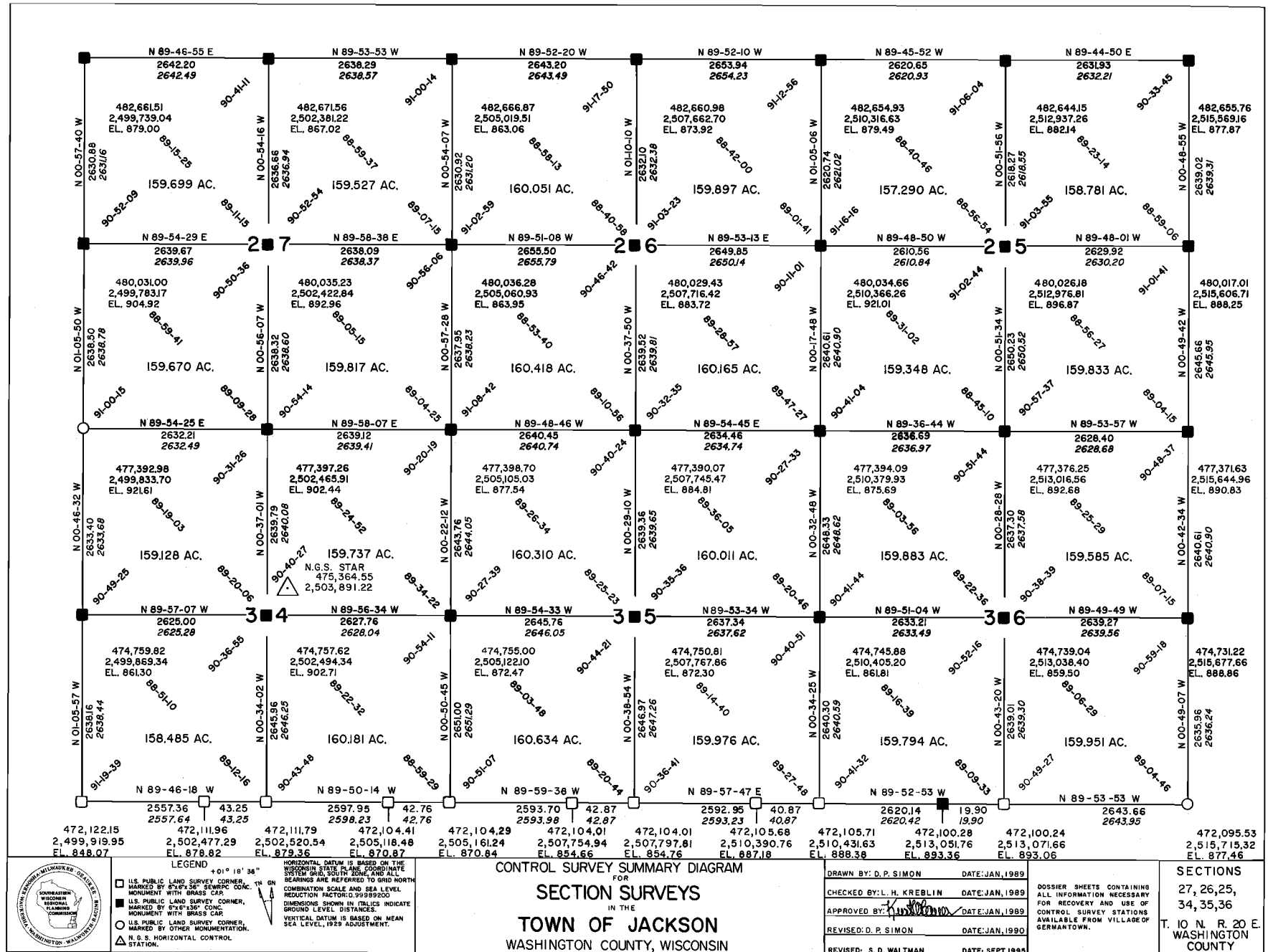


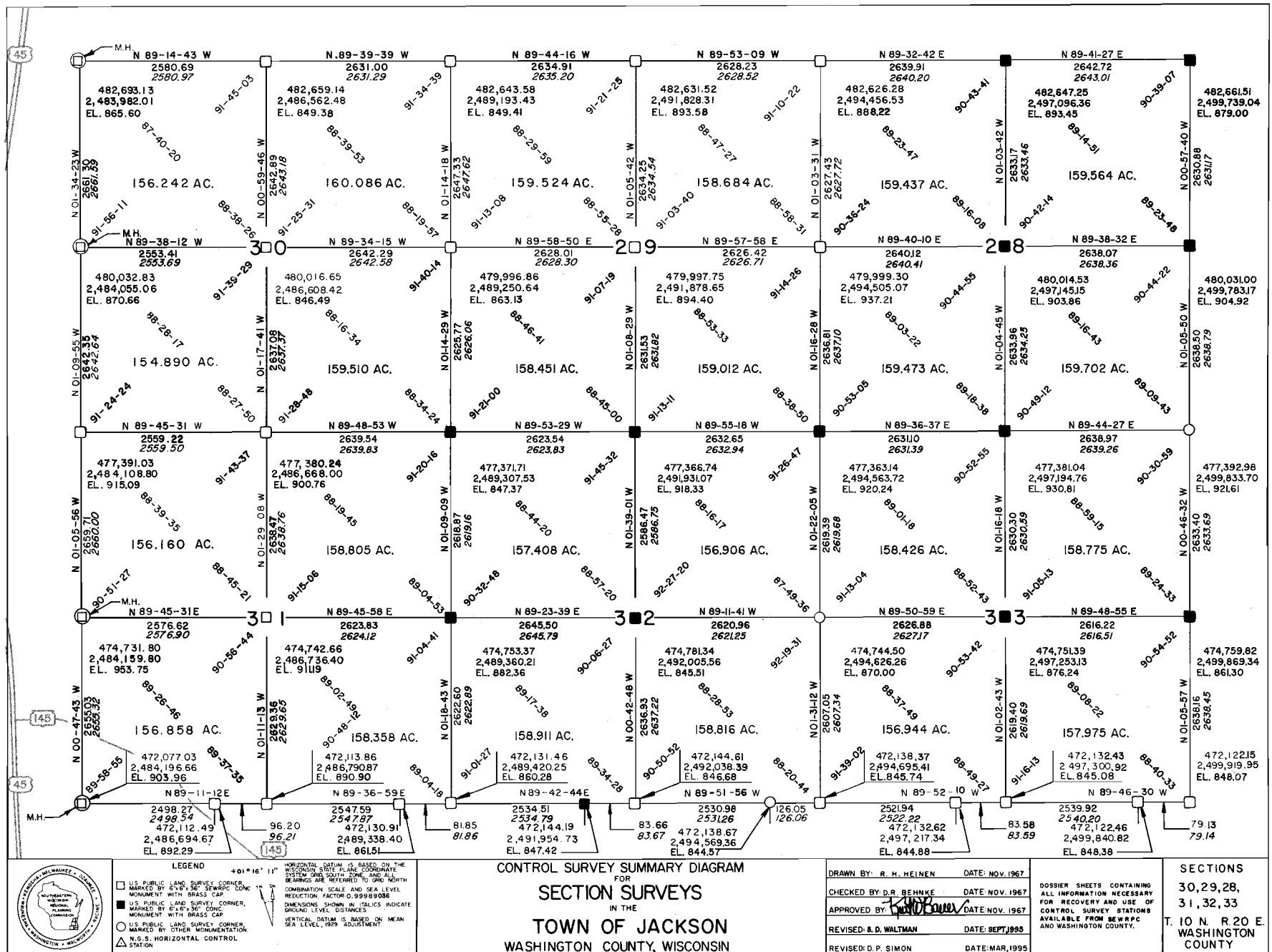


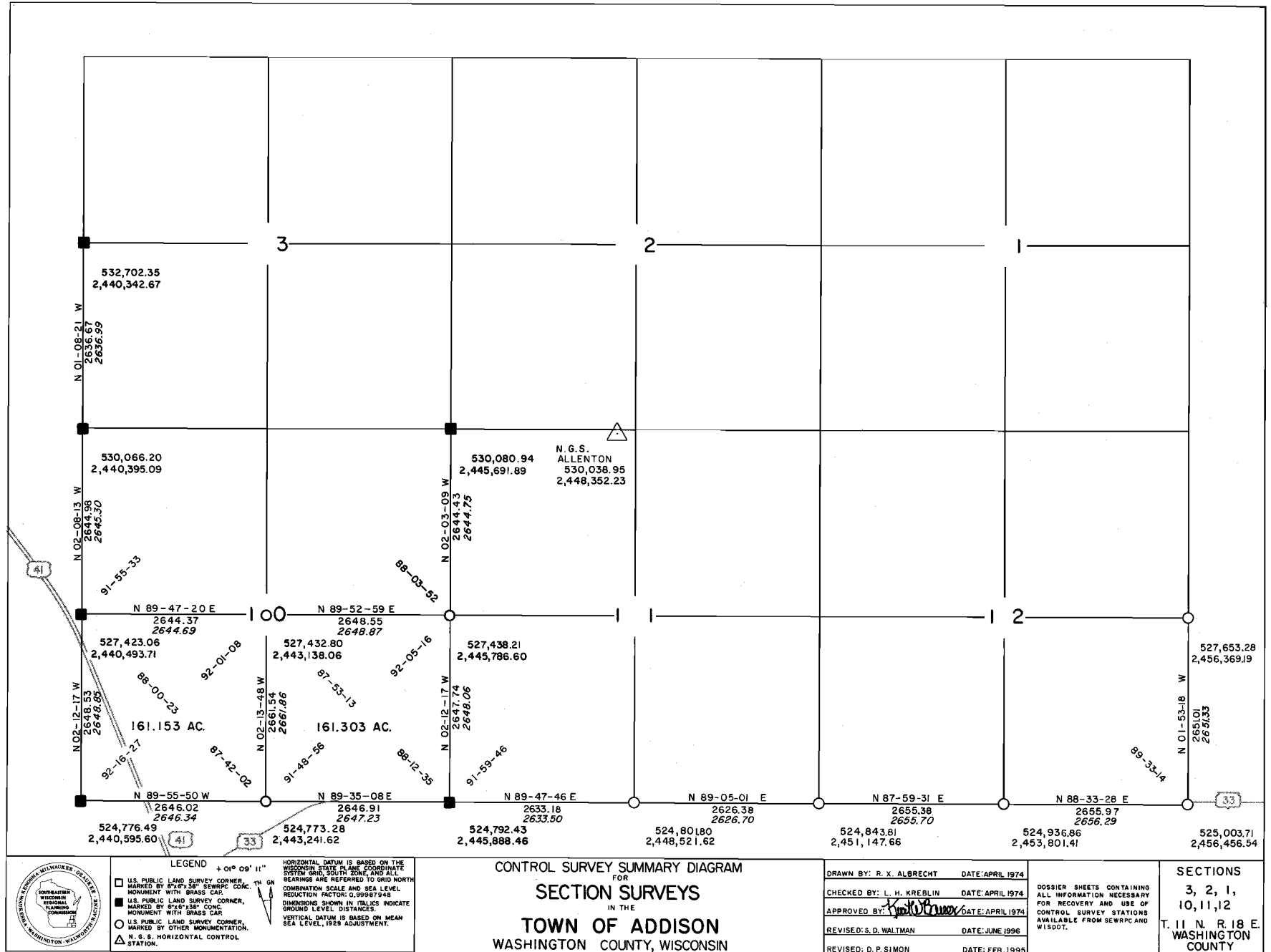


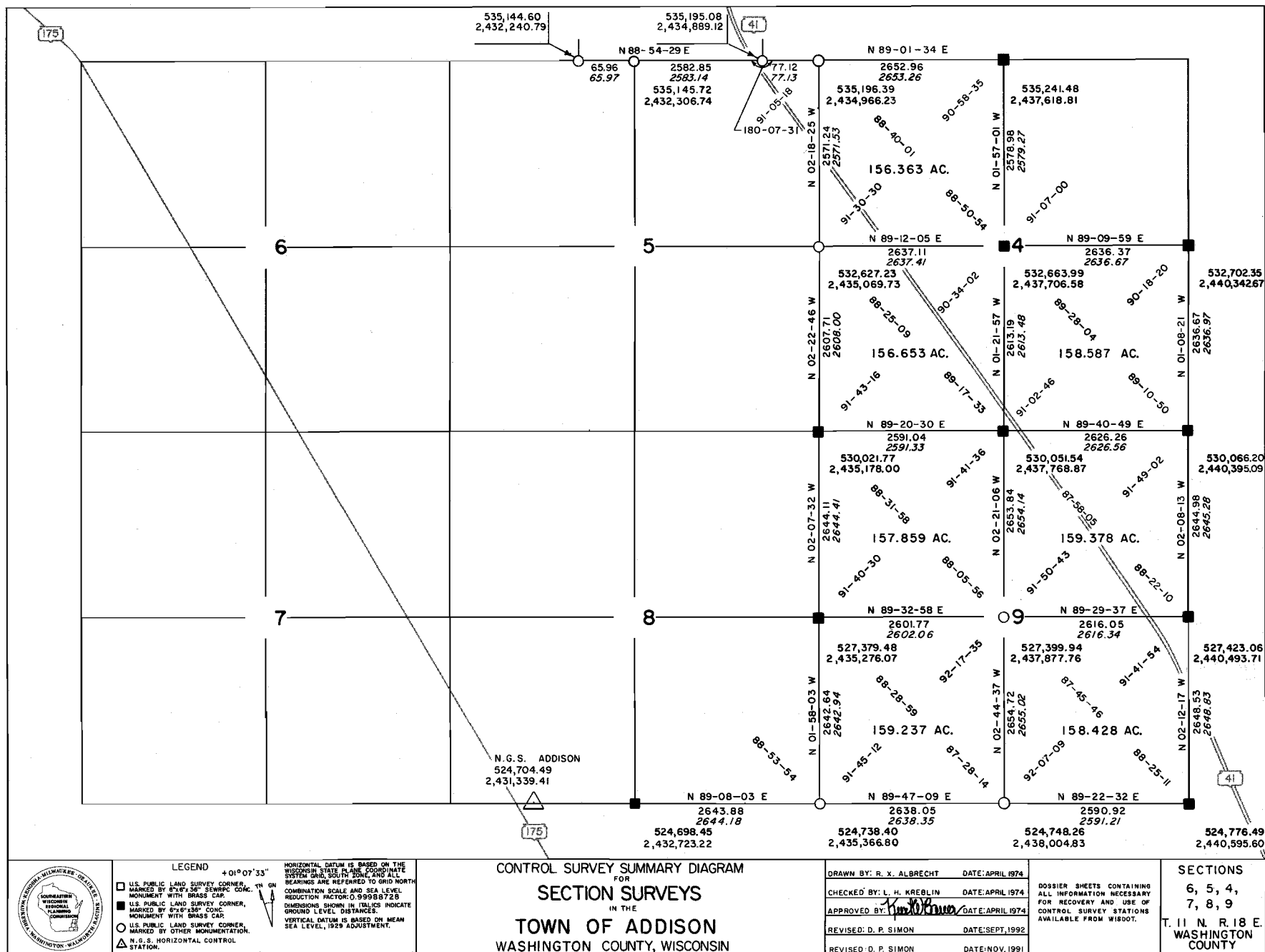


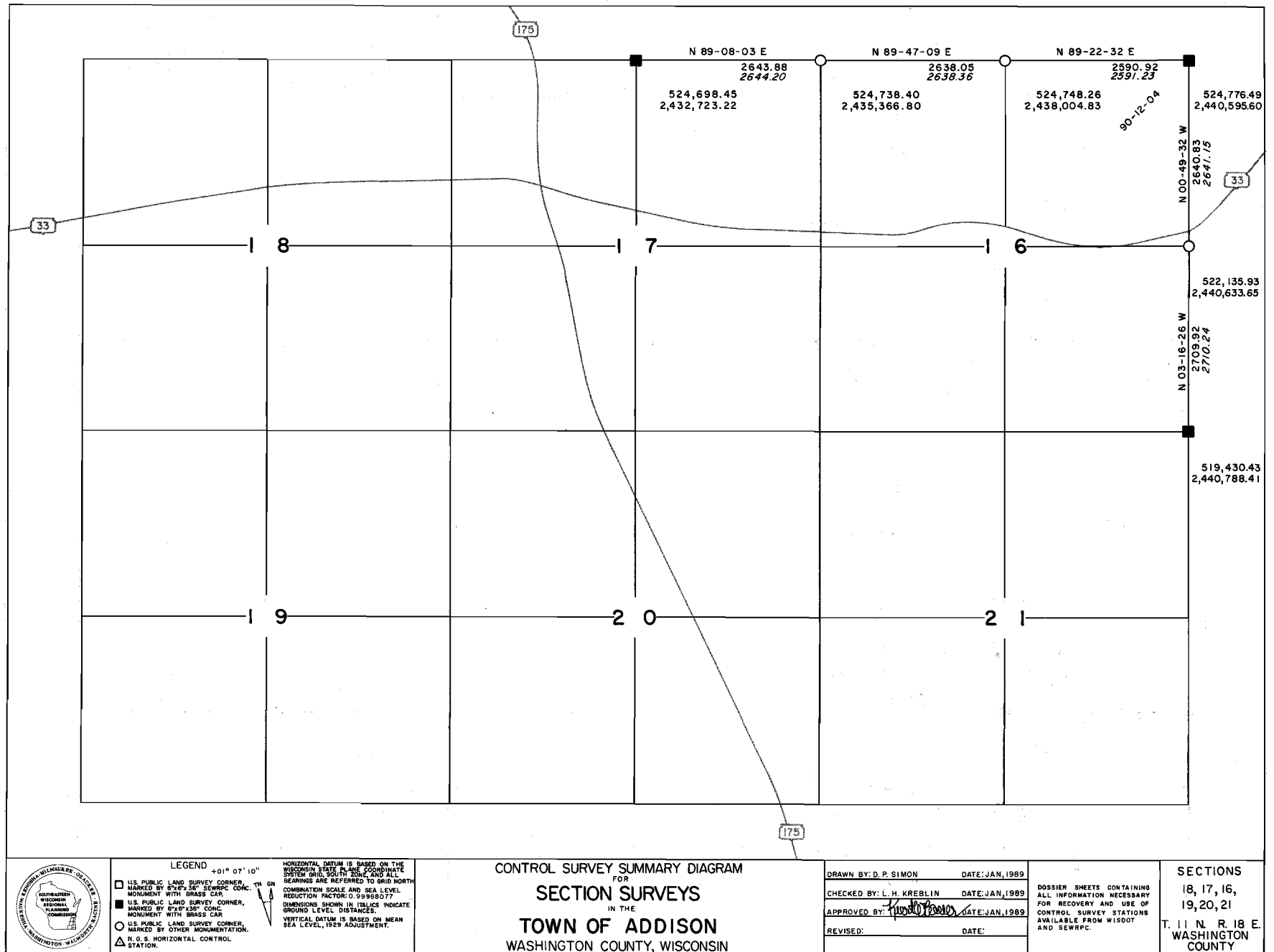


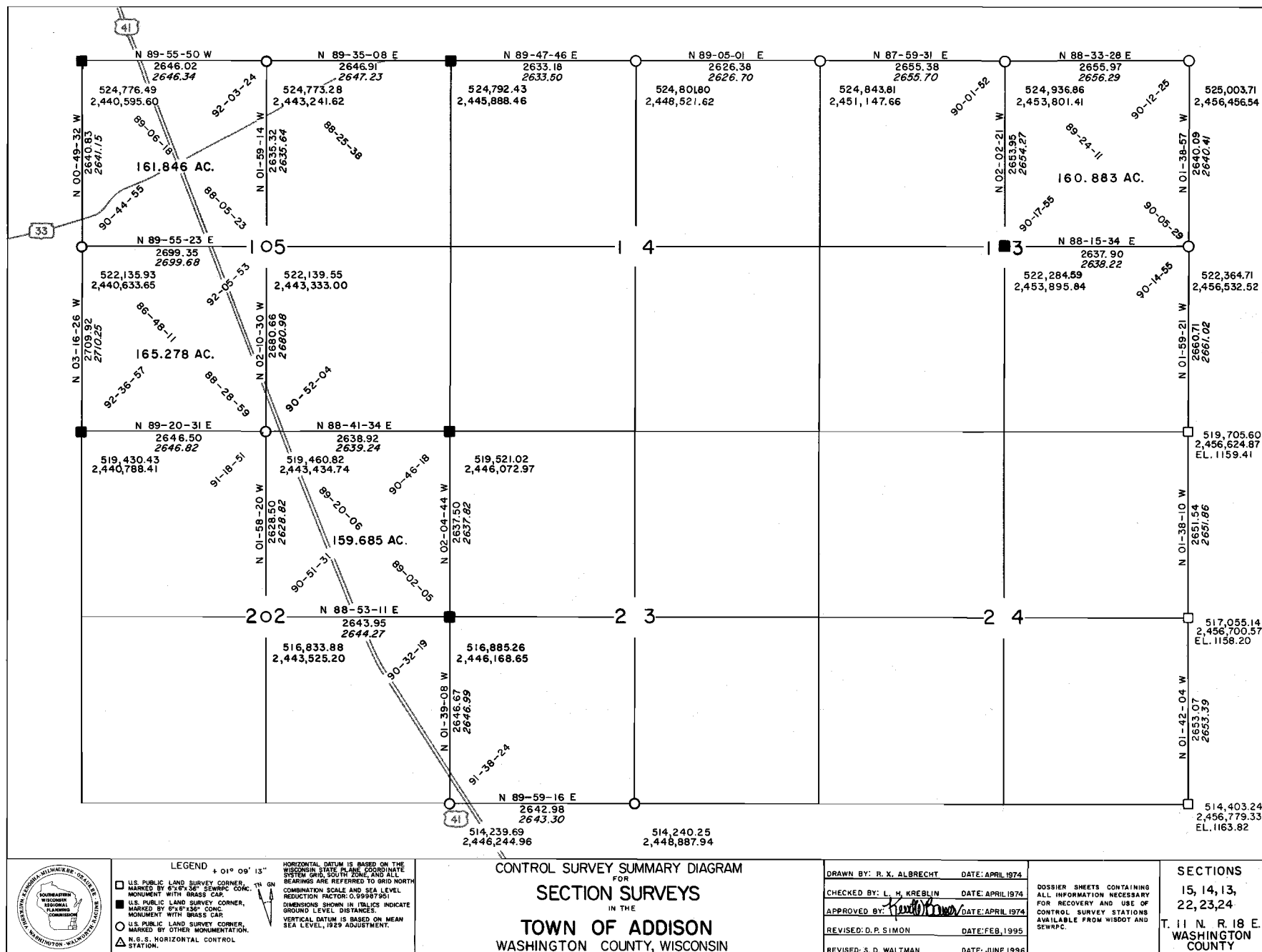


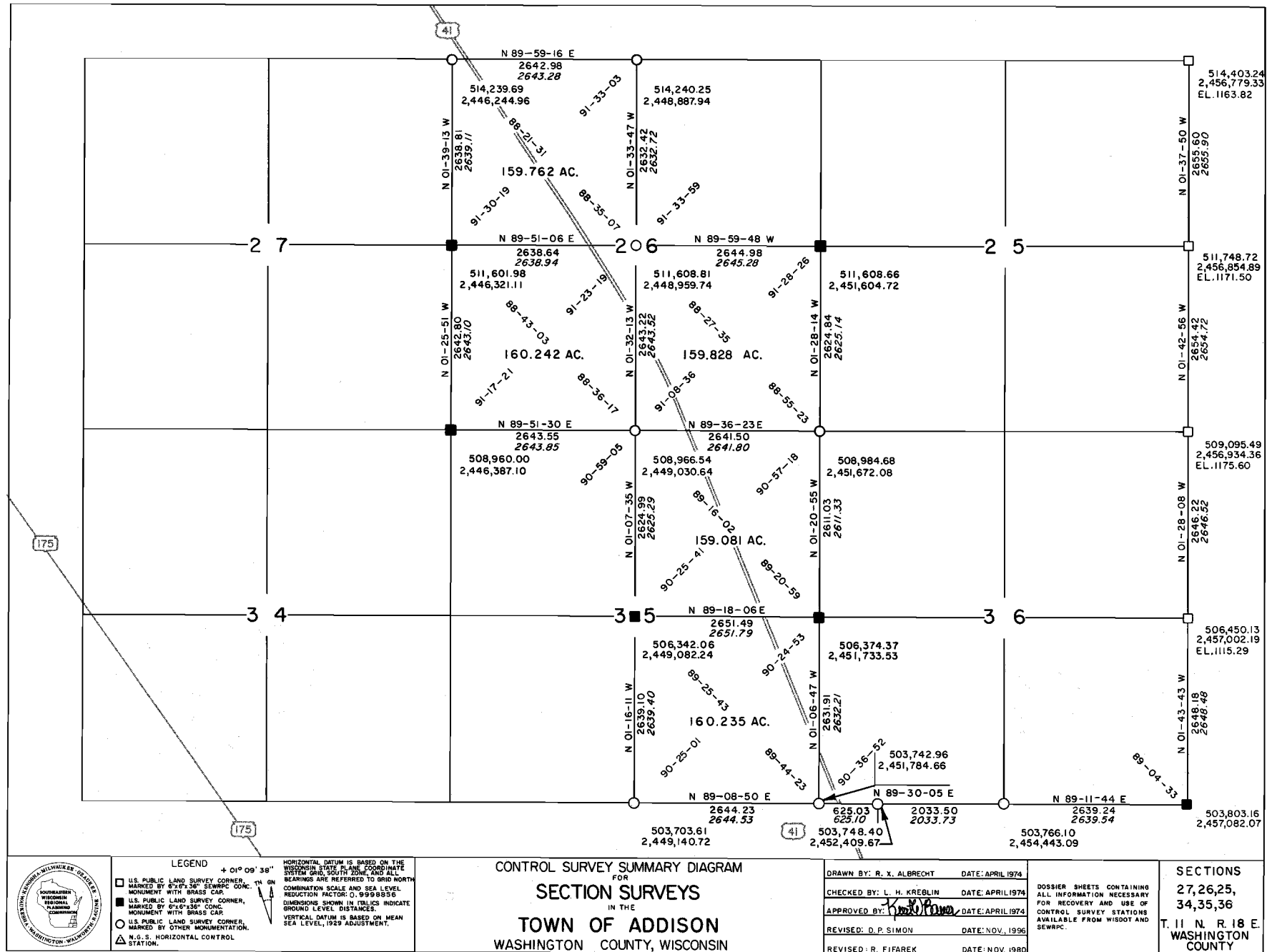


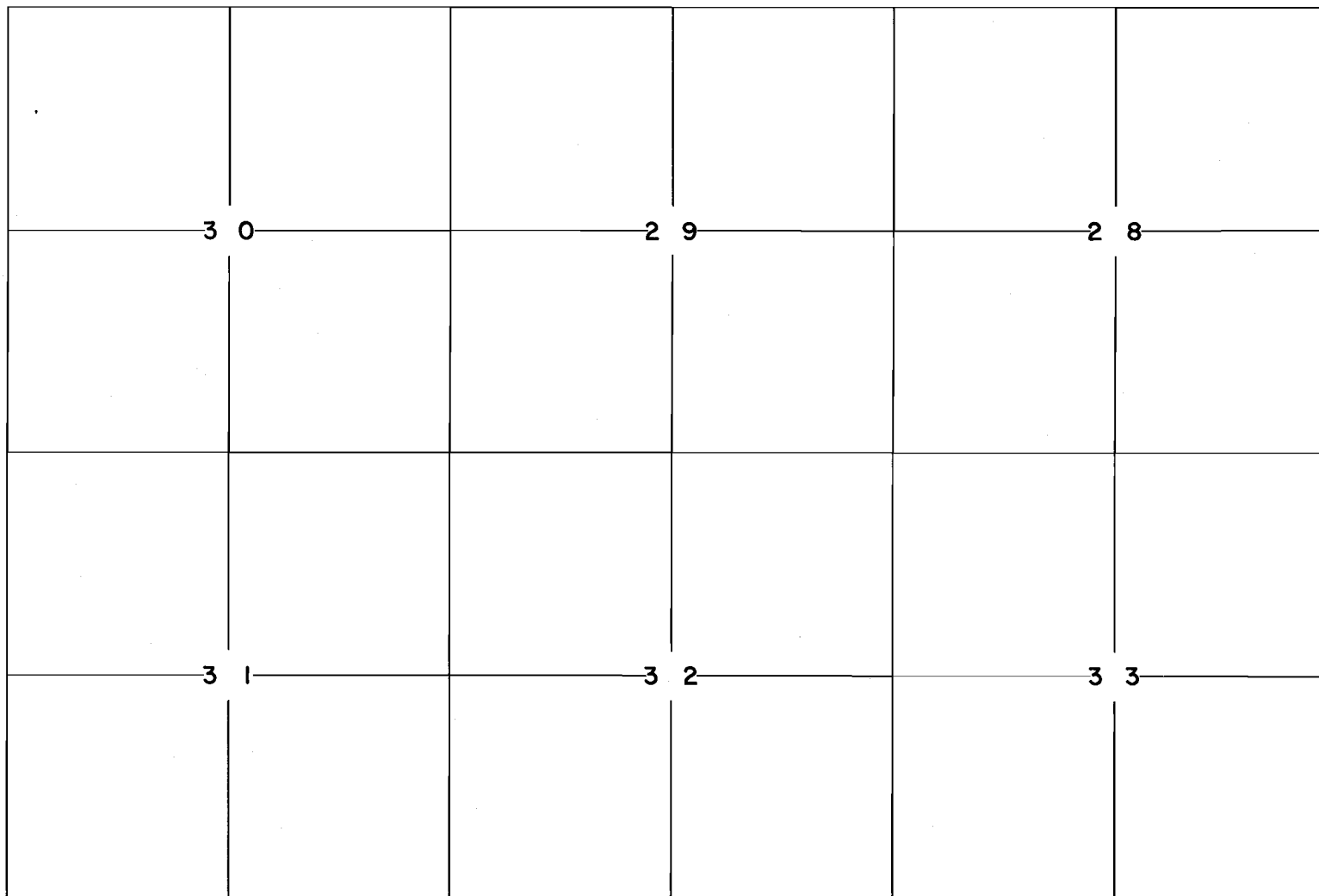












LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 8"x8"x16" CONCRETE CORNER.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 8"x8"x16" CONC. CORNER WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- ☐ N. G. S. HORIZONTAL CONTROL STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM AND SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

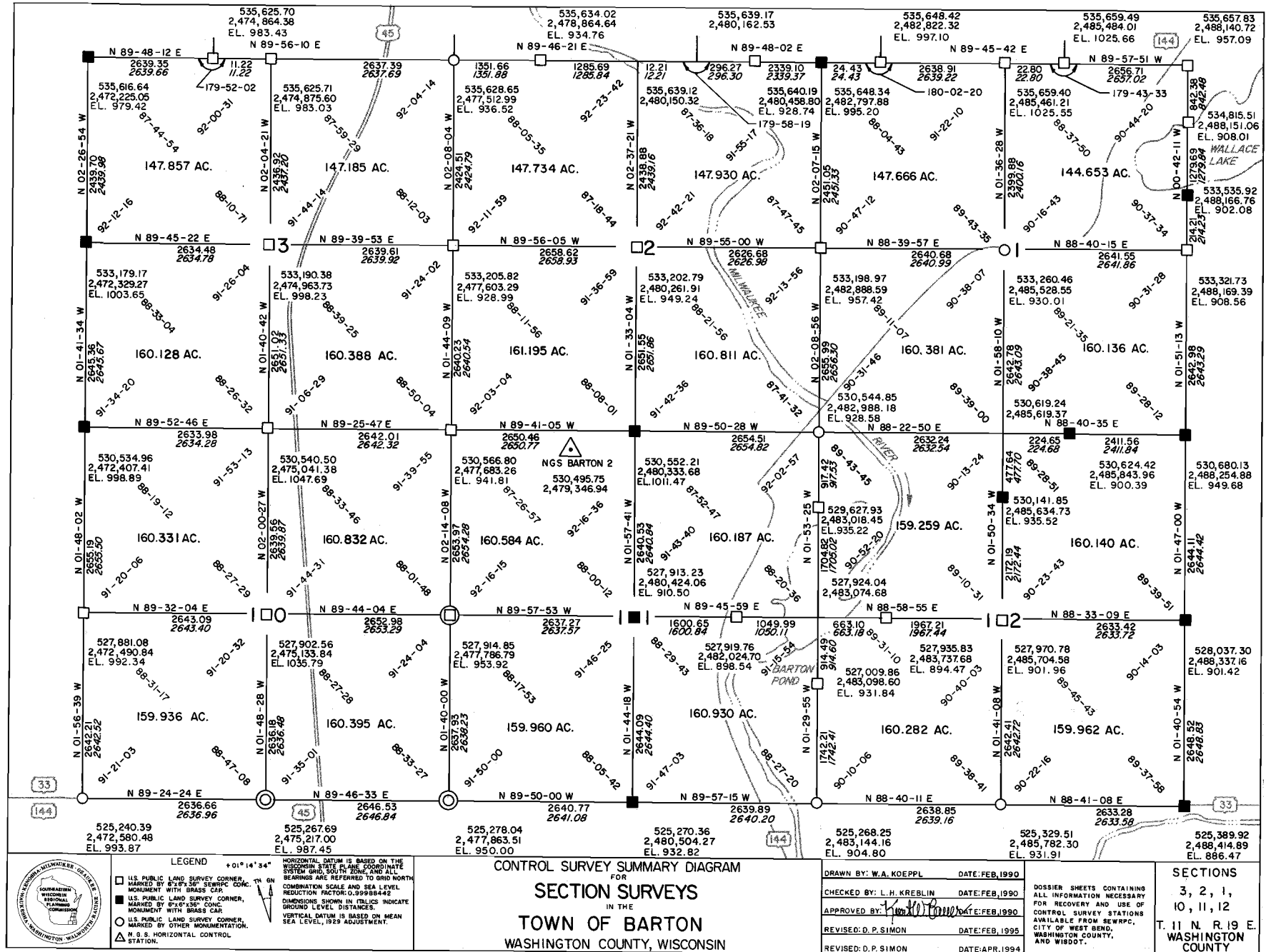
CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF ADDISON WASHINGTON COUNTY, WISCONSIN

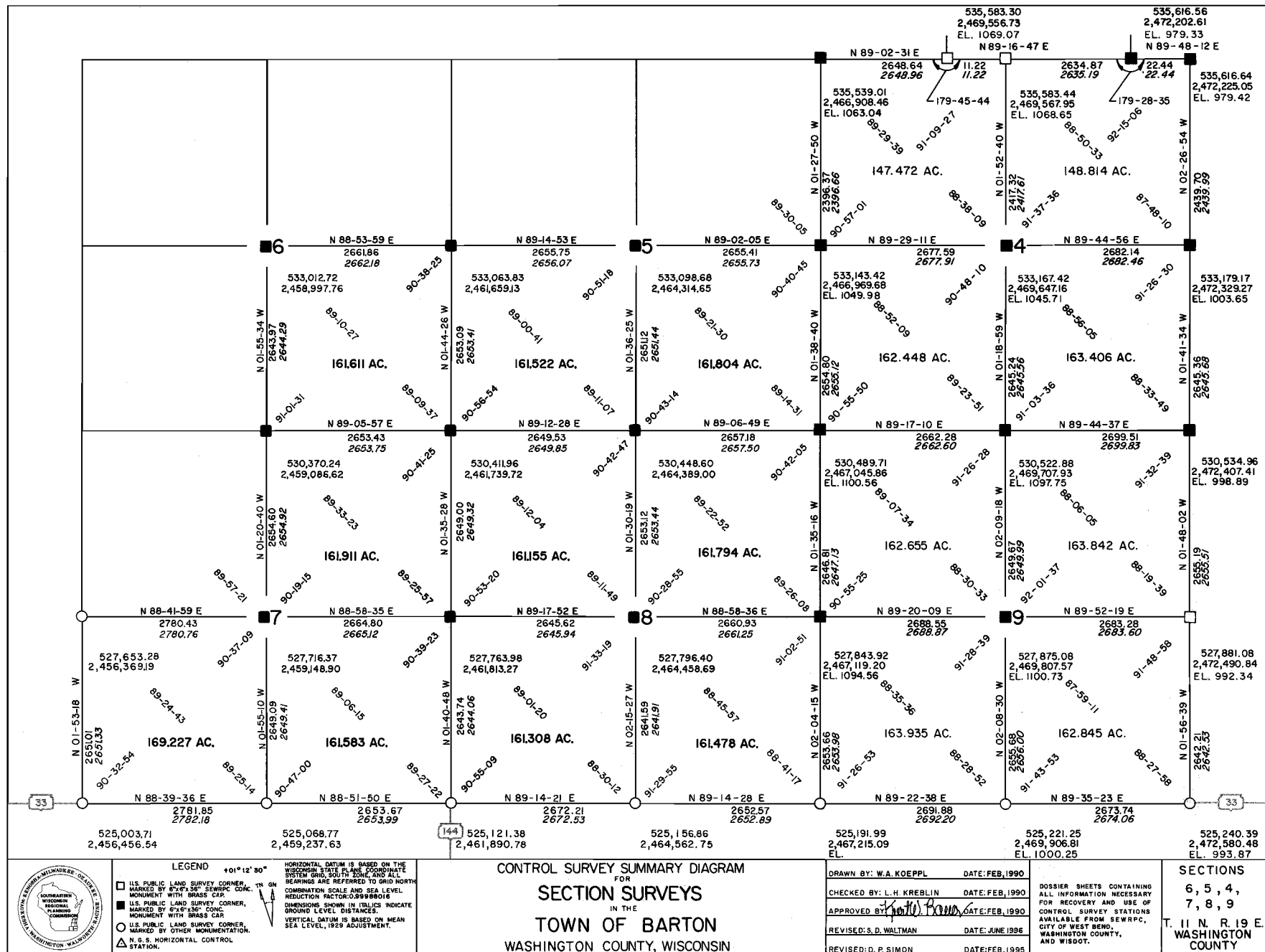
DRAWN BY:	DATE:
CHECKED BY:	DATE:
APPROVED BY:	DATE:
REVISED:	DATE:

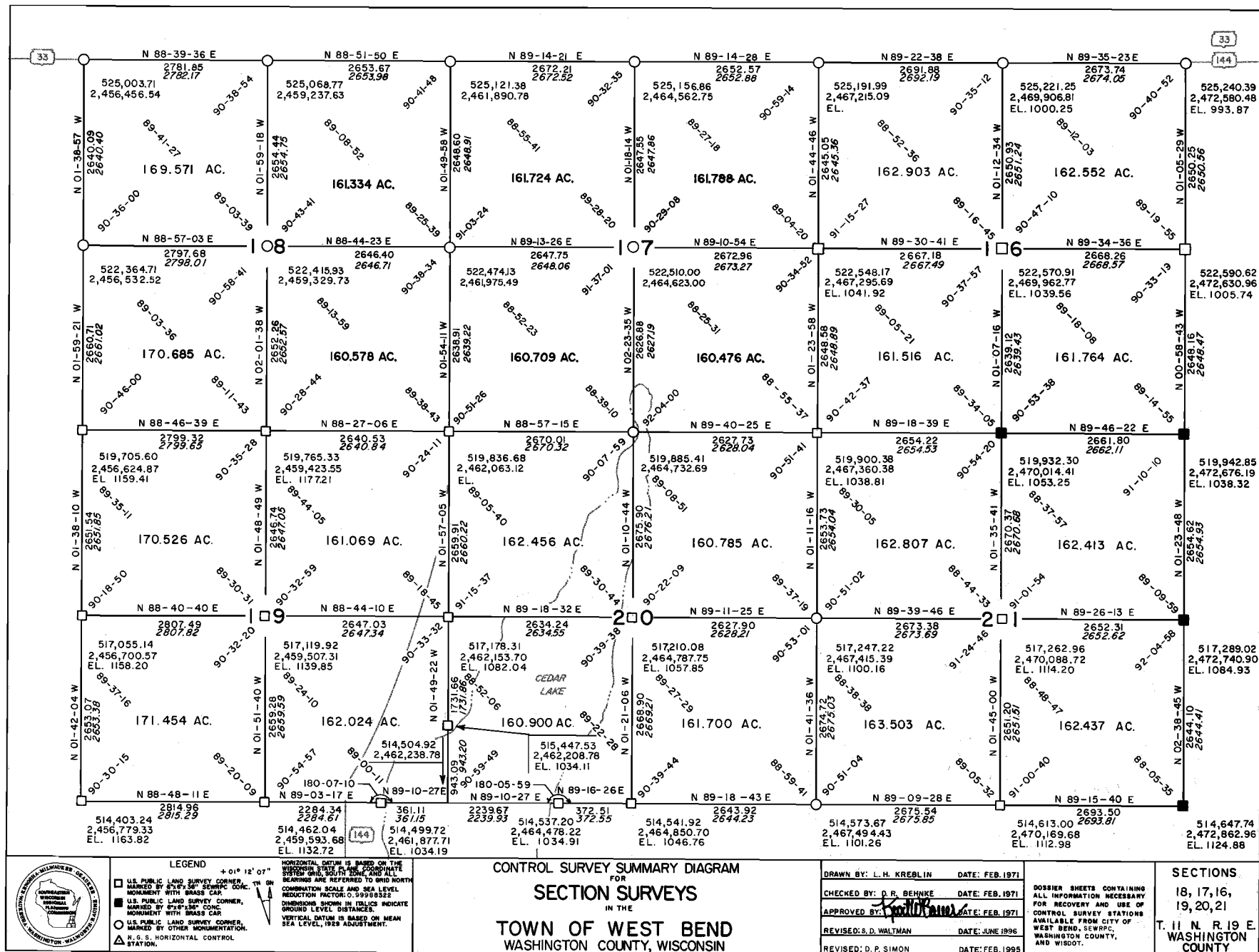
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

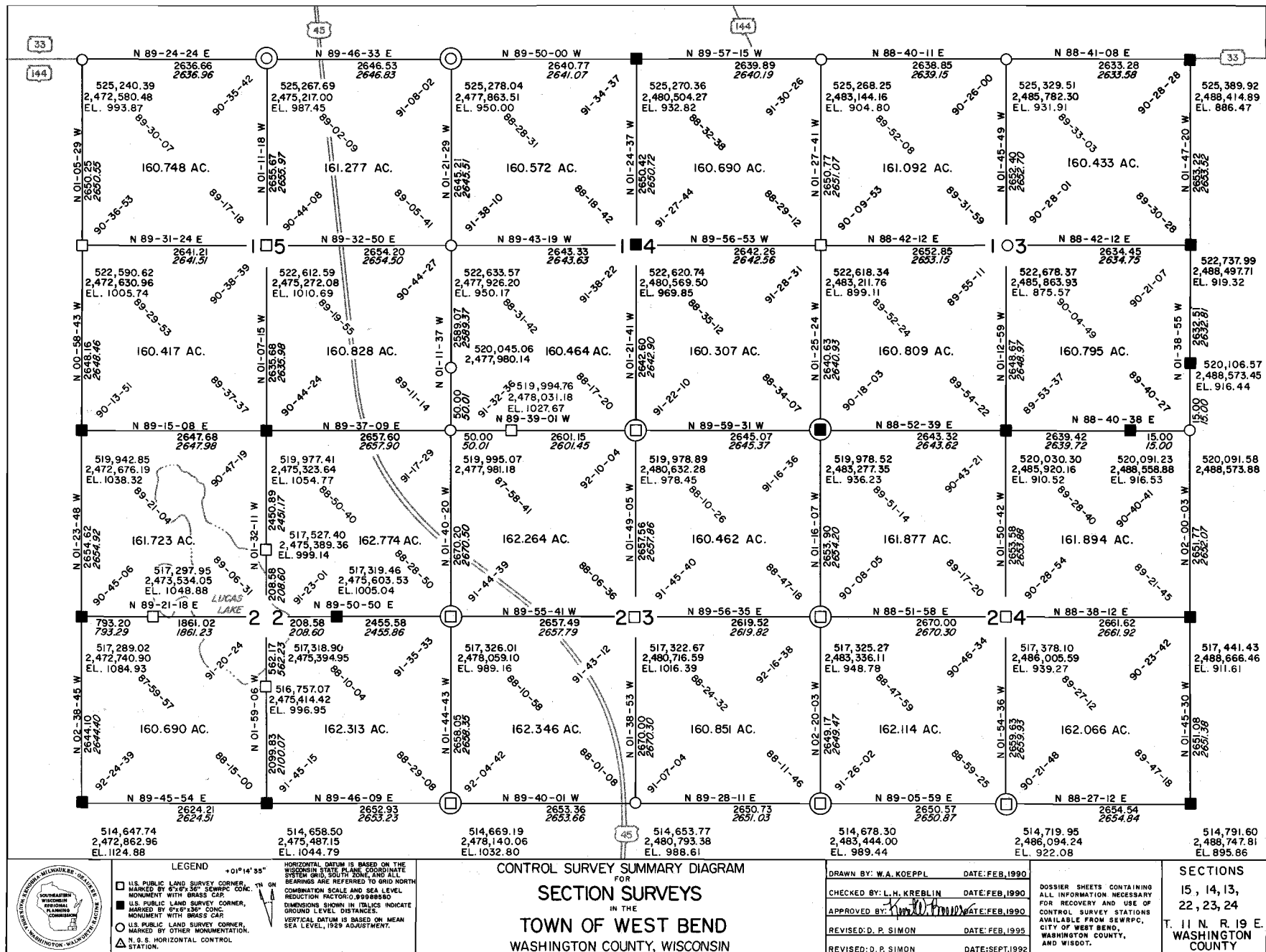
SECTIONS
30, 29, 28,
31, 32, 33

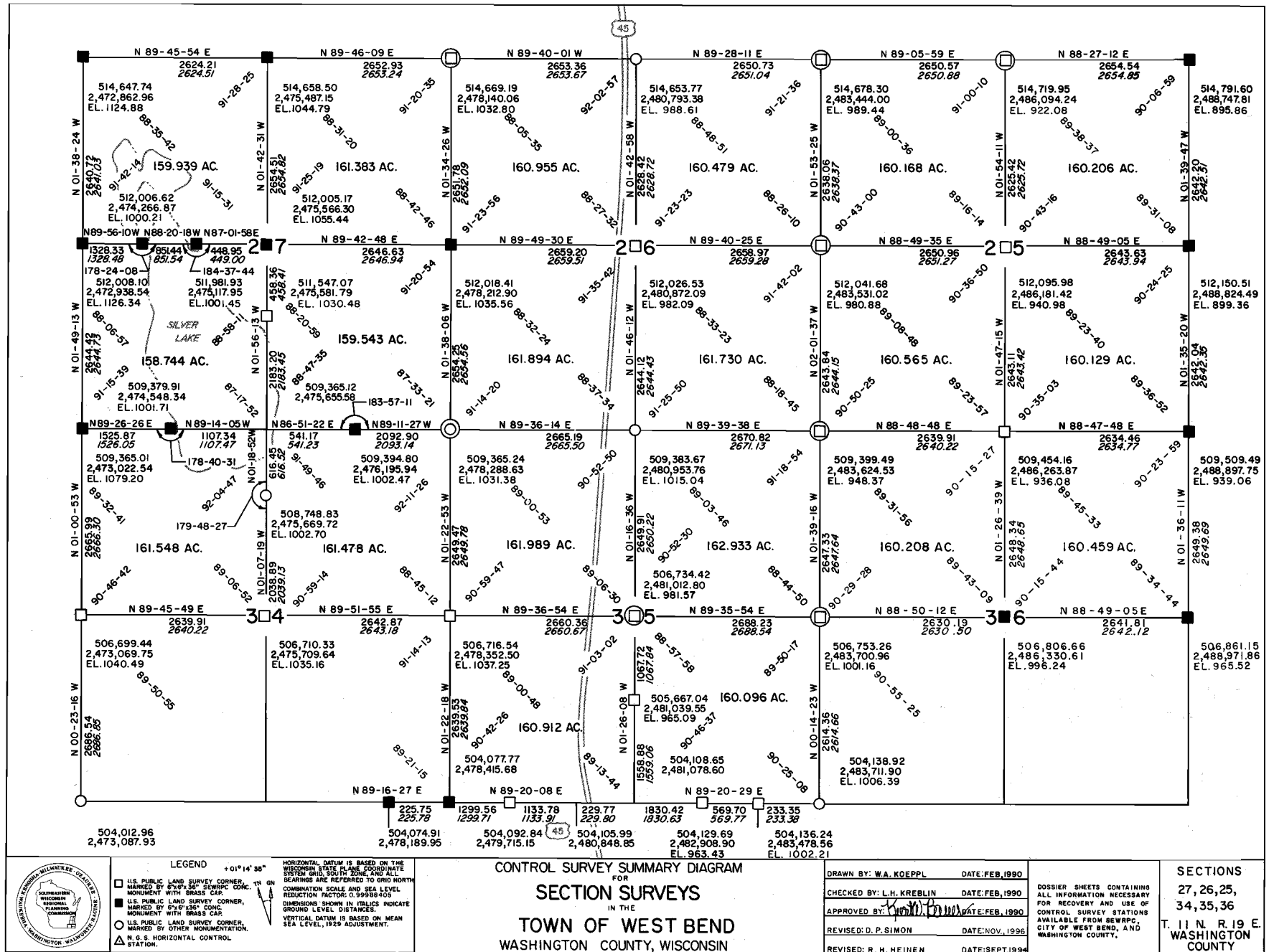
T. 11 N. R. 18 E.
WASHINGTON
COUNTY

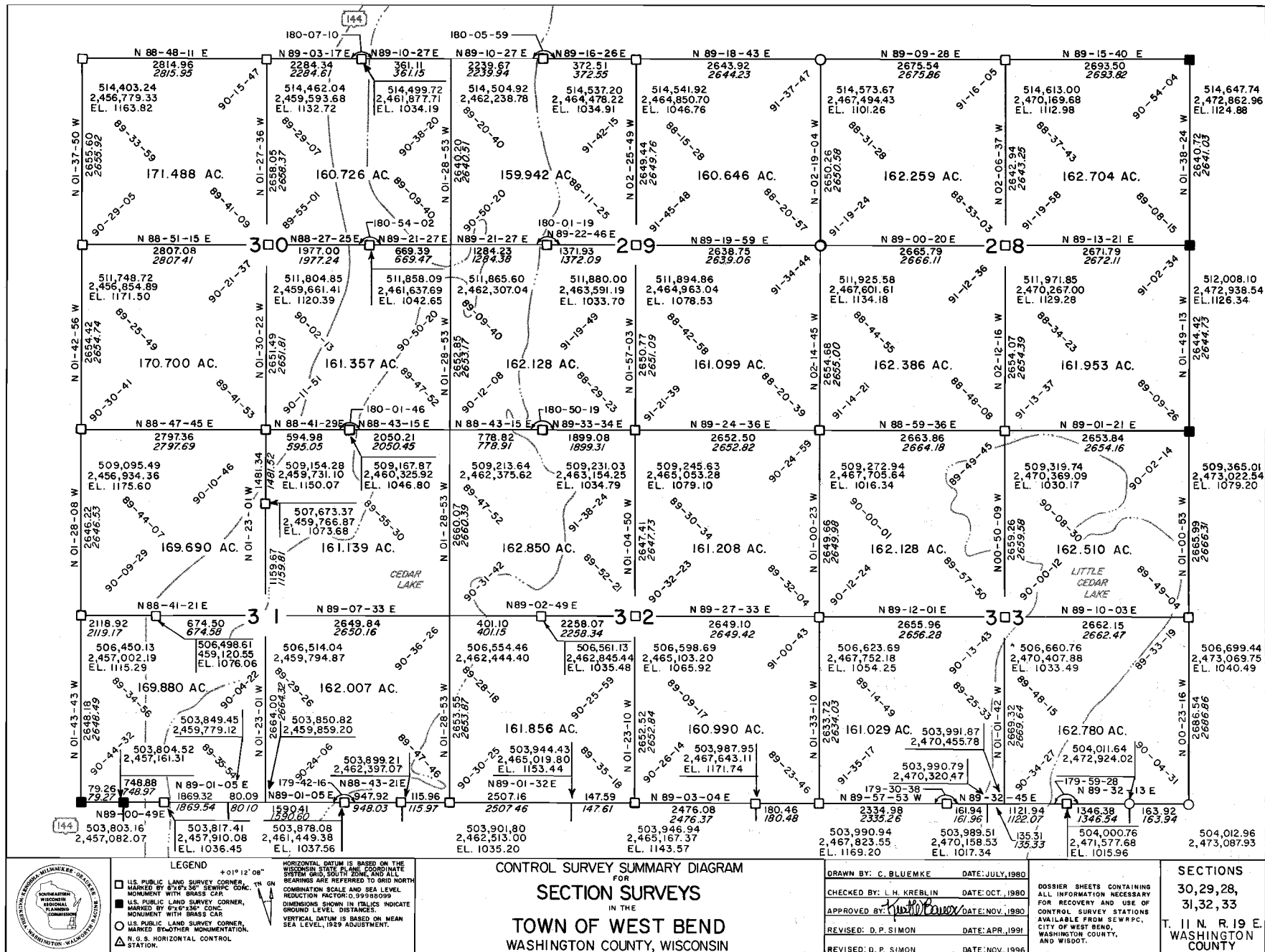


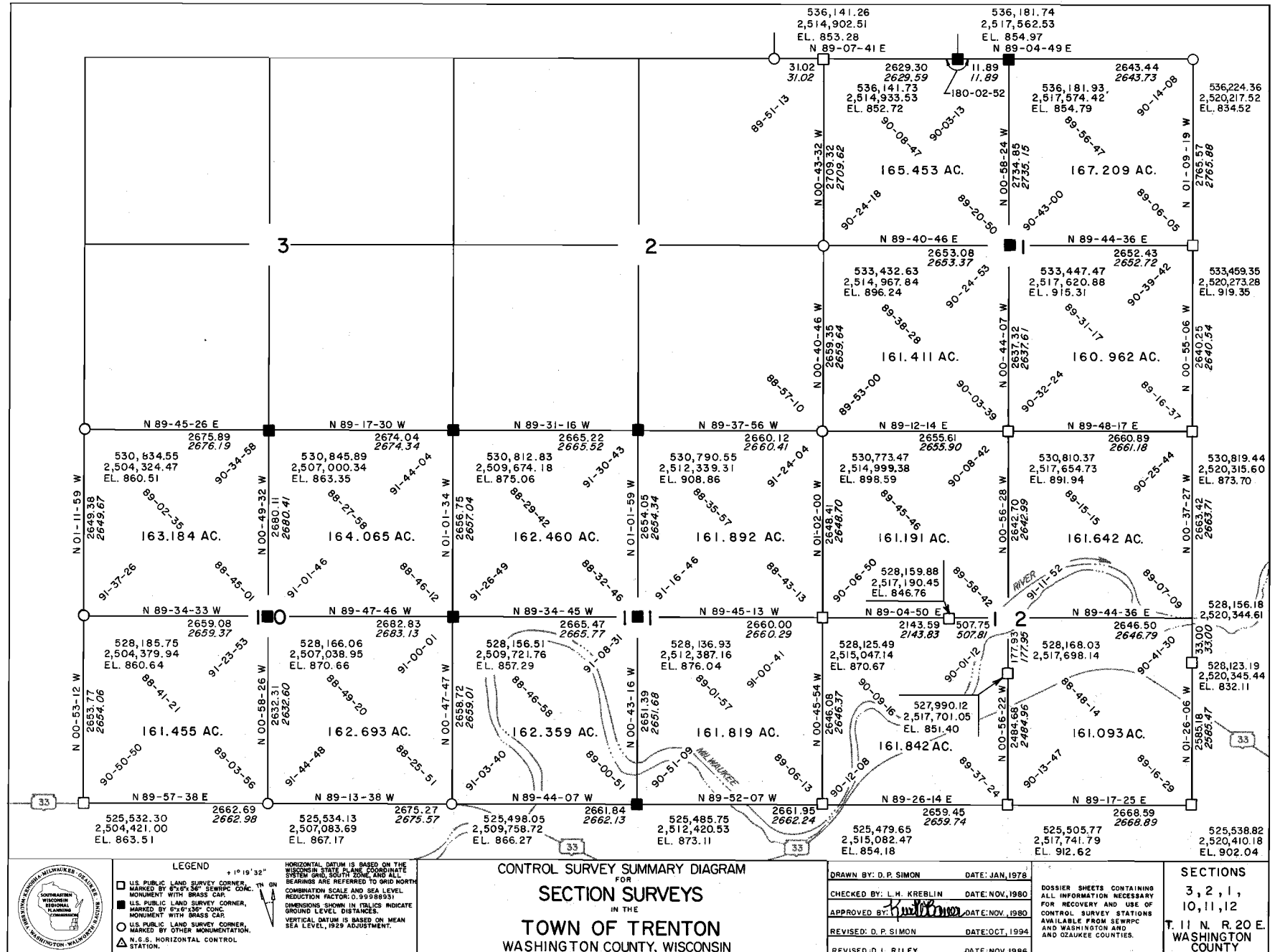


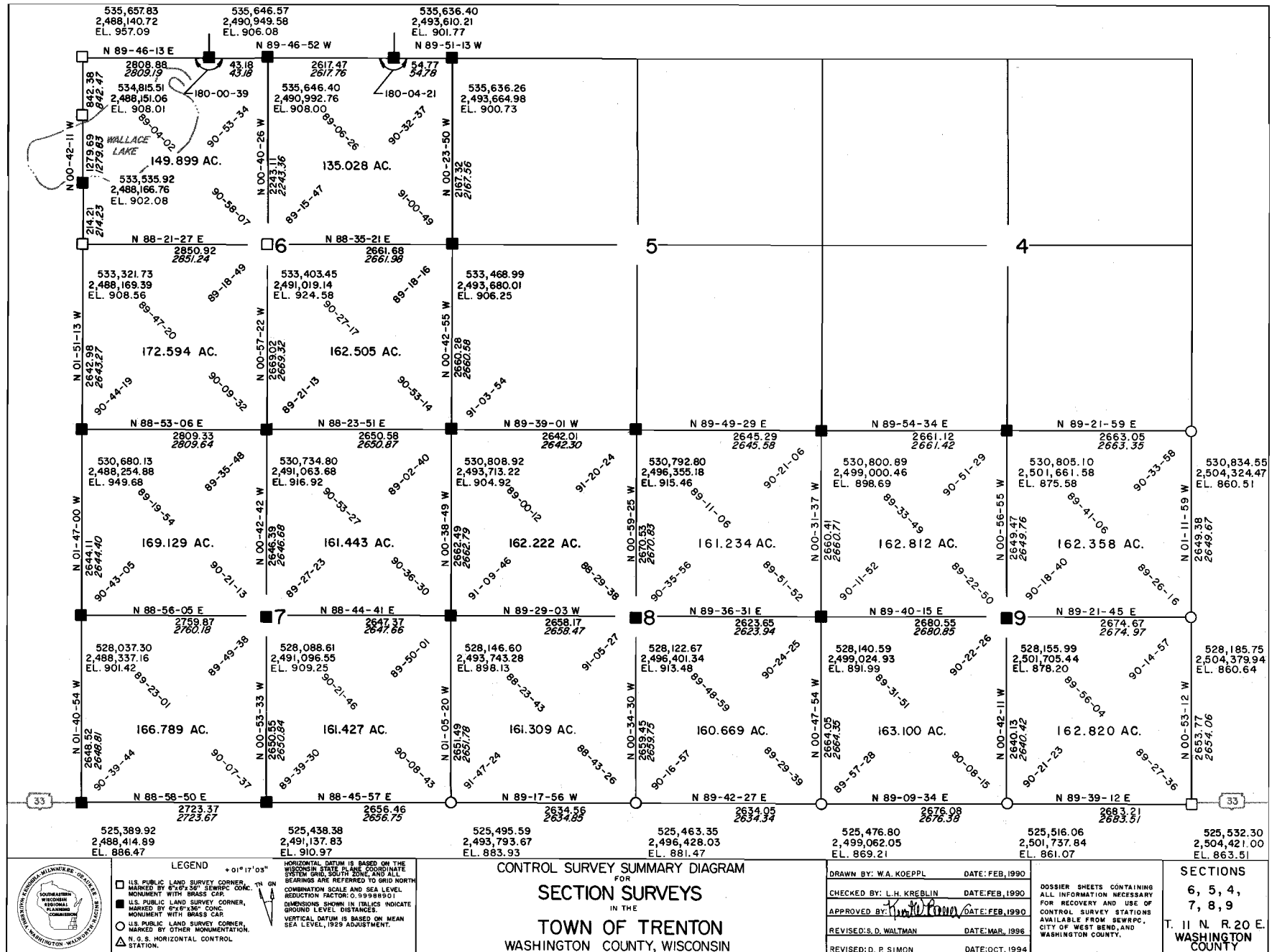


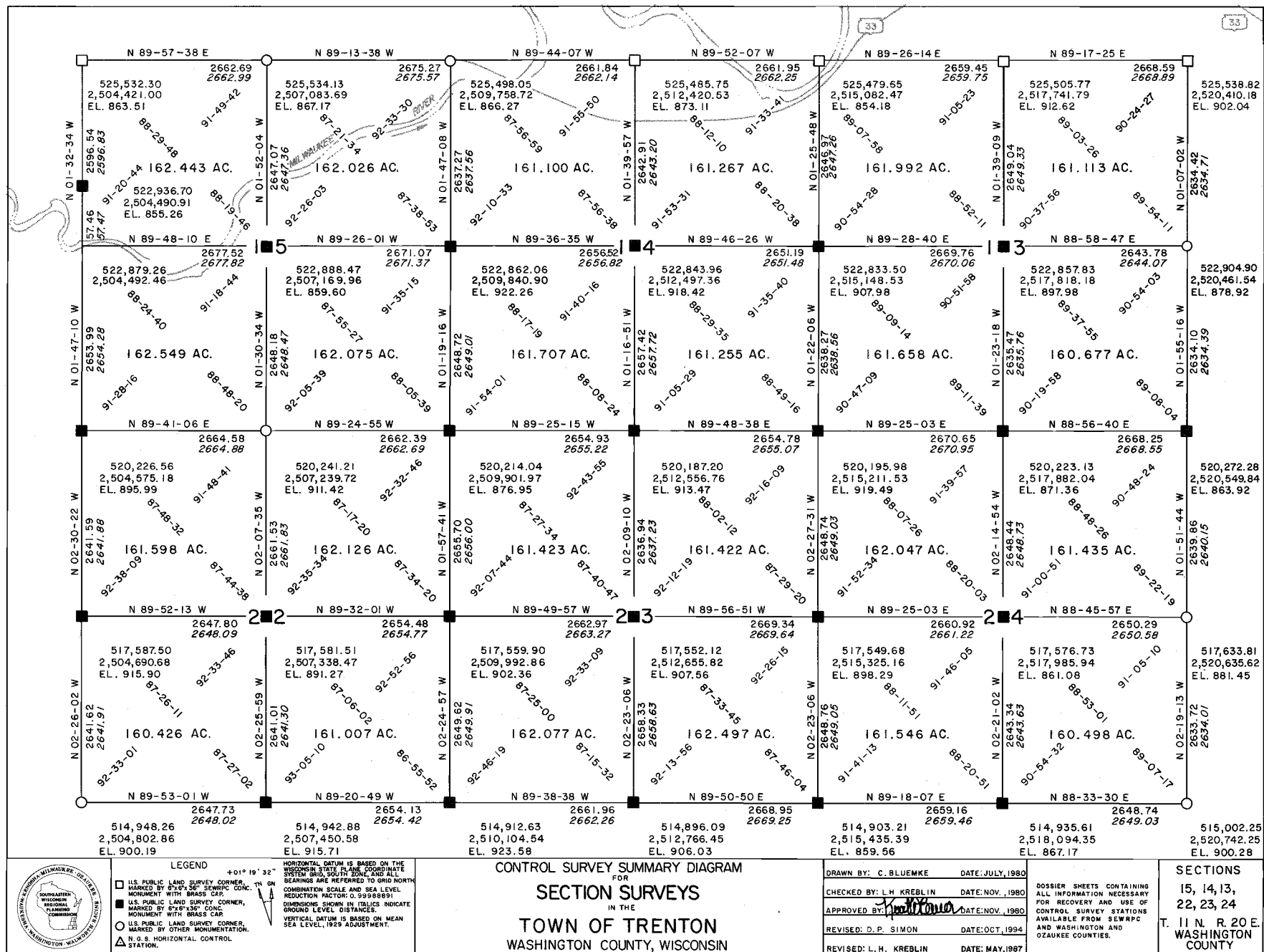


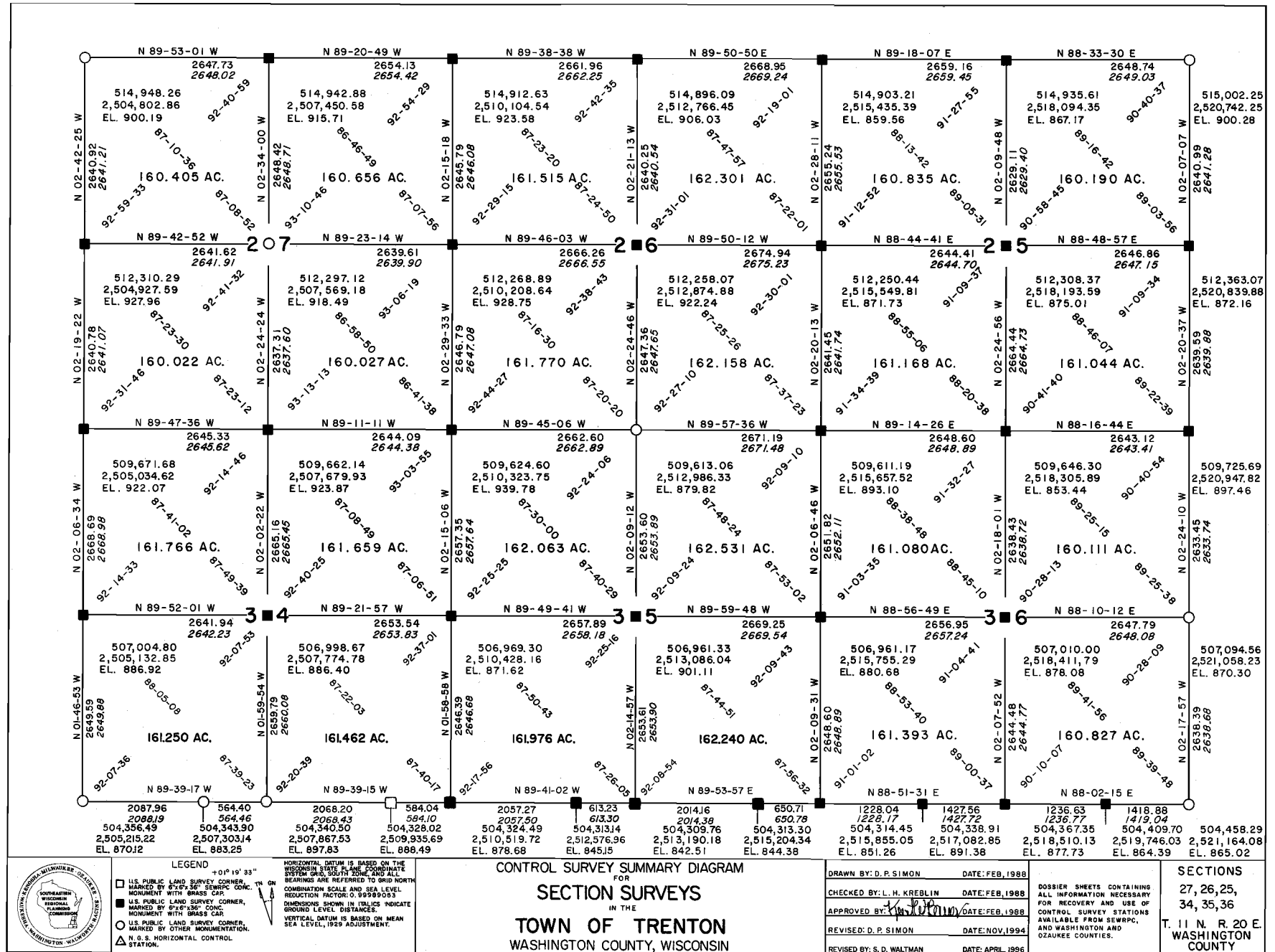












$+ 01^{\circ} 17' 05''$

- ☐ U.S. PUBLIC LAND SURVEY CORNER
MARKED BY 6"x6"x36" SEWRPP CONC
MONUMENT WITH BRASS CAP.
- ☒ U.S. PUBLIC LAND SURVEY CORNER,
MARKED BY 6"x6"x36" CONC.
MONUMENT WITH BRASS CAP.
- ☐ U.S. PUBLIC LAND SURVEY CORNER,
MARKED BY OTHER MONUMENTATION.
- ☐ N. G. S. HORIZONTAL CONTROL
STATION.

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.

COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99988665

DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

SECTION SURVEYS

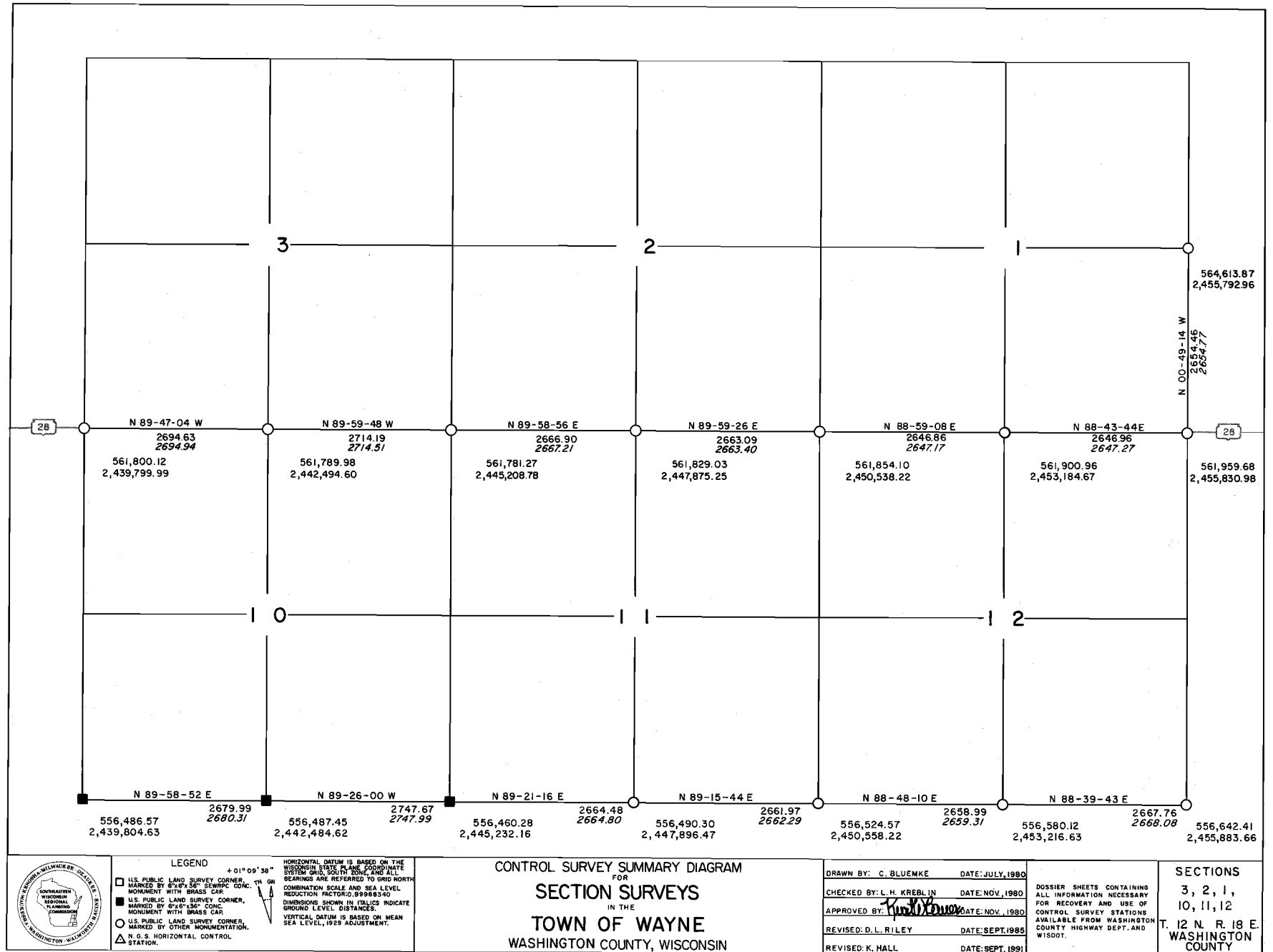
IN THE
TOWN OF TRENTON
WASHINGTON COUNTY, WISCONSIN

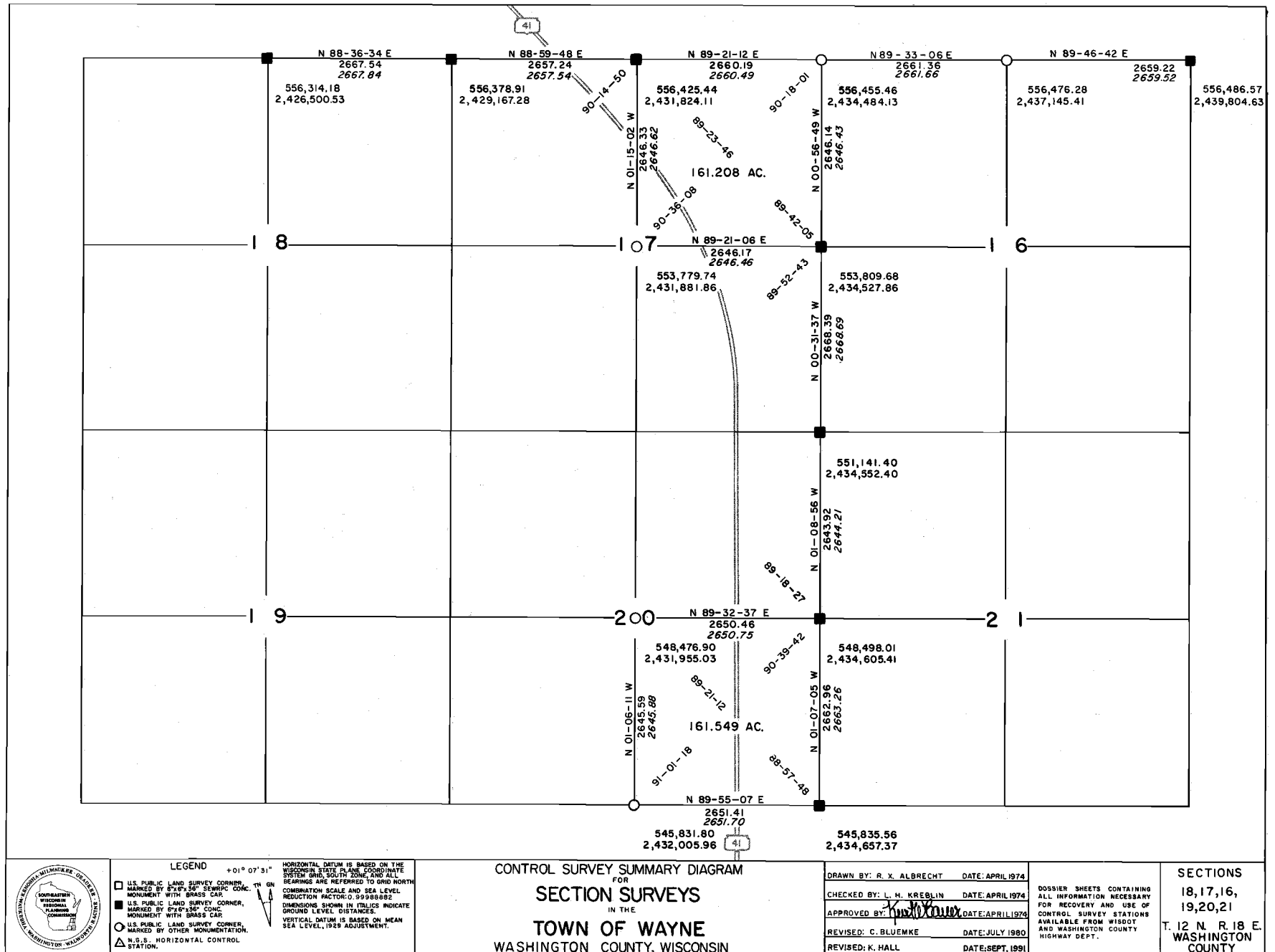
REVISOR: D. P. SIMON DATE: NOV, 1996

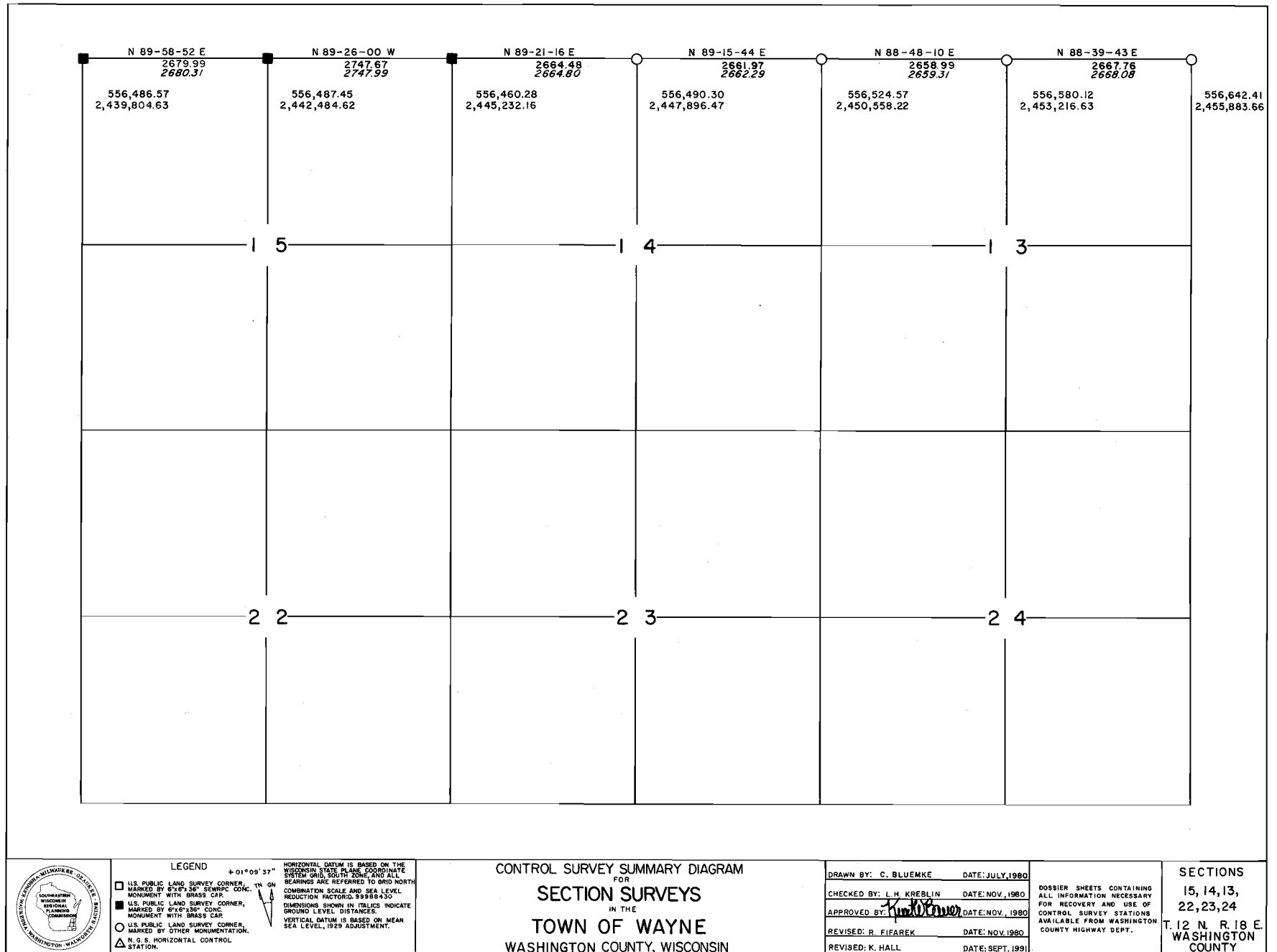
DOSSIER SHEETS CONTAINING
ALL INFORMATION NECESSARY
FOR RECOVERY AND USE OF
CONTROL SURVEY STATIONS
AVAILABLE FROM SEWRPC,
CITY OF WEST BEND, AND
WASHINGTON COUNTY.

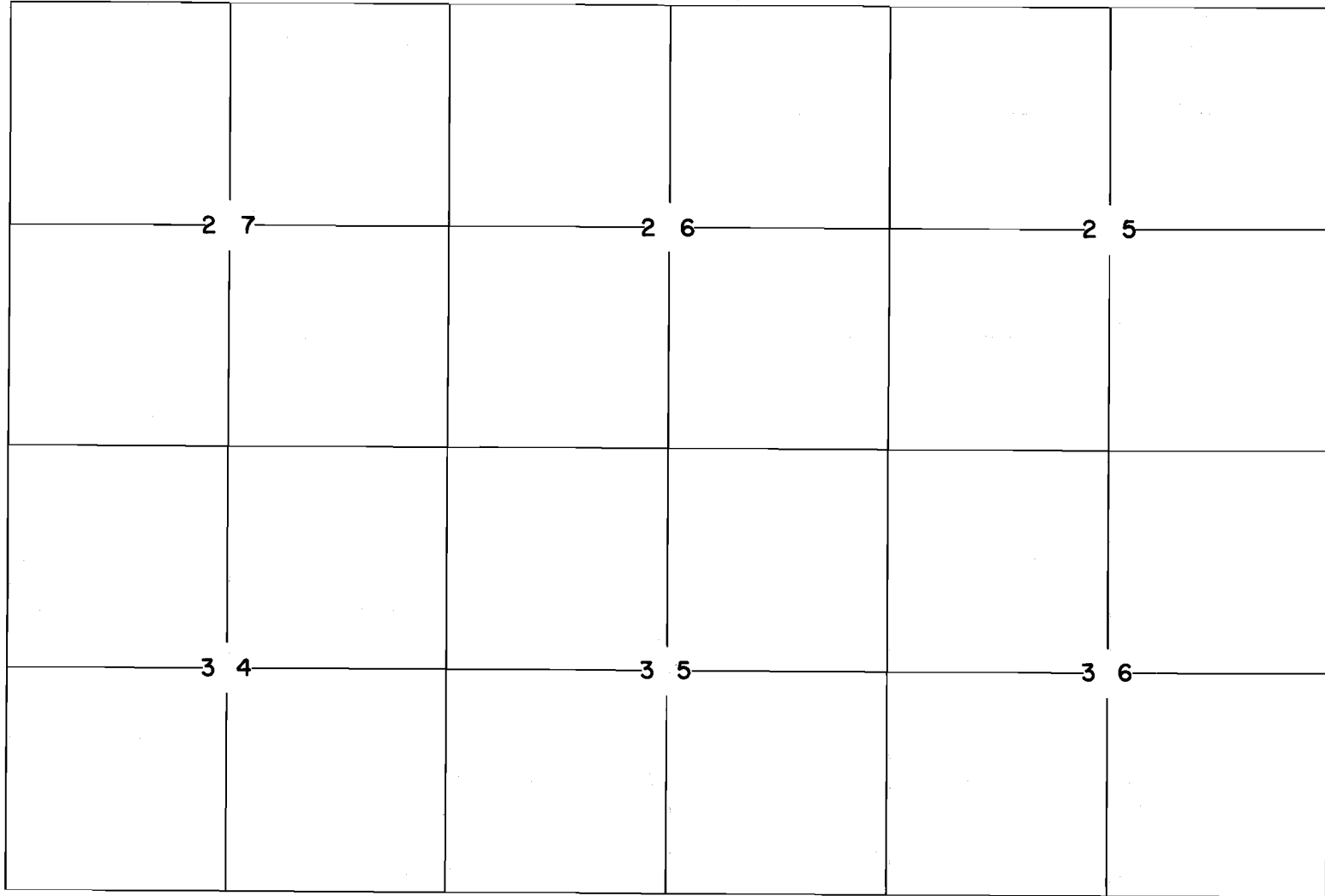
30, 29, 28,
31, 32, 33

T. 11 N. R. 20 E.
WASHINGTON
COUNTY









LEGEND

- ☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" SEWPC CONC. MONUMENT WITH BRASS CAP.
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"X6"X36" CONC. MONUMENT WITH BRASS CAP.
☐ U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
☐ N. G. S. HORIZONTAL CONTROL STATION.

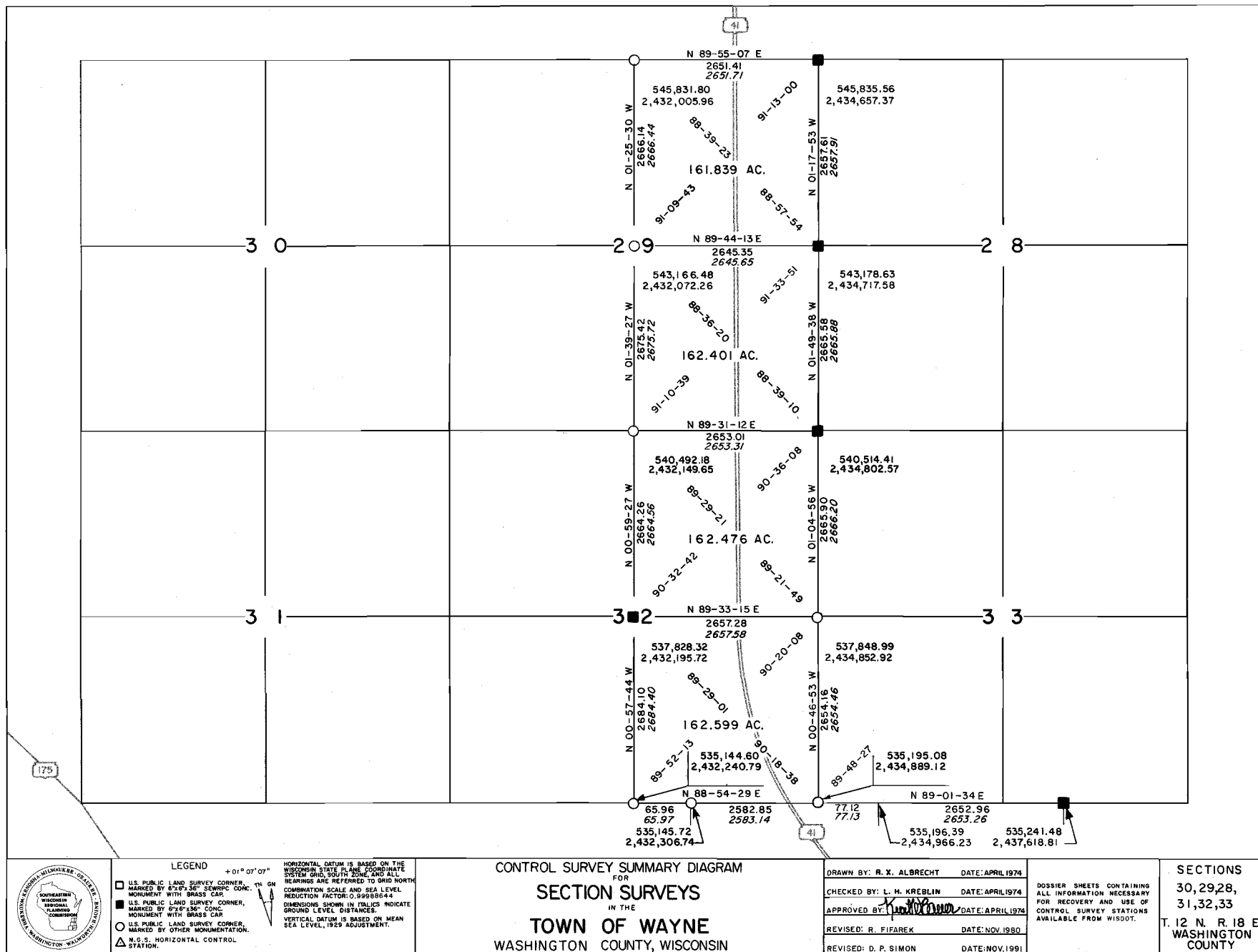
HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.
 REDUCTION FACTOR:
 DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.
 VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

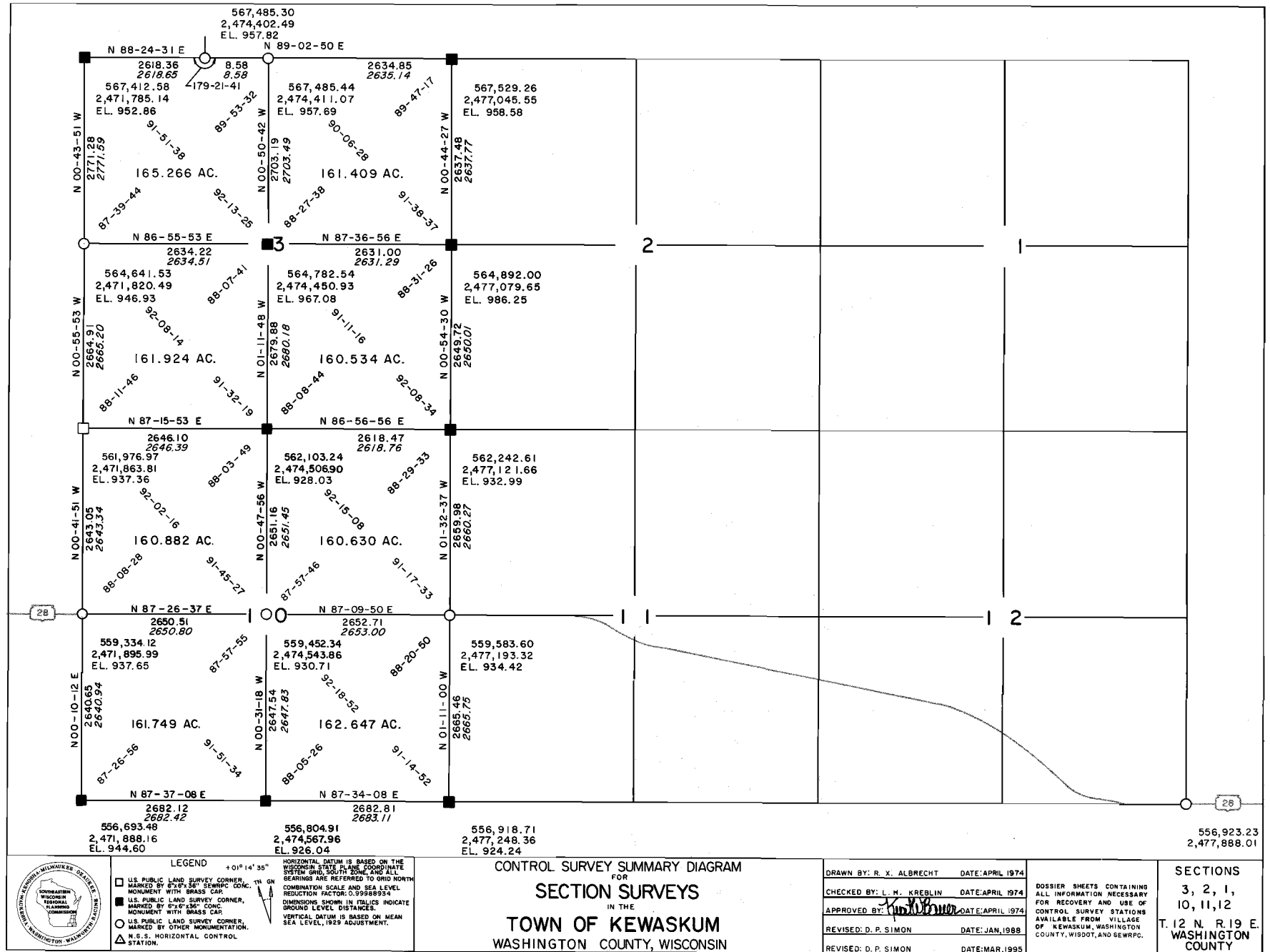
CONTROL SURVEY SUMMARY DIAGRAM
 FOR
SECTION SURVEYS
 IN THE
TOWN OF WAYNE
 WASHINGTON COUNTY, WISCONSIN

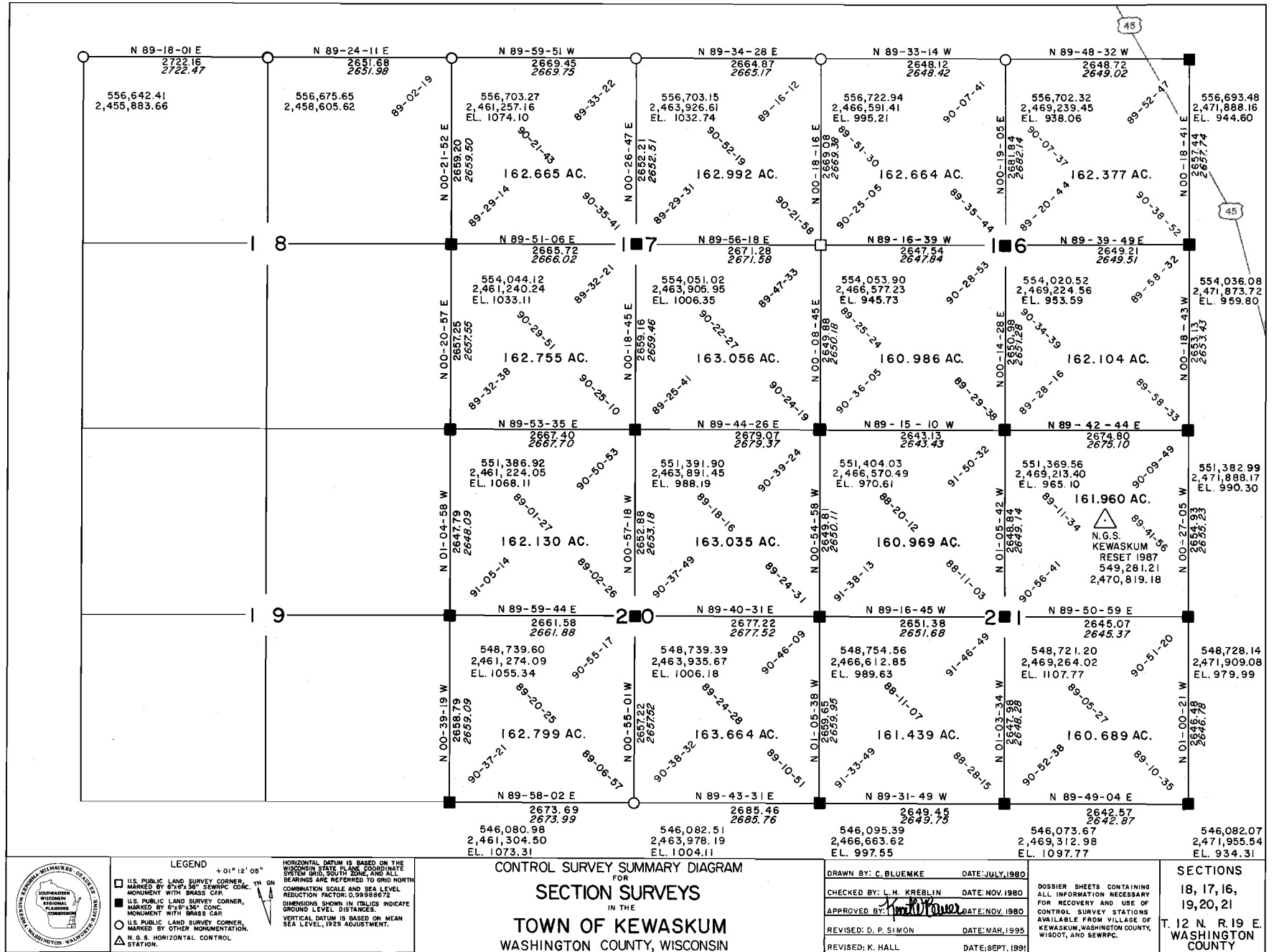
DRAWN BY: _____ DATE: _____
 CHECKED BY: _____ DATE: _____
 APPROVED BY: _____ DATE: _____
 REVISED: _____ DATE: _____

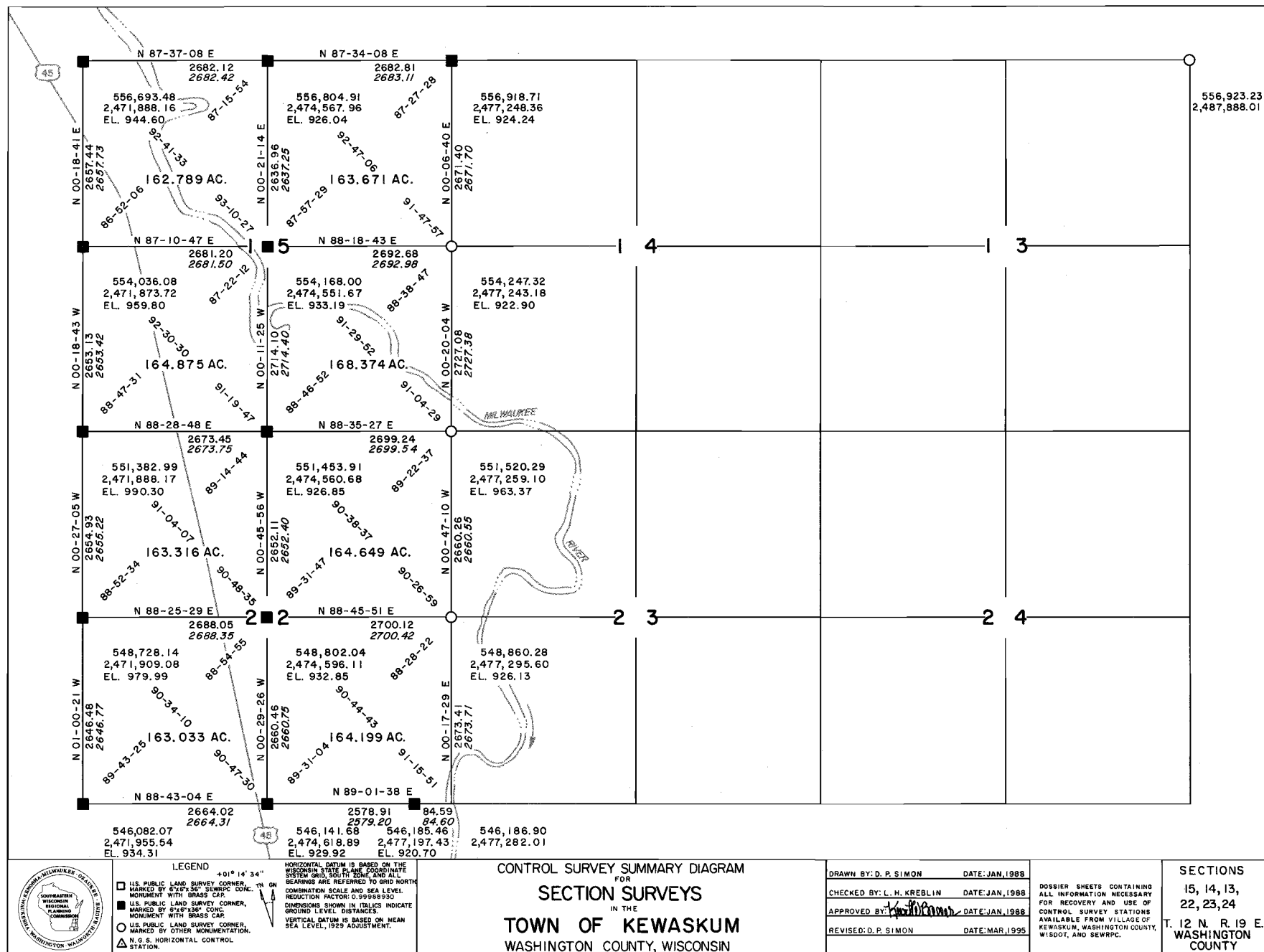
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM

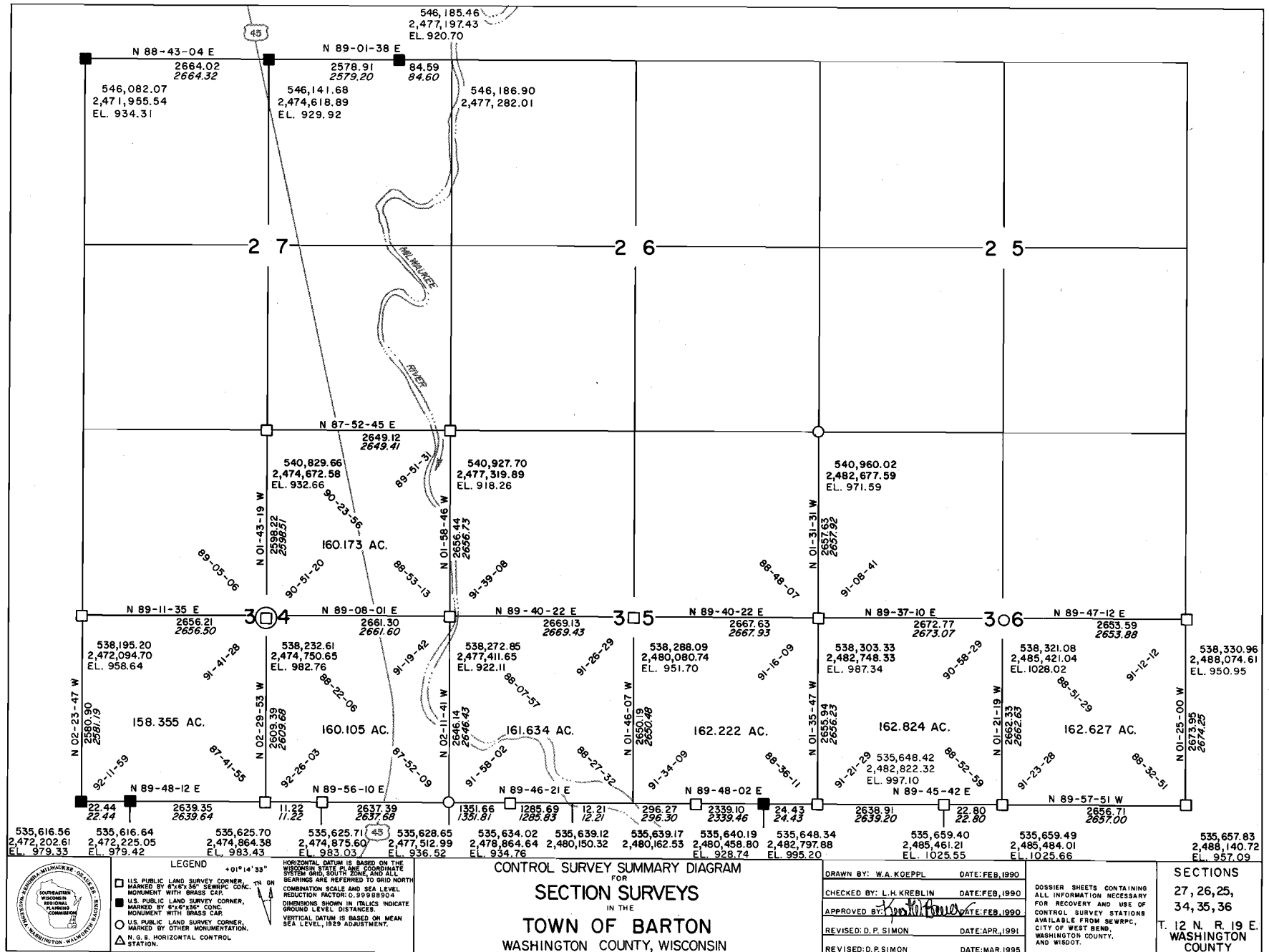
SECTIONS
 27, 26, 25,
 34, 35, 36
 T. 12 N. R. 18 E.
 WASHINGTON COUNTY

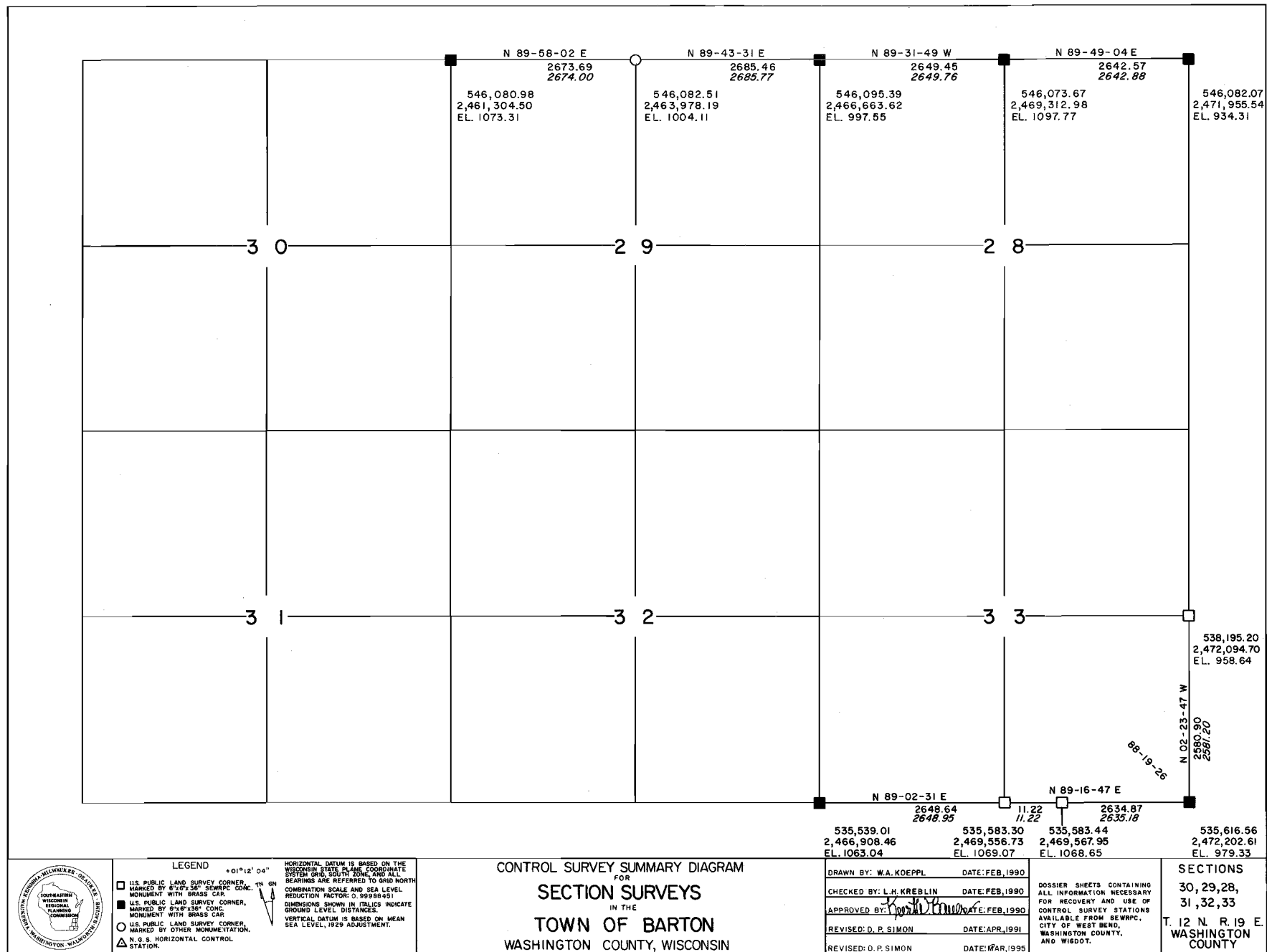


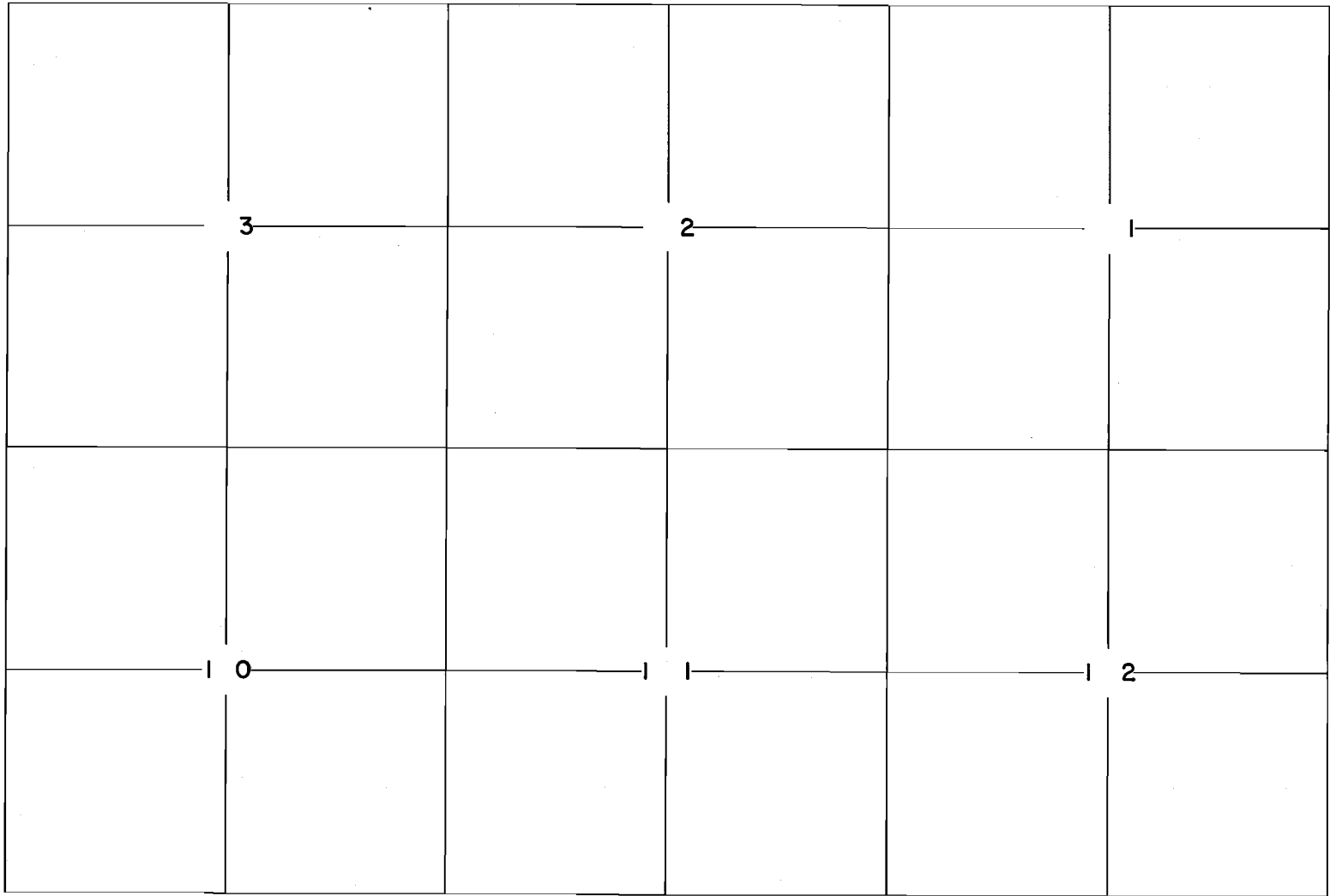




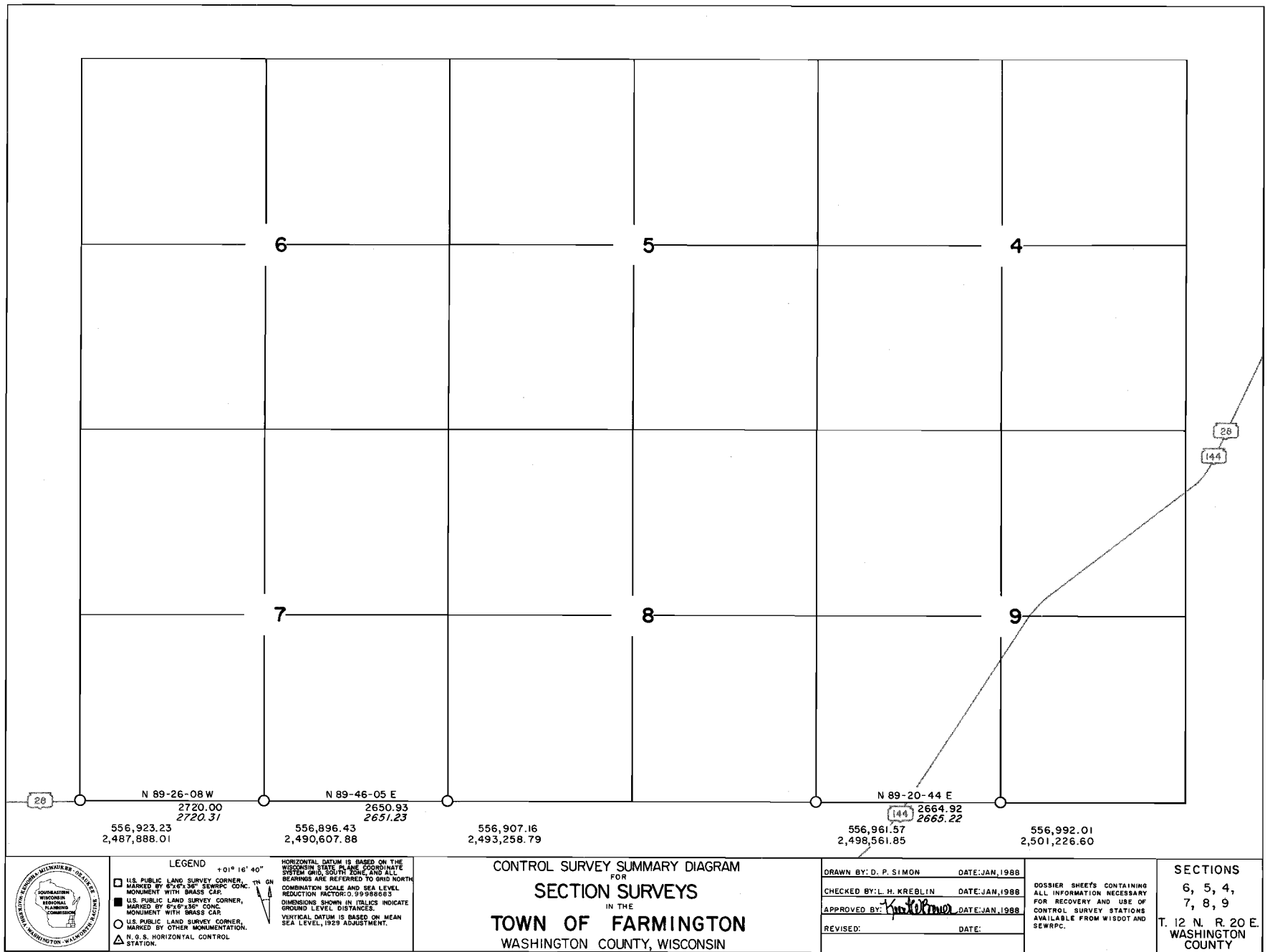


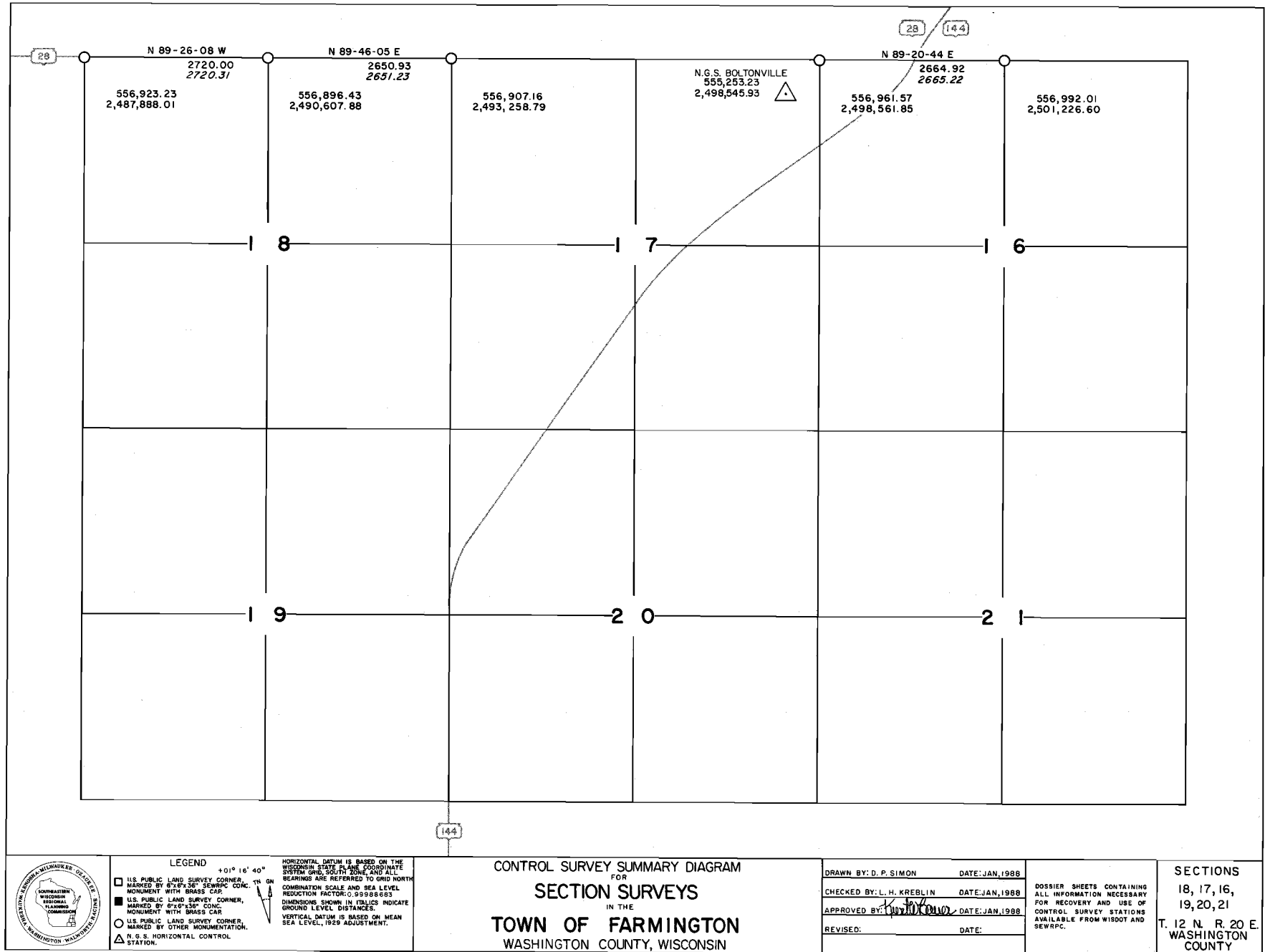


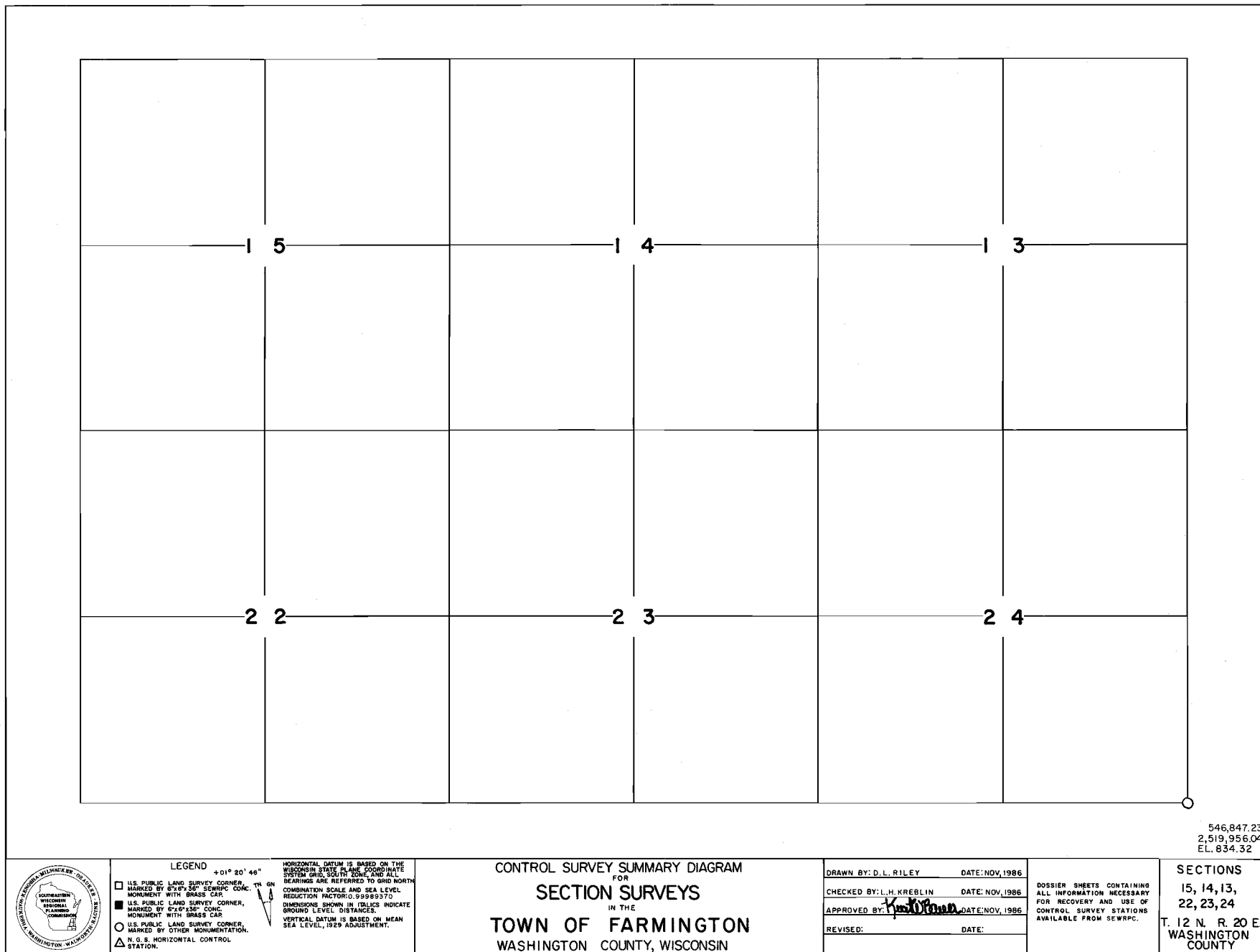


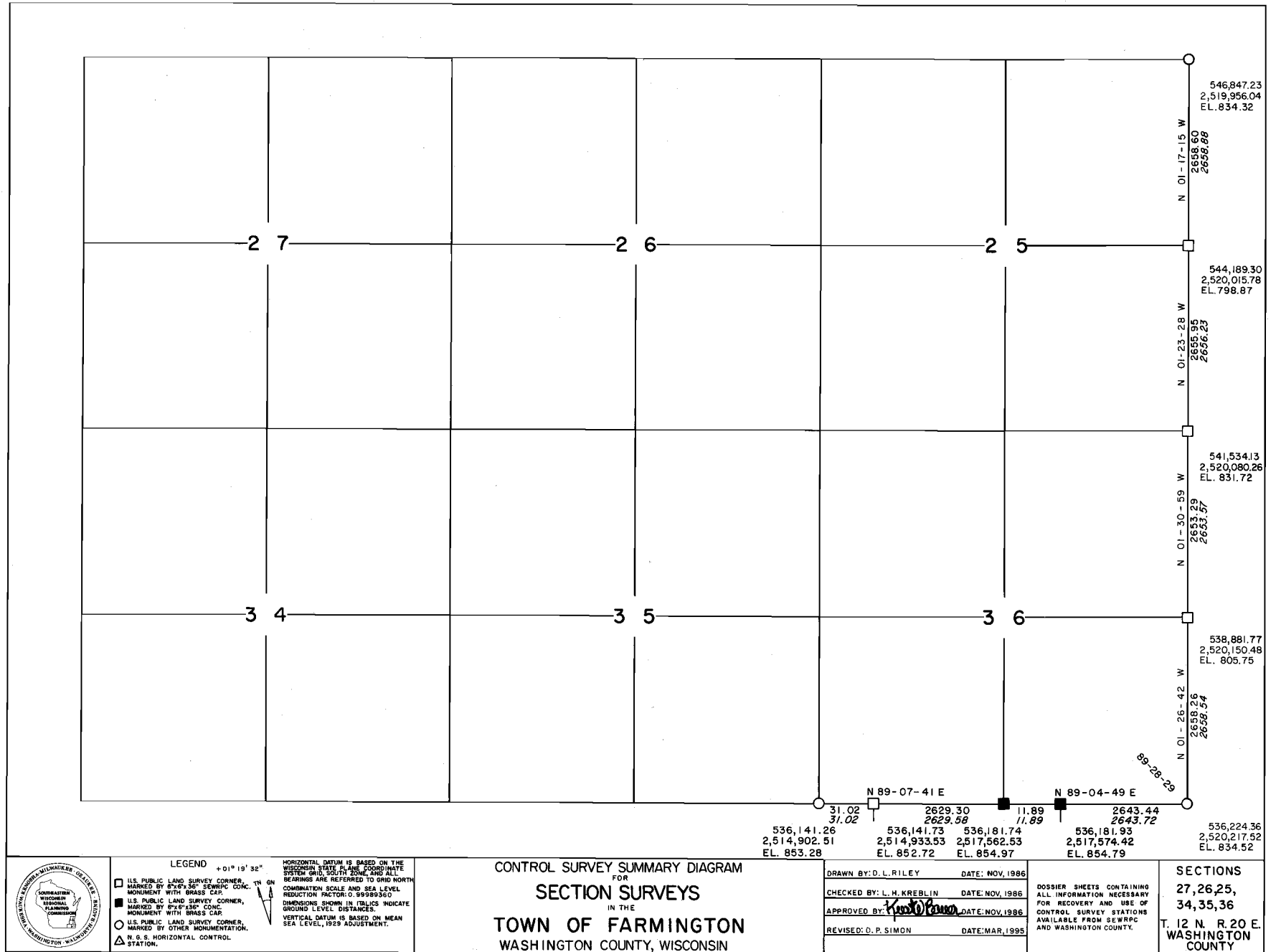


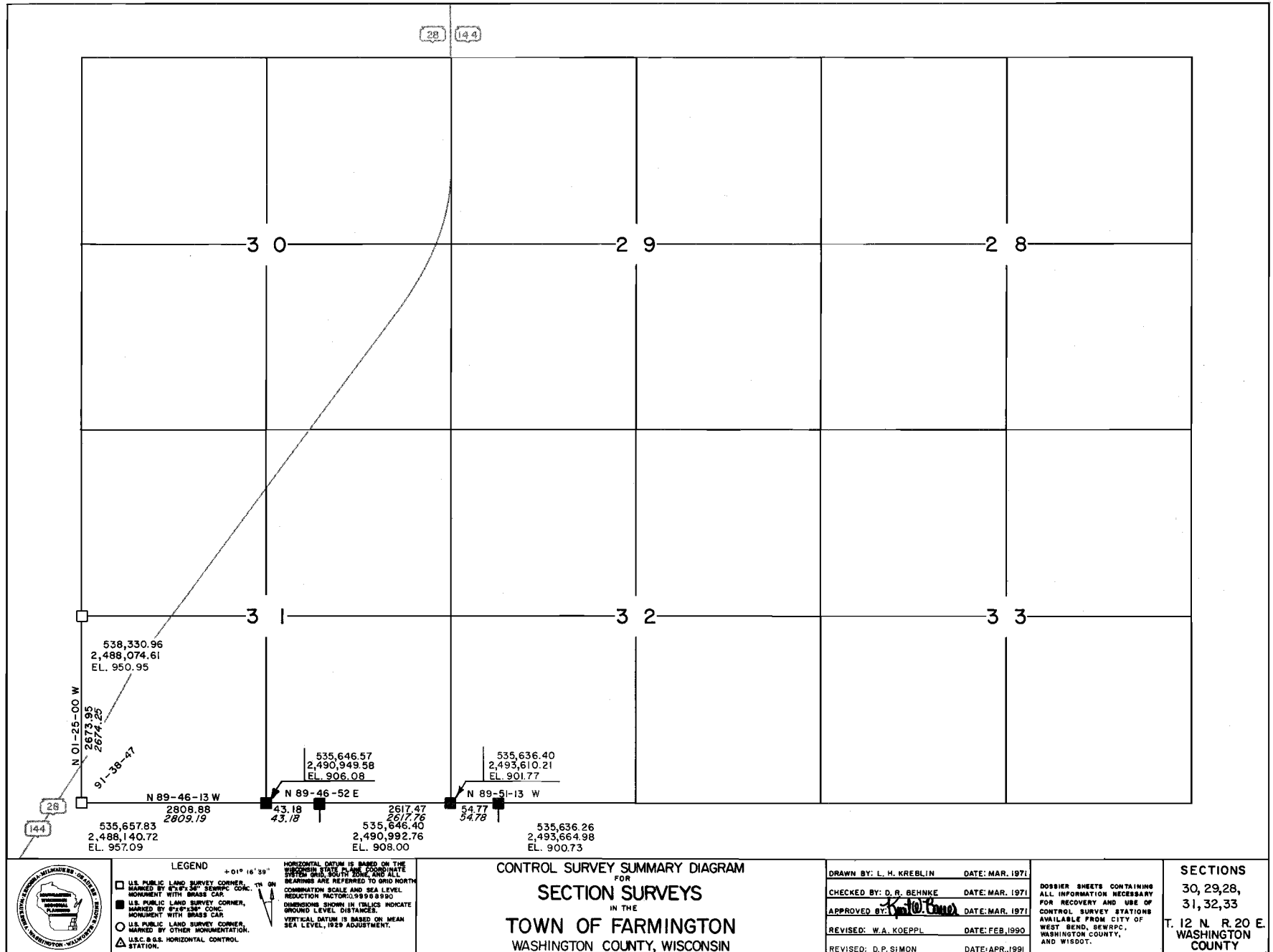
	LEGEND <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEWPC CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP. <input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION. <input type="checkbox"/> N. G. S. HORIZONTAL CONTROL STATION.	HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.	CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF FARMINGTON WASHINGTON COUNTY, WISCONSIN		DRAWN BY: _____ DATE: _____ CHECKED BY: _____ DATE: _____ APPROVED BY: _____ DATE: _____ REVISED: _____ DATE: _____	DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM SECTIONS 3, 2, 1, 10, 11, 12 T. 12 N. R. 20 E. WASHINGTON COUNTY
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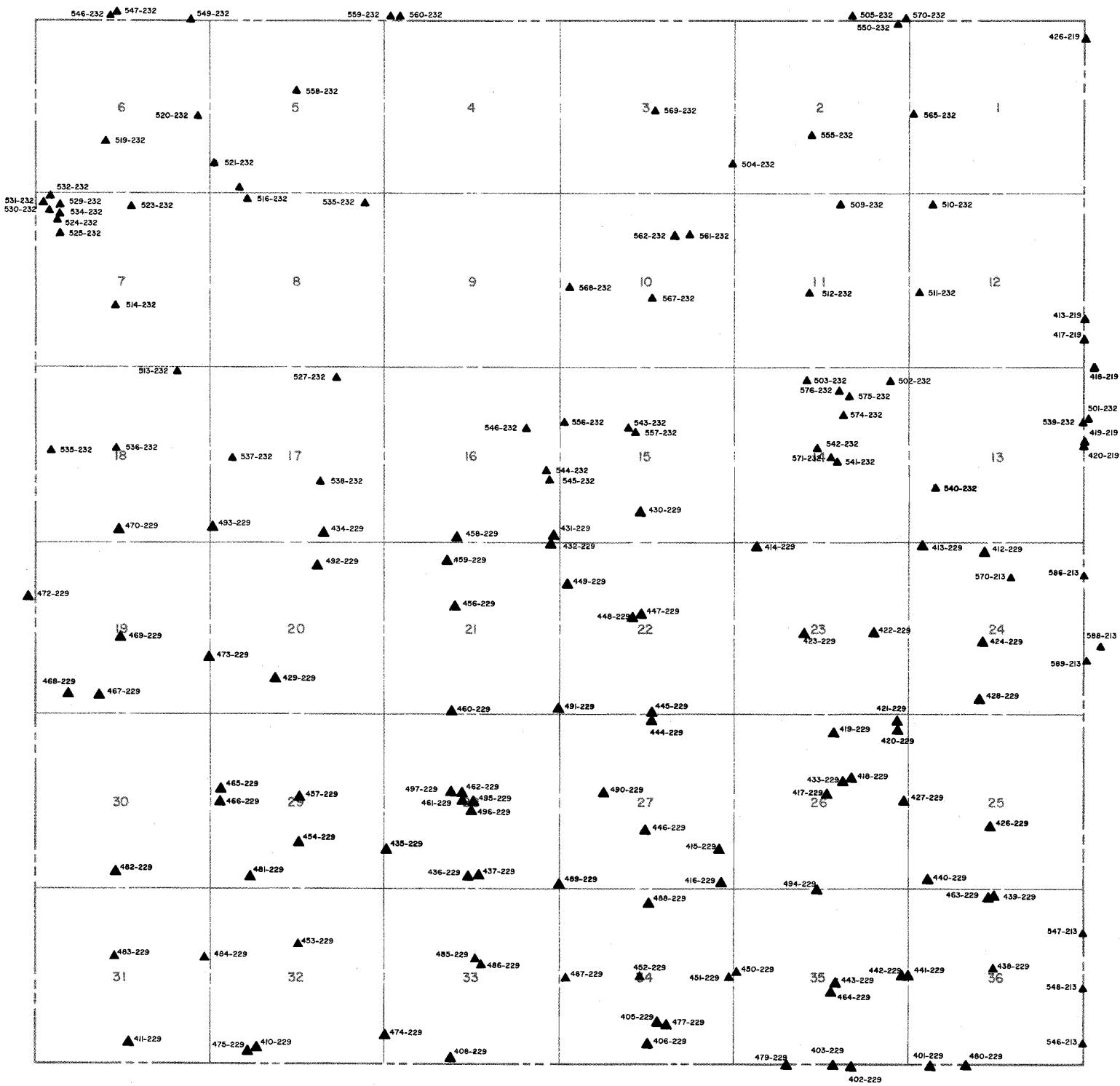








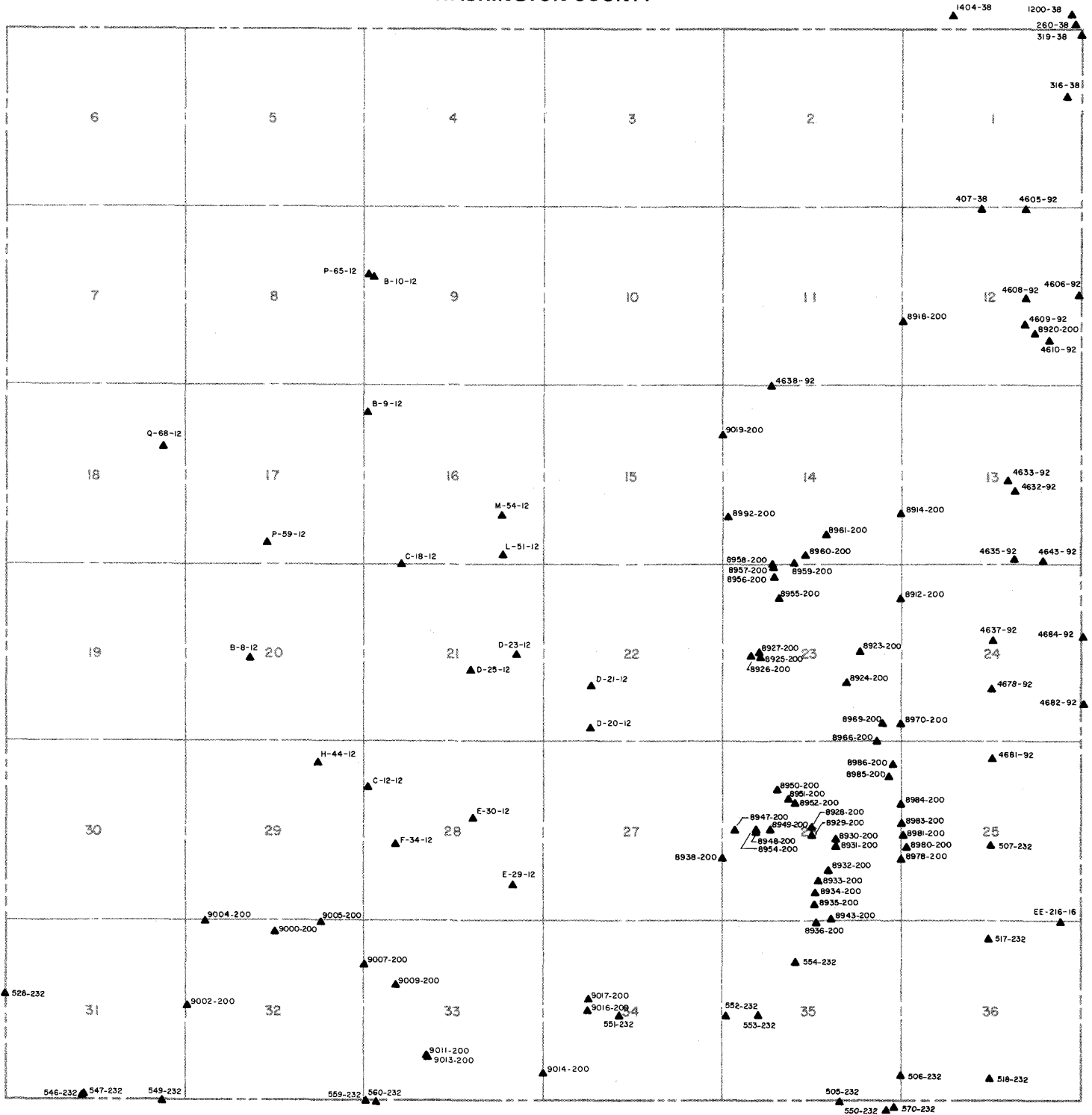
**TRAVERSE DIAGRAM, TOWNSHIP 9 NORTH, RANGE 18 EAST
WASHINGTON COUNTY**



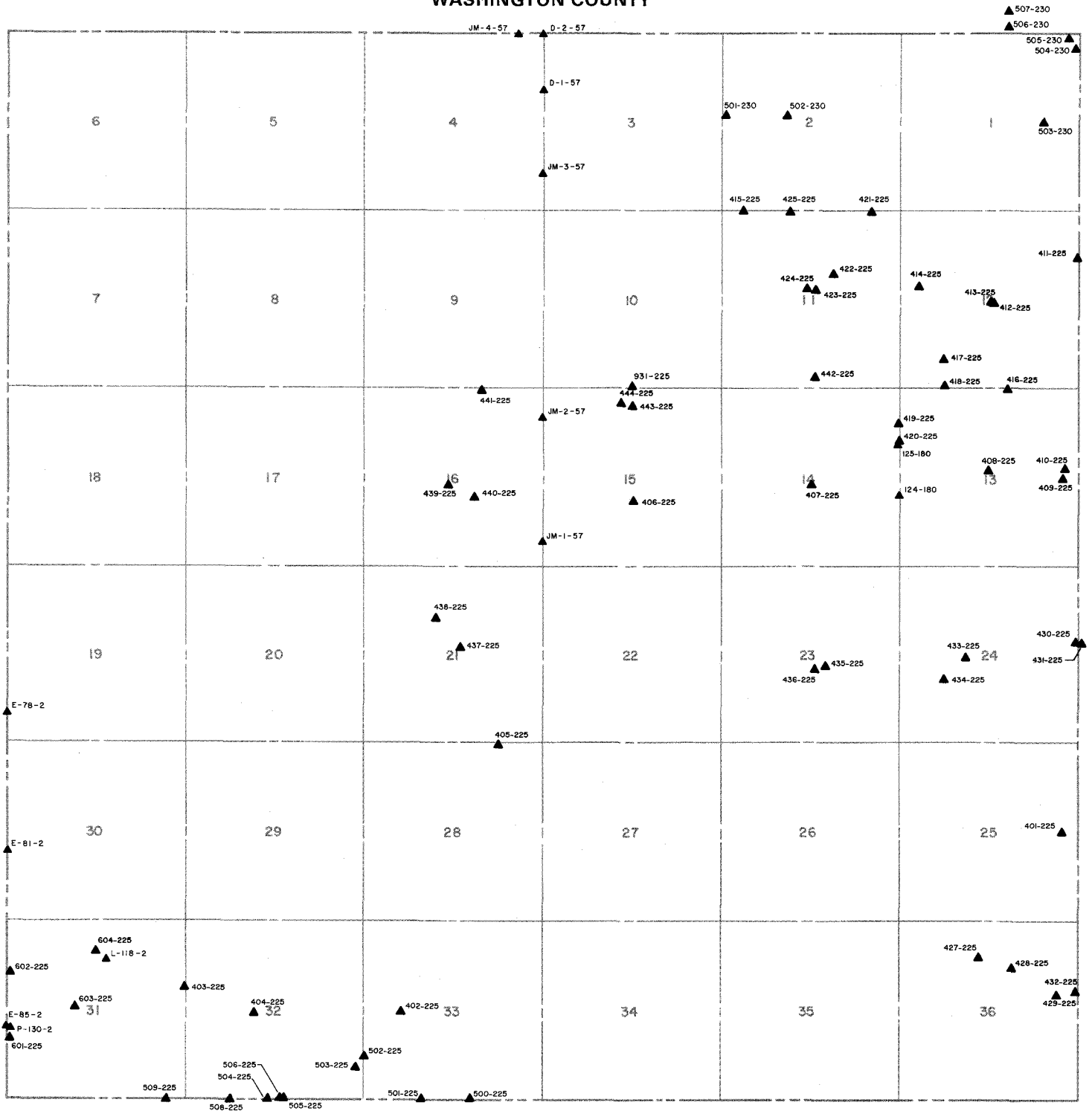
TRAVERSE DIAGRAM, TOWNSHIP 9 NORTH, RANGE 20 EAST
WASHINGTON COUNTY

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19 ▲ 653-213	20	21	22	23	24
▲ 654-213					
▲ 655-213					
30	29	28	27	26	25
31	32	33	34	35	36

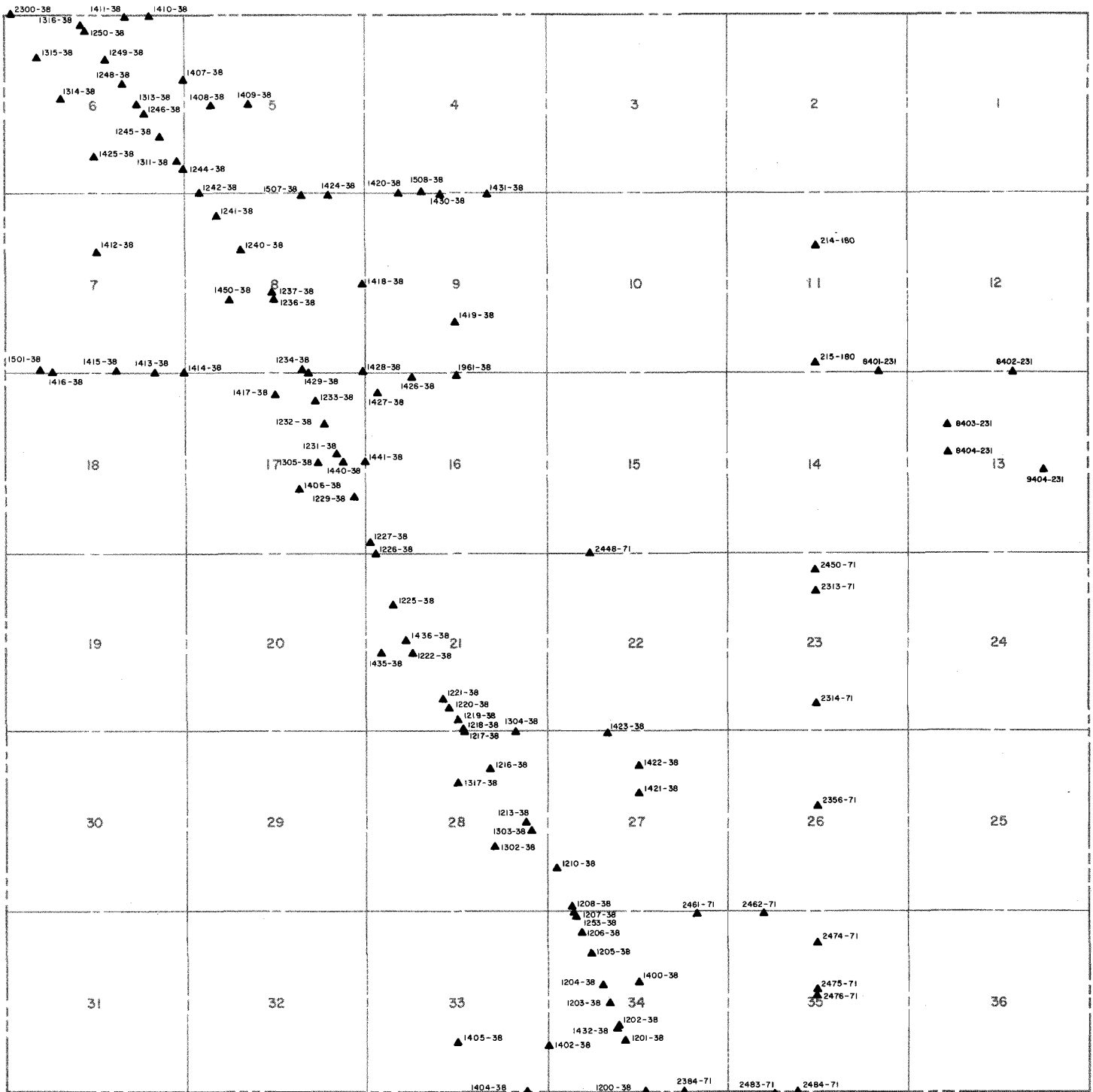
TRAVERSE DIAGRAM, TOWNSHIP 10 NORTH, RANGE 18 EAST WASHINGTON COUNTY



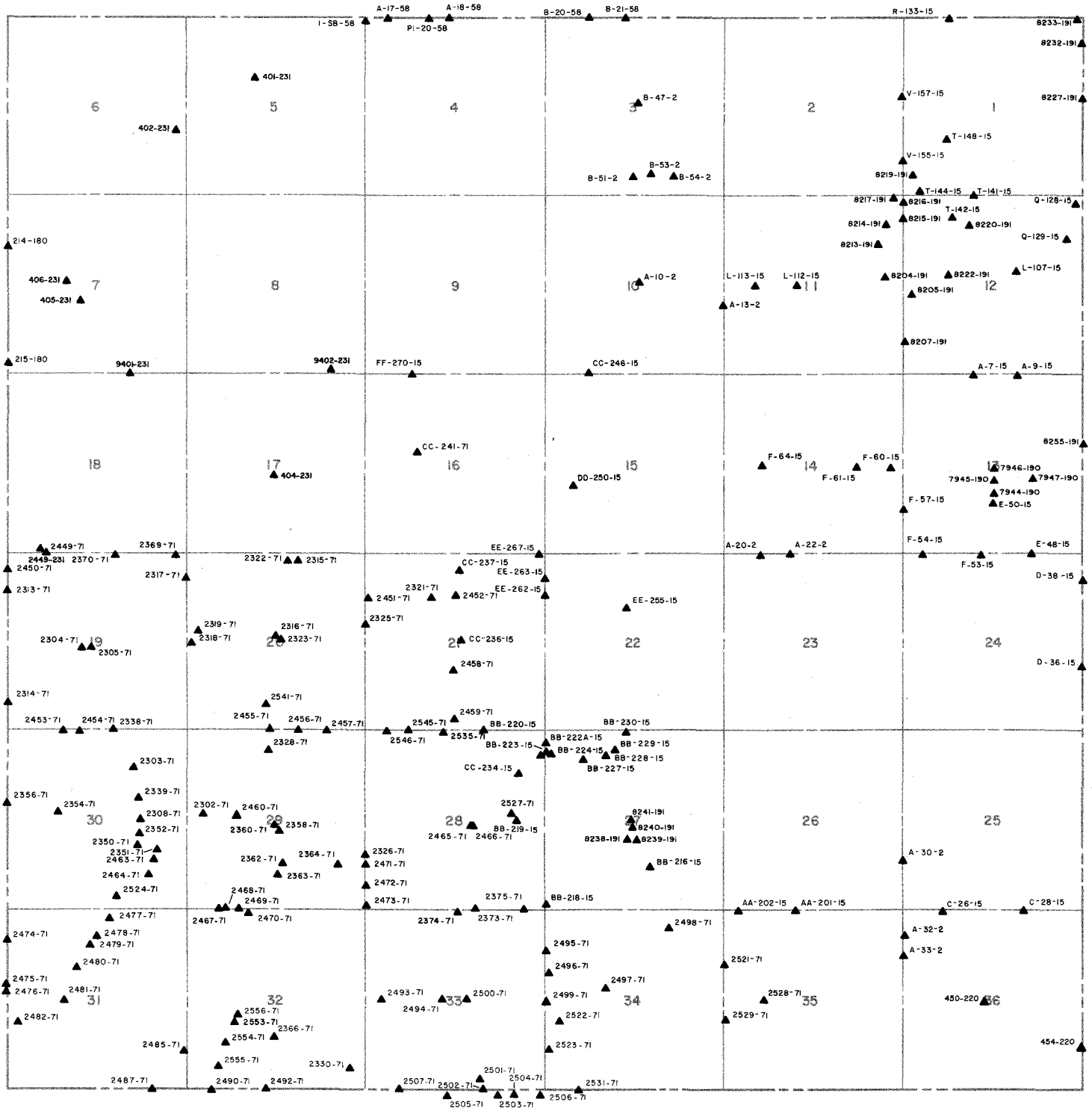
TRAVERSE DIAGRAM, TOWNSHIP 10 NORTH, RANGE 20 EAST WASHINGTON COUNTY



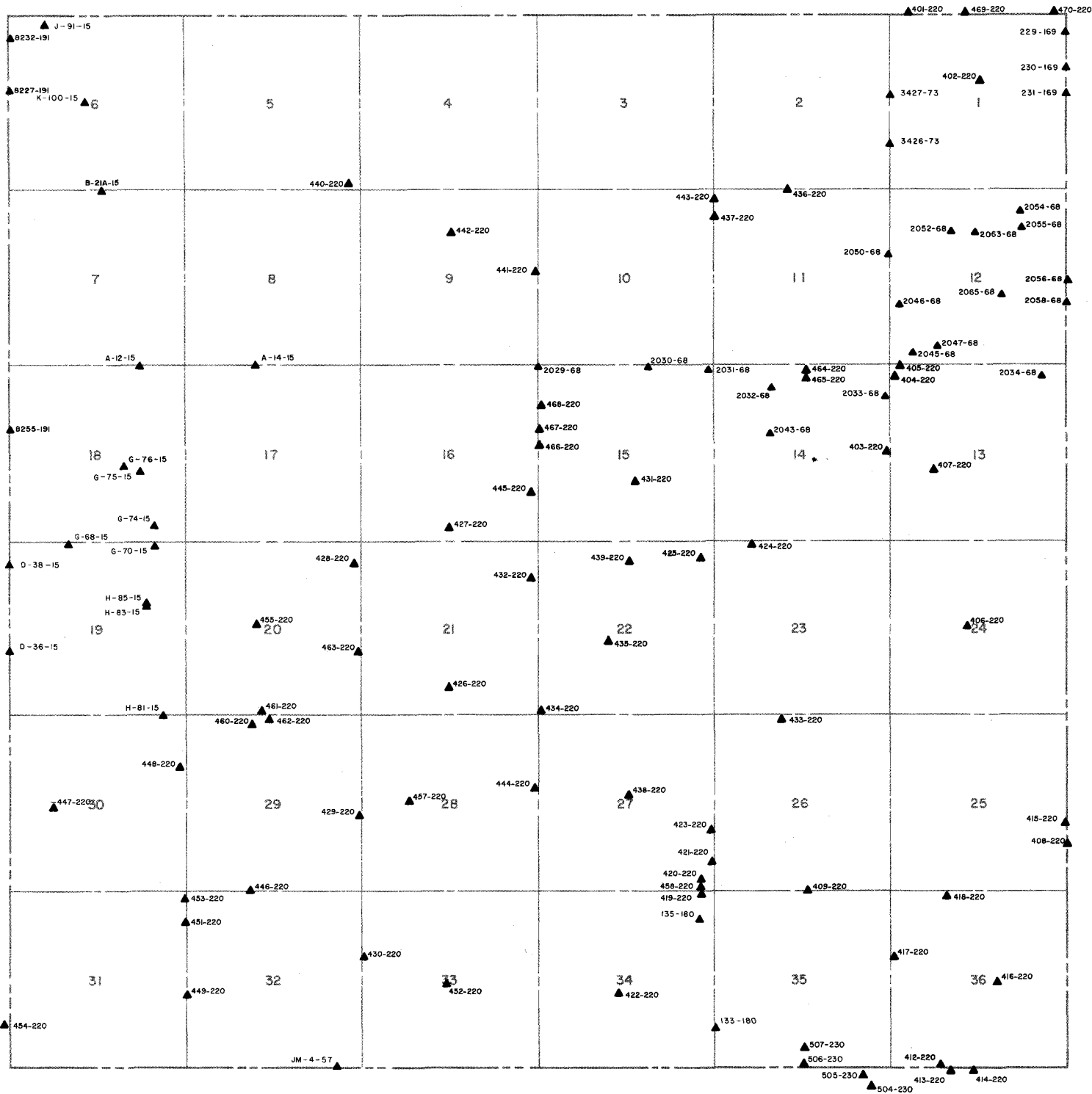
TRAVERSE DIAGRAM, TOWNSHIP 11 NORTH, RANGE 18 EAST WASHINGTON COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 11 NORTH, RANGE 19 EAST WASHINGTON COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 11 NORTH, RANGE 20 EAST WASHINGTON COUNTY



The map displays a grid of 36 numbered squares, likely representing a coordinate system for the Hawaiian Islands. The squares are numbered 1 through 36, arranged in a 6x6 grid. The map includes numerous labeled points, mostly in the western and central squares, representing various locations. The labels are in the format 'XXXX-YY' or 'XX-YY-YY'. The grid is bounded by latitude and longitude lines. The islands are represented by small black triangles. The map is oriented with North at the top.

Key labeled points include:

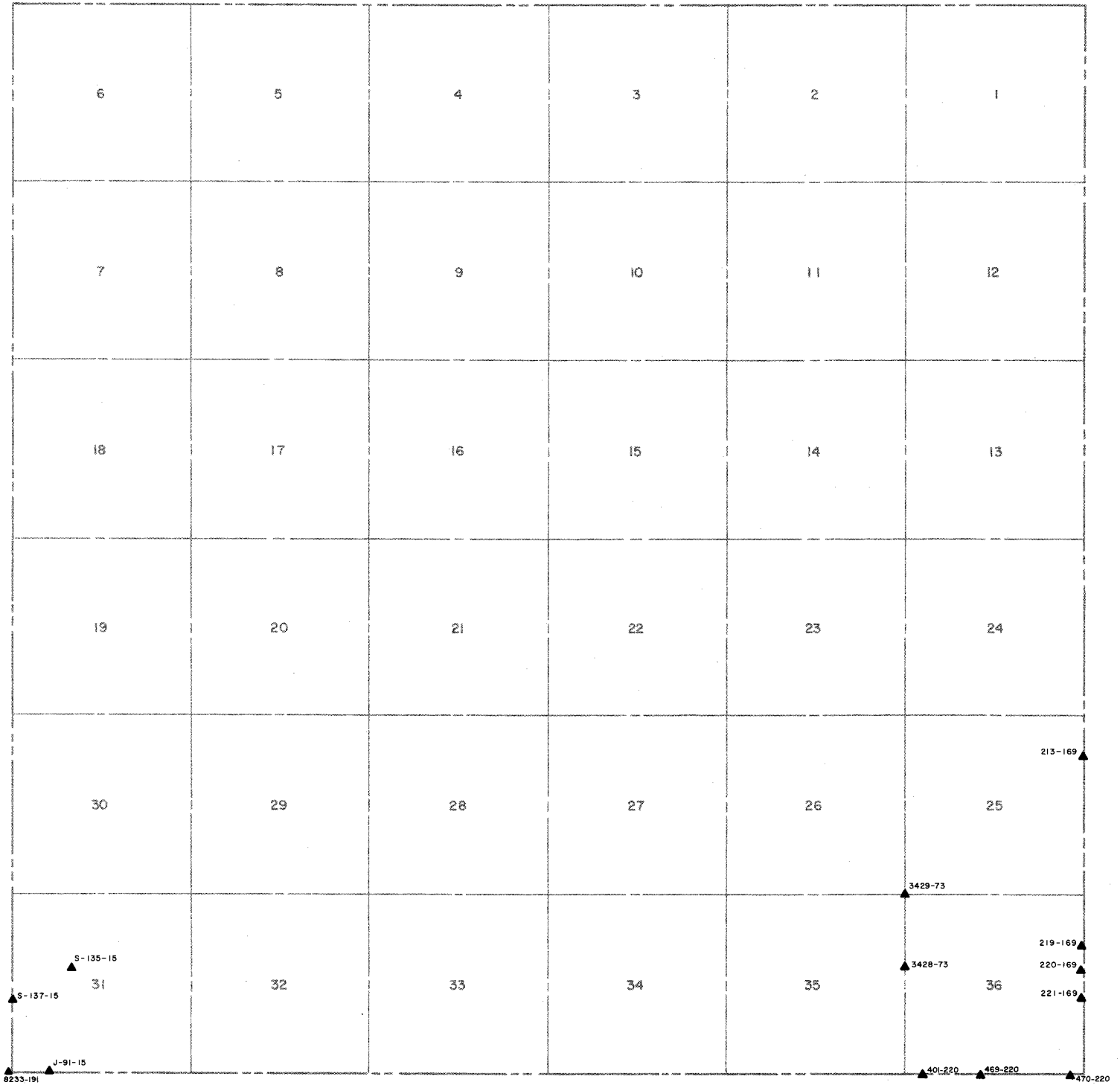
- 2430-38, 2416-38, 2504-38 (top left)
- 2254-38, 2253-38 (top left)
- 2252-38, 2251-38, 2250-38 (top left)
- 2248-38 (top left)
- 2420-38, 2246-38, 2244-38 (top left)
- 2243-38, 2242-38 (top left)
- 2419-38, 2418-38, 2417-38 (top left)
- 2240-38, 2381-38, 2412-38 (top center)
- 2380-38, 2239-38, 2411-38 (top center)
- 2237-38, 2410-38, 2409-38, 2408-38 (top center)
- 2232-38, 2229-38 (top center)
- 2227-38, 2421-38, 2226-38, 2225-38, 2270-38, 2222-38 (top center)
- 2407-38, 2406-38 (top center)
- 2221-38, 2220-38, 2219-38, 2216-38 (top center)
- 2405-38 (top center)
- 2215-38, 2212-38, 2423-38, 2810-38, 2456-38, 2422-38, 2211-38 (top center)
- 2453-38, 2210-38, 2454-38, 2209-38, 2208-38 (top center)
- 2206-38, 2205-38 (top center)
- 2300-38, 2401-38, 2400-38, 1411-38, 1410-38 (bottom center)
- C-31-58, PI-11-58, C-30-58, A-10-58, A-11-58 (bottom center)
- D-5-58, PI-14-58, PI-13-58, D-4-58 (bottom right)
- PI-15-58, A-12-58, A-13-58 (bottom right)

This map displays a grid of numbered squares (1-36) representing a region of the Pacific Ocean. The grid is bounded by 10°N to 30°N latitude and 150°E to 120°E longitude. Various data points are marked with triangles and alphanumeric codes, including:

- Top Row (Squares 1-6):** 214-221, 209-221, 211-221, 206-221, 216-221, 217-221.
- Second Row (Squares 7-12):** 212-221, 207-221, 210-221, 215-221, 354-39, 374-39, 355-39, 380-39, 379-39, 377-39, 218-221, 219-221.
- Third Row (Squares 13-18):** 213-221, 356-39, 357-39, 363-39, 358-39, 359-39, 228-221, 226-221, 240-221.
- Fourth Row (Squares 19-24):** 205-221, 233-221, 220-221, 235-221, 225-221, 227-221, 203-221, 360-39, 237-221, 224-221.
- Fifth Row (Squares 25-30):** 204-221, 201-221, 234-221, 202-221, 221-221, 222-221, 200-221, 231-221, 22-221.
- Sixth Row (Squares 31-36):** 20-221, 23-221, 21-221, 24-221, 25-221, 26-221, 27-221, 28-221, 29-221, 30-221, 31-221, 32-221, 33-221, 34-221, 35-221, 36-221.
- Bottom Row (Squares 37-42):** 20-71-58, 1-SA-58, 2-S-58, A-15-58, A-16-58, I-NA-58, P1-20-58, 2-NB-58, I-NB-58, A-18-58, FF-279-15, C-57-2, FF-280-15, C-56-2, FF-277-15, C-59-2, 2-NA-58, I-NC-58, B-21-58, B-43-58, W-164-15, W-166-15, J-95-15, R-133-15, R-131-15, J-93-15, S-137-15.

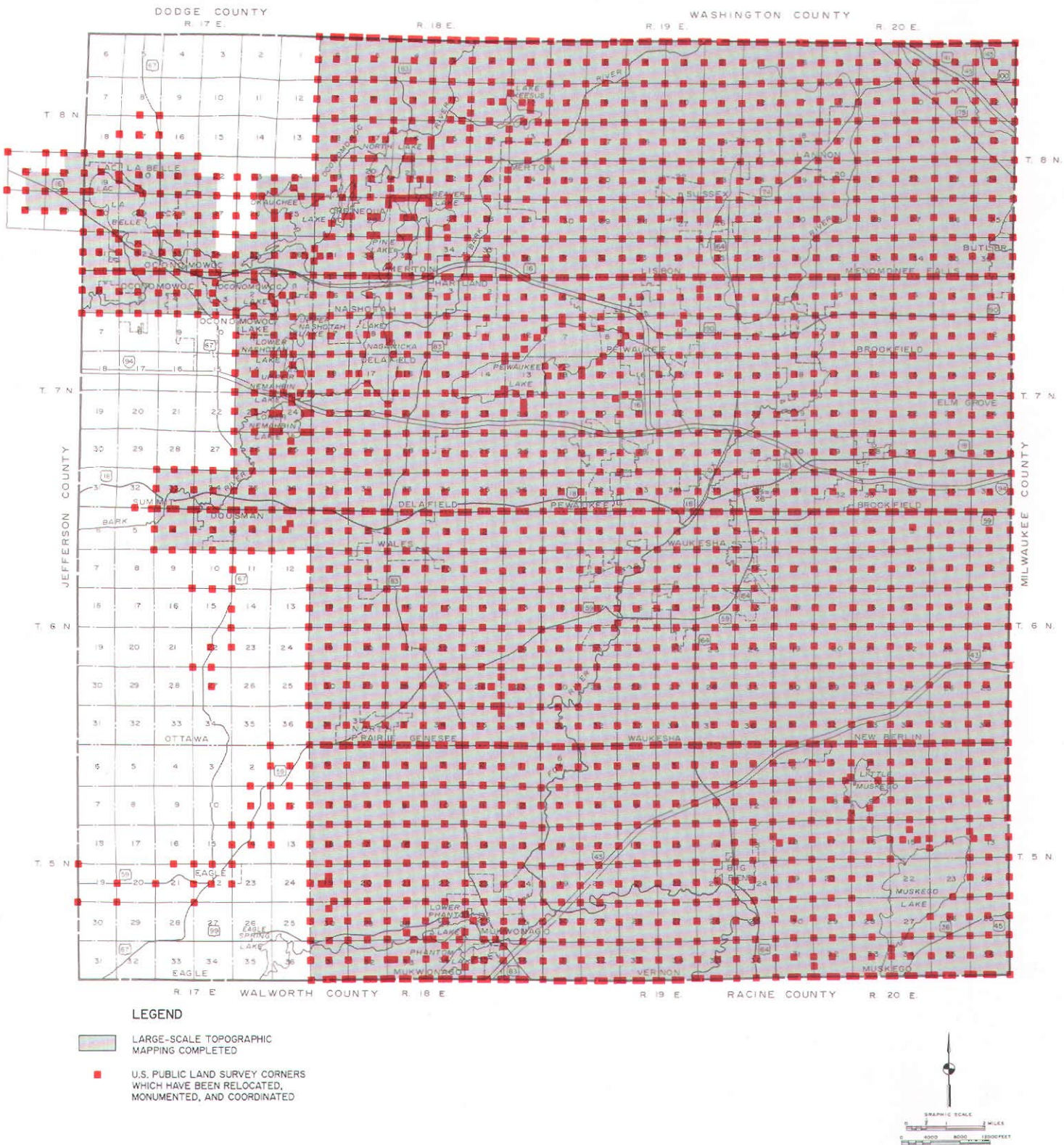
The map includes latitude and longitude markings along the edges and a scale bar at the bottom.

**TRAVERSE DIAGRAM, TOWNSHIP 12 NORTH, RANGE 20 EAST
WASHINGTON COUNTY**

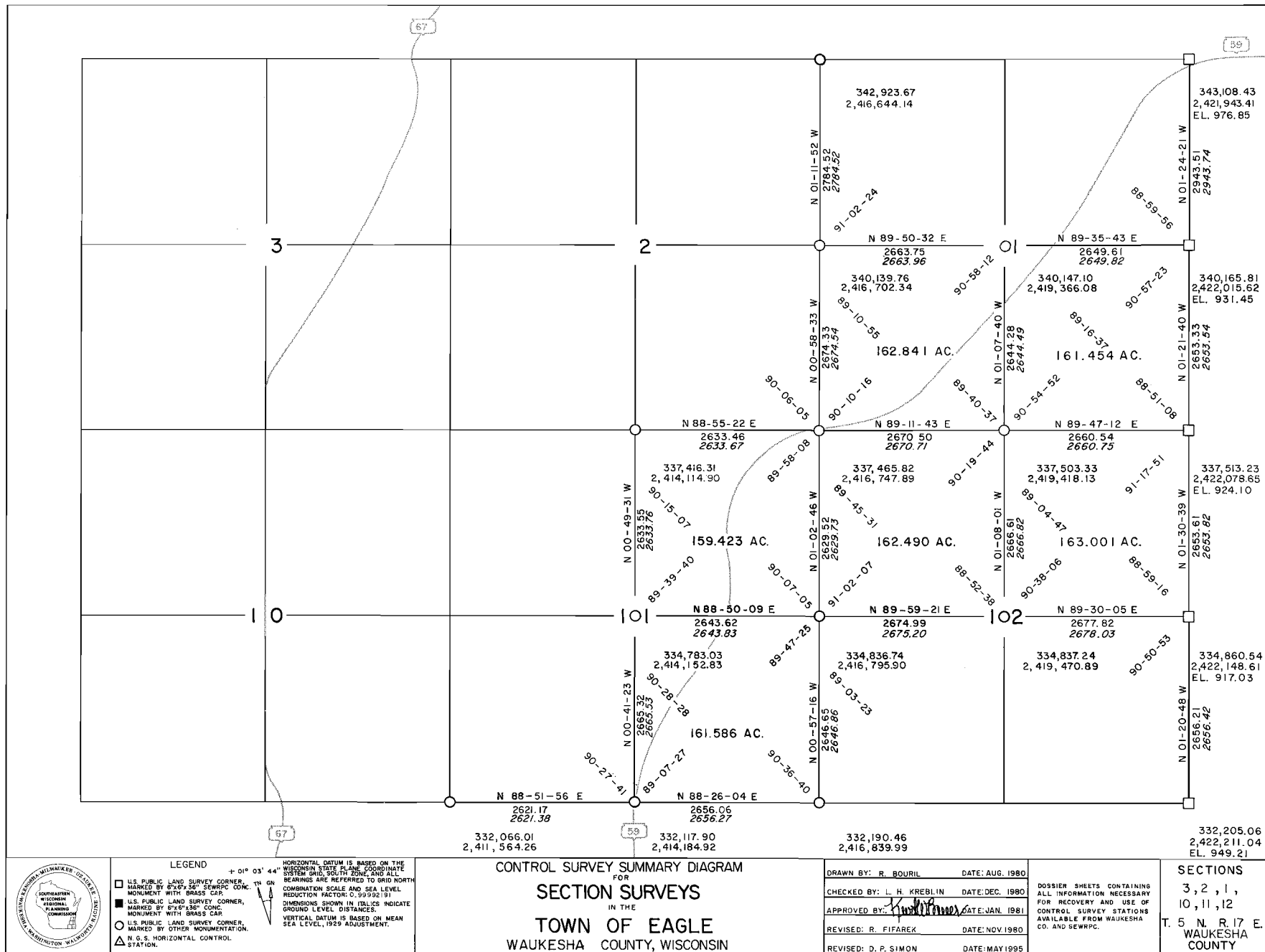


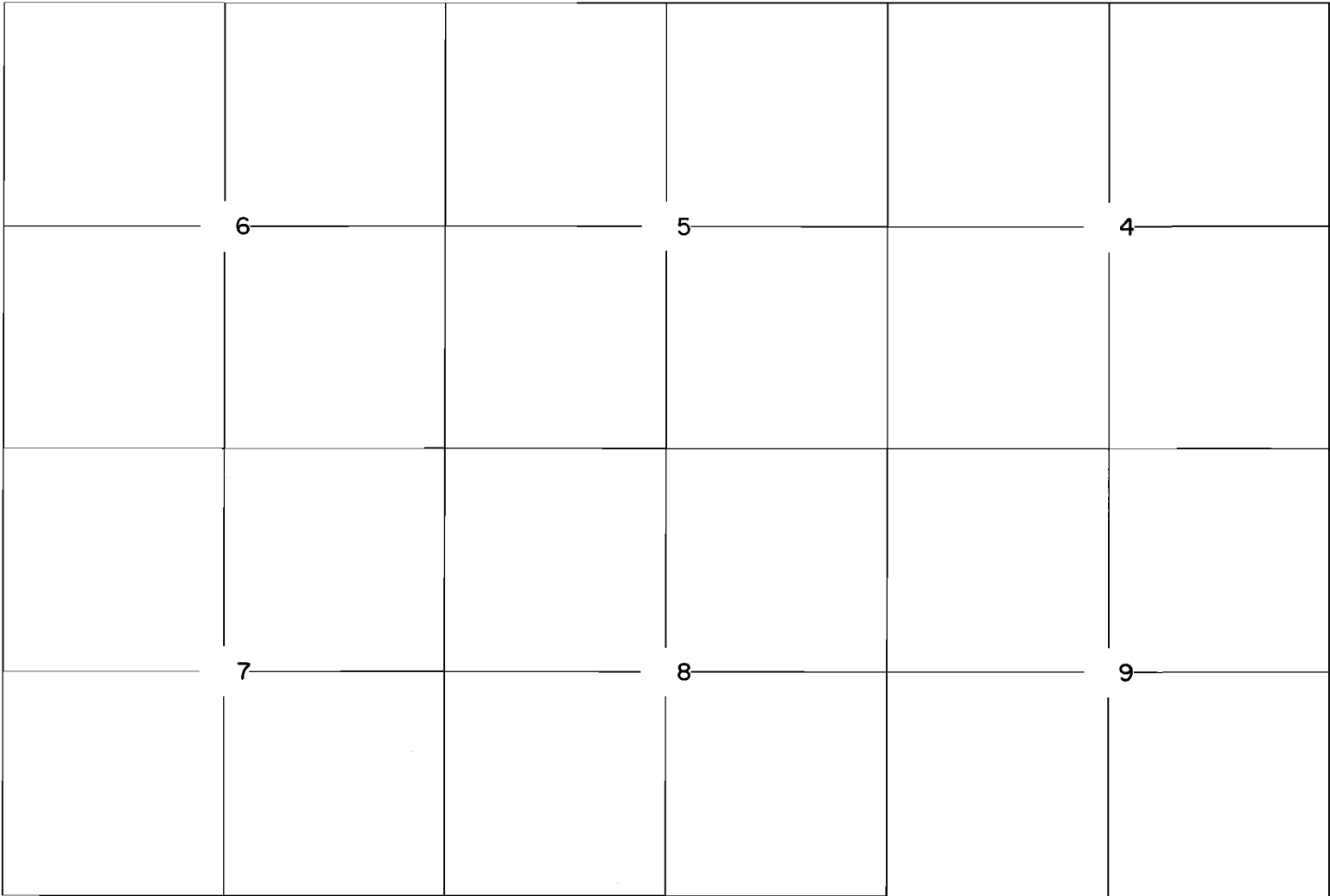

Map C-7

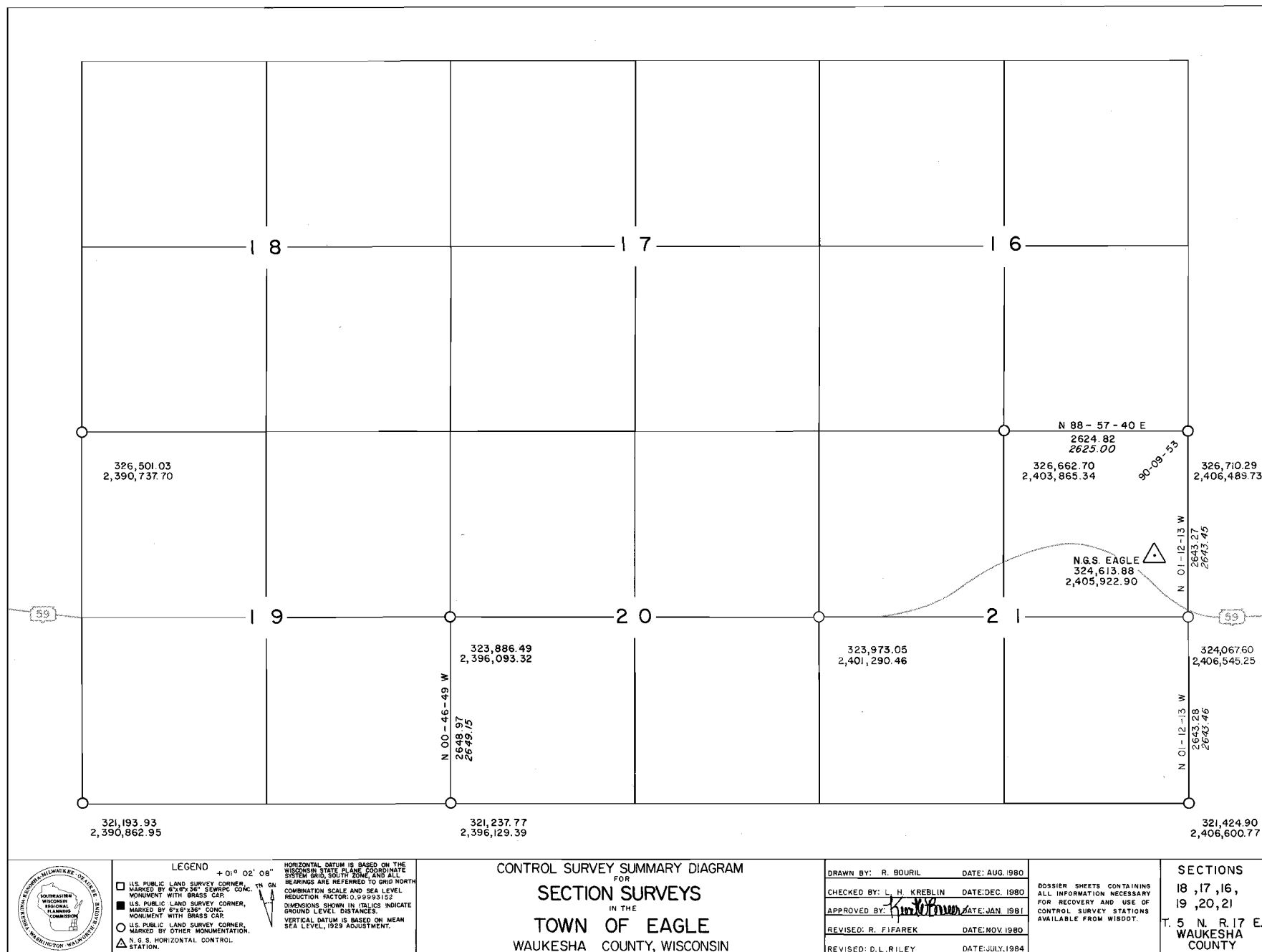
STATUS OF LARGE-SCALE TOPOGRAPHIC MAPPING AND THE RELOCATION, MONUMENTATION, AND COORDINATION OF U. S. PUBLIC LAND SURVEY CORNERS IN WAUKESHA COUNTY: SEPTEMBER 1996

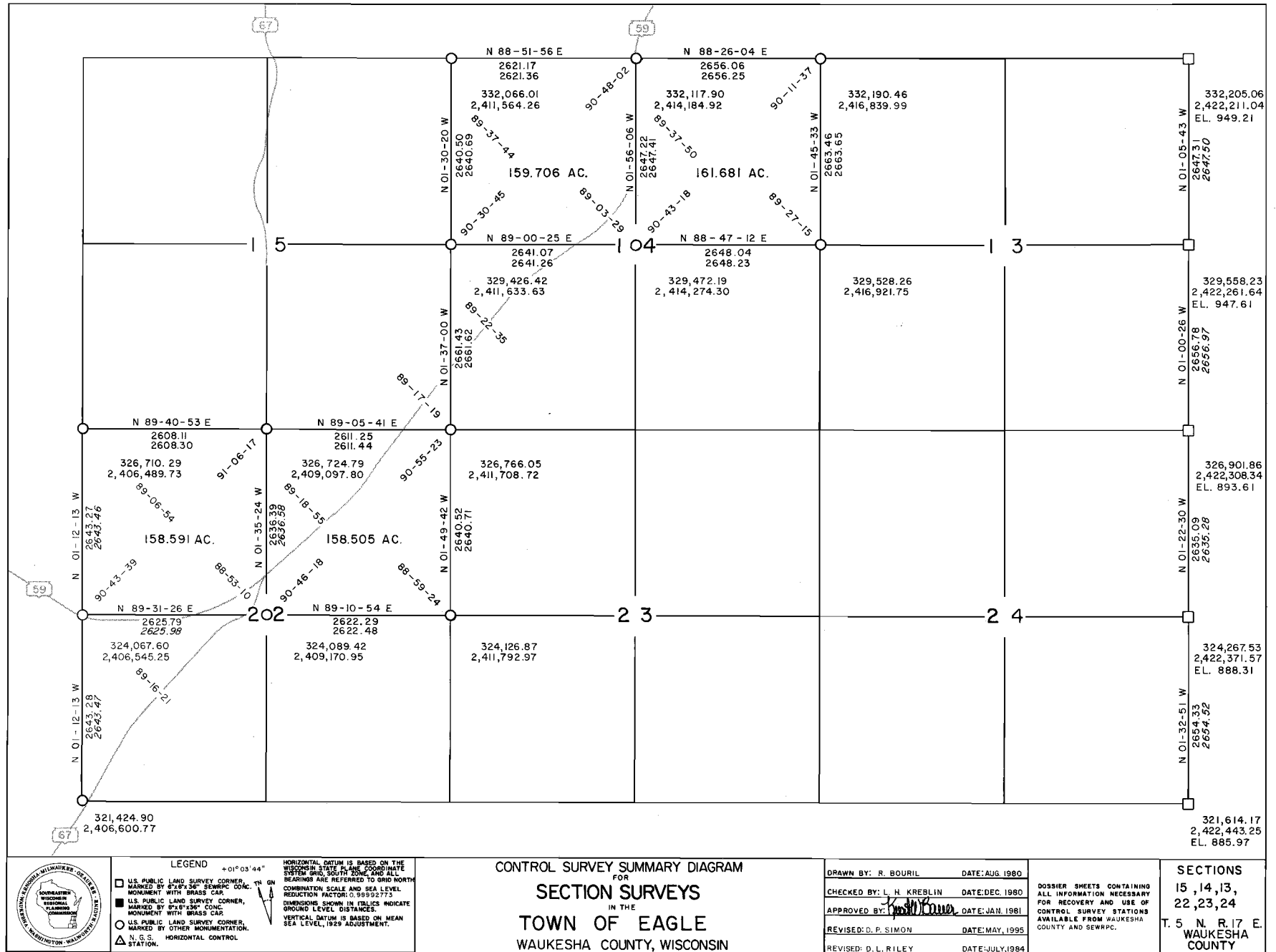


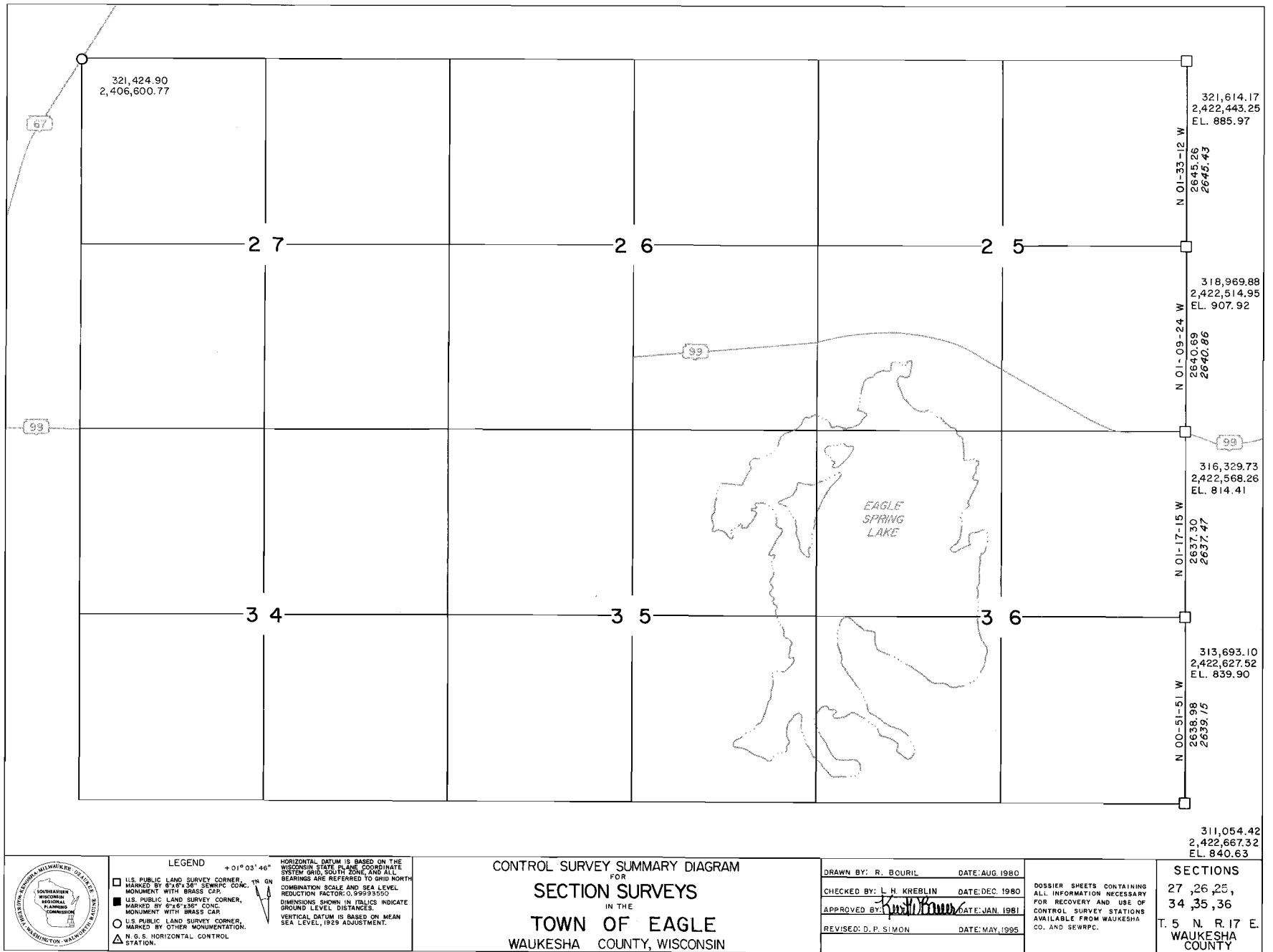
Source: SEWRPC.

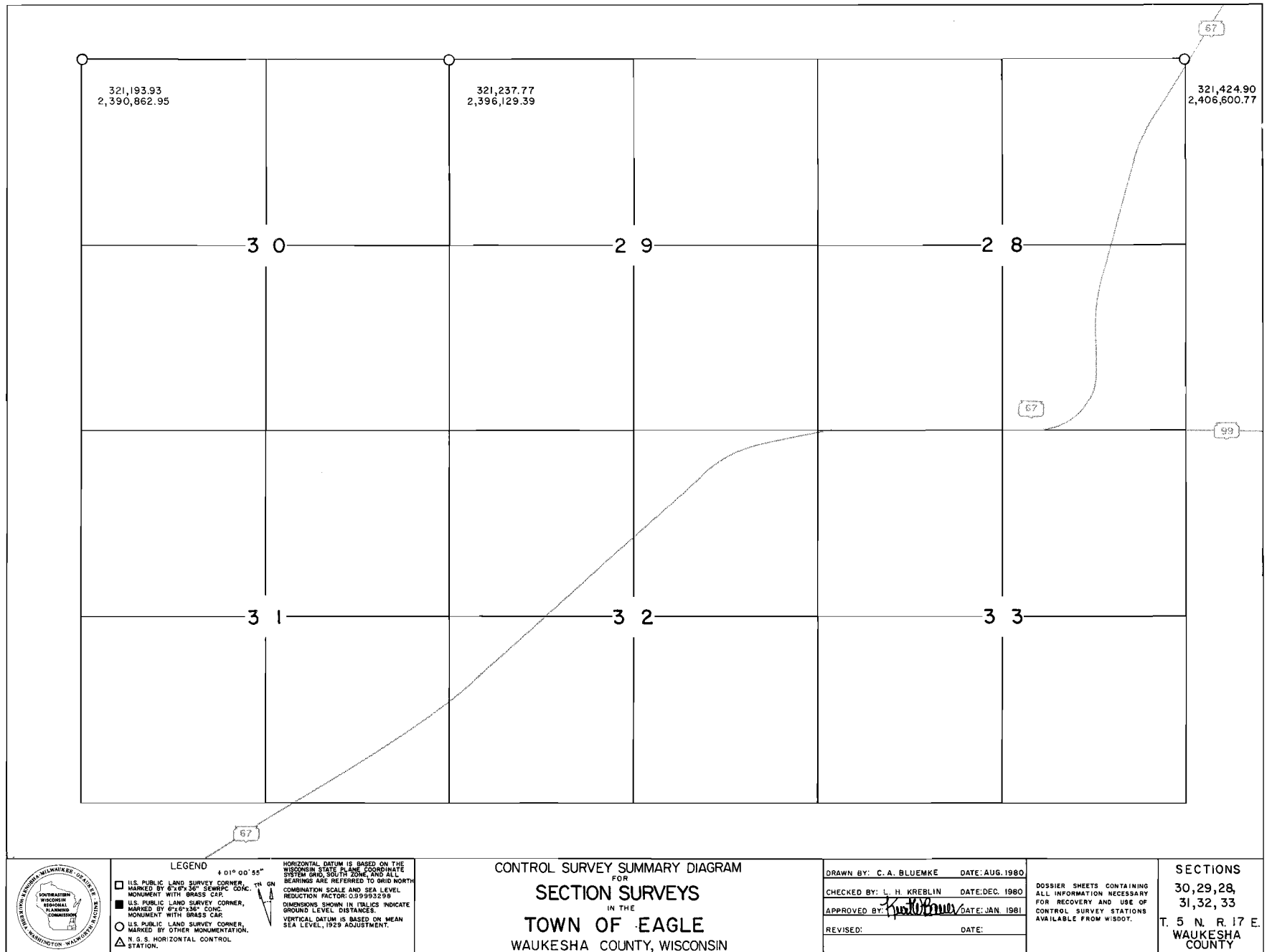


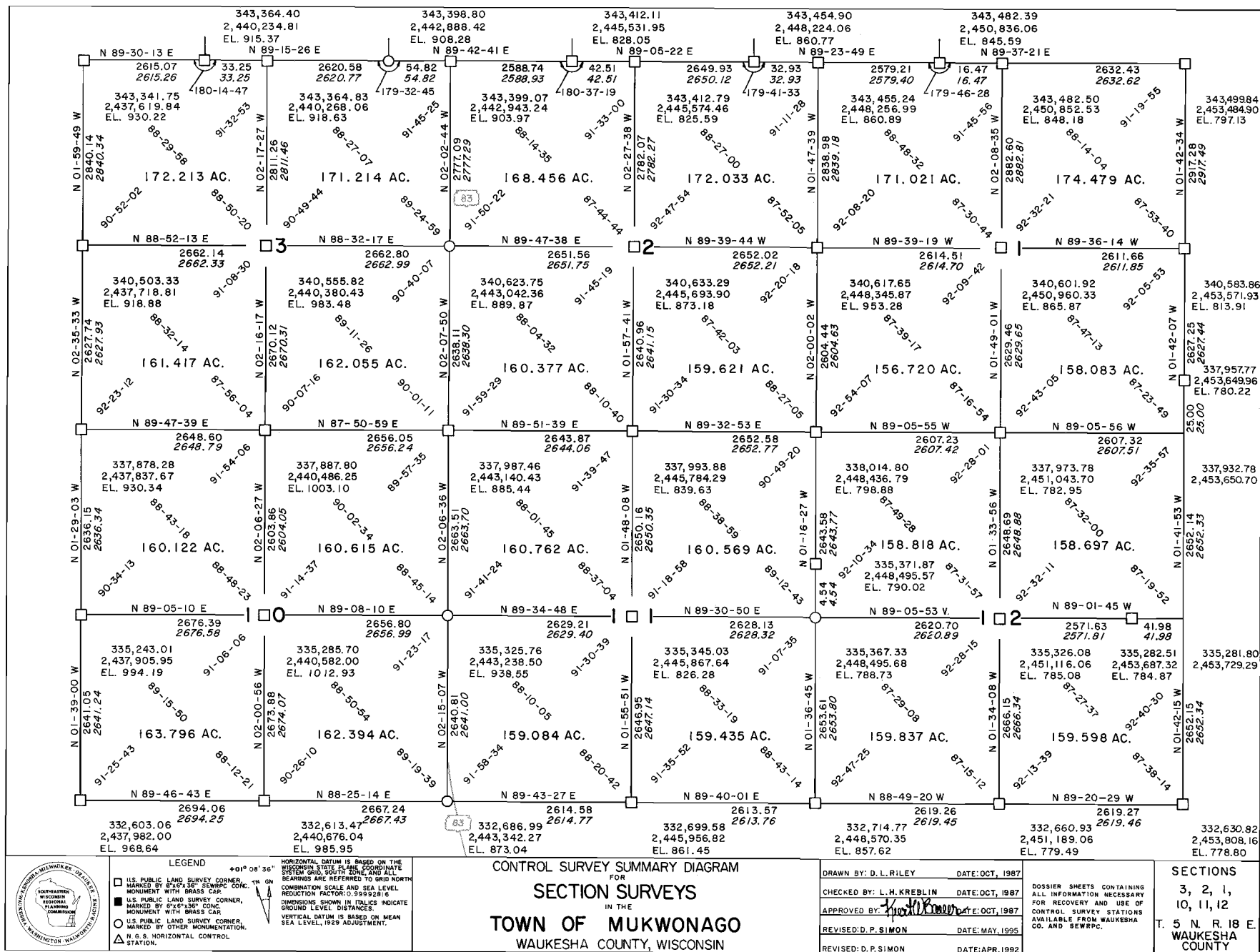
																
	LEGEND		HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES. VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.		CONTROL SURVEY SUMMARY DIAGRAM FOR SECTION SURVEYS IN THE TOWN OF EAGLE WAUKESHA COUNTY, WISCONSIN		<table border="1"><tr><td>DRAWN BY:</td><td>DATE:</td></tr><tr><td>CHECKED BY:</td><td>DATE:</td></tr><tr><td>APPROVED BY:</td><td>DATE:</td></tr><tr><td>REVISED:</td><td>DATE:</td></tr></table>		DRAWN BY:	DATE:	CHECKED BY:	DATE:	APPROVED BY:	DATE:	REVISED:	DATE:
	DRAWN BY:	DATE:														
	CHECKED BY:	DATE:														
	APPROVED BY:	DATE:														
REVISED:	DATE:															
<input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x8"x36" SOWPC CON. MONUMENT WITH BRASS CAP		<table border="1"><tr><td colspan="2">DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM</td></tr><tr><td colspan="2">T. 5 N. R. 17 E. WAUKESHA COUNTY</td></tr></table>		DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM		T. 5 N. R. 17 E. WAUKESHA COUNTY										
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM																
T. 5 N. R. 17 E. WAUKESHA COUNTY																
<input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CON. MONUMENT WITH BRASS CAP																
<input type="checkbox"/> U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.																
<input type="checkbox"/> N. G. S. HORIZONTAL CONTROL STATION.																

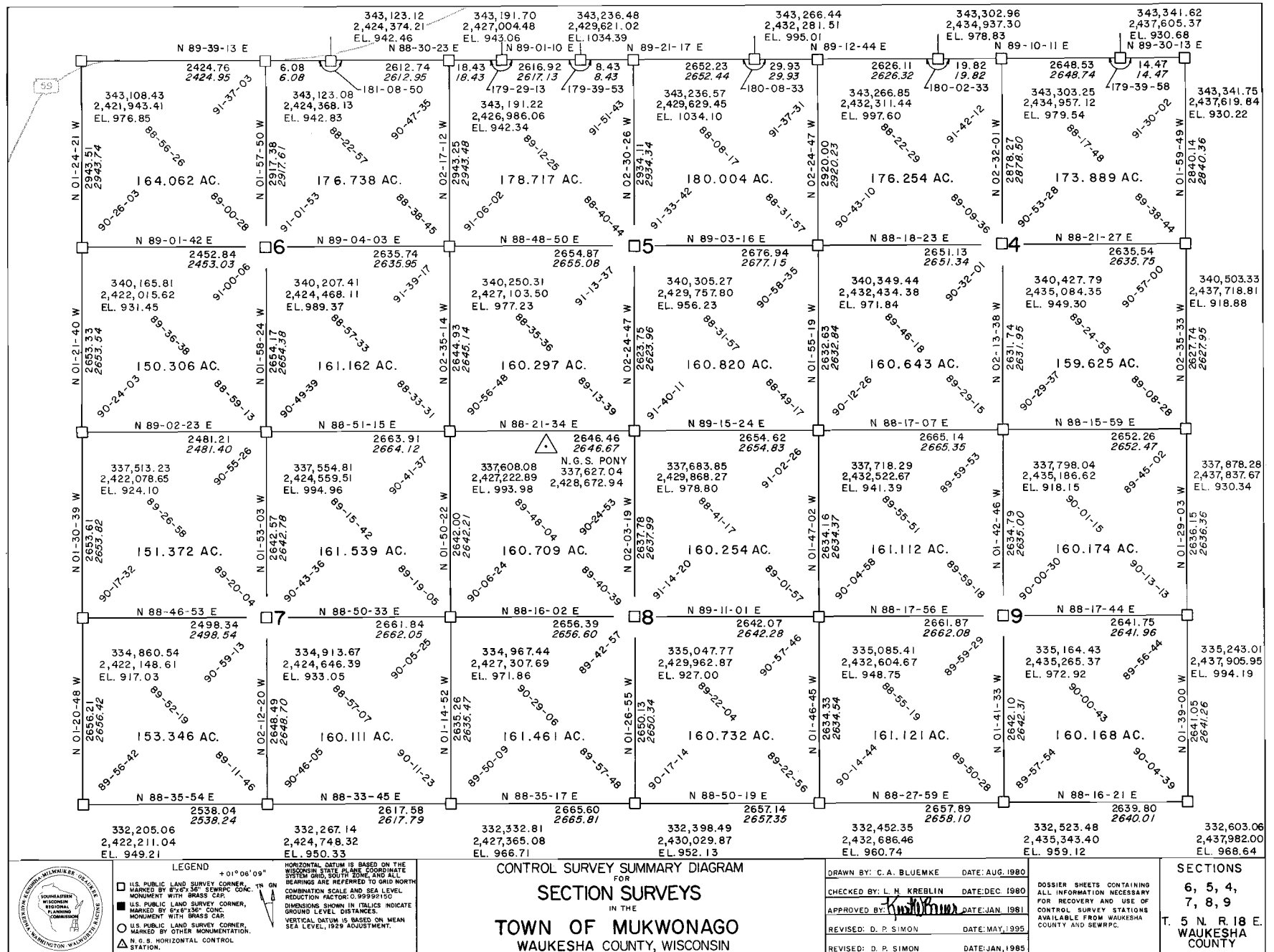


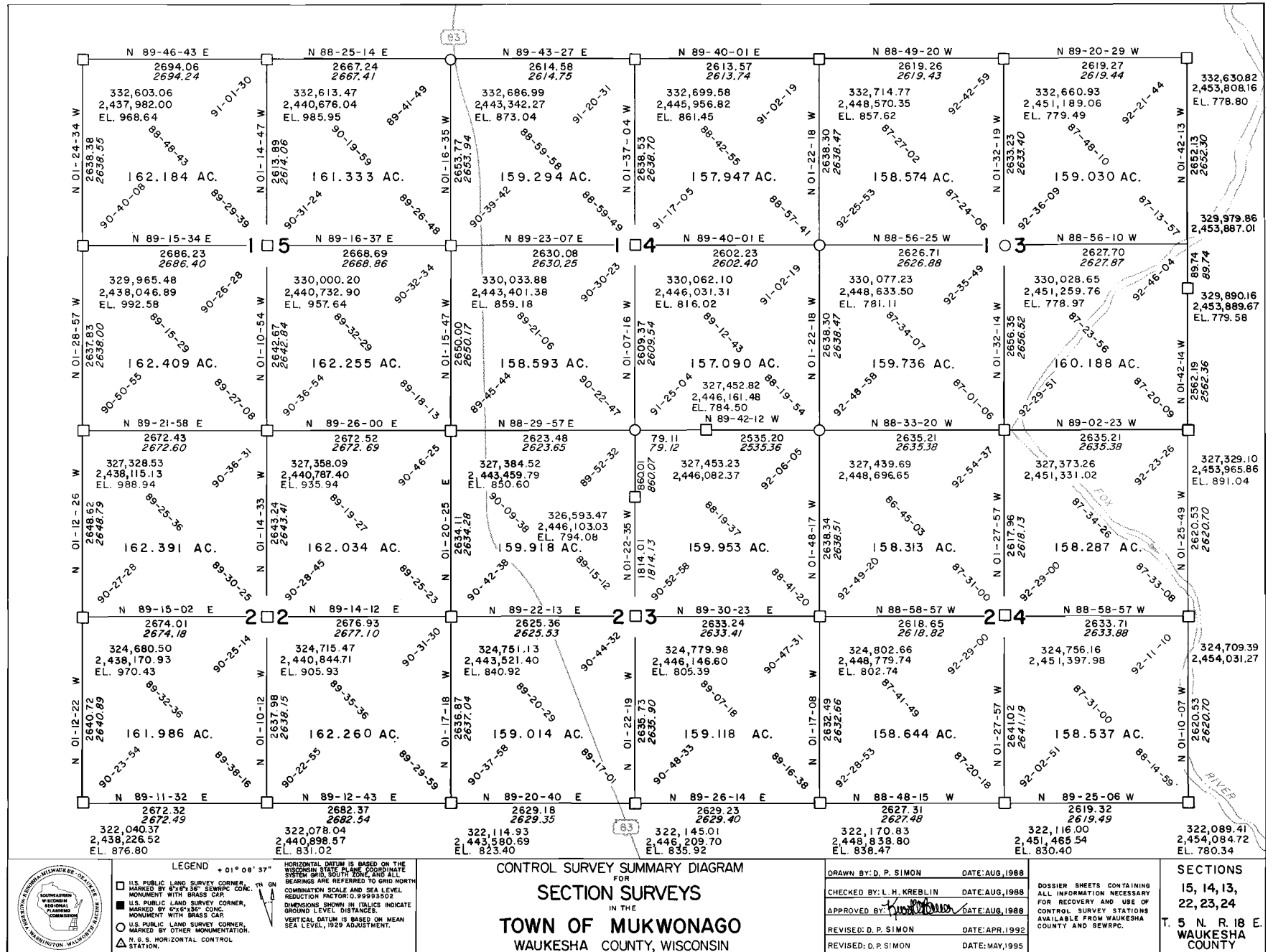


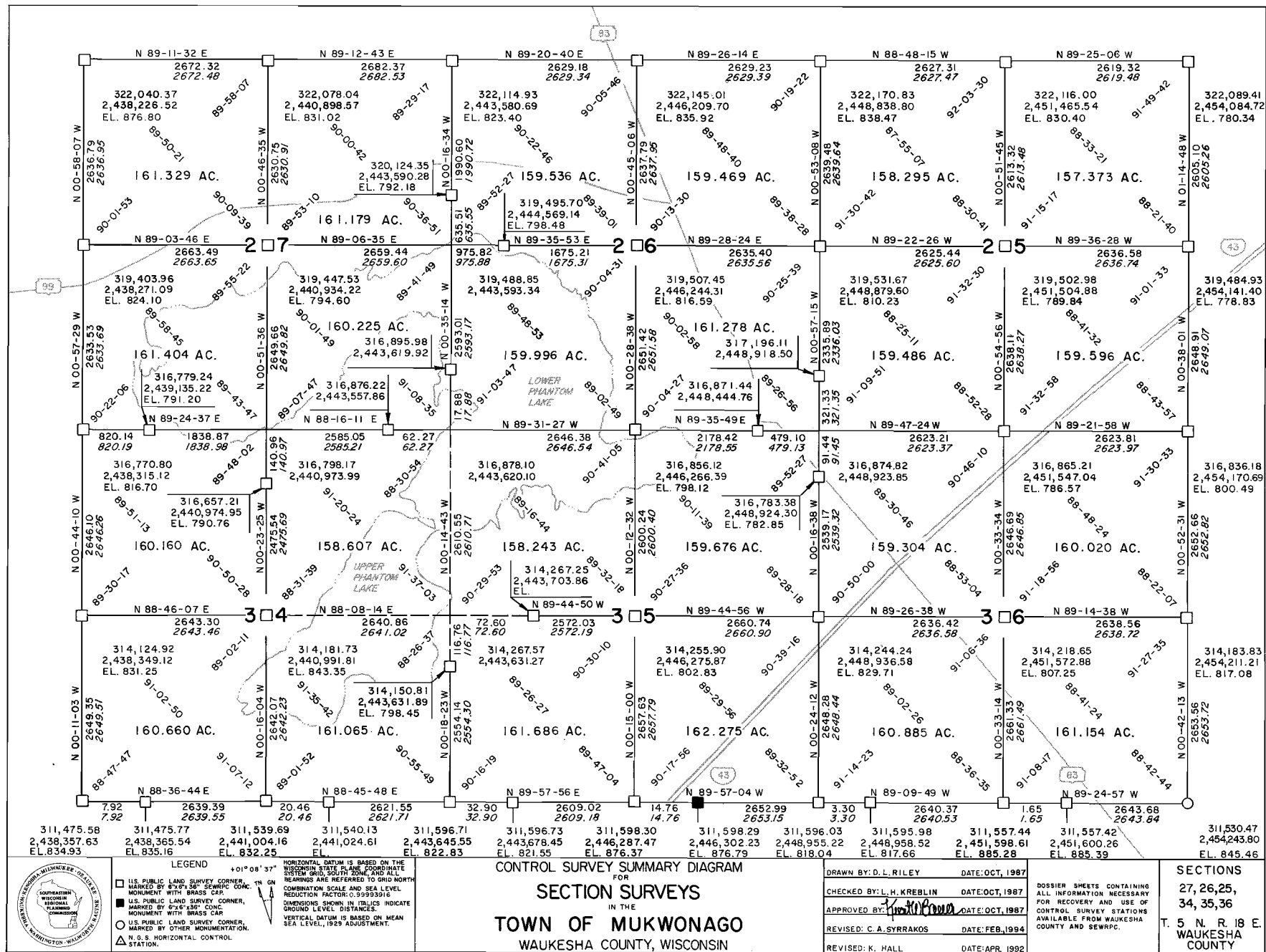


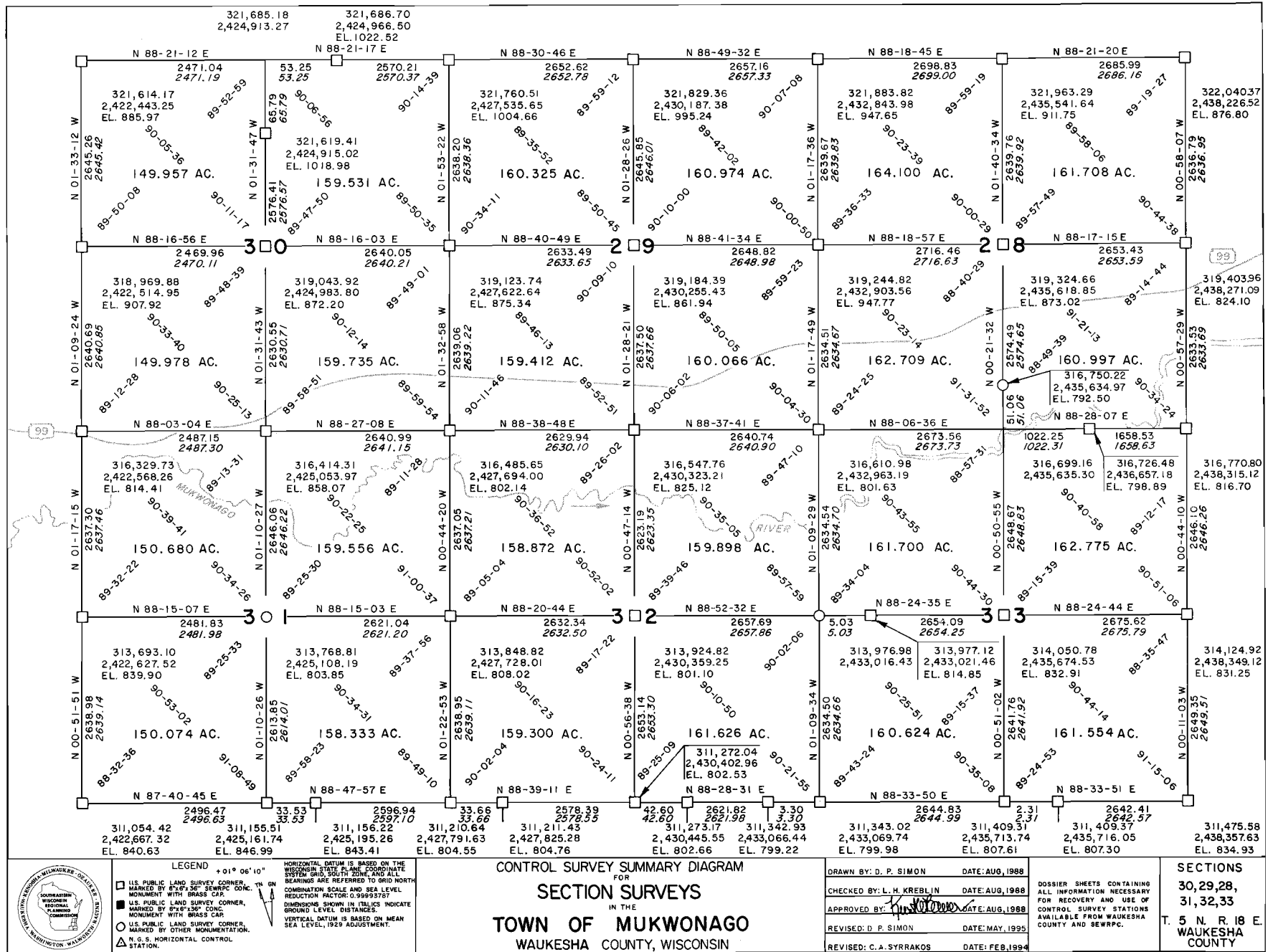


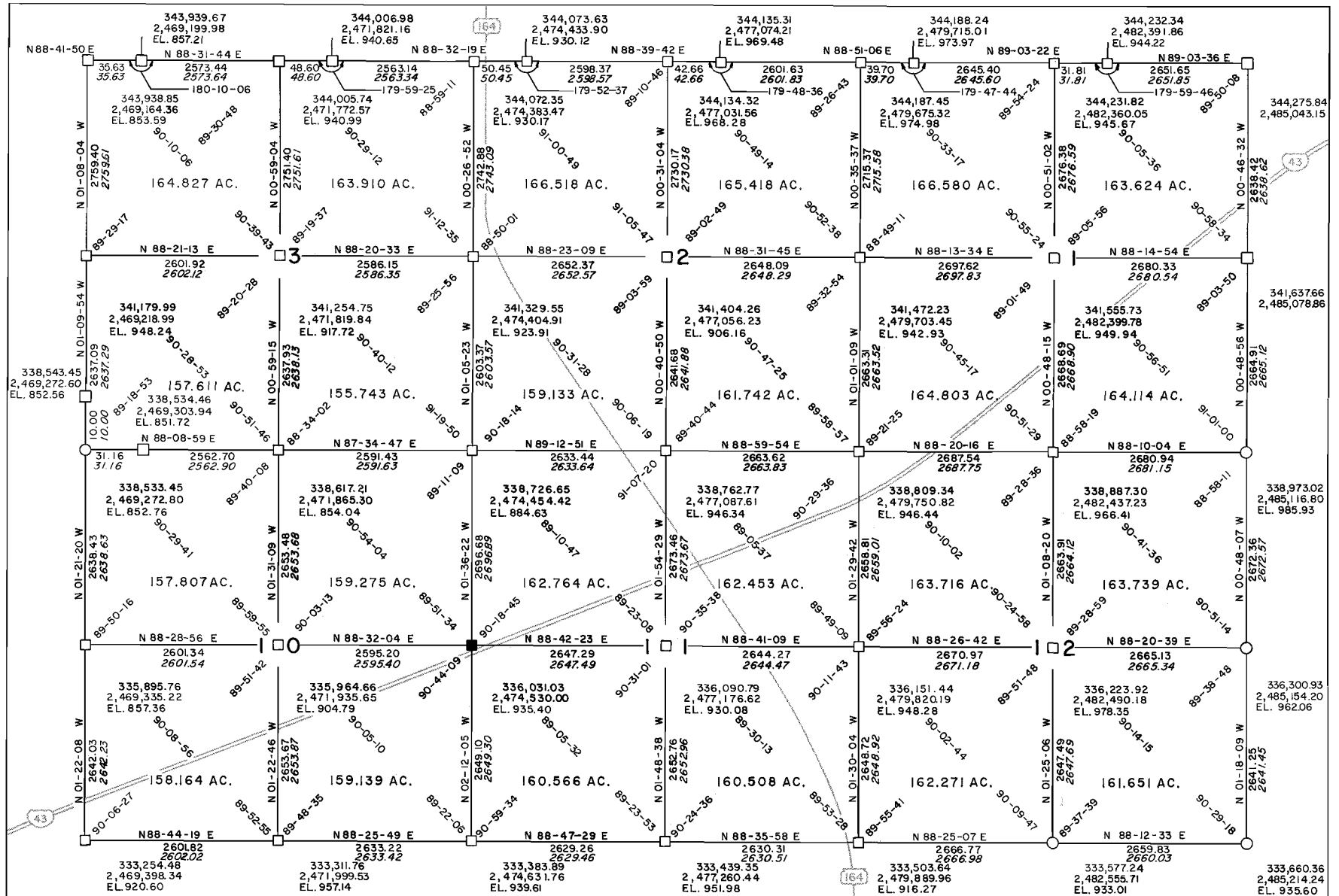












LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 1 1/2" SERRATED CONC.
 - U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 1 1/2" CONC.
 - U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
 - △ N.G.S. HORIZONTAL CONTROL STATION.
- *01°13'26"
- HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM, GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH.
- CONVERSION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99992301
- DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.
- VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM

SECTION SURVEYS

IN THE
TOWN OF VERNON
WAUKESHA COUNTY, WISCONSIN

DRAWN BY: D. L. RILEY

DATE: OCT, 1987

CHECKED BY: L. H. KREBLIN

DATE: OCT, 1987

APPROVED BY: *[Signature]*

DATE: OCT, 1987

REVISED: D. P. SIMON

DATE: FEB, 1993

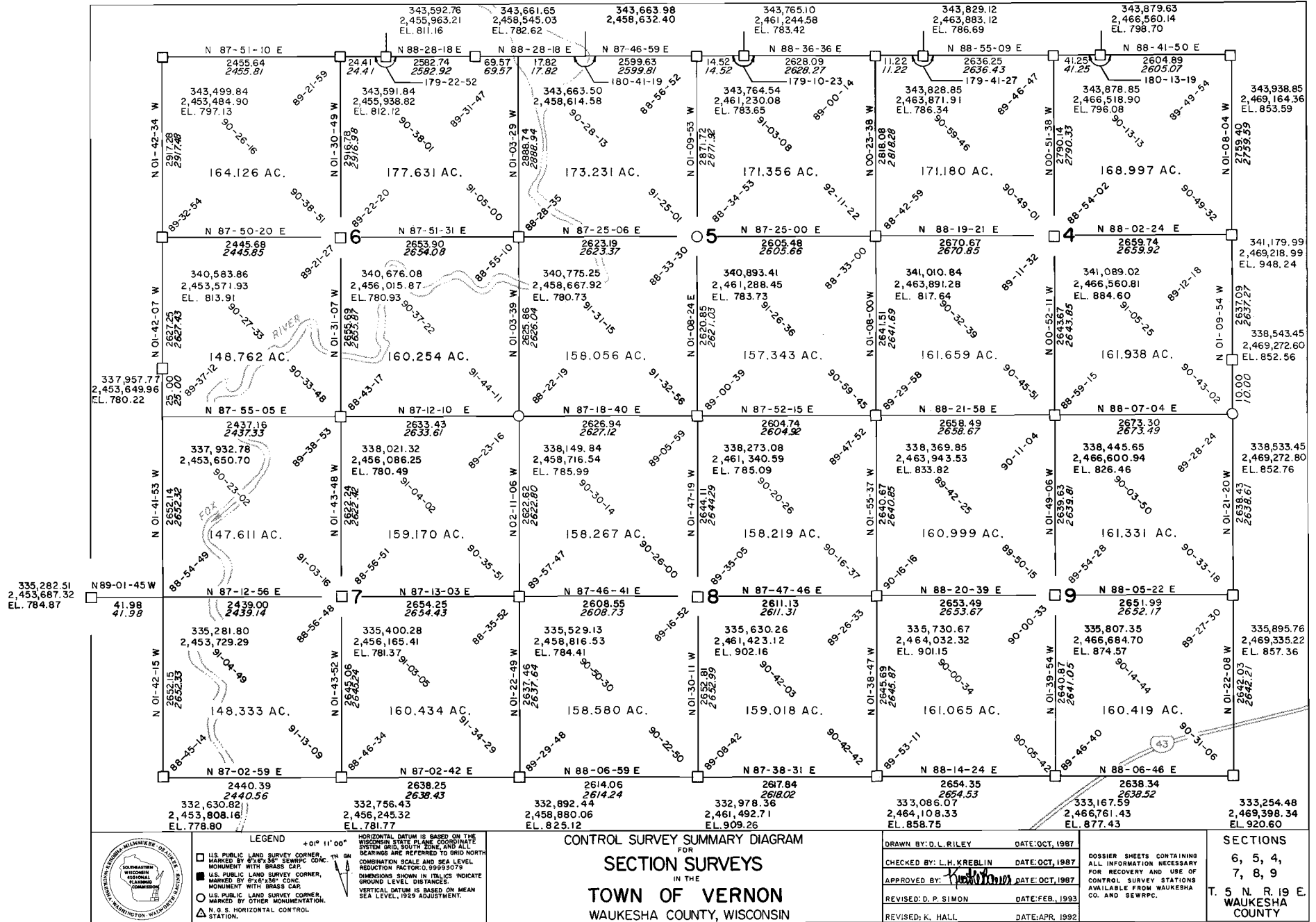
REVISED: K. HALL

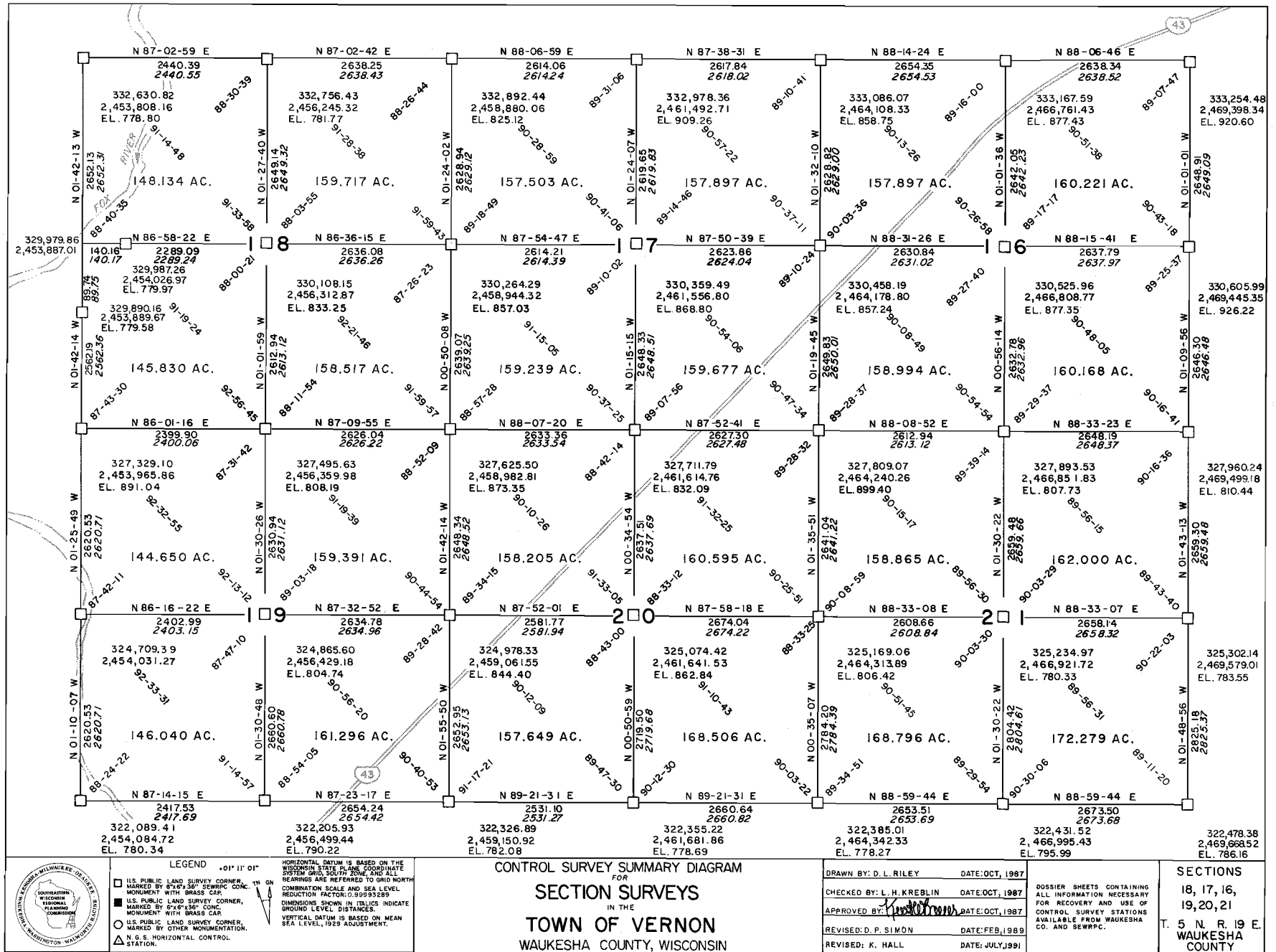
DATE: JUNE 1991

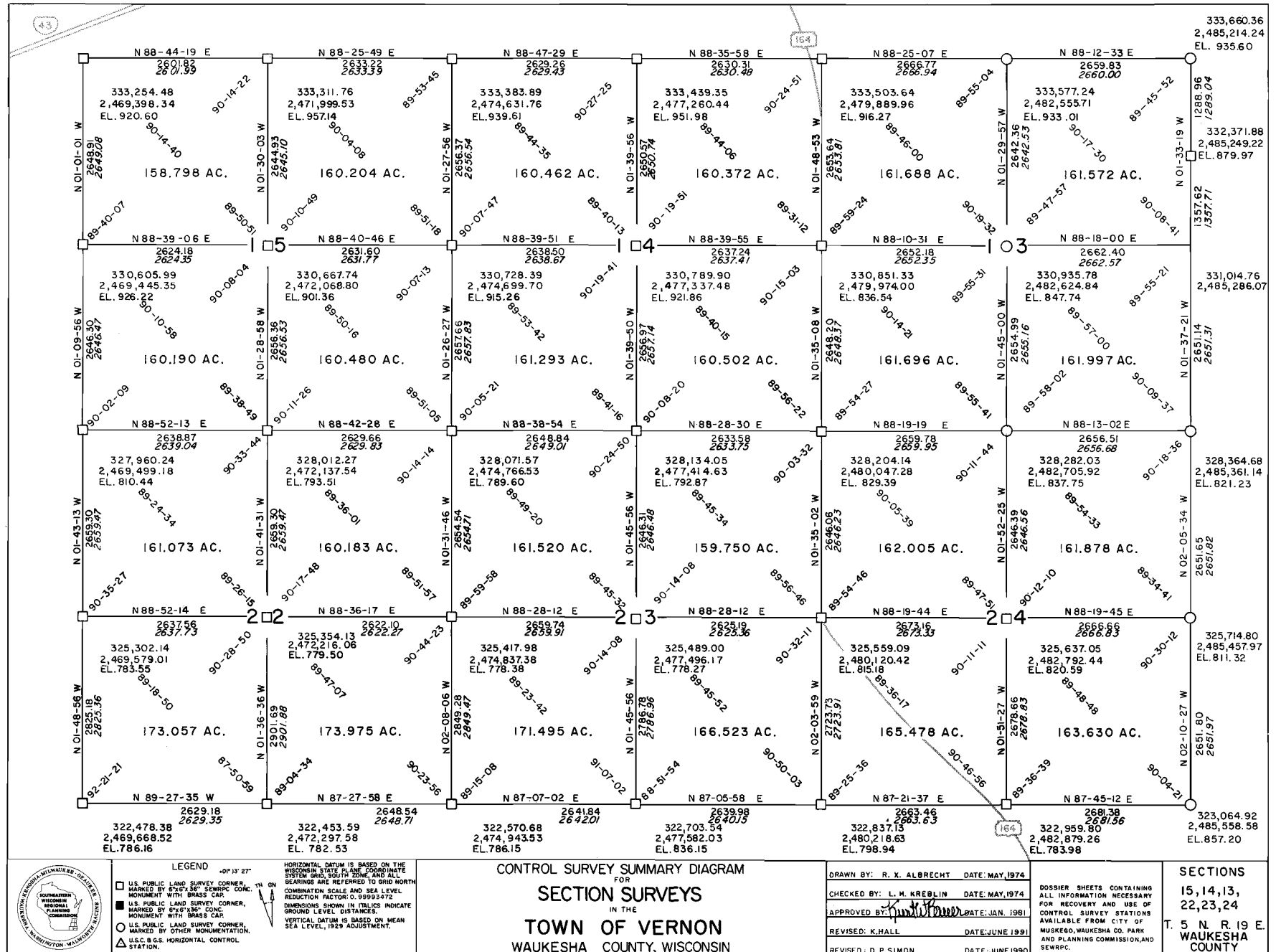
SECTIONS

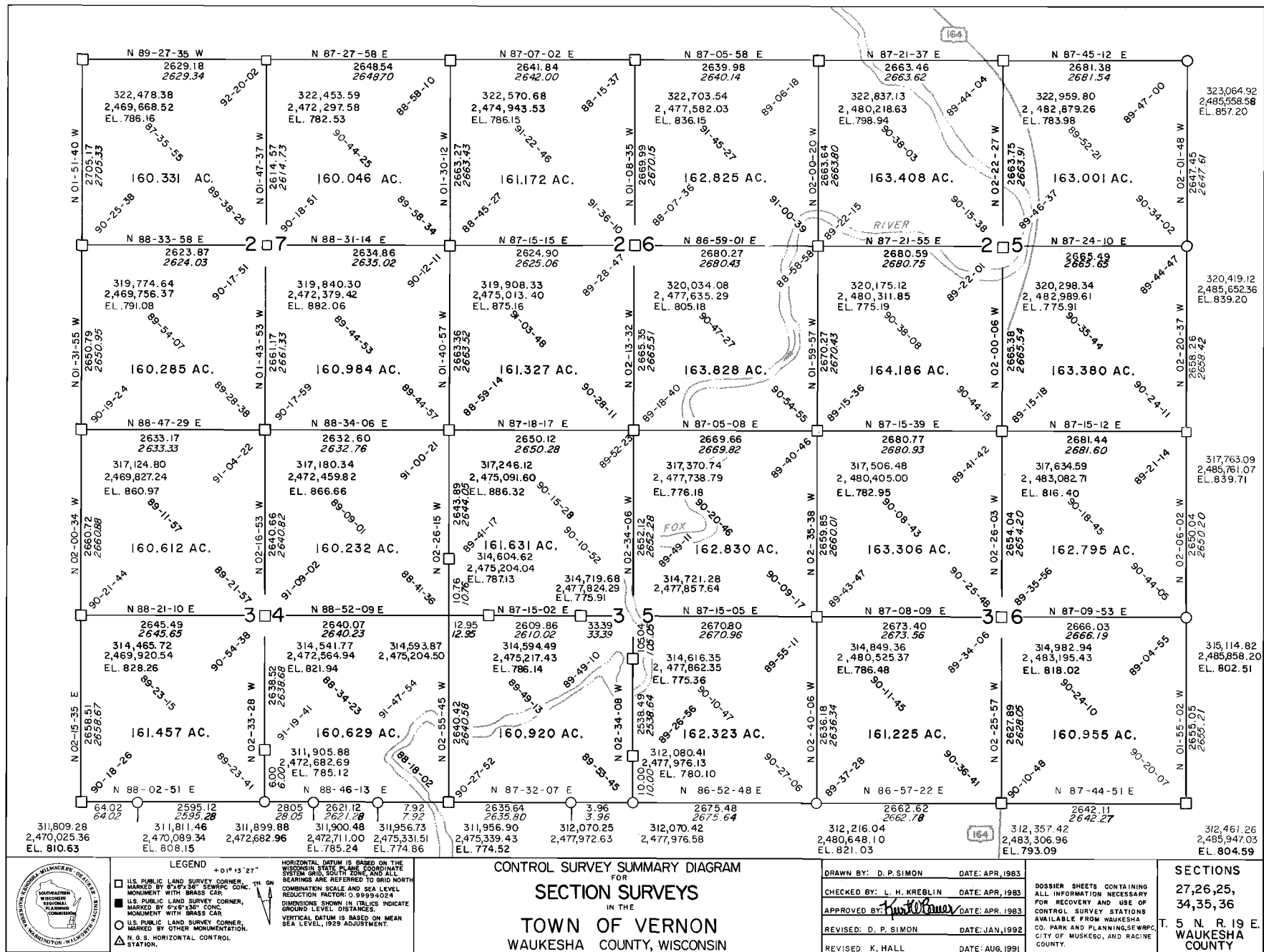
3, 2, 1,
10, 11, 12
T. 5 N. R. 19 E.
WAUKESHA
COUNTY

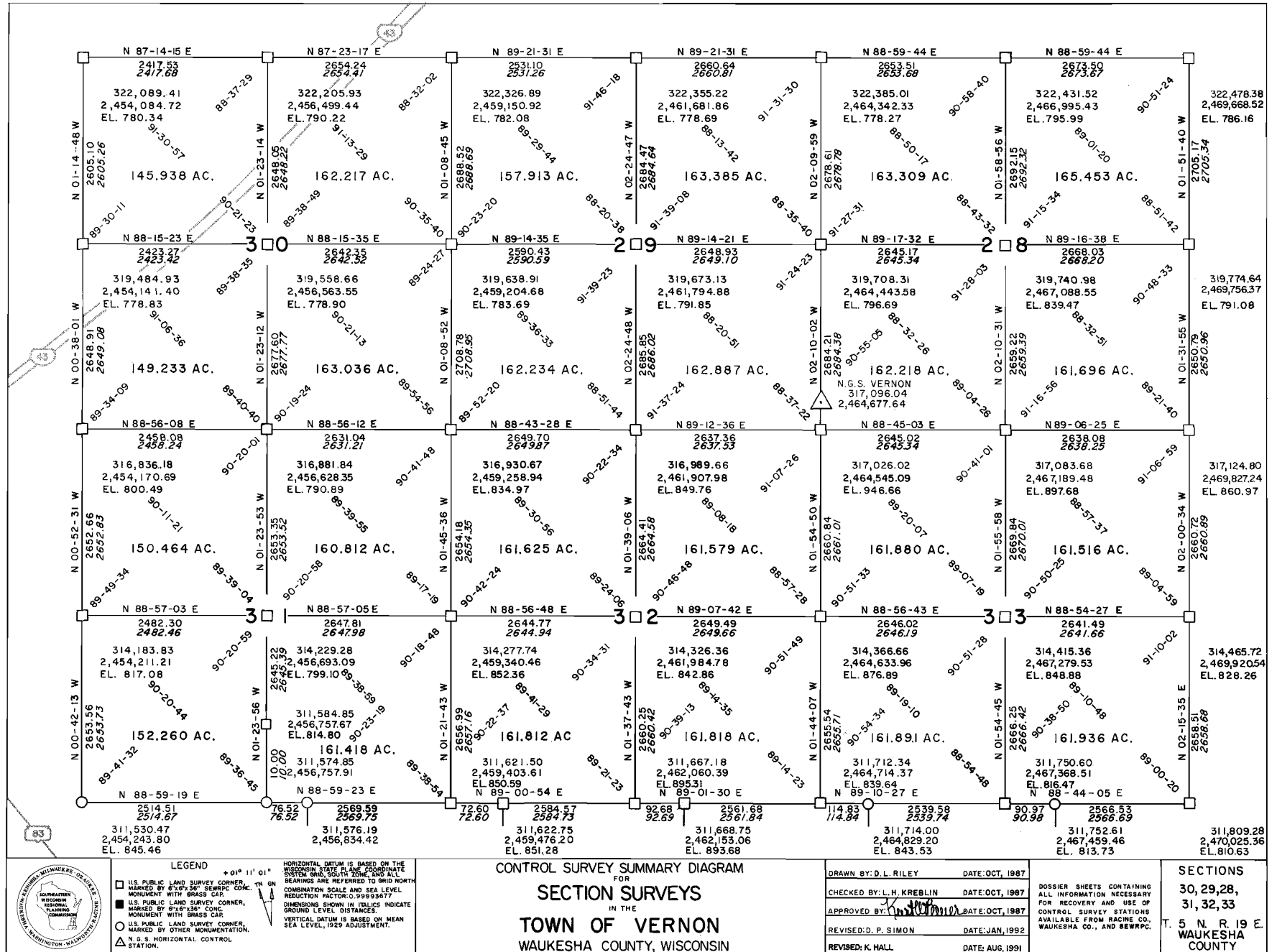
DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM CITY OF MUSKOGEE, WAUKESHA CO., AND SEWRPC.

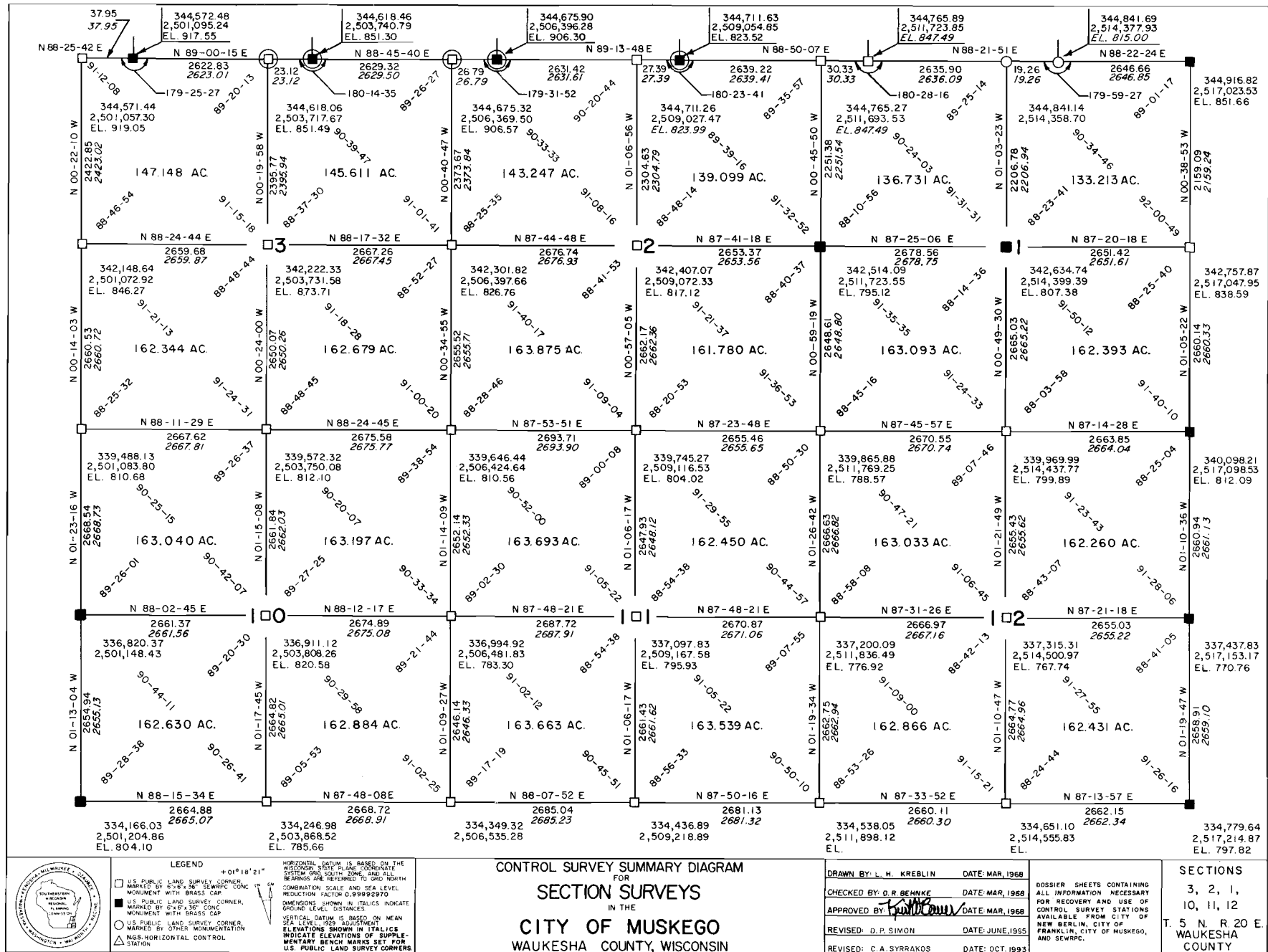


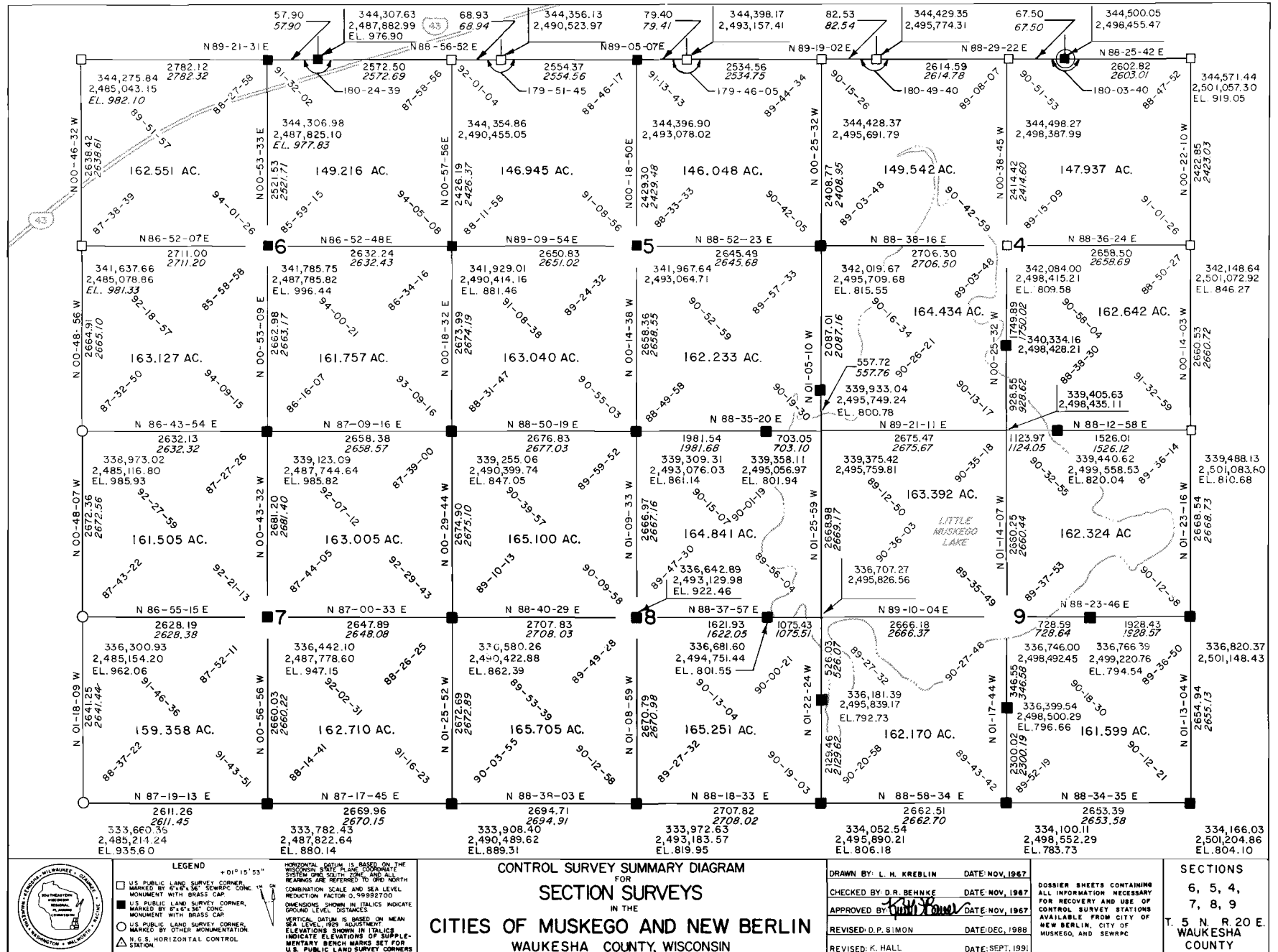


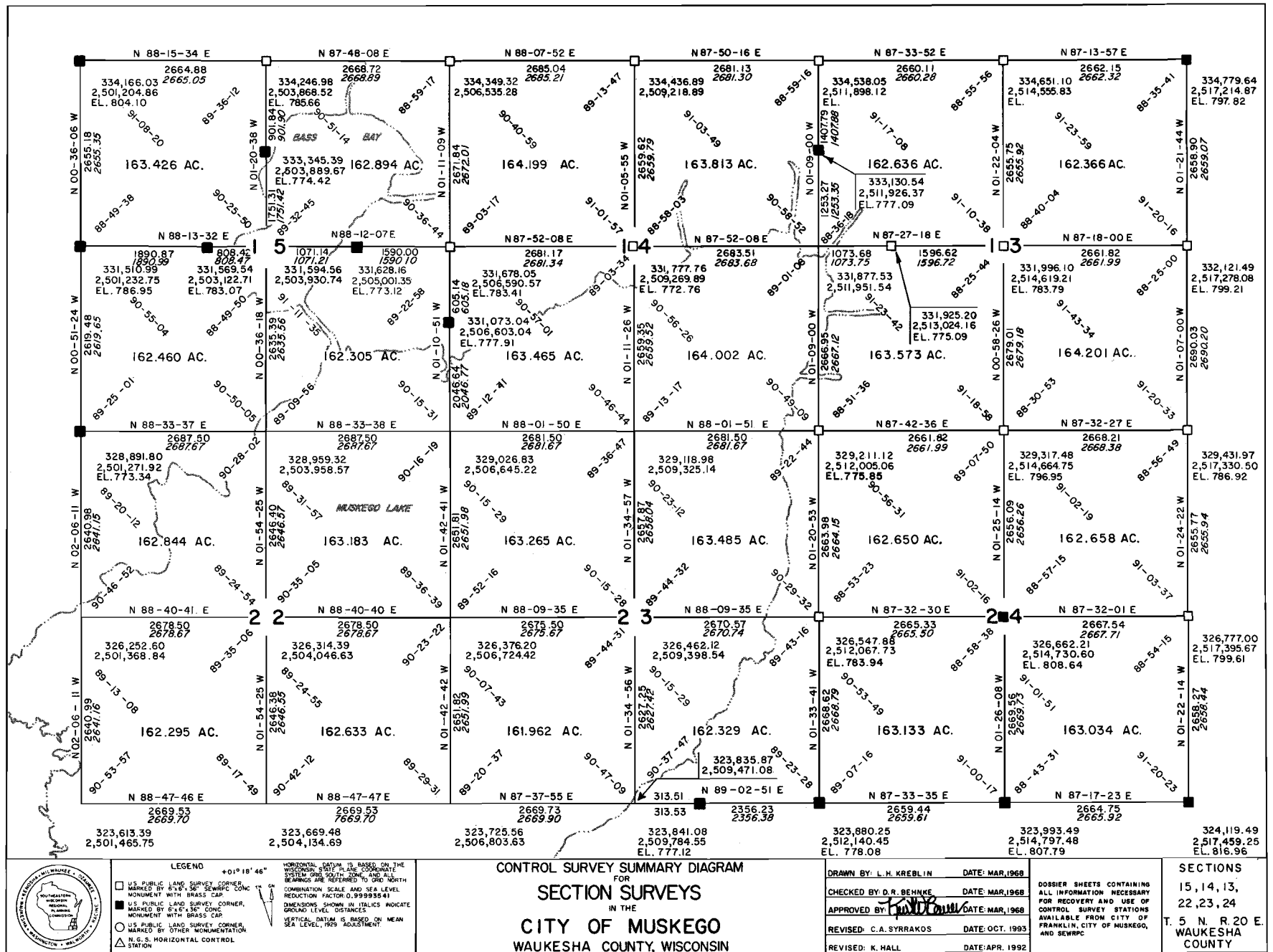


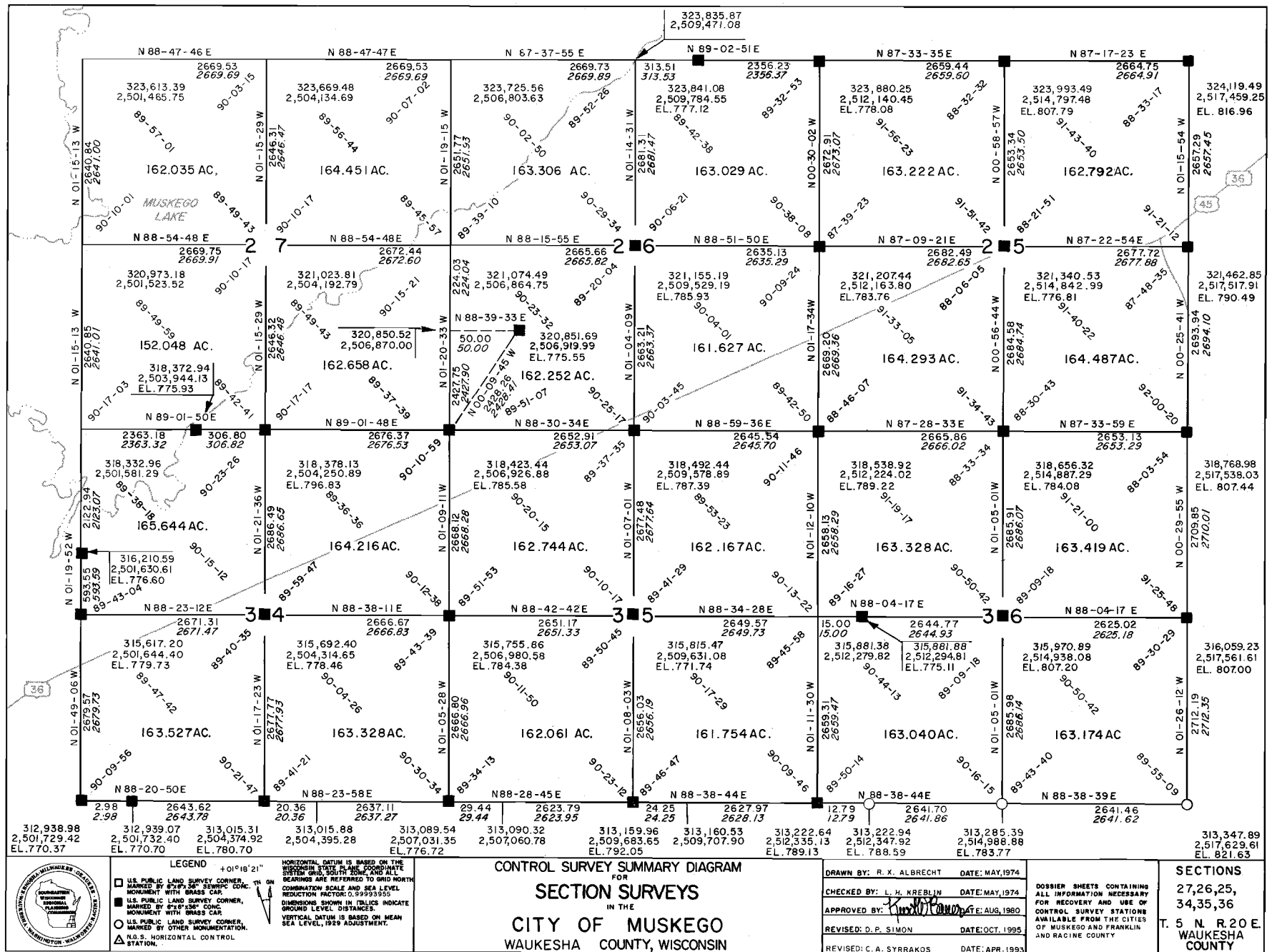


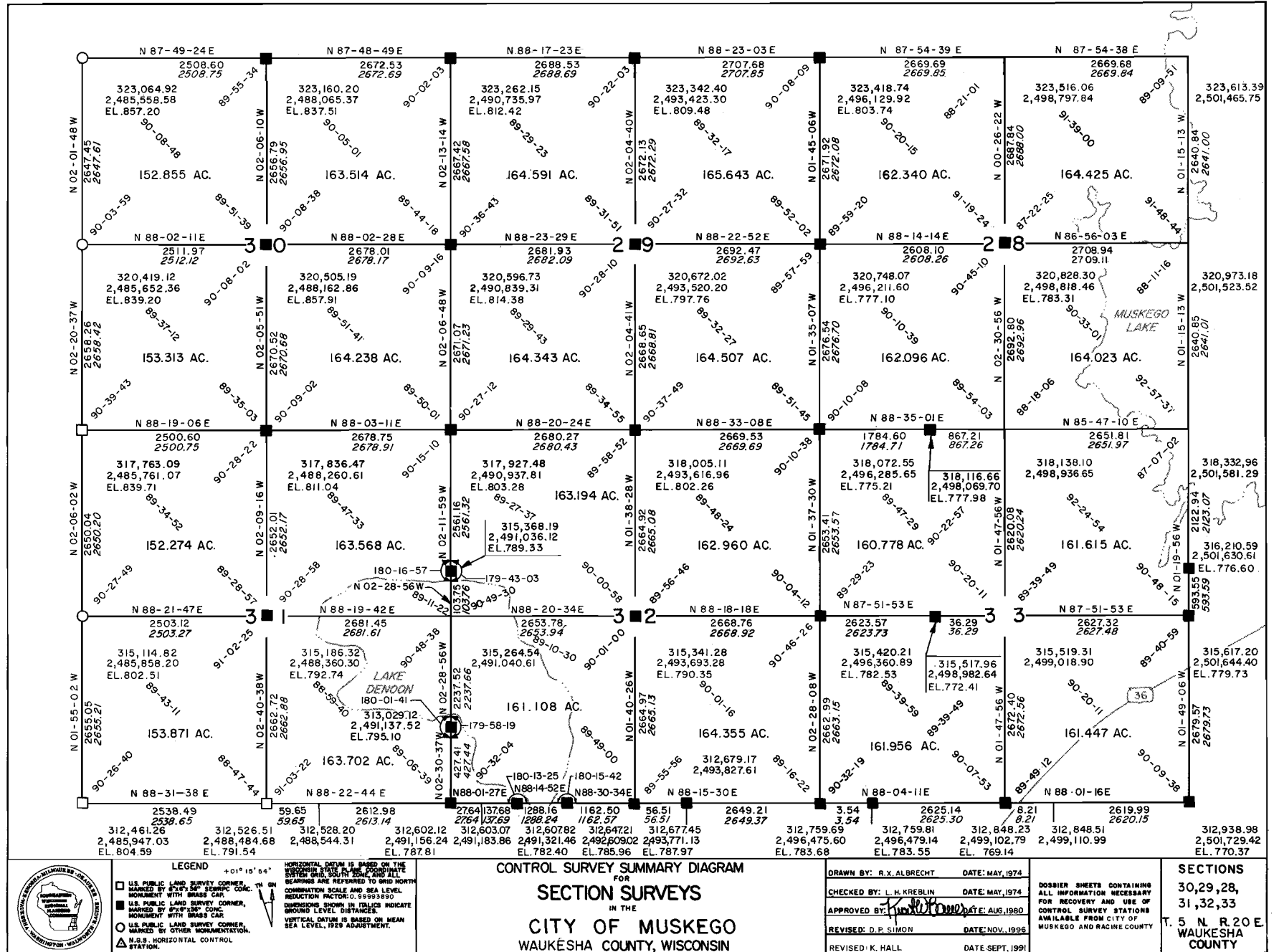


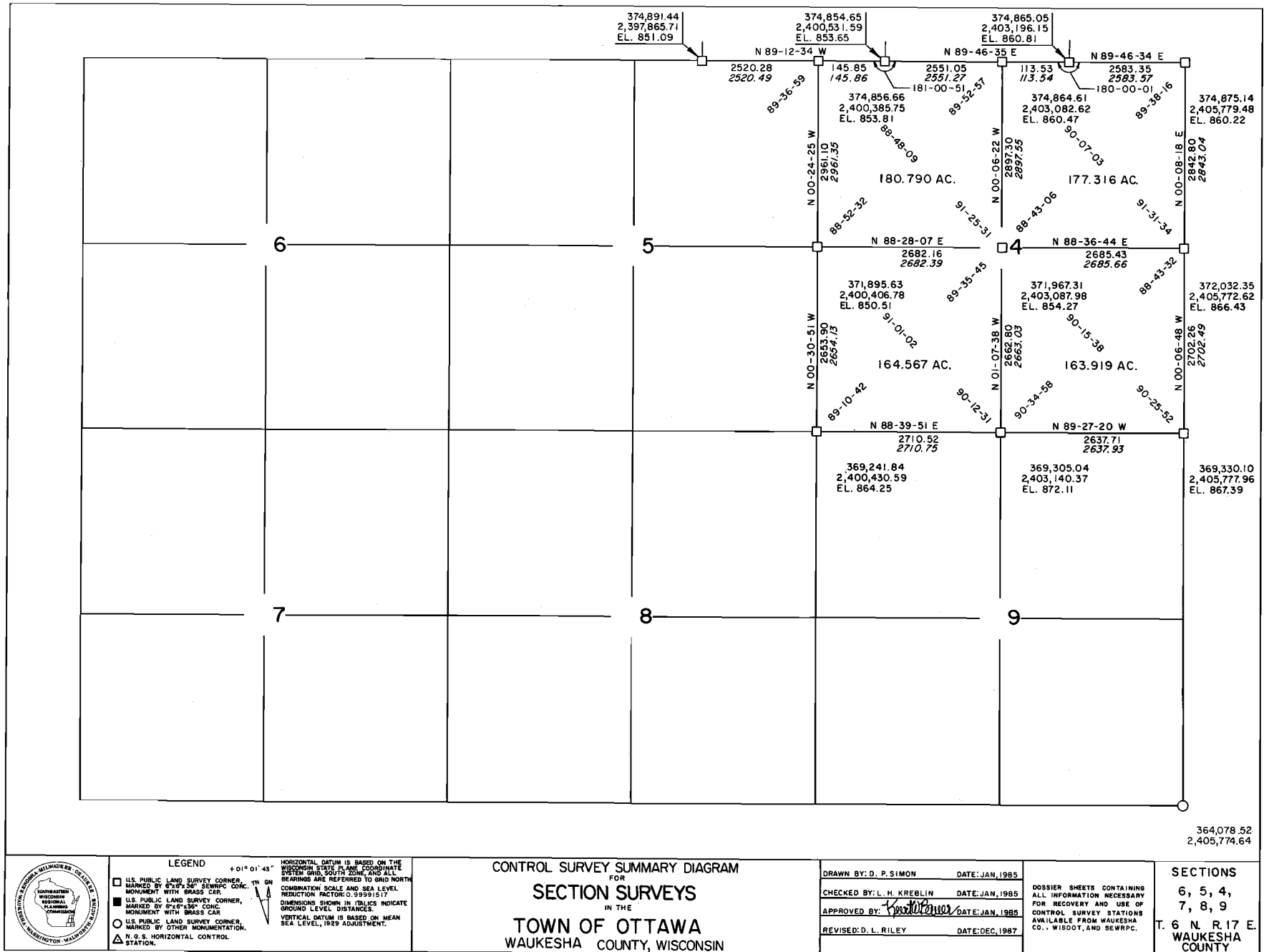


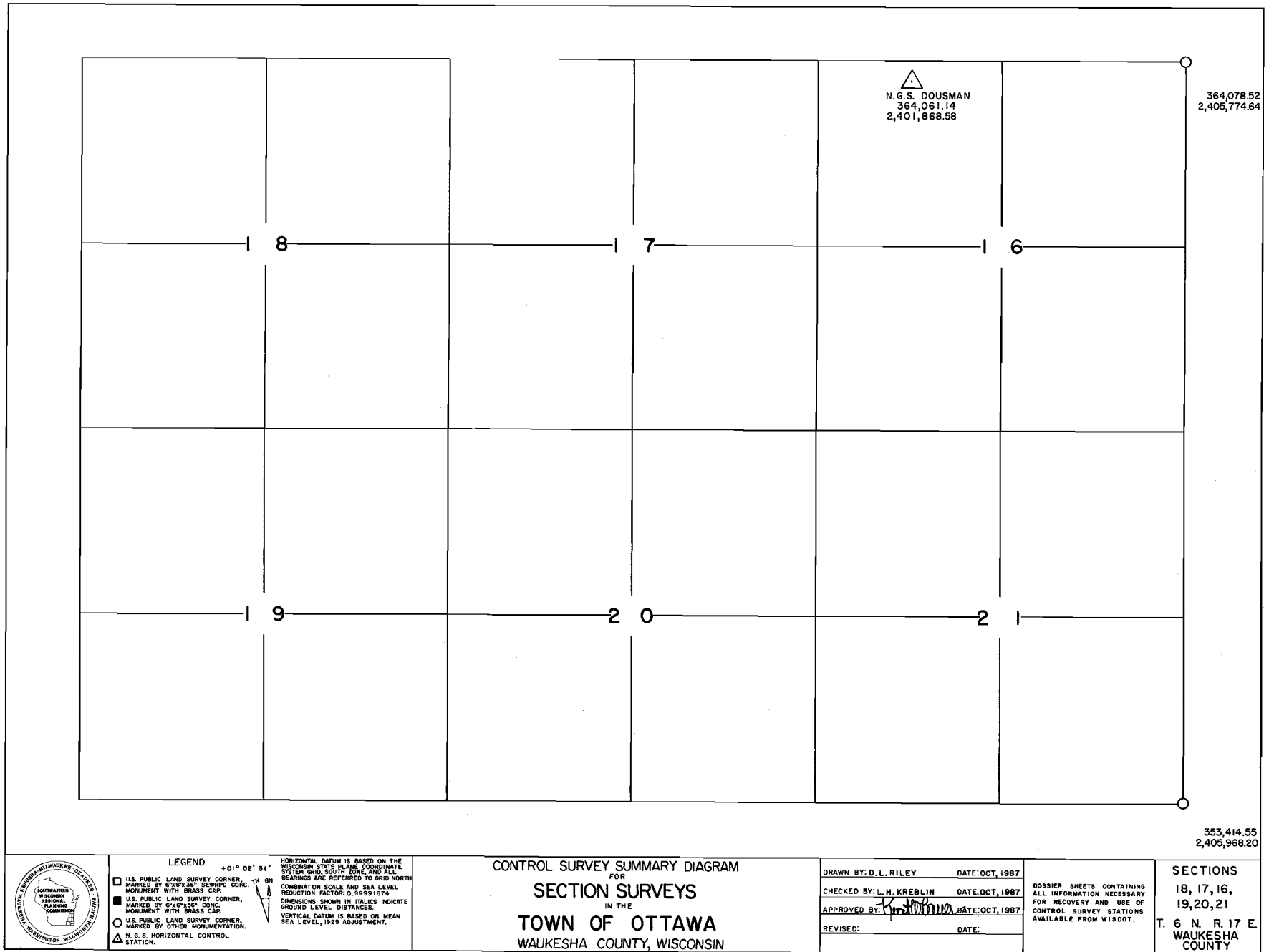


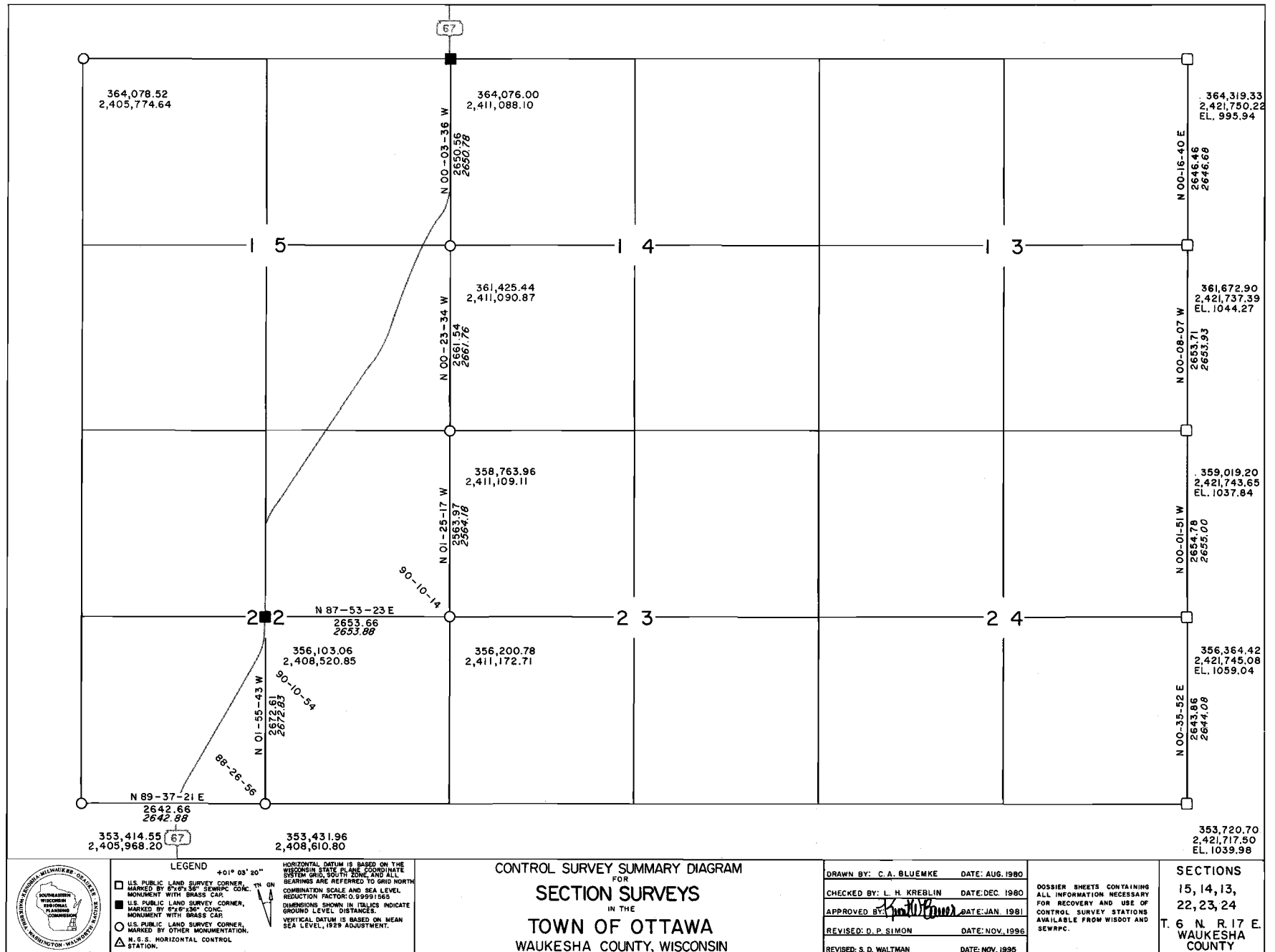


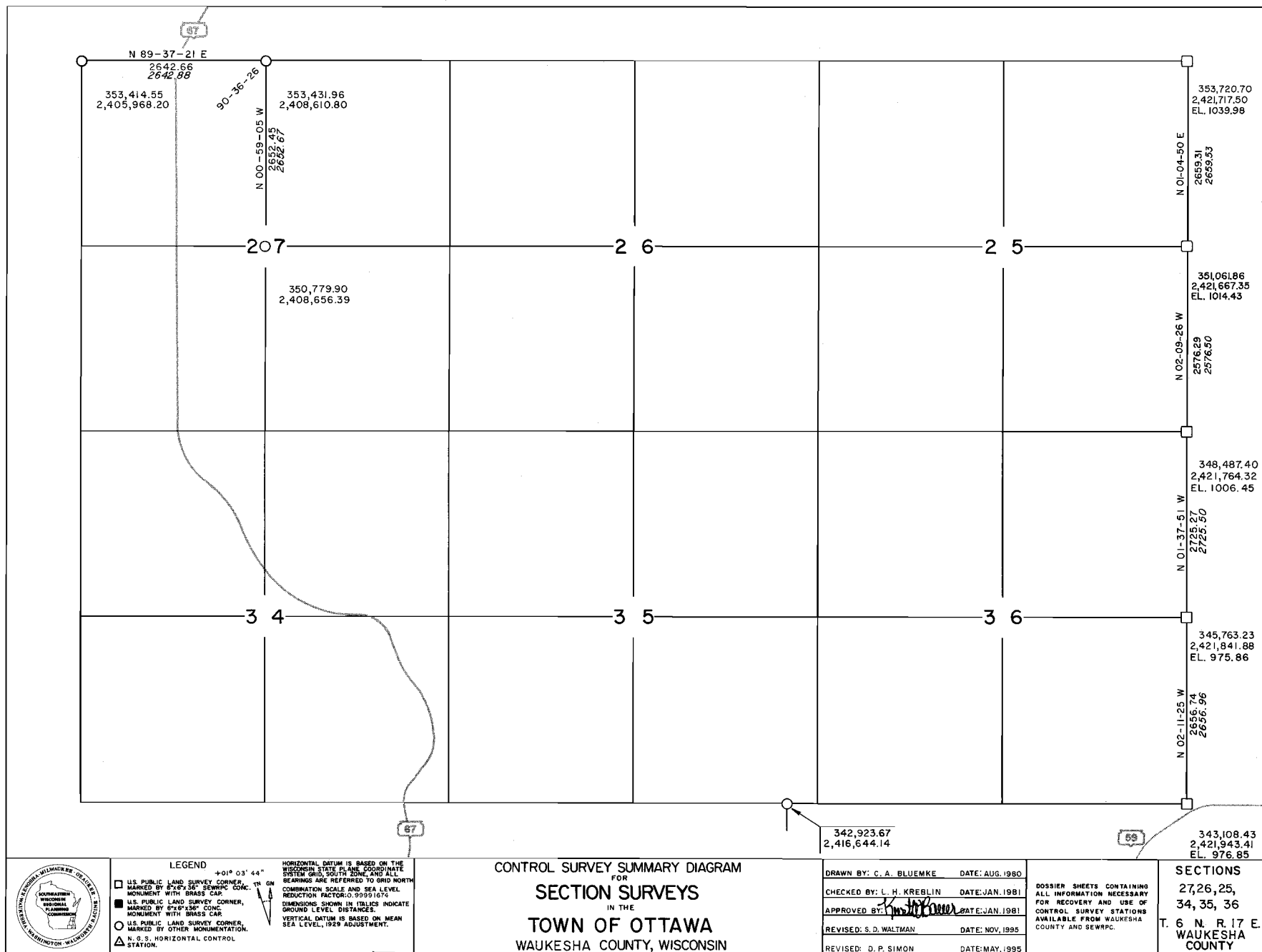


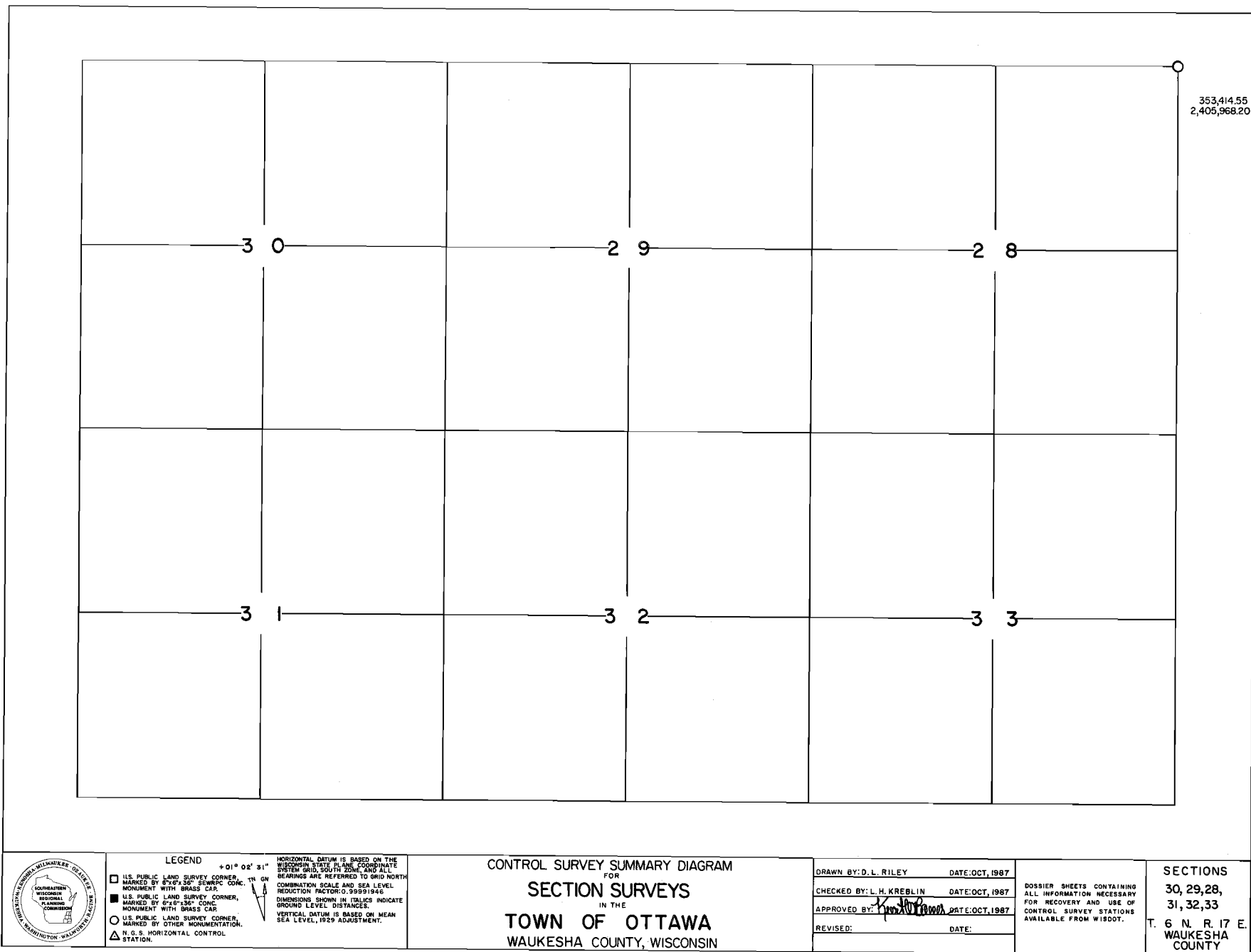


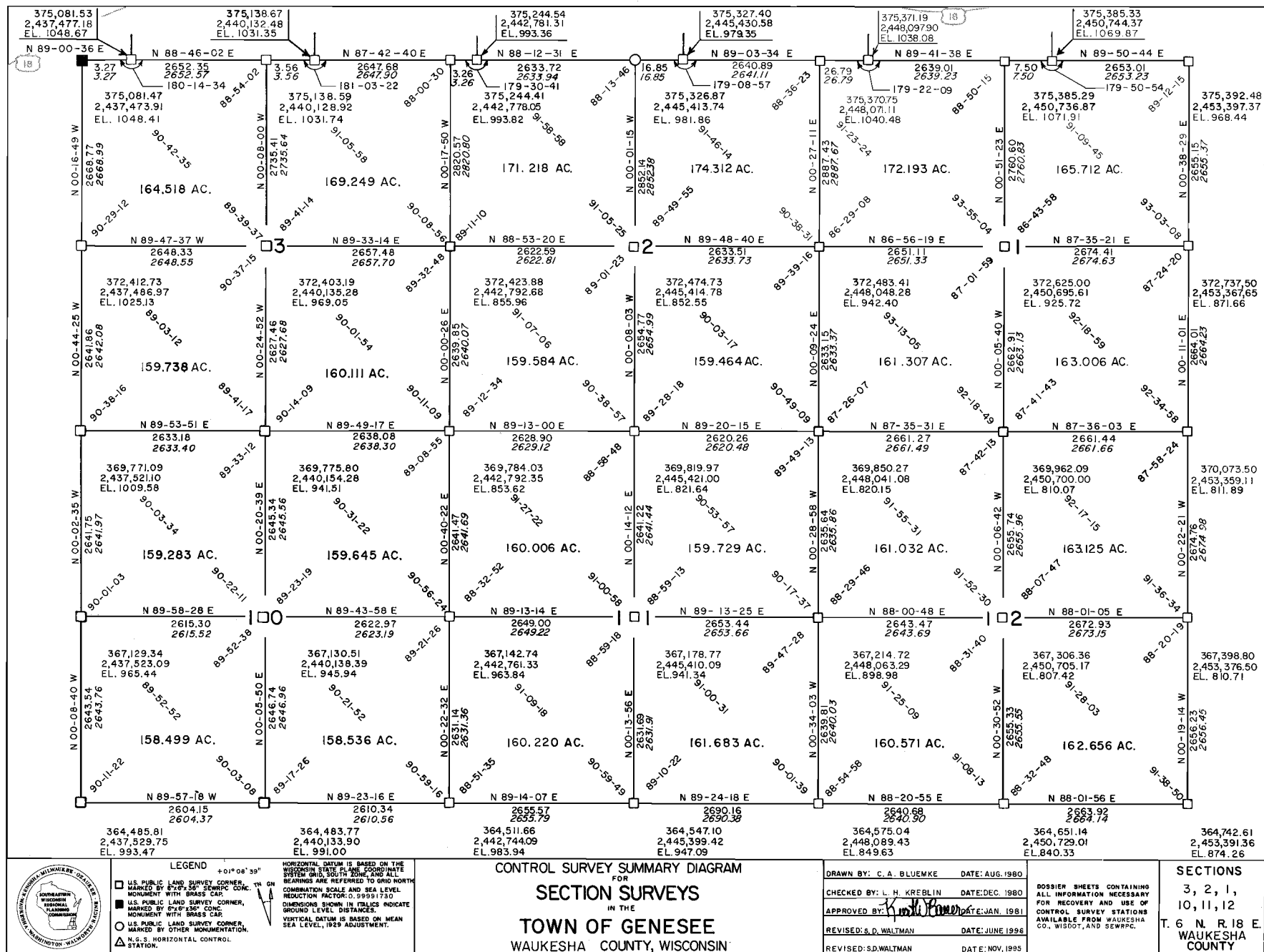


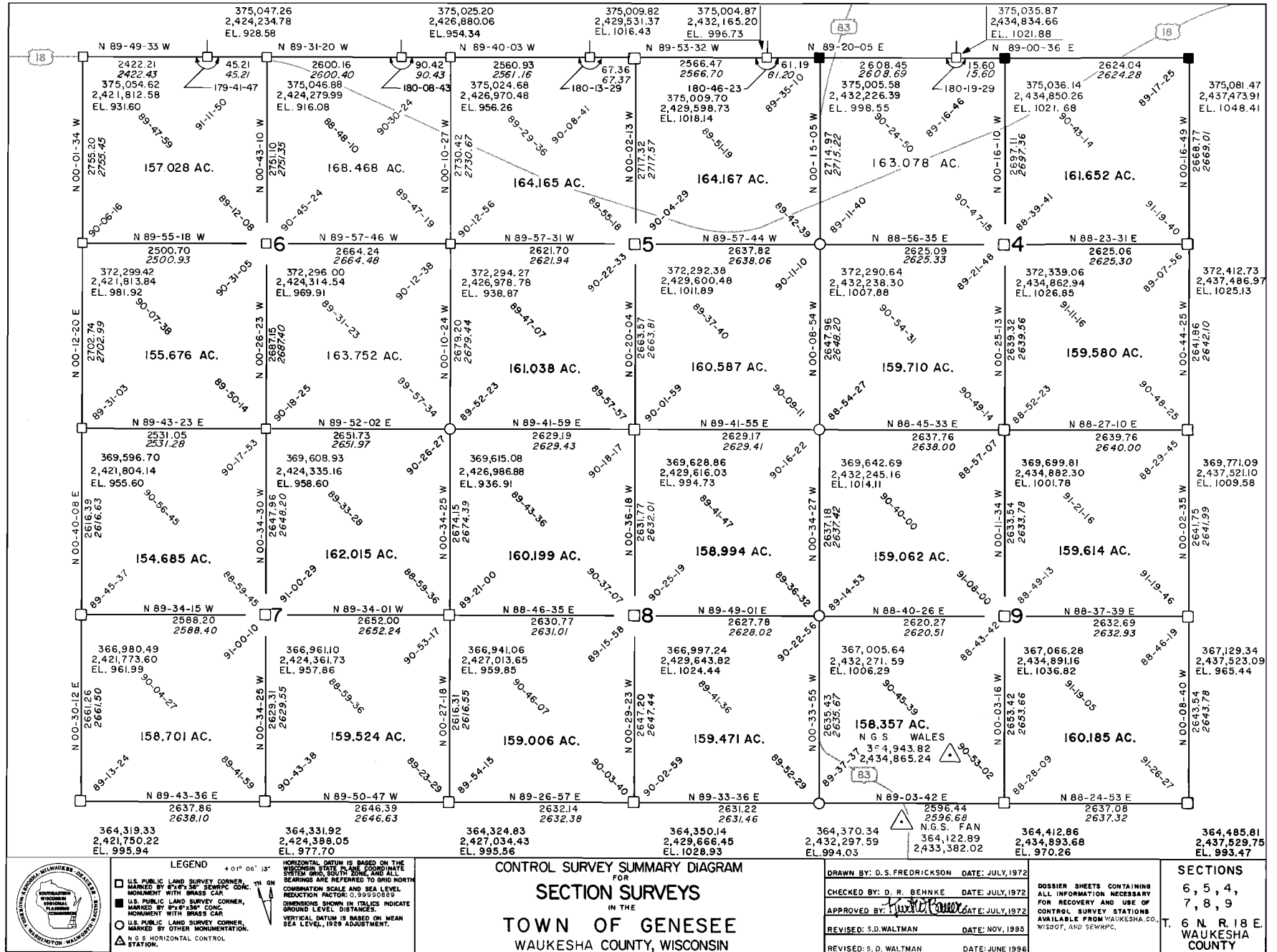
















LEGEND	
	U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEWRPP CONC. MONUMENT WITH BRASS CAP.
	U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC. MONUMENT WITH BRASS CAP.
	U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
	N.G.S. HORIZONTAL CONTROL STATION.

— 2000 —

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99991294. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM

SECTION SURVEYS

IN THE

TOWN OF GENESEE

WAUKESHA COUNTY, WISCONSIN

DRAWN BY: D. P. SIMON DATE: MAR, 1990

CHECKED BY: J. H. KREBLIN DATE: MAR 1990

APPROVED BY: [Signature] DATE: MAR, 1990

REVISD:S.D.WALTMAN DATE:NOV, 1995

REVISOR: D. P. SIMON DATE: MAY, 1995

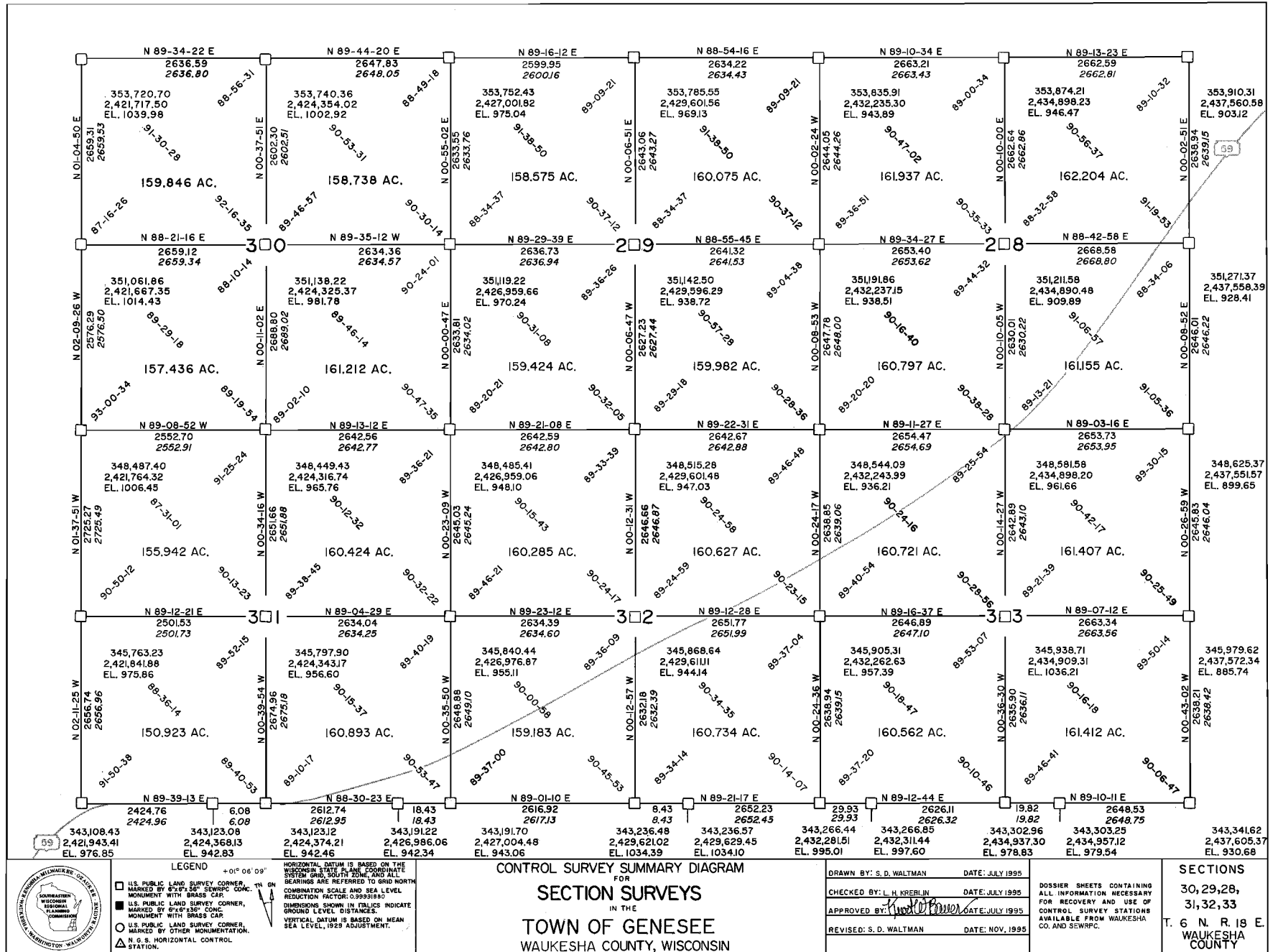
DOSSIER SHEETS CONTAINING
ALL INFORMATION NECESSARY
FOR RECOVERY AND USE OF
CONTROL SURVEY STATIONS
AVAILABLE FROM WAUKESHA
COUNTY AND SEWRPC.

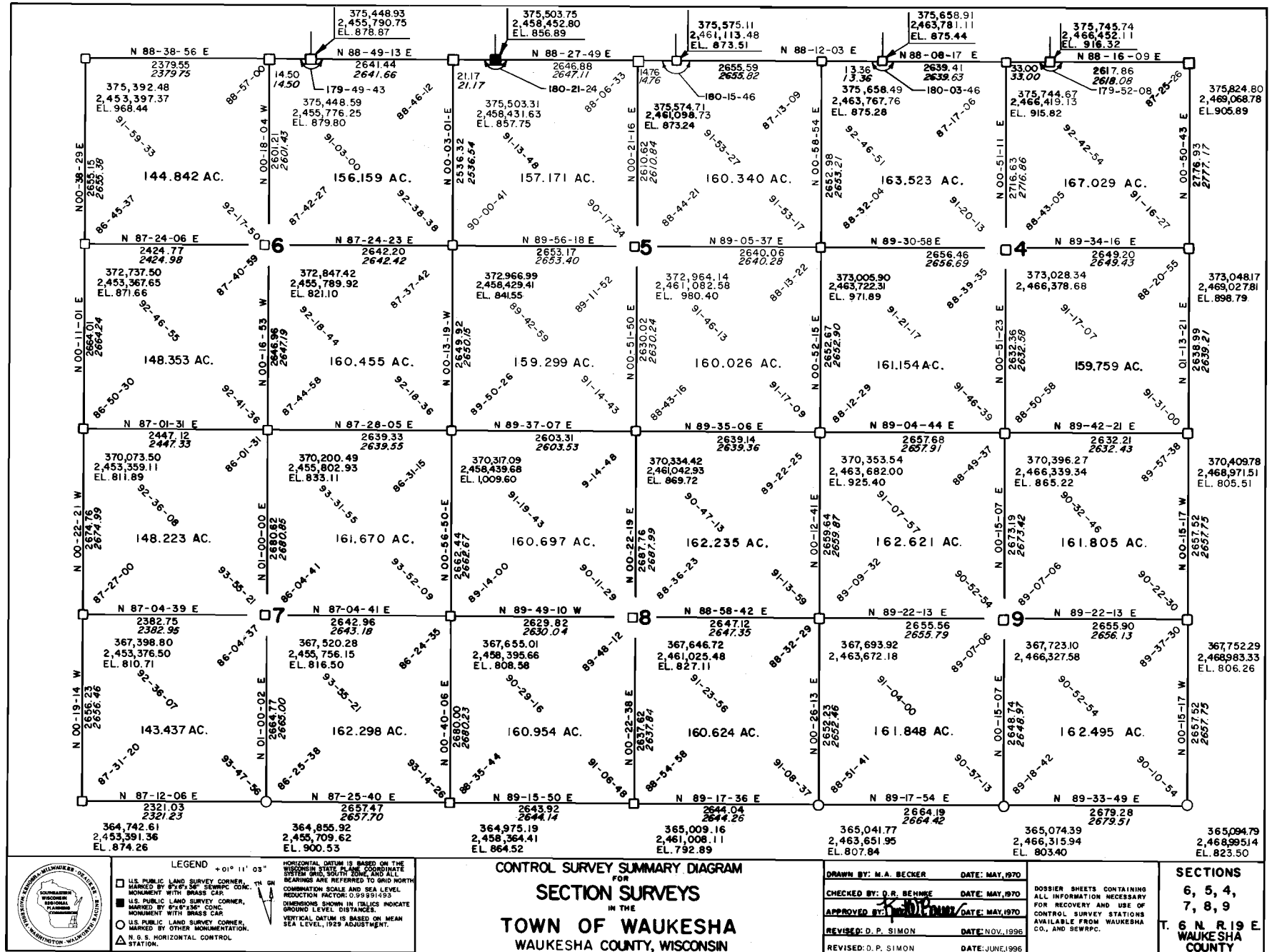
SECTIONS

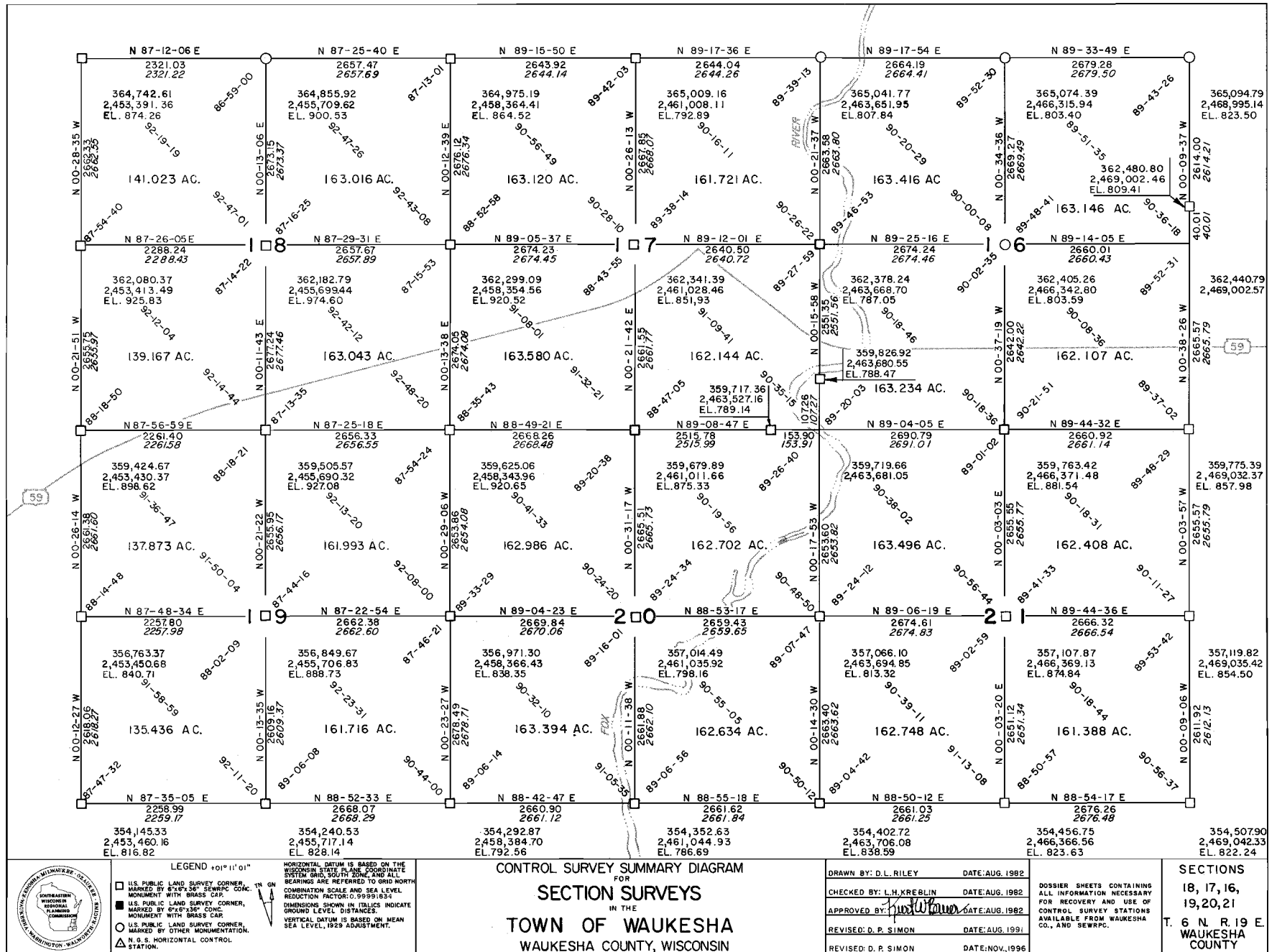
18, 17, 16,
19, 20, 21

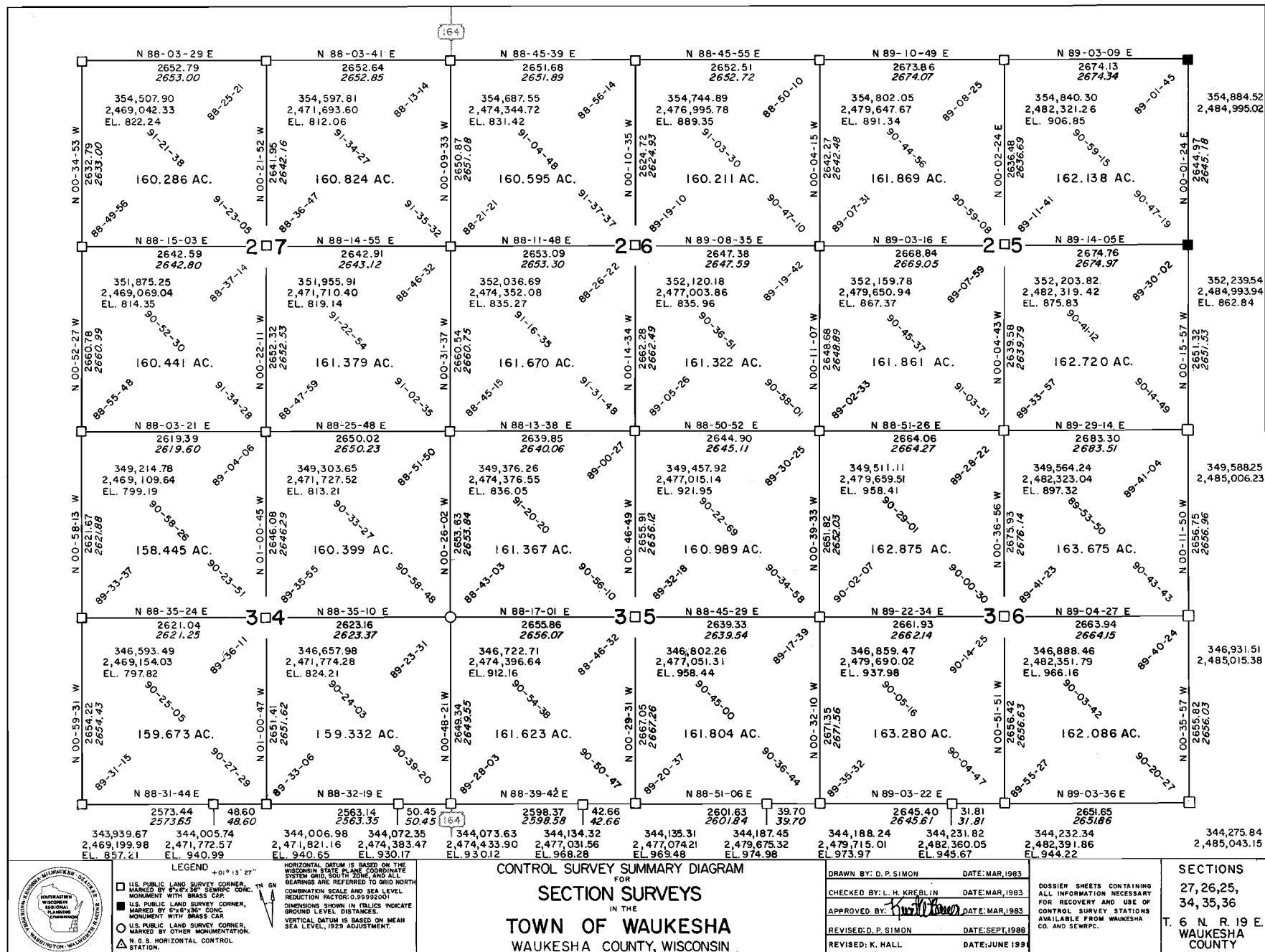
T. 6 N. R. 18 E.
WAUKESHA
COUNTY

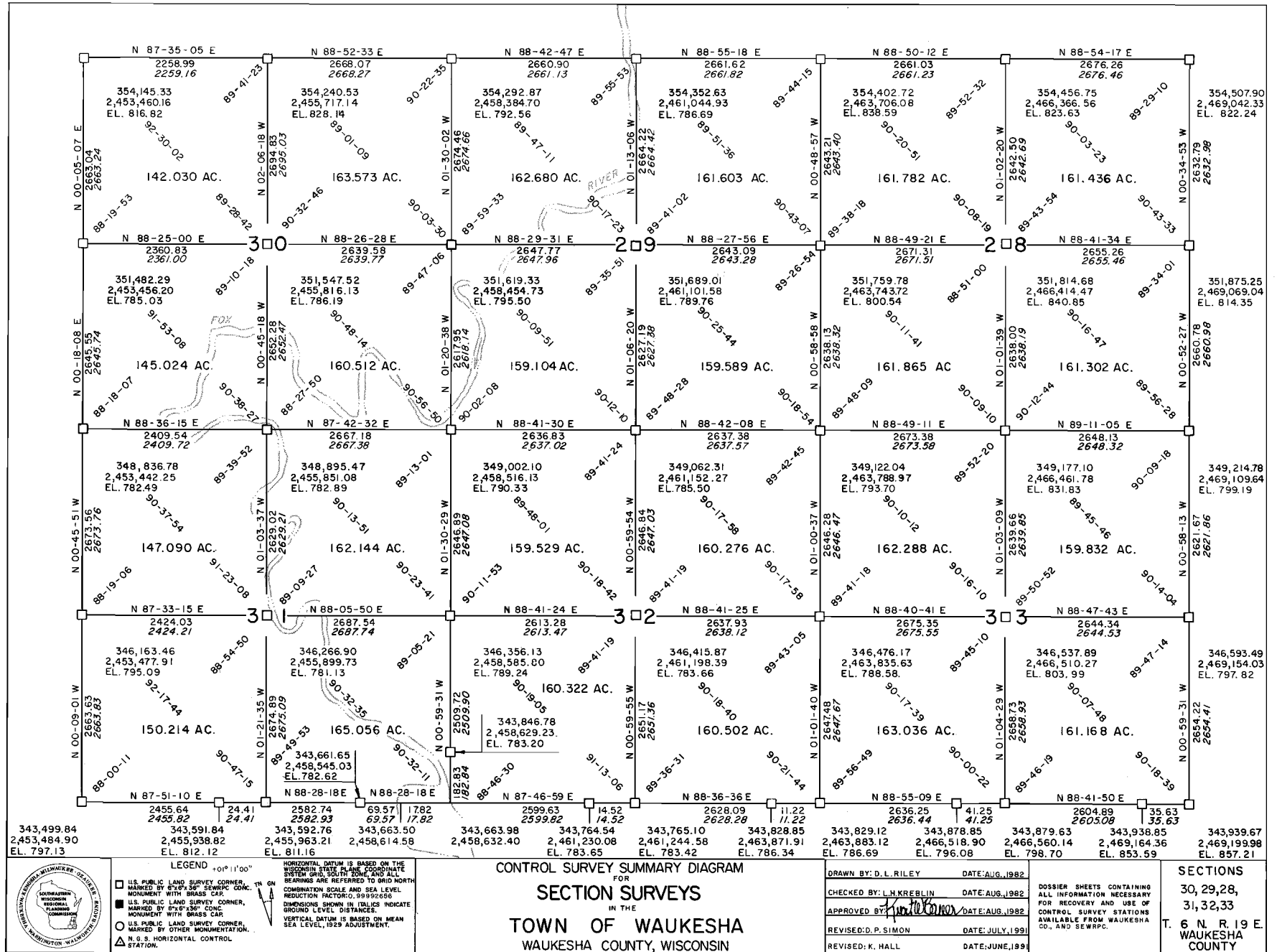




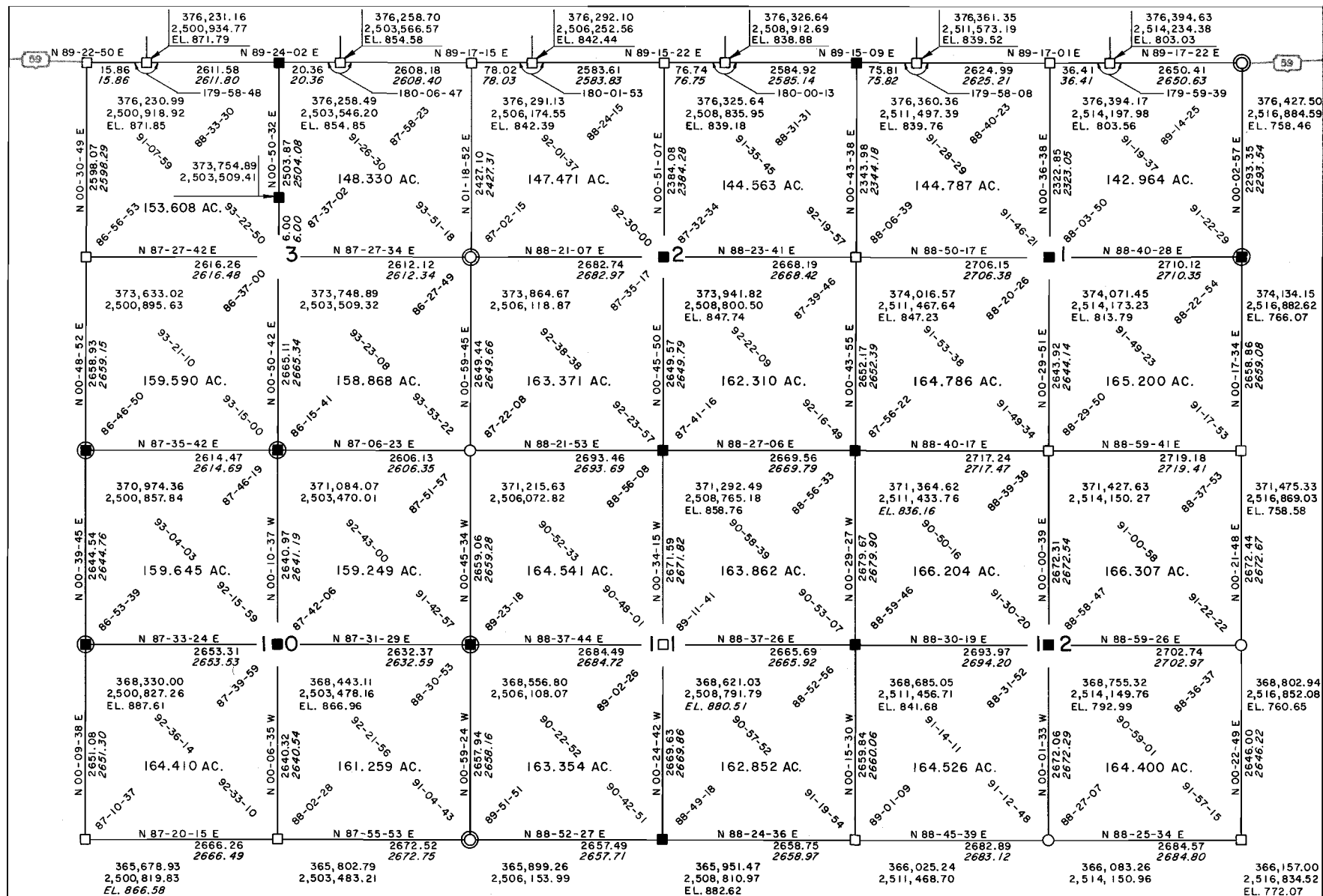


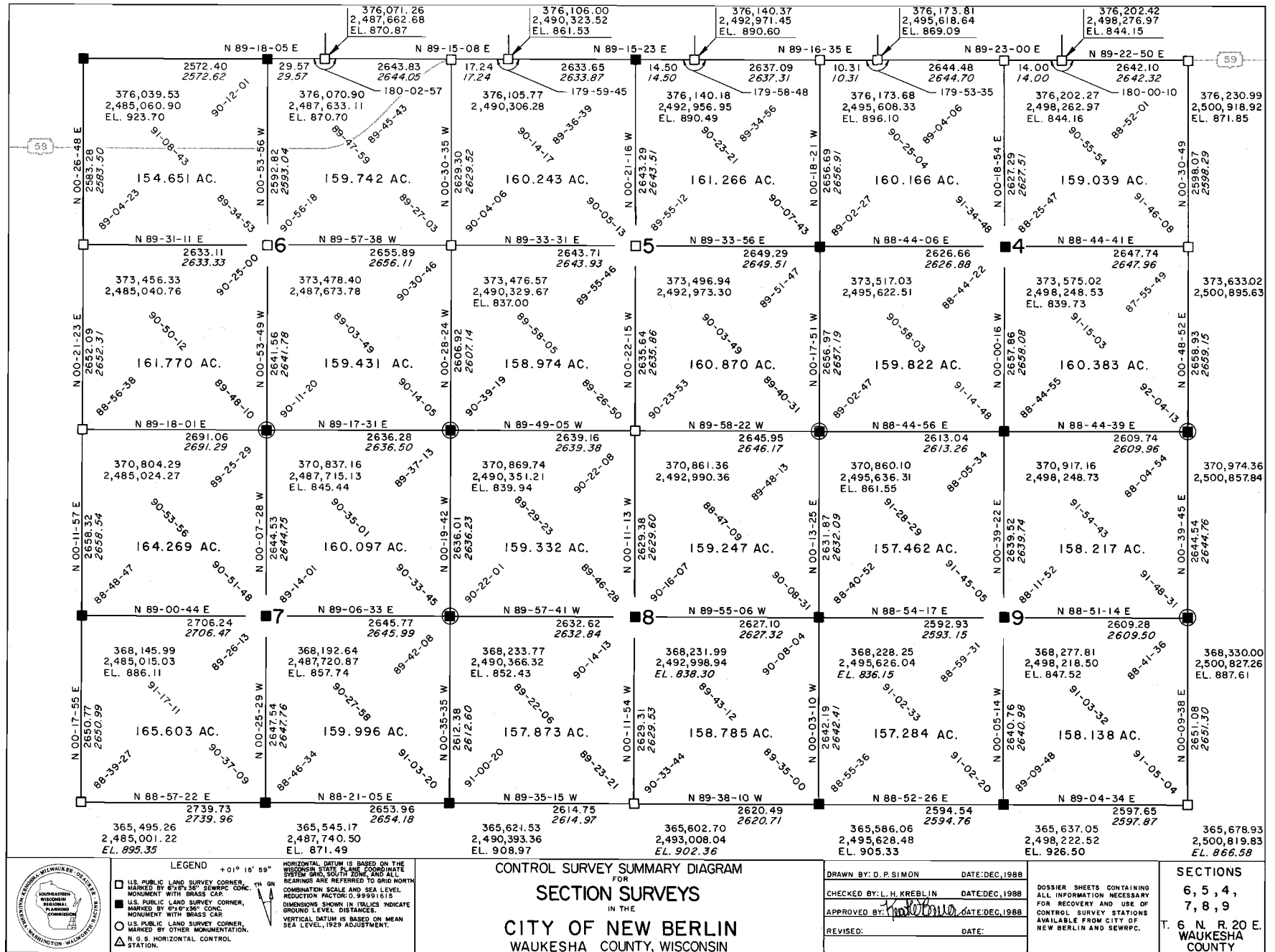


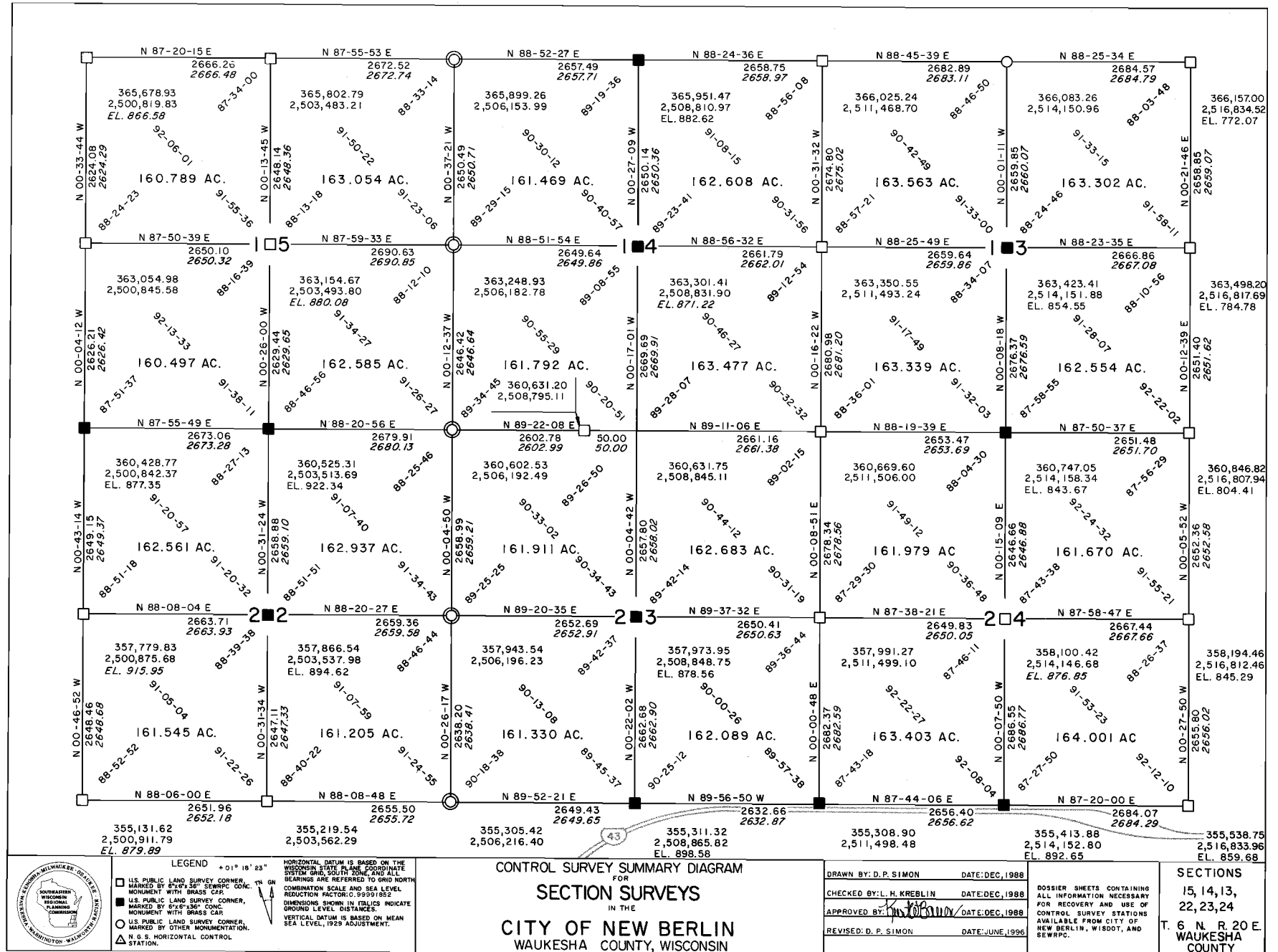


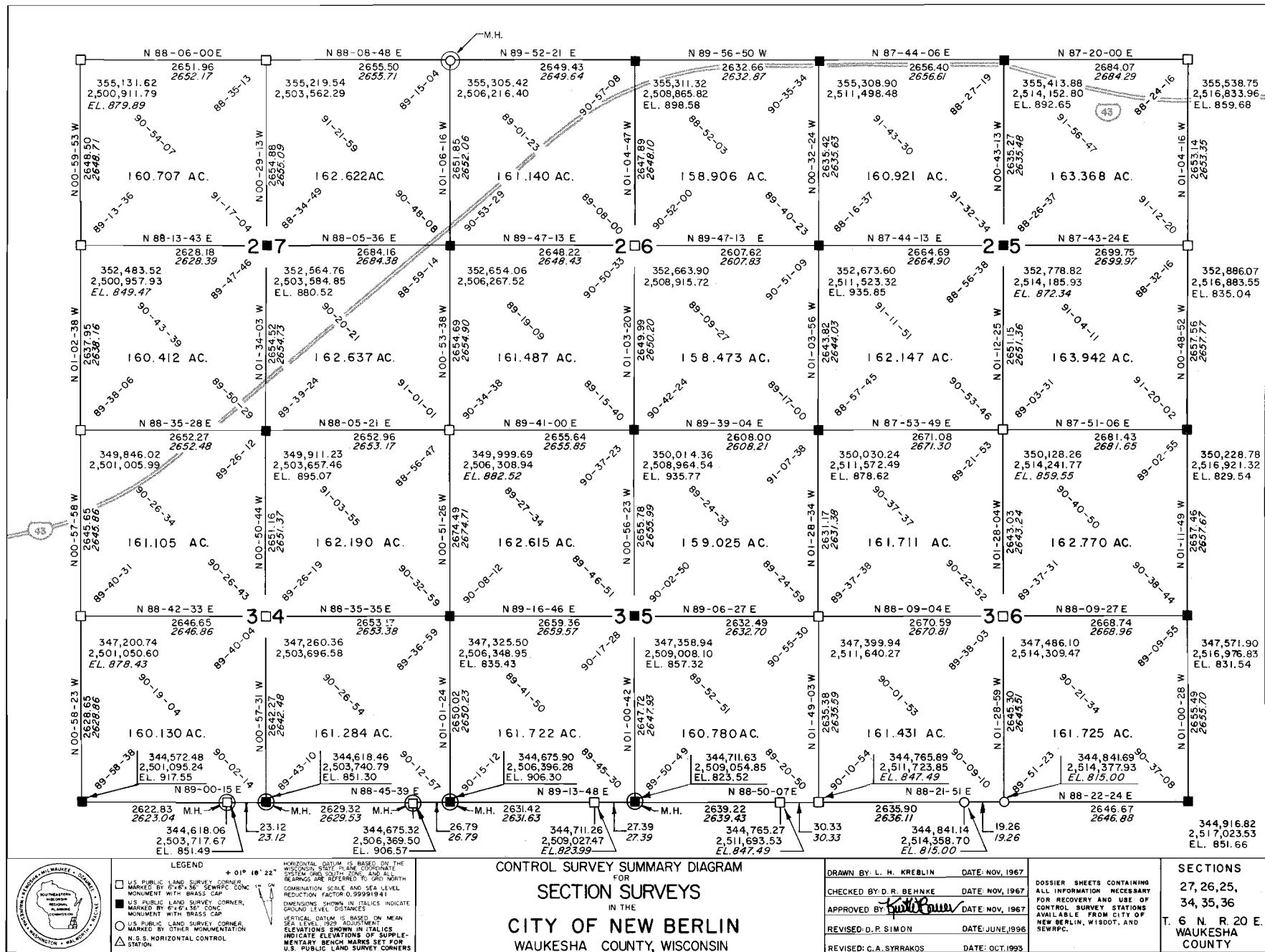


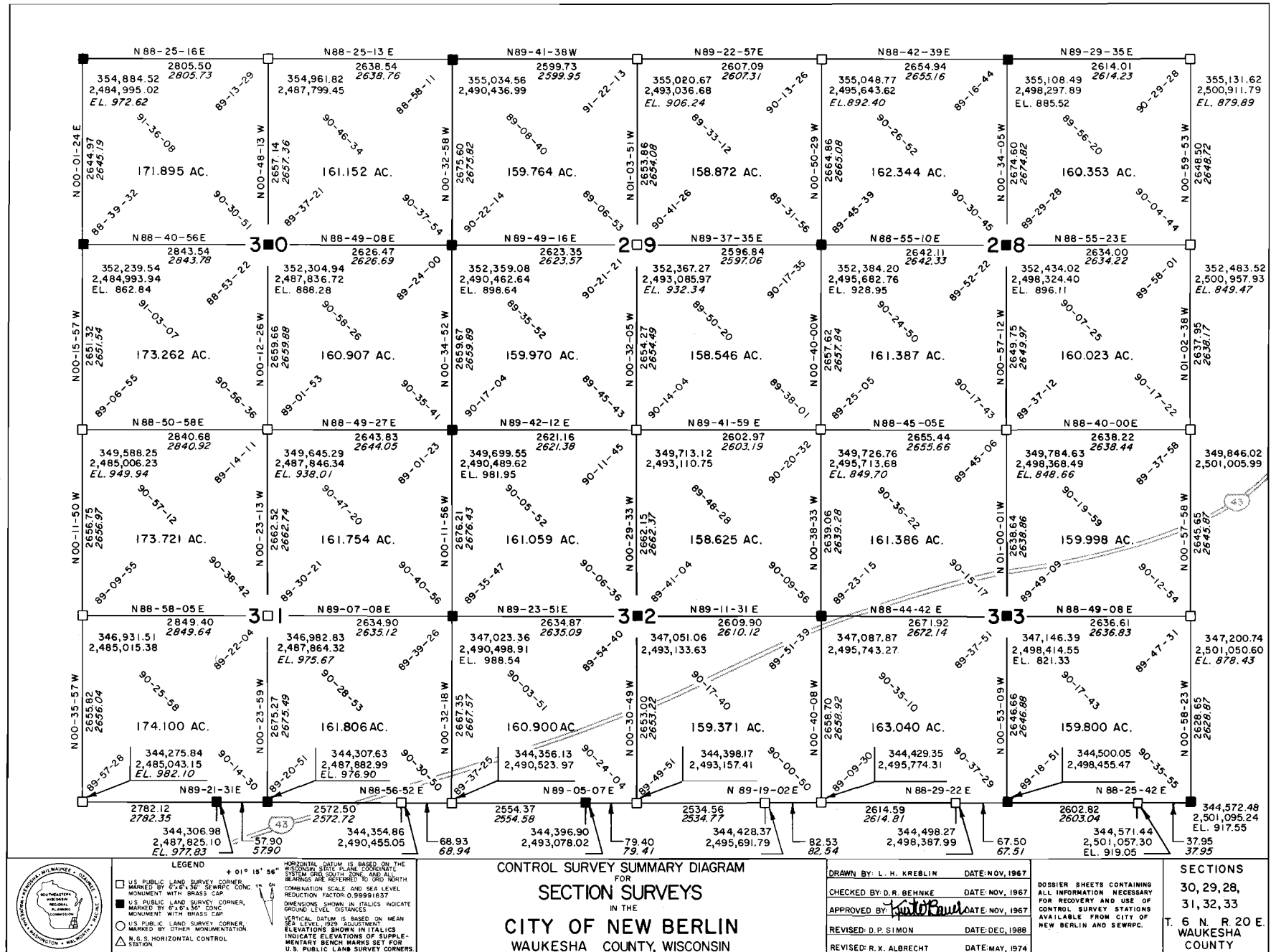
SECTIONS
30, 29, 28,
31, 32, 33
T. 6 N. R. 19 E.
WAUKESHA
COUNTY

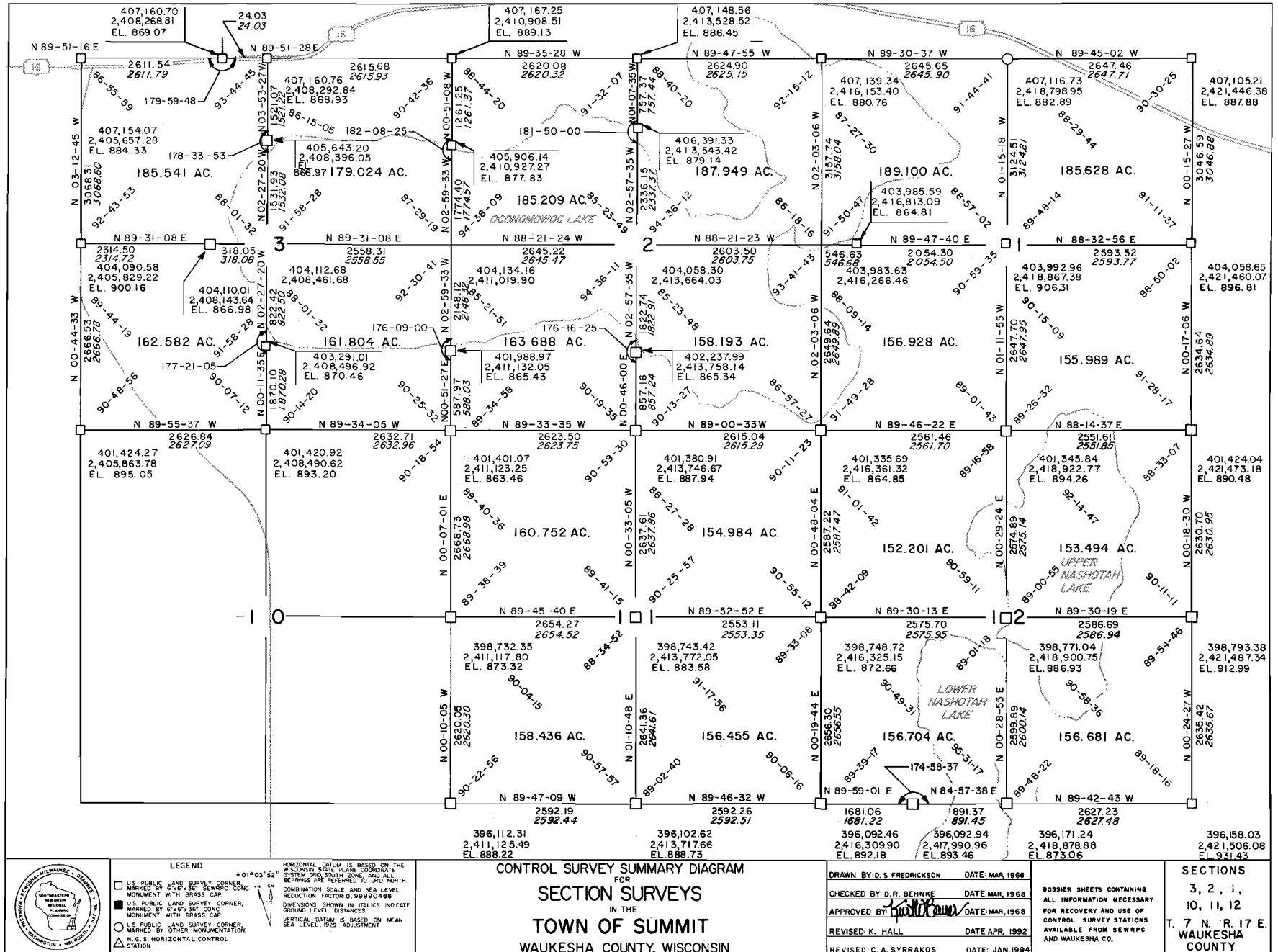


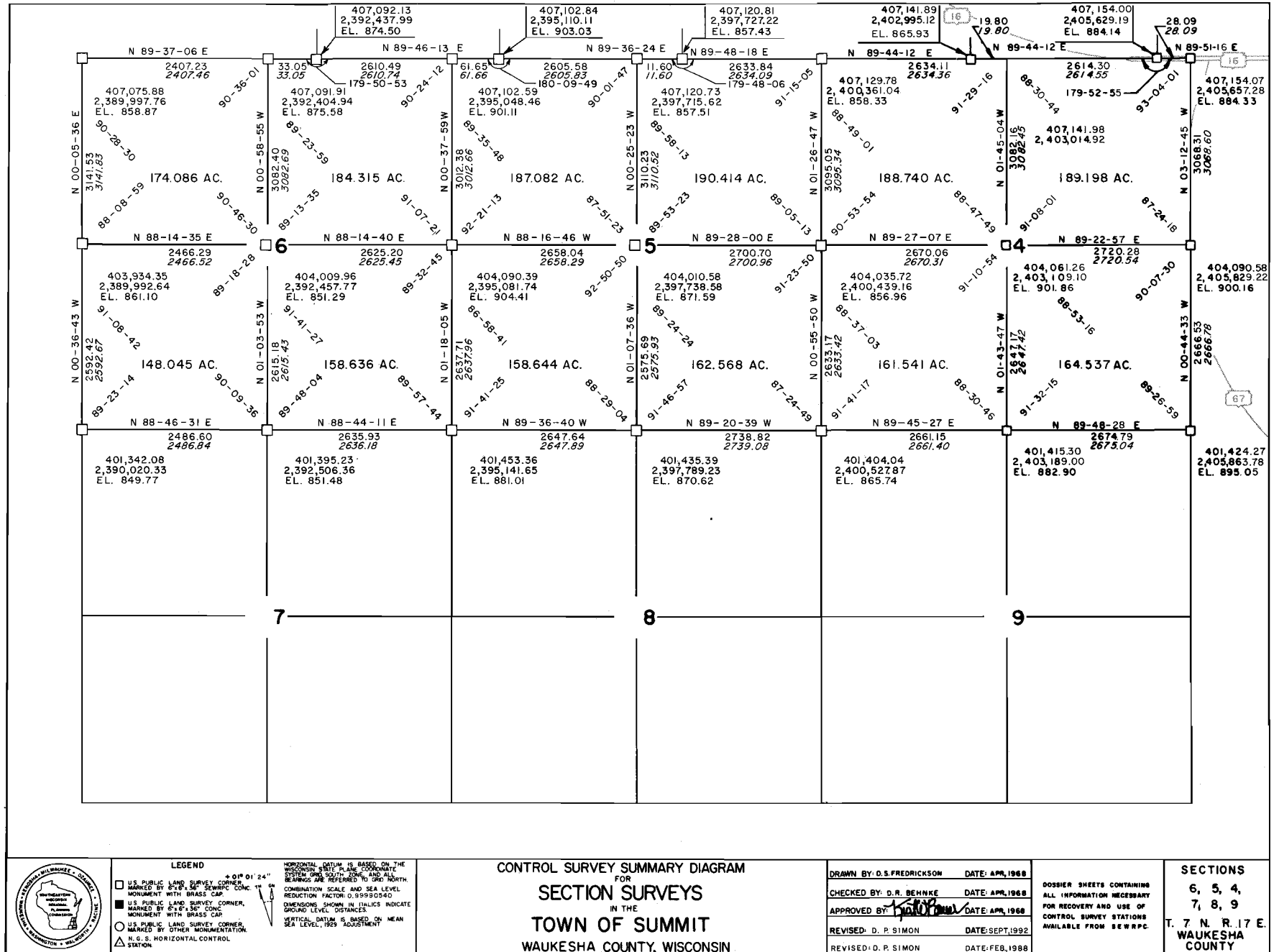


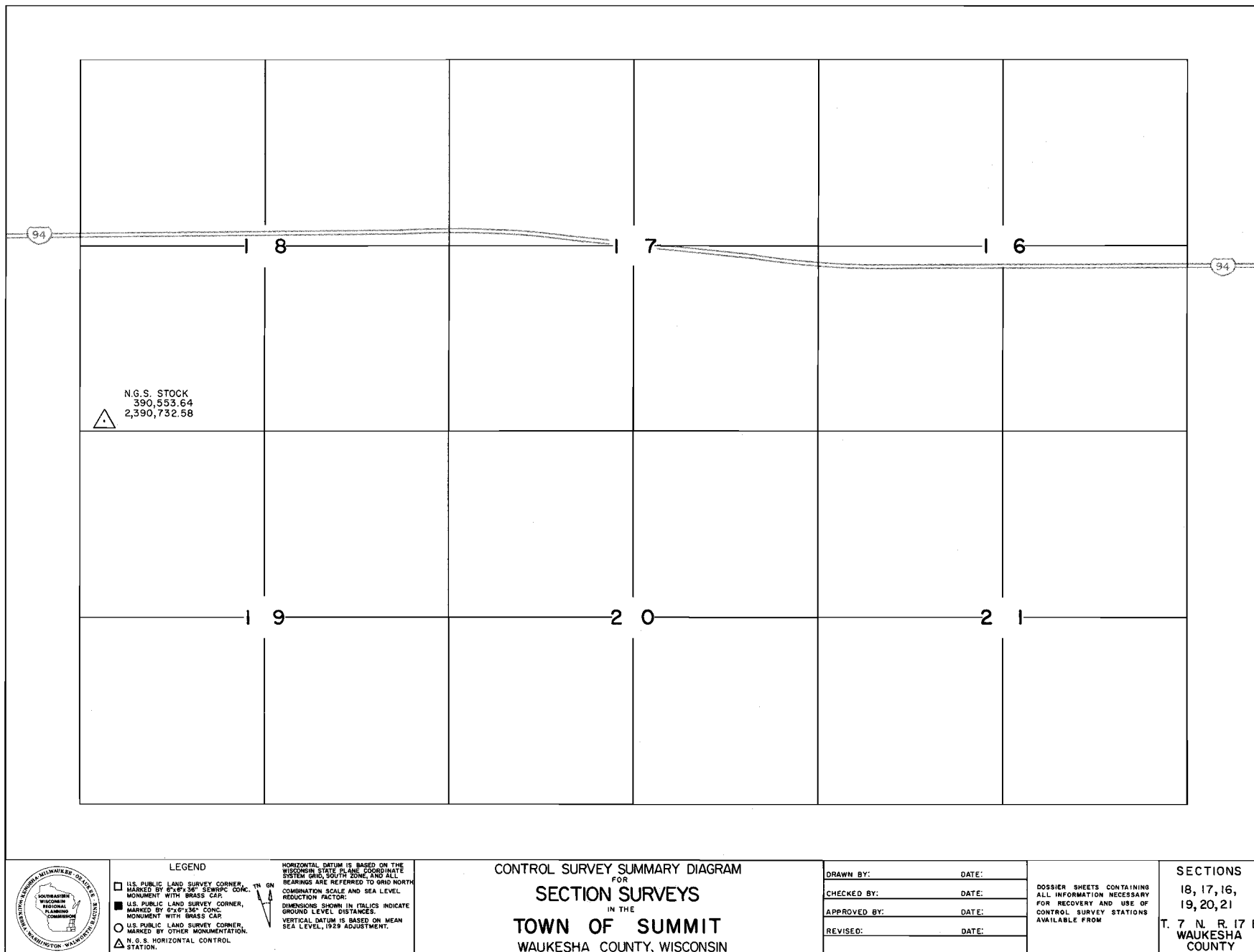


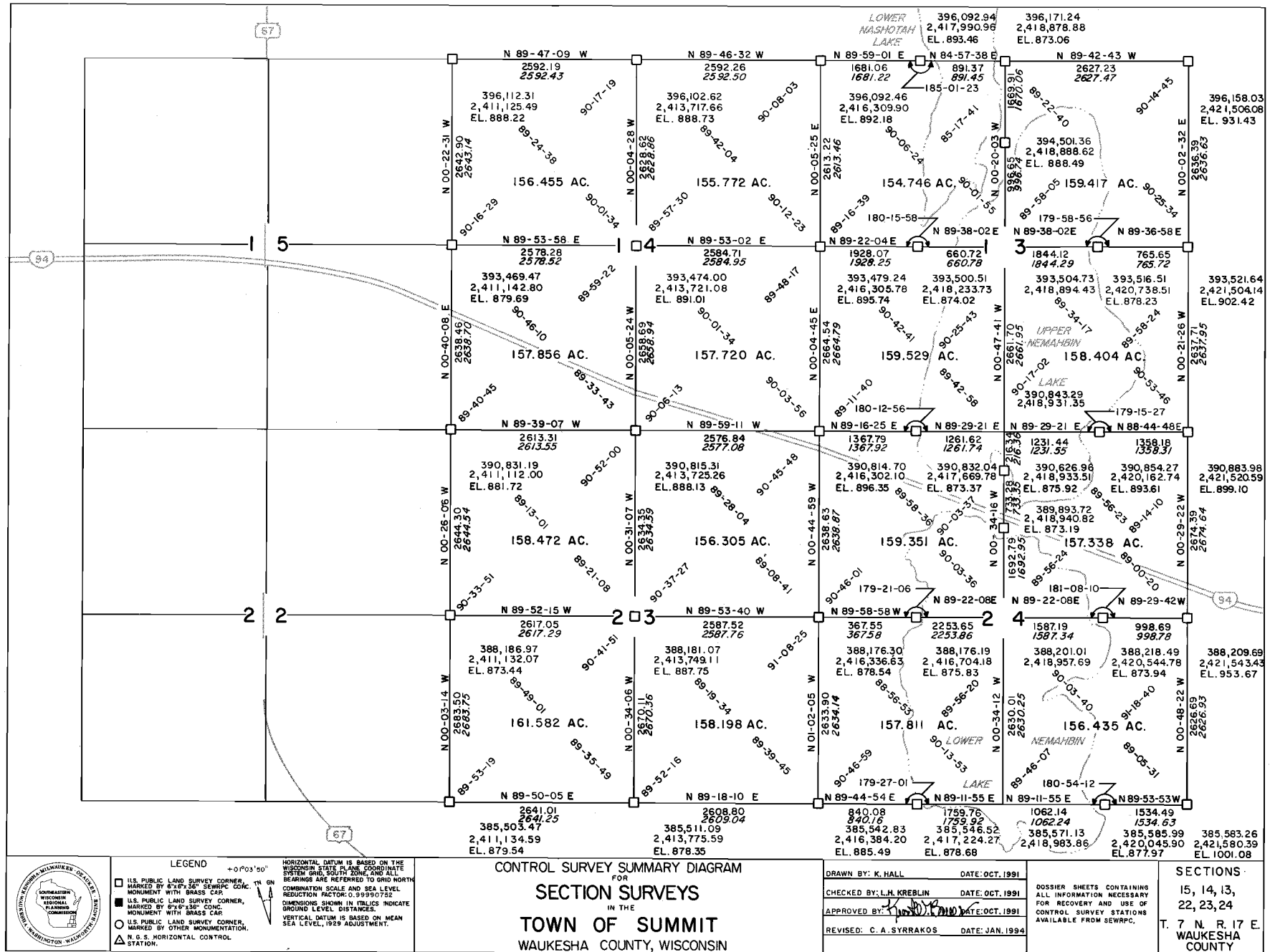


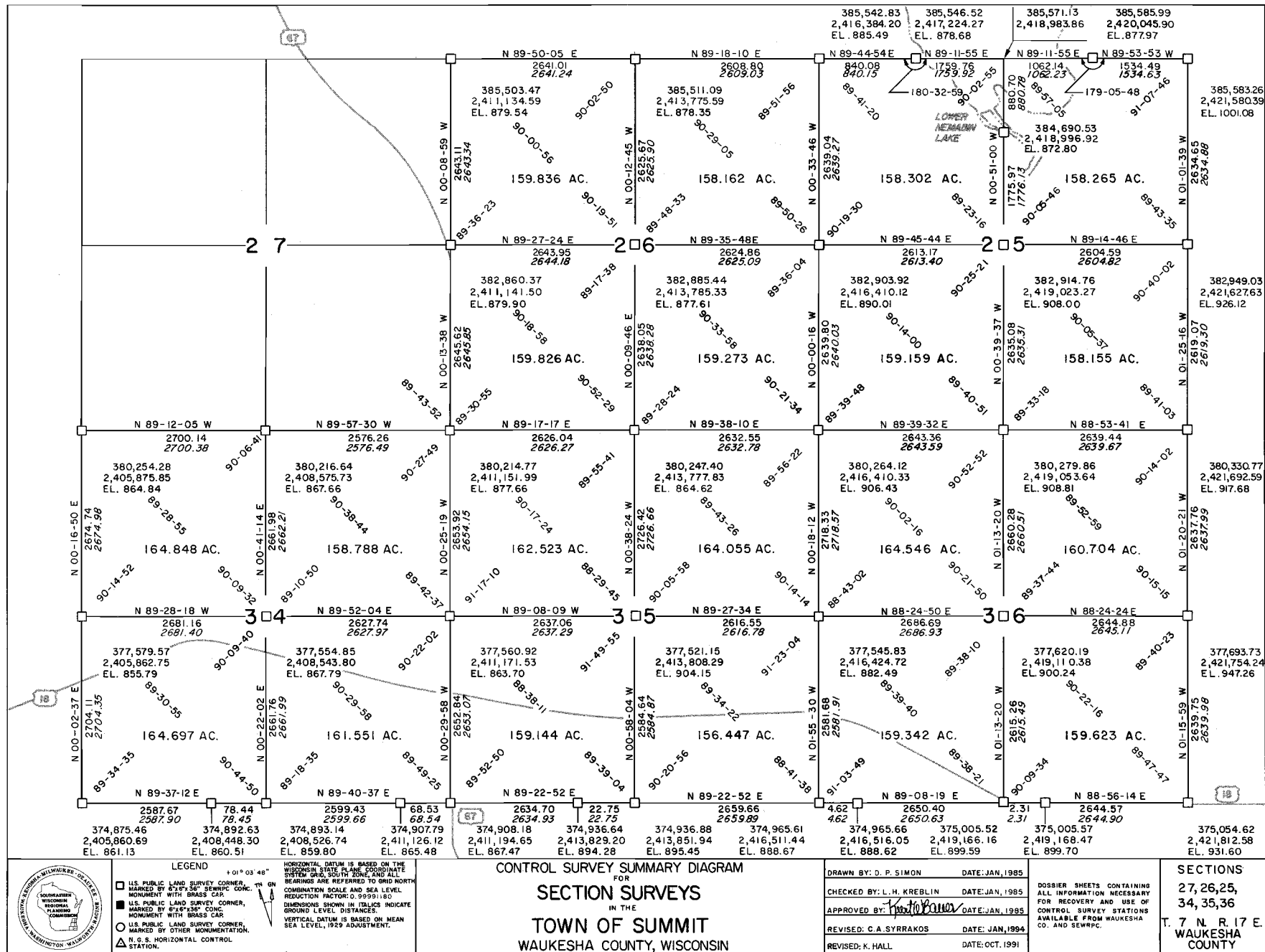


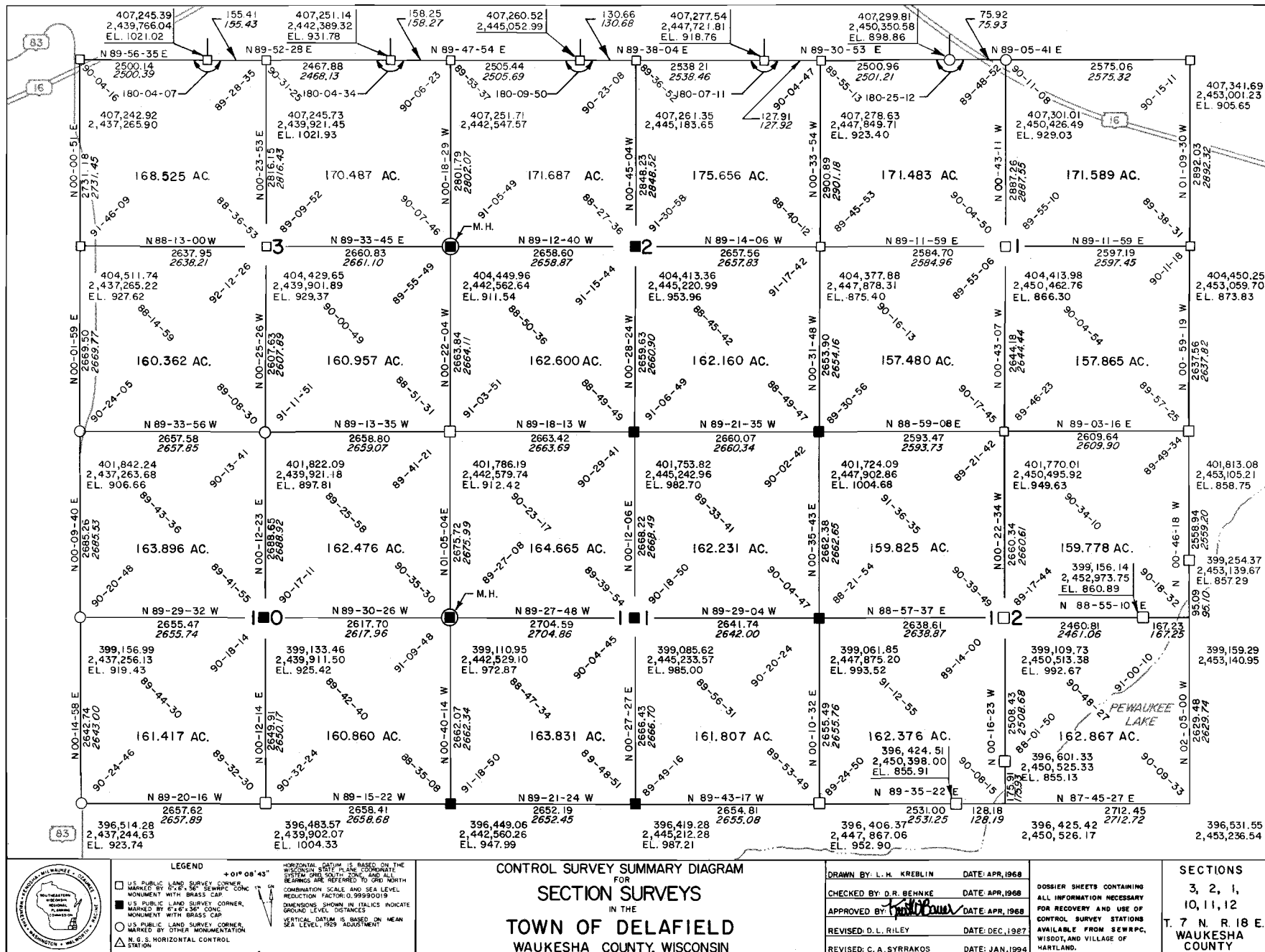


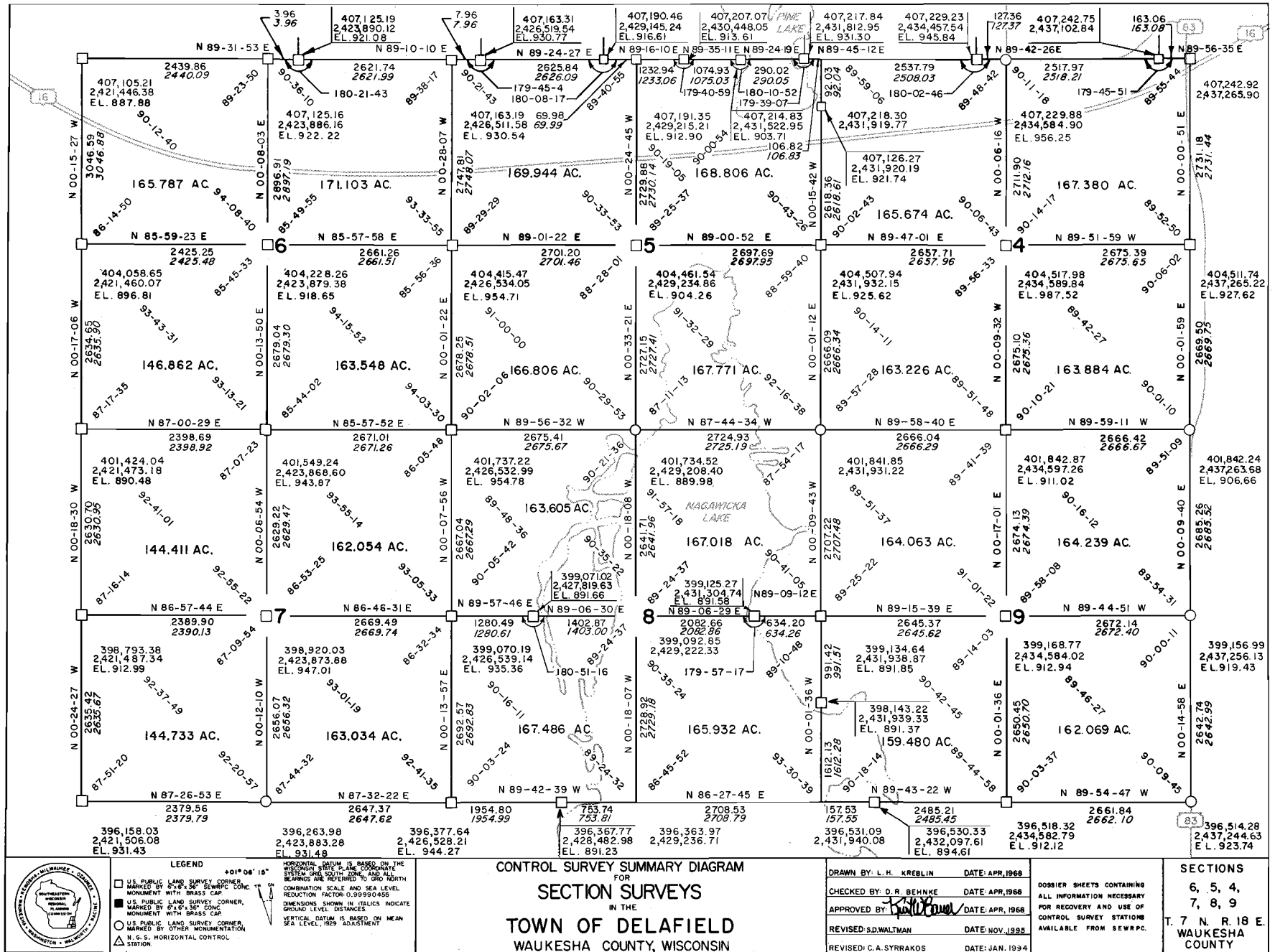


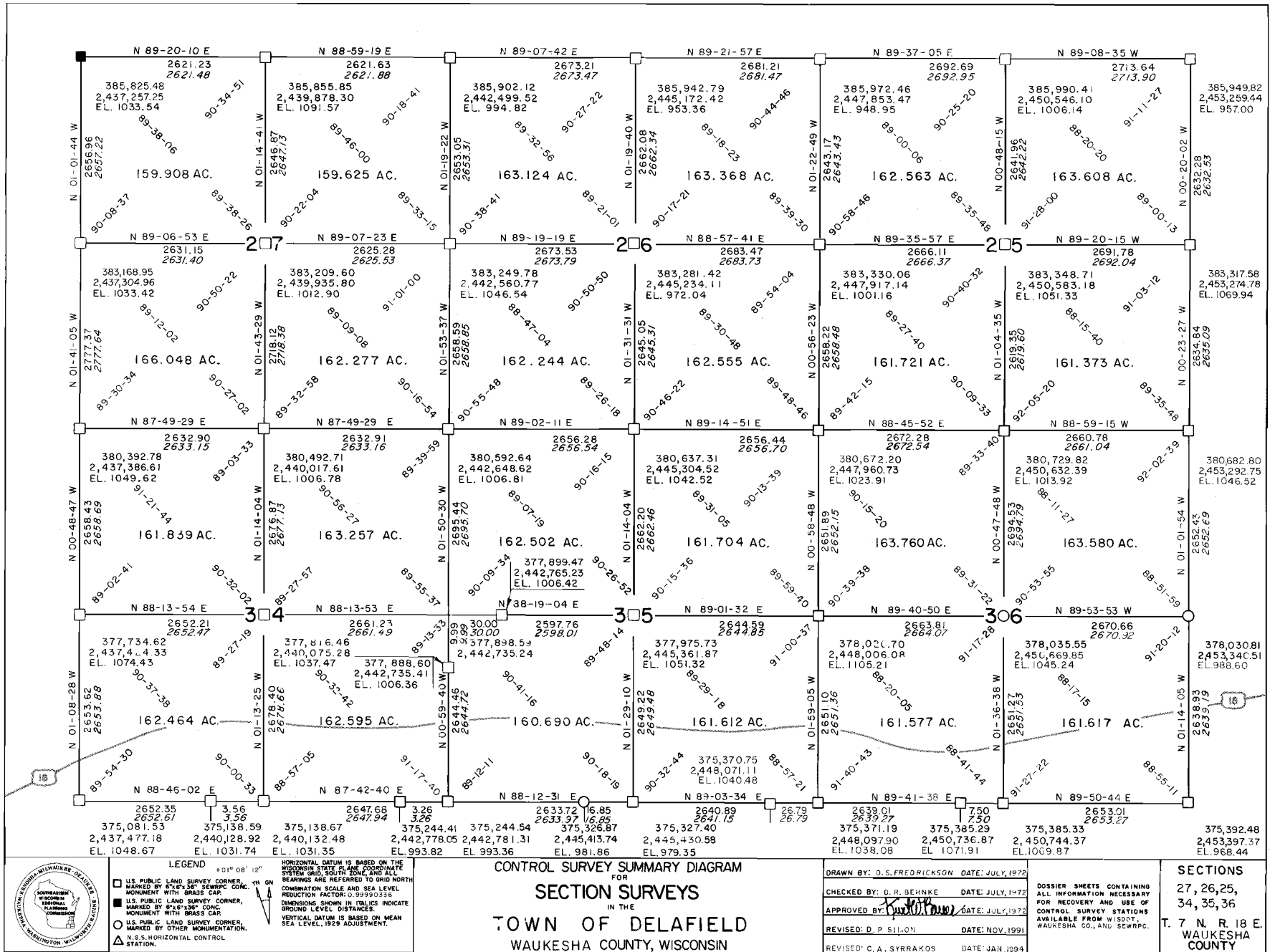


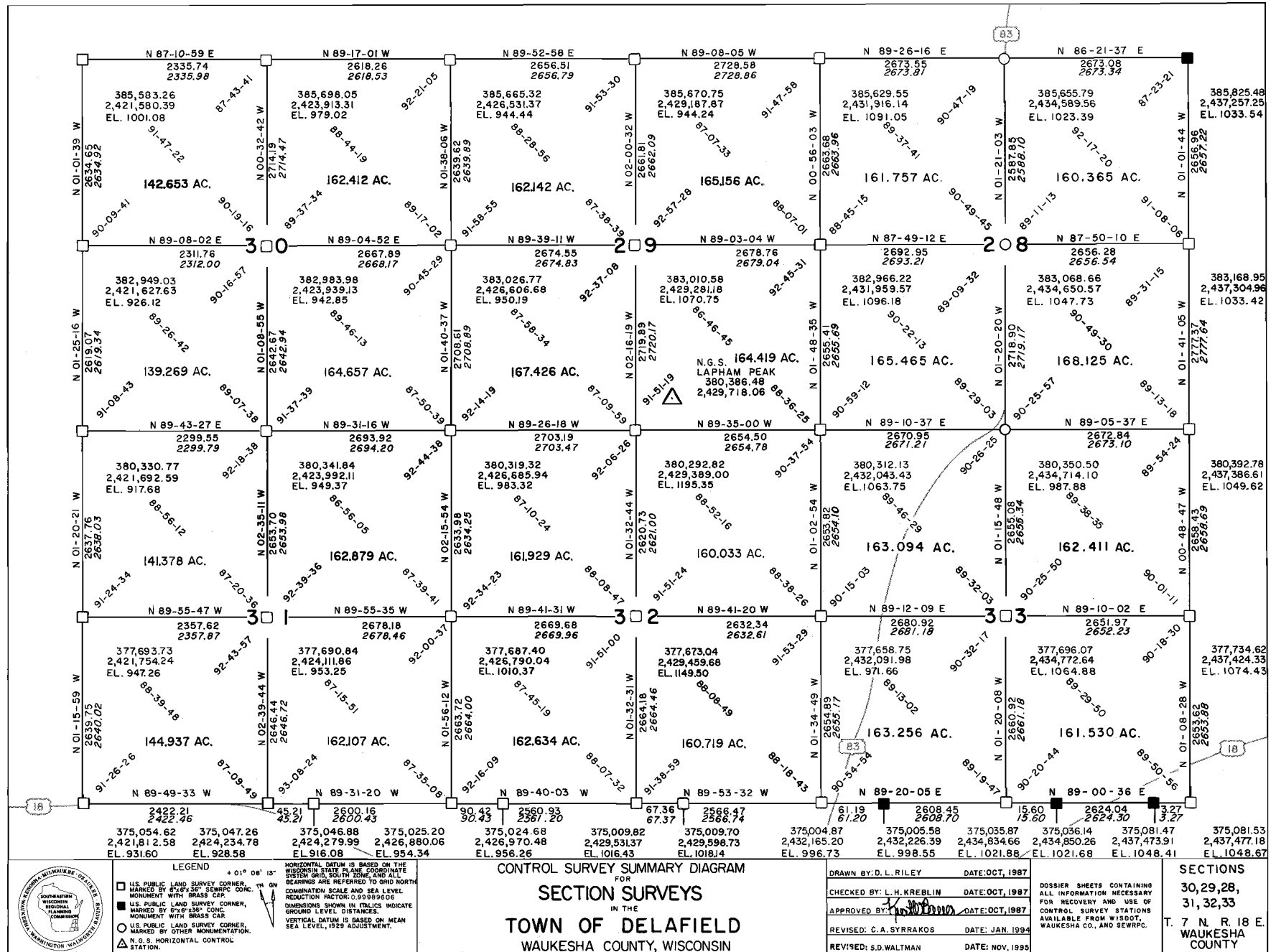


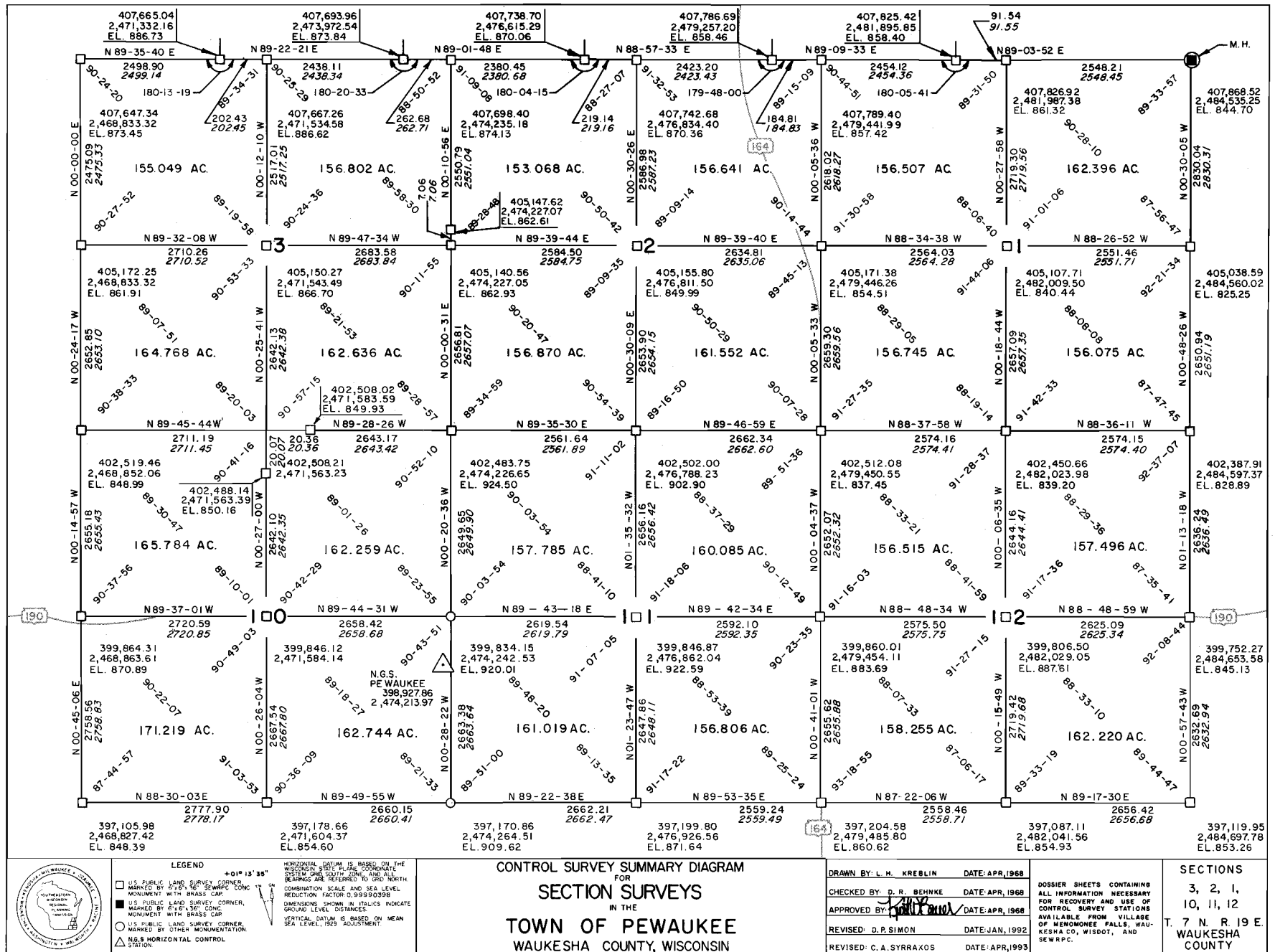


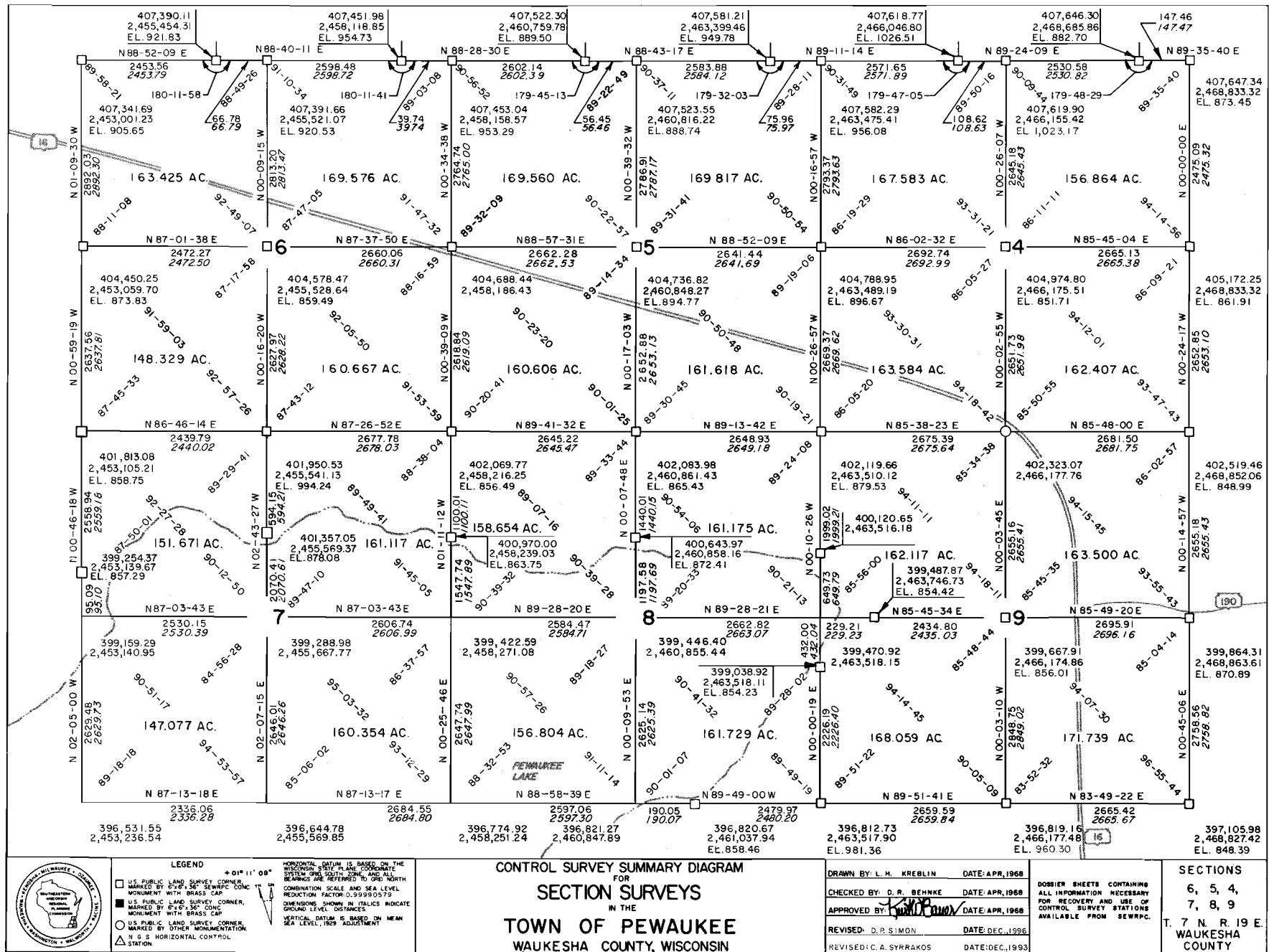




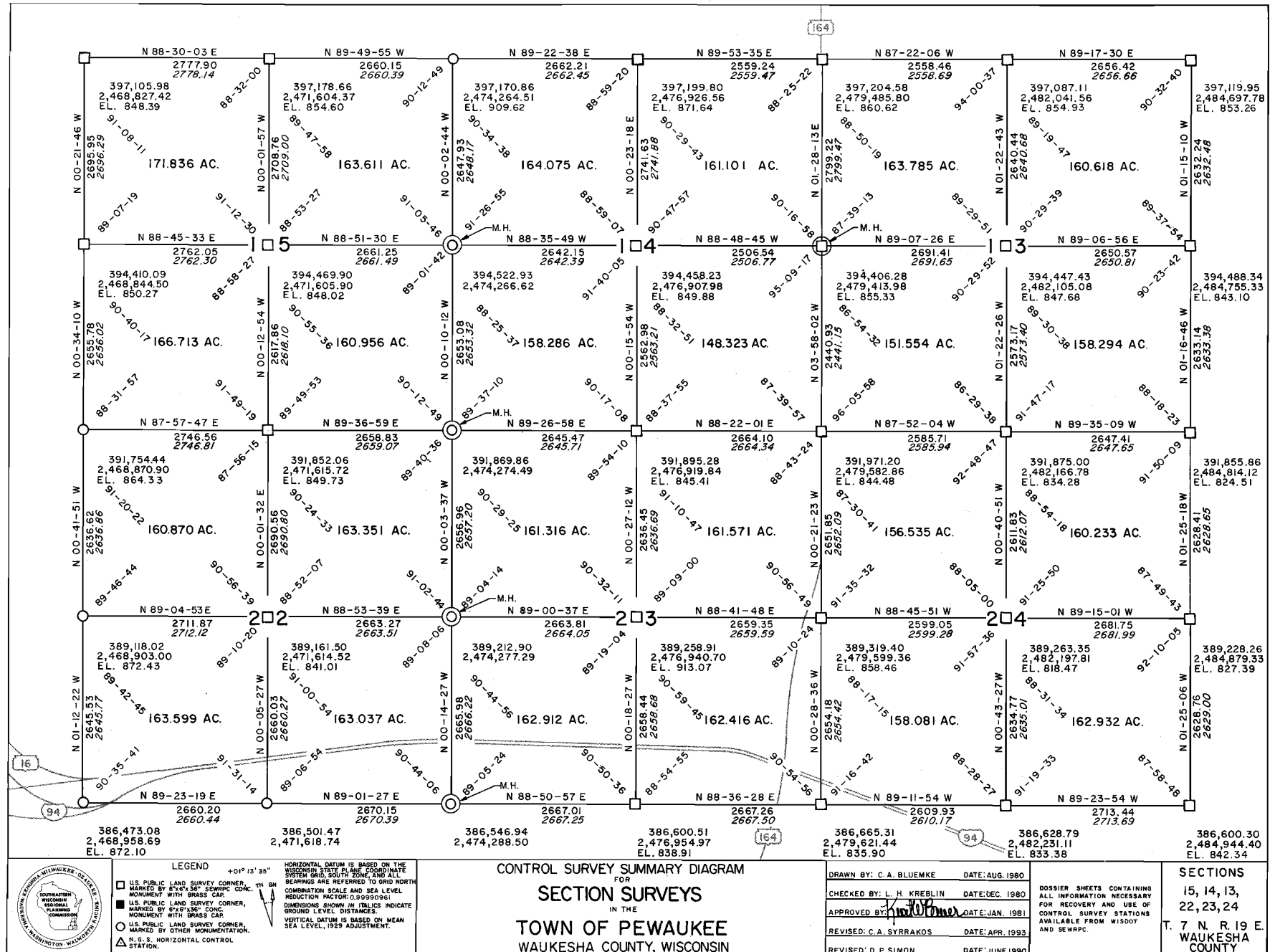


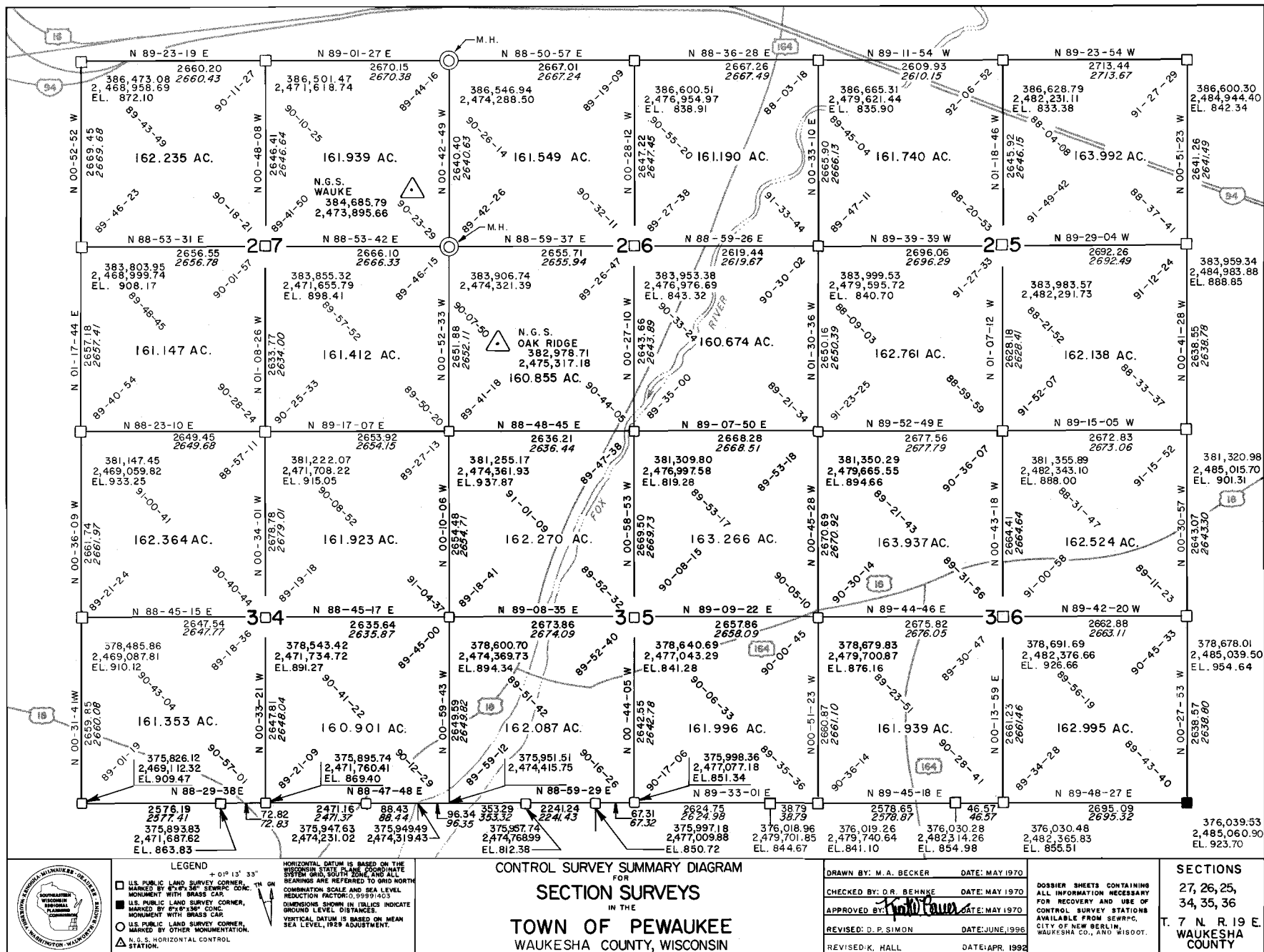


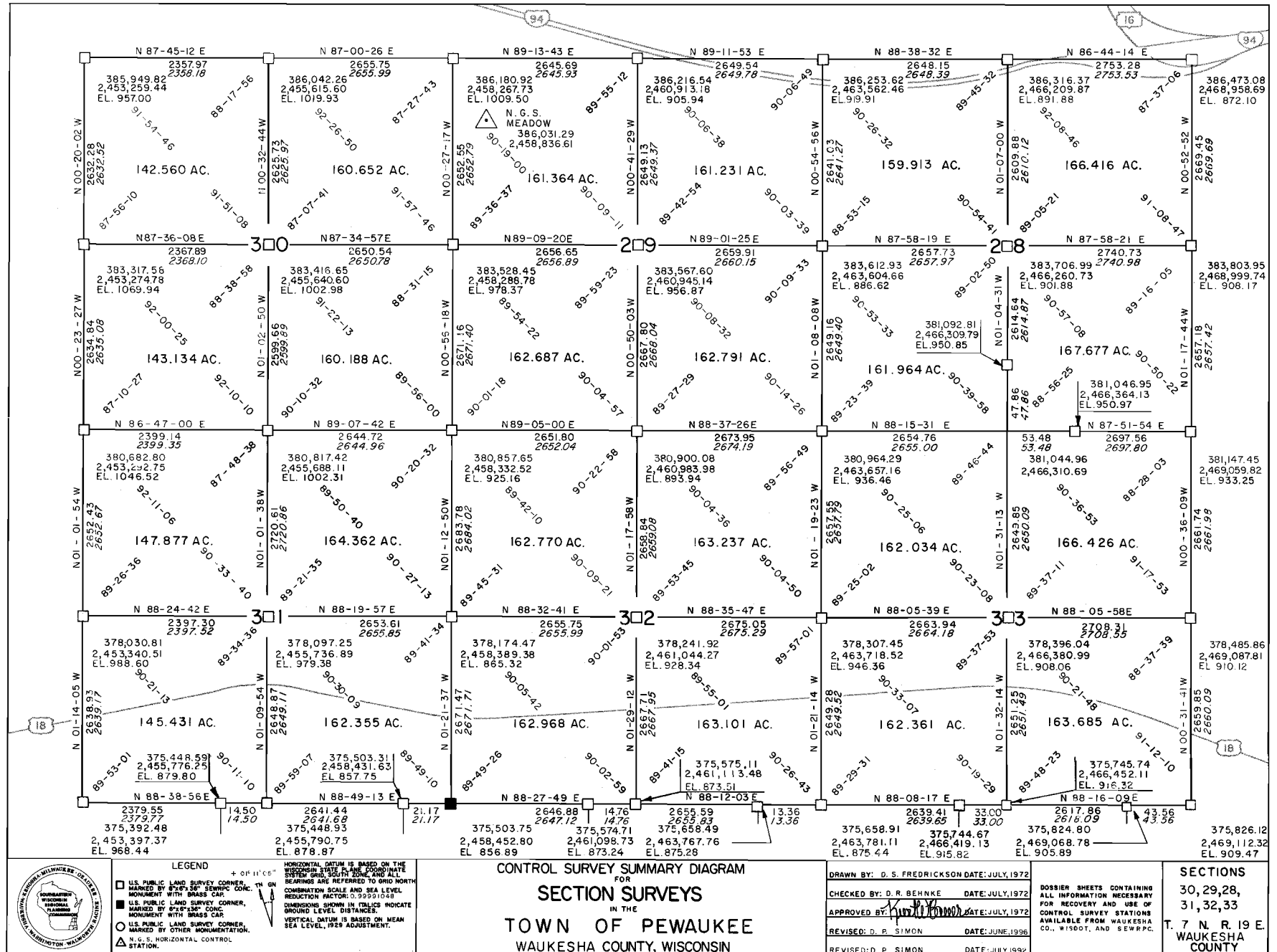


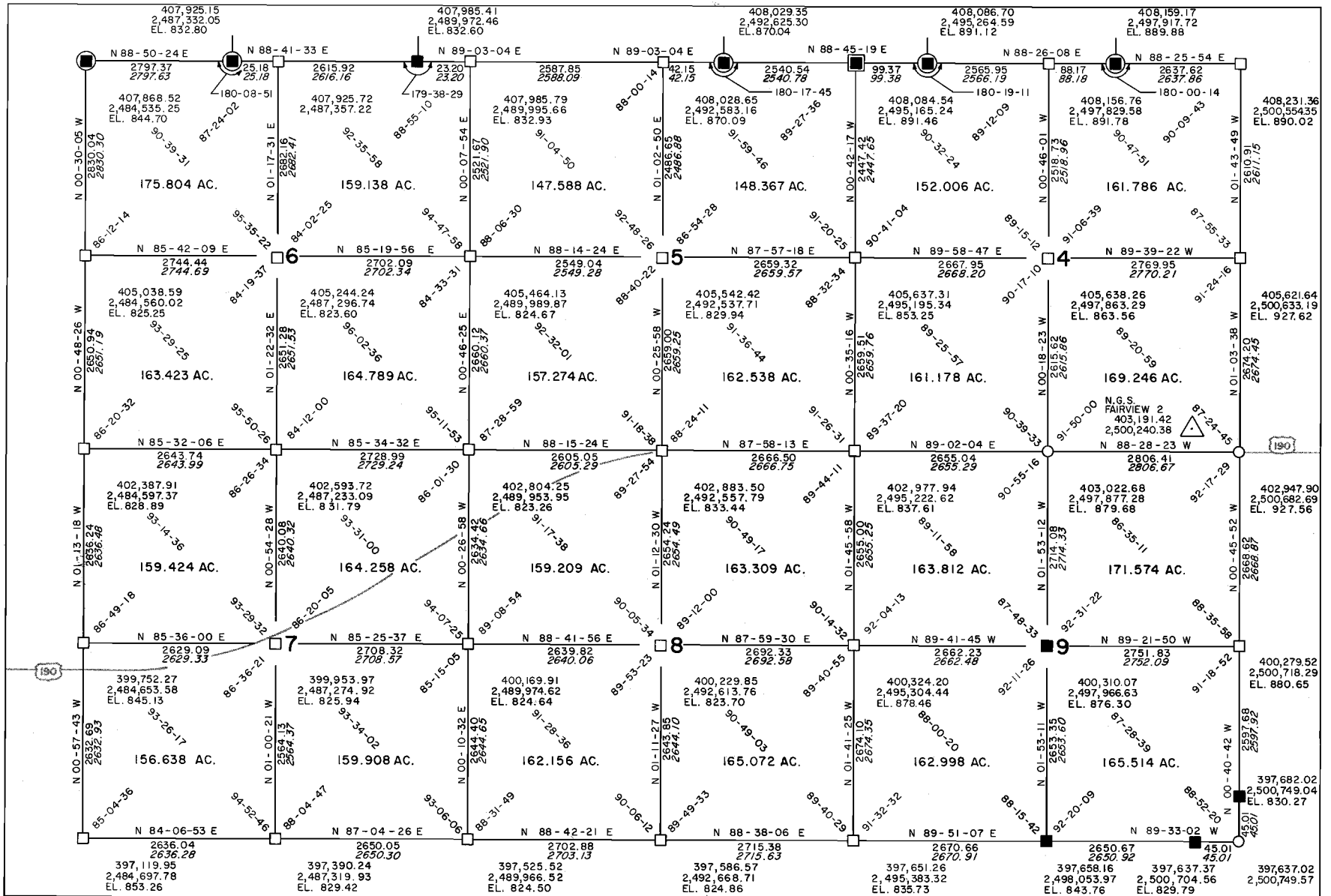












LAND SURVEY CORNER,
8'x6'x36" SEWAPPC CONC.
WITH BRASS CAP

LAND SURVEY CORNER,
8'x6'x36" CONC.
WITH BRASS CAP

LAND SURVEY CORNER,
CONC. WITH BRASS CAP

SYSTEM GRID, SOUTH ZONE, AND ALL
BEARINGS ARE REFERRED TO GRID NORTH
COMBINATION SCALE AND SEA LEVEL
REDUCTION FACTOR: 0.99990729

DIMENSIONS SHOWN IN ITALICS INDICATE
GROUND LEVEL DISTANCES.

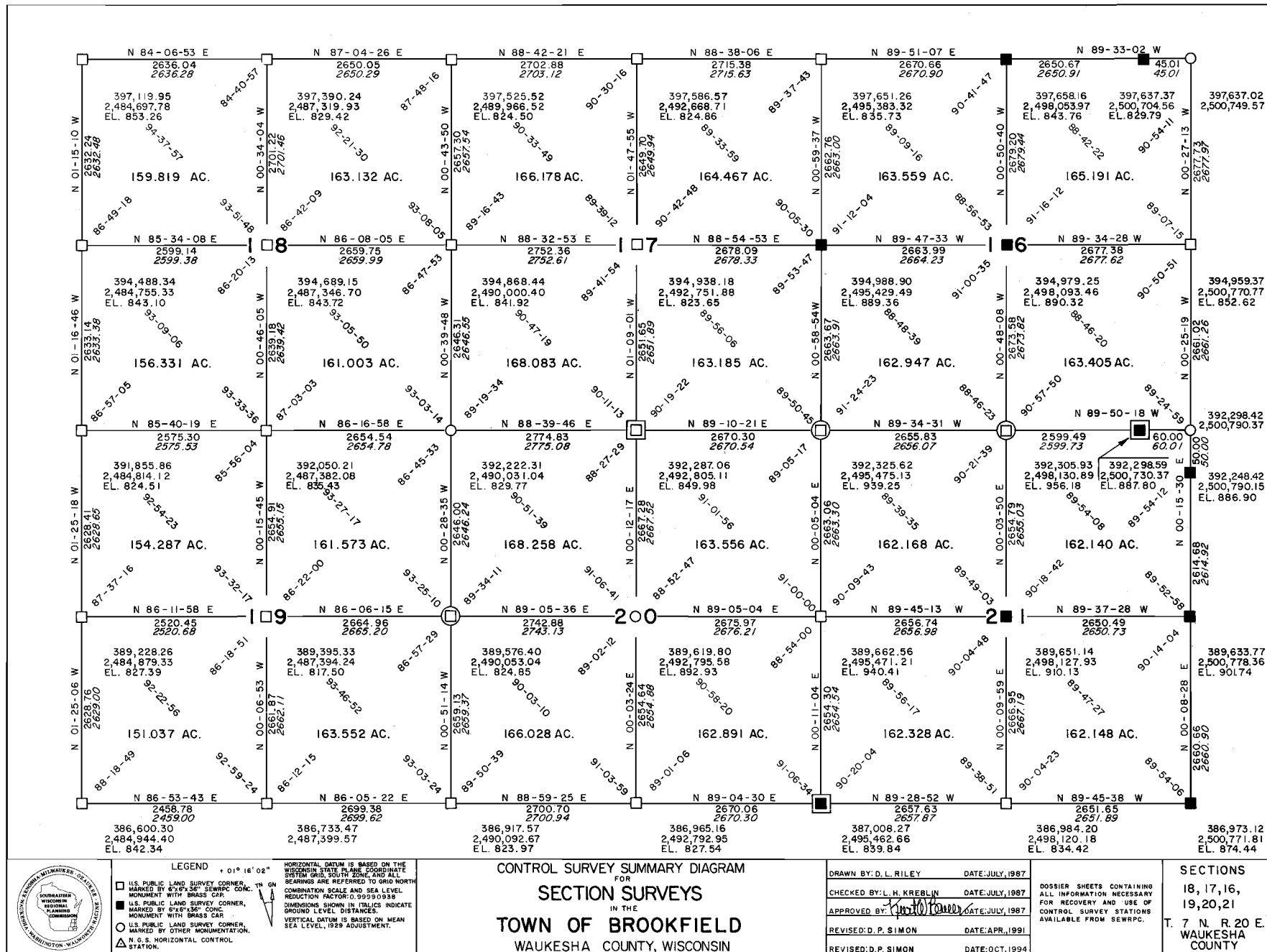
VERTICAL DATUM IS BASED ON MEAN
SEA LEVEL, 1929 ADJUSTMENT.

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF BROOKFIELD
WAUKESHA COUNTY, WISCONSIN

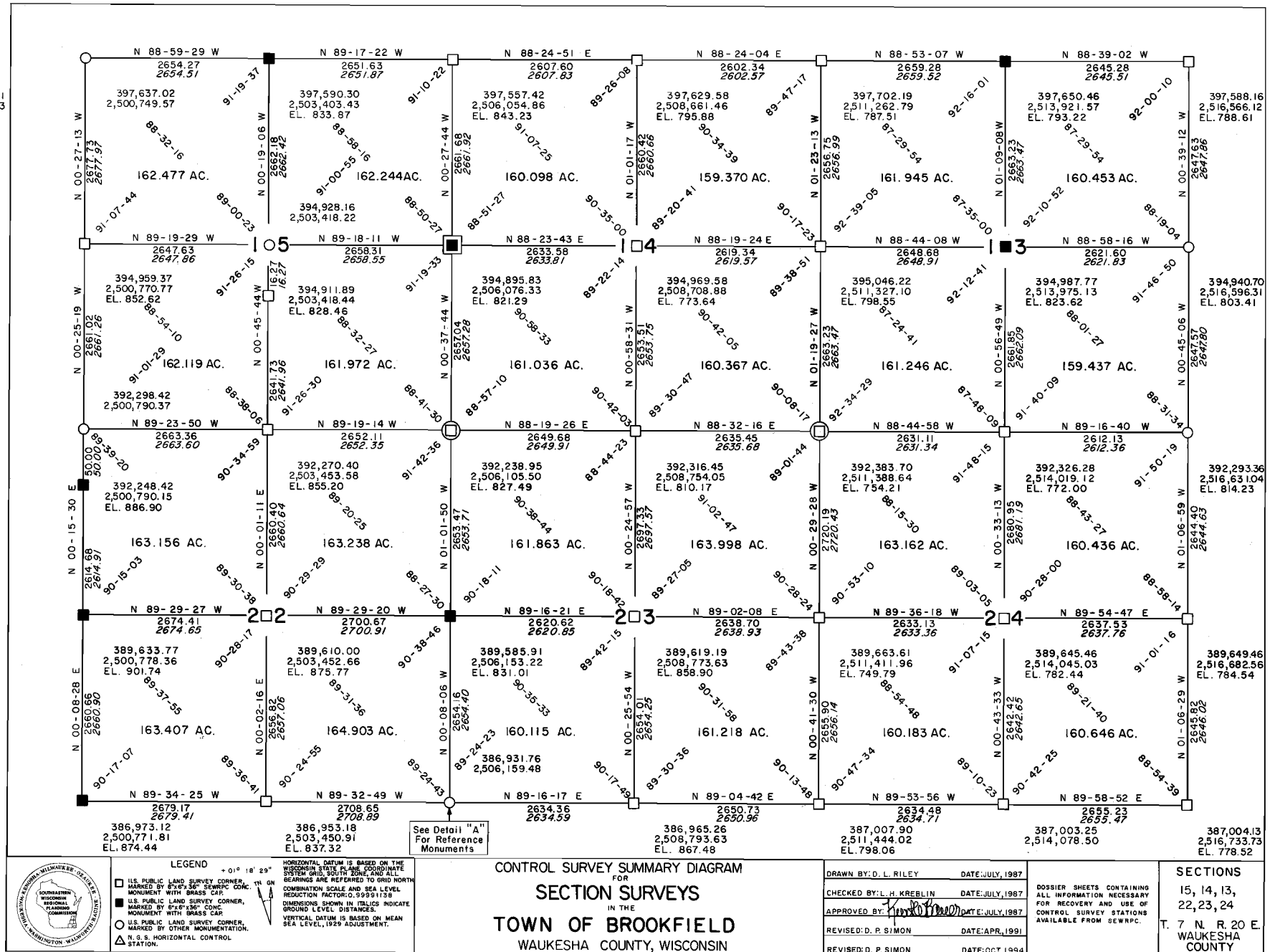
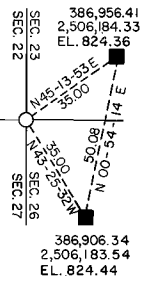
DRAWN BY: D. L. RILEY	DATE: JULY, 1987
CHECKED BY: L. H. KREBLIN	DATE: JULY, 1987
APPROVED BY: <i>[Signature]</i>	DATE: JULY, 1987
REVISED: D. P. SIMON	DATE: FEB, 1989
REVISED: D. P. SIMON	DATE: APR., 1991

DOSSIER SHEETS CONTAINING
ALL INFORMATION NECESSARY
FOR RECOVERY AND USE OF
CONTROL SURVEY STATIONS
AVAILABLE FROM SEWRPC.

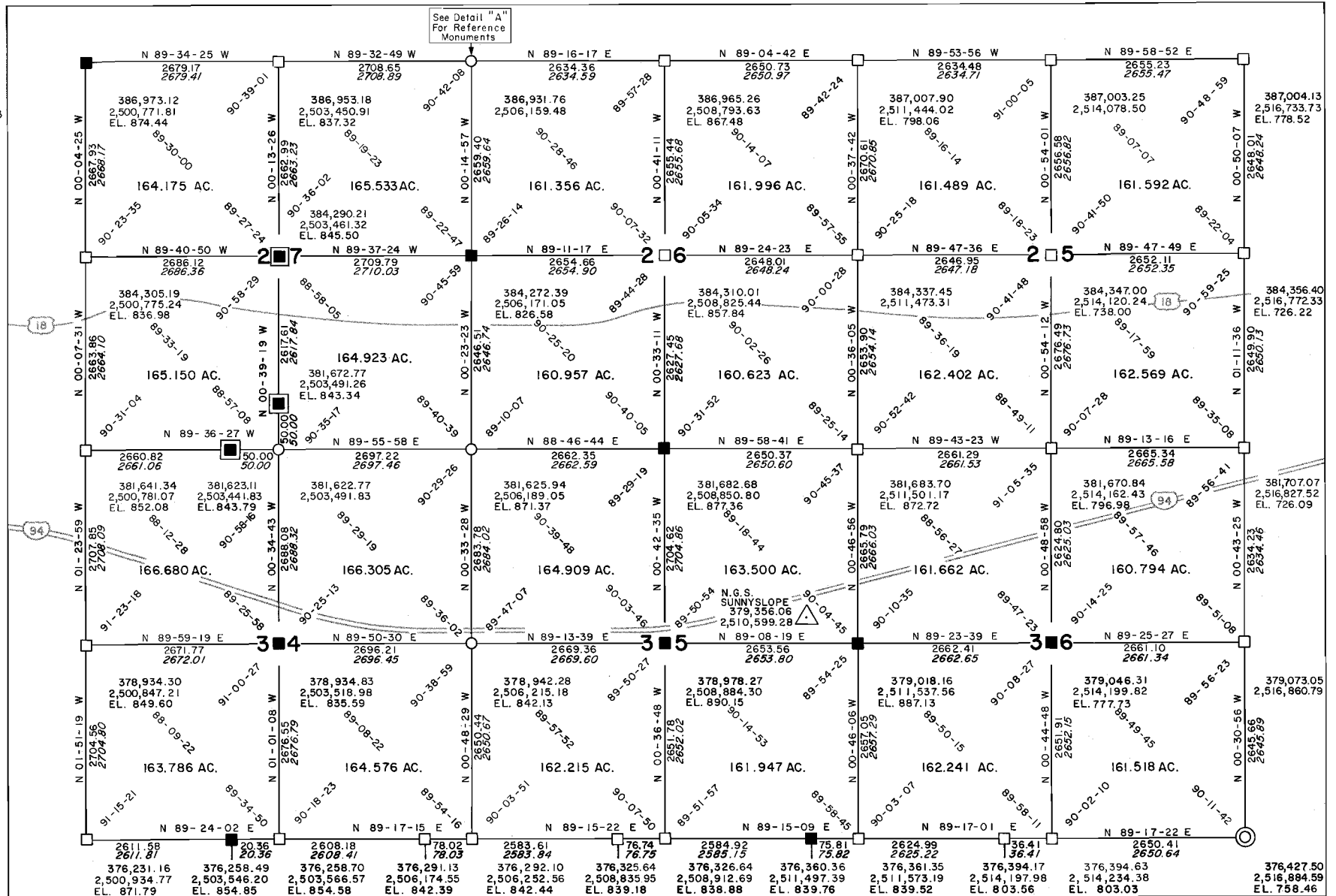
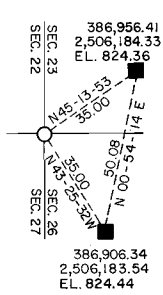
SECTIONS
6, 5, 4,
7, 8, 9
7 N. R. 20 E.
WAUKESHA
COUNTY



Detail "A"



Detail "A"



LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MONUMENTED WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6" x 13" CONC. MONUMENT WITH BRASS CAP.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- △ N.G.S. HORIZONTAL CONTROL STATION.

1" = 60'

CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF BROOKFIELD
WAUKESHA COUNTY, WISCONSIN

DRAWN BY: D.L. RILEY **DATE:** JULY, 1987
CHECKED BY: L.M. KREBLIN **DATE:** JULY, 1987
APPROVED BY: *[Signature]* **DATE:** JULY, 1987
REVISED BY: D.P. SIMON **DATE:** JUNE, 1996
REVISED BY: D.P. SIMON **DATE:** DEC. 1996

DOSSIER SHEETS CONTAINING ALL INFORMATION NECESSARY FOR RECOVERY AND USE OF CONTROL SURVEY STATIONS AVAILABLE FROM SEWRPC.

SECTIONS
27, 26, 25,
34, 35, 36
T. 7 N. R. 20 E.
WAUKESHA
COUNTY



LEGEND

- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" SEWER CON.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY 6"x6"x36" CONC.
- U.S. PUBLIC LAND SURVEY CORNER, MARKED BY OTHER MONUMENTATION.
- △ N. S. S. HORIZONTAL CONTROL STATION.

+01° 03' 58"

HORIZONTAL DATUM IS BASED ON THE WISCONSIN STATE PLANE COORDINATE SYSTEM GRID, SOUTH ZONE, AND ALL BEARINGS ARE REFERRED TO GRID NORTH. COMBINATION SCALE AND SEA LEVEL REDUCTION FACTOR: 0.99989642. DIMENSIONS SHOWN IN ITALICS INDICATE GROUND LEVEL DISTANCES.

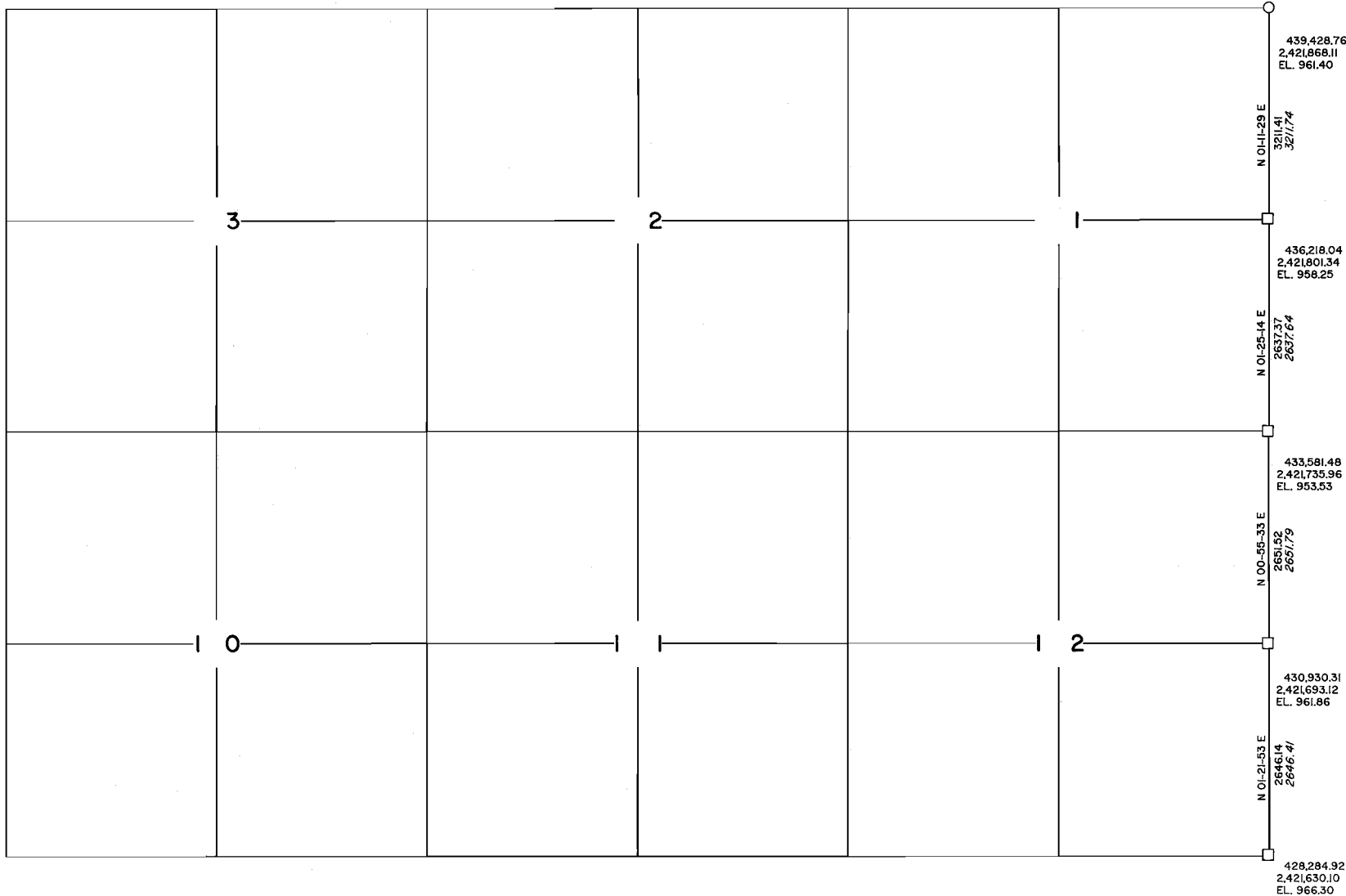
CONTROL SURVEY SUMMARY DIAGRAM
FOR
SECTION SURVEYS
IN THE
TOWN OF OCONOMOWOC
WAUKESHA COUNTY, WISCONSIN

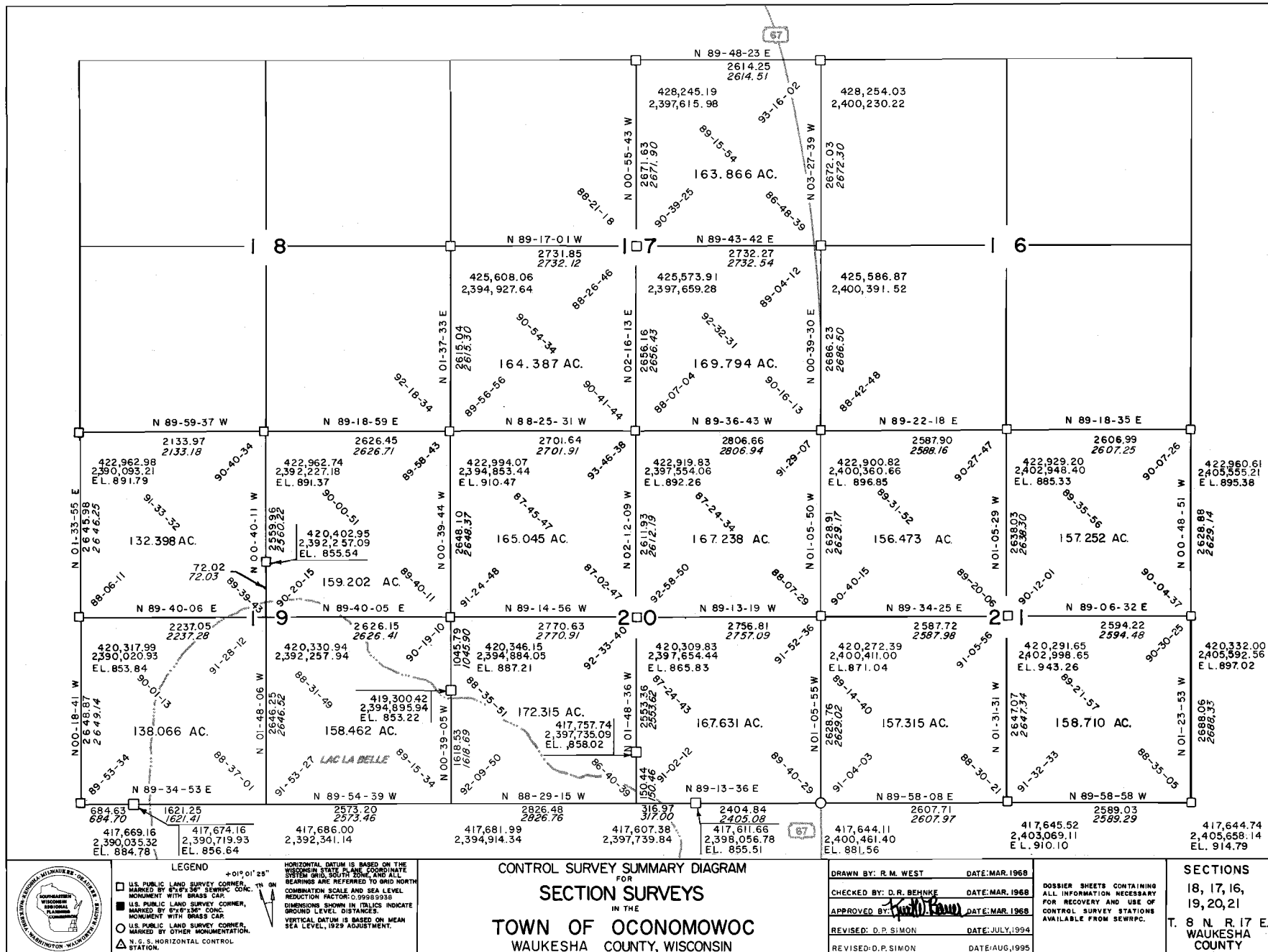
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CHECKED BY: L. H. KREBLIN DATE: DEC. 1996
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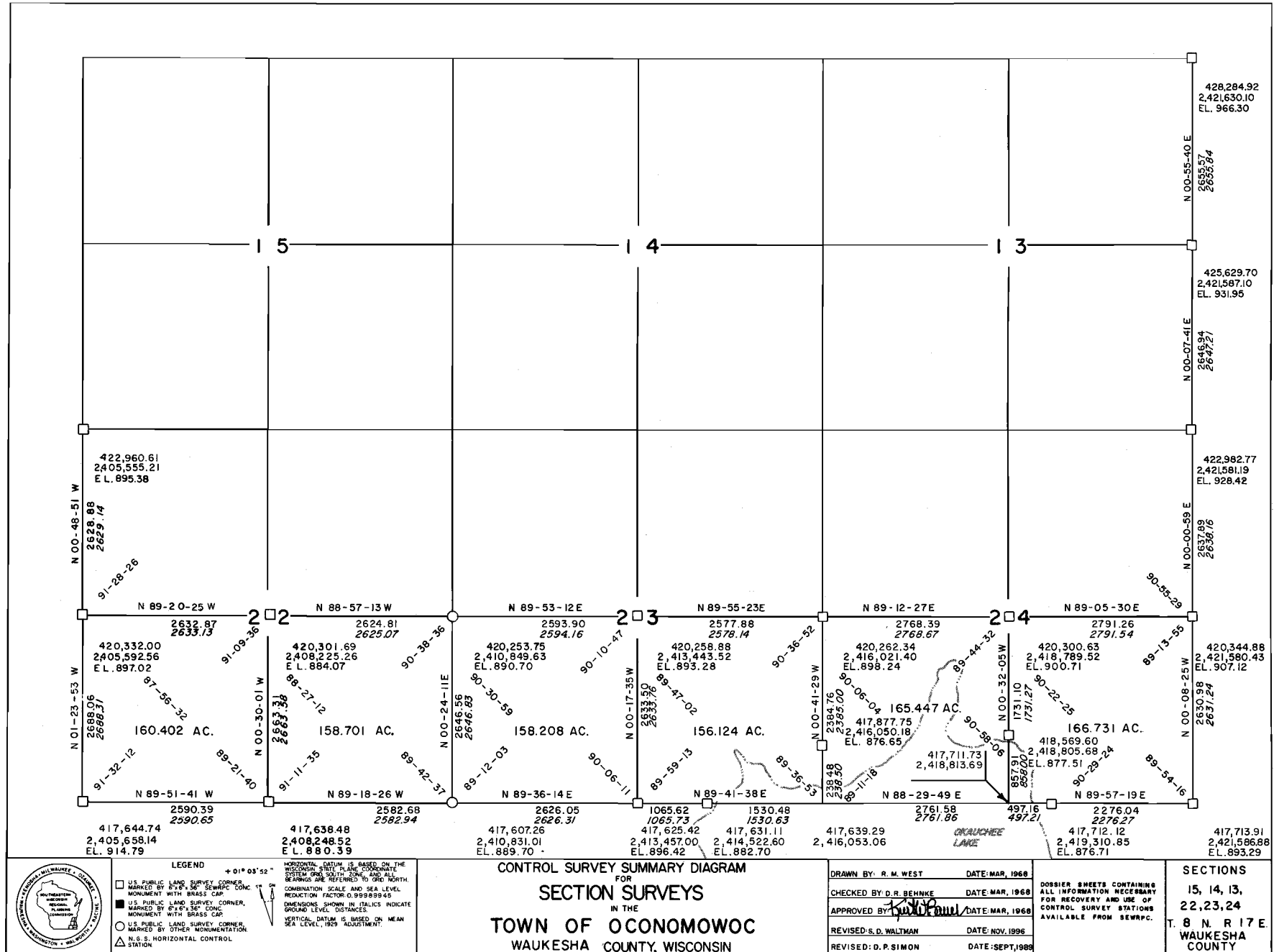
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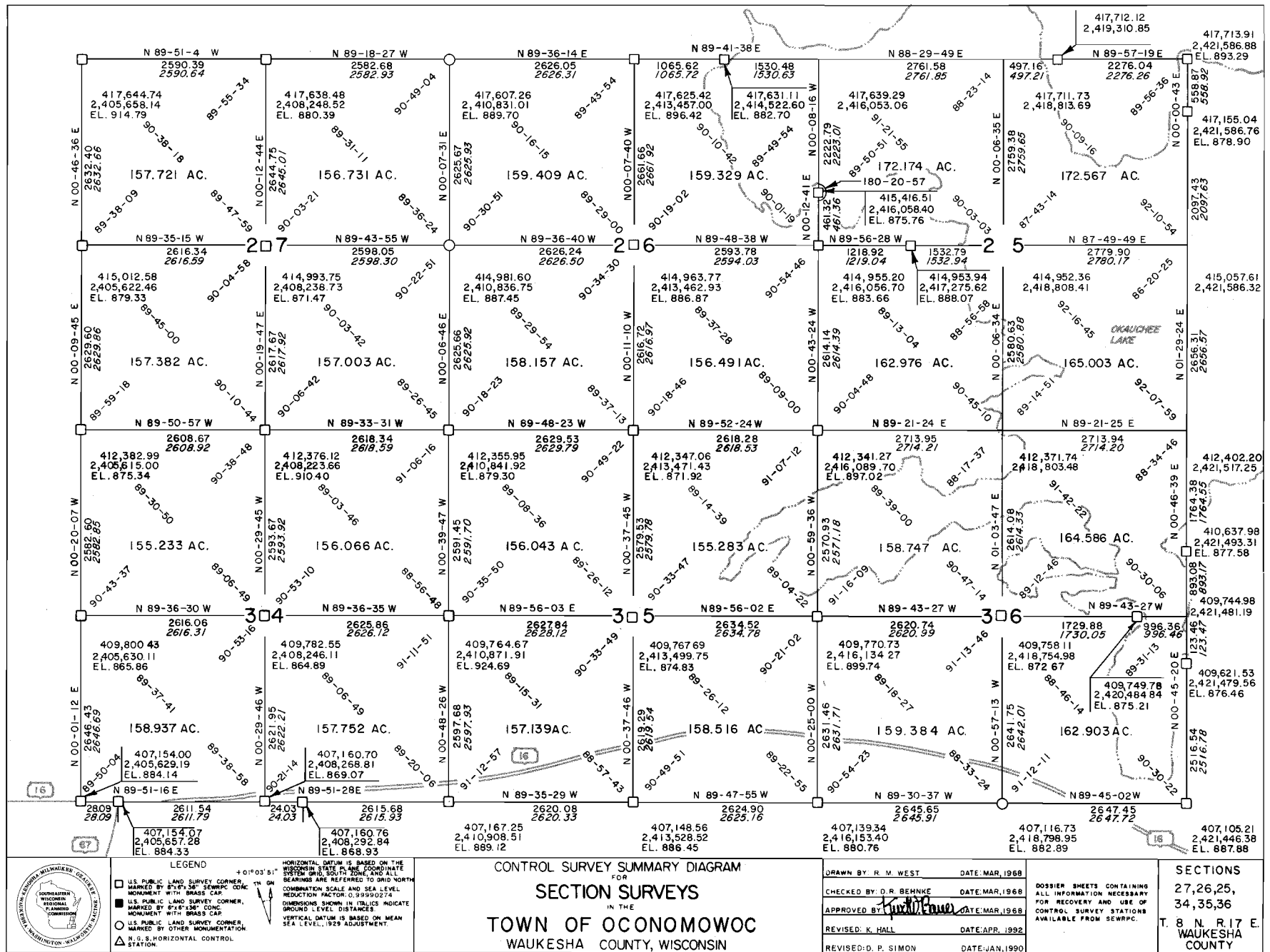
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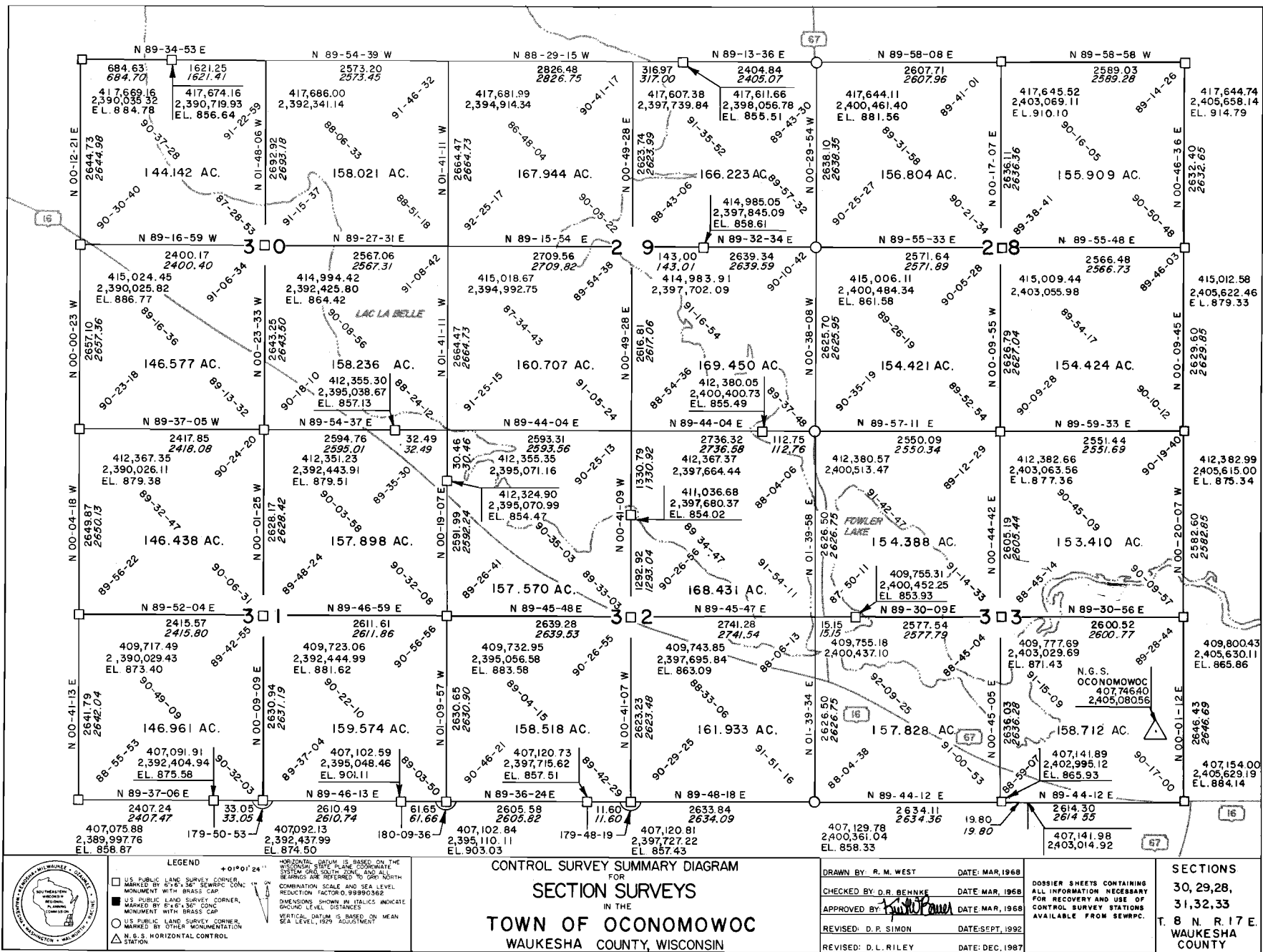
3, 2, 1,
10, 11, 12
T. 8 N. R. 17 E.
WAUKESHA COUNTY

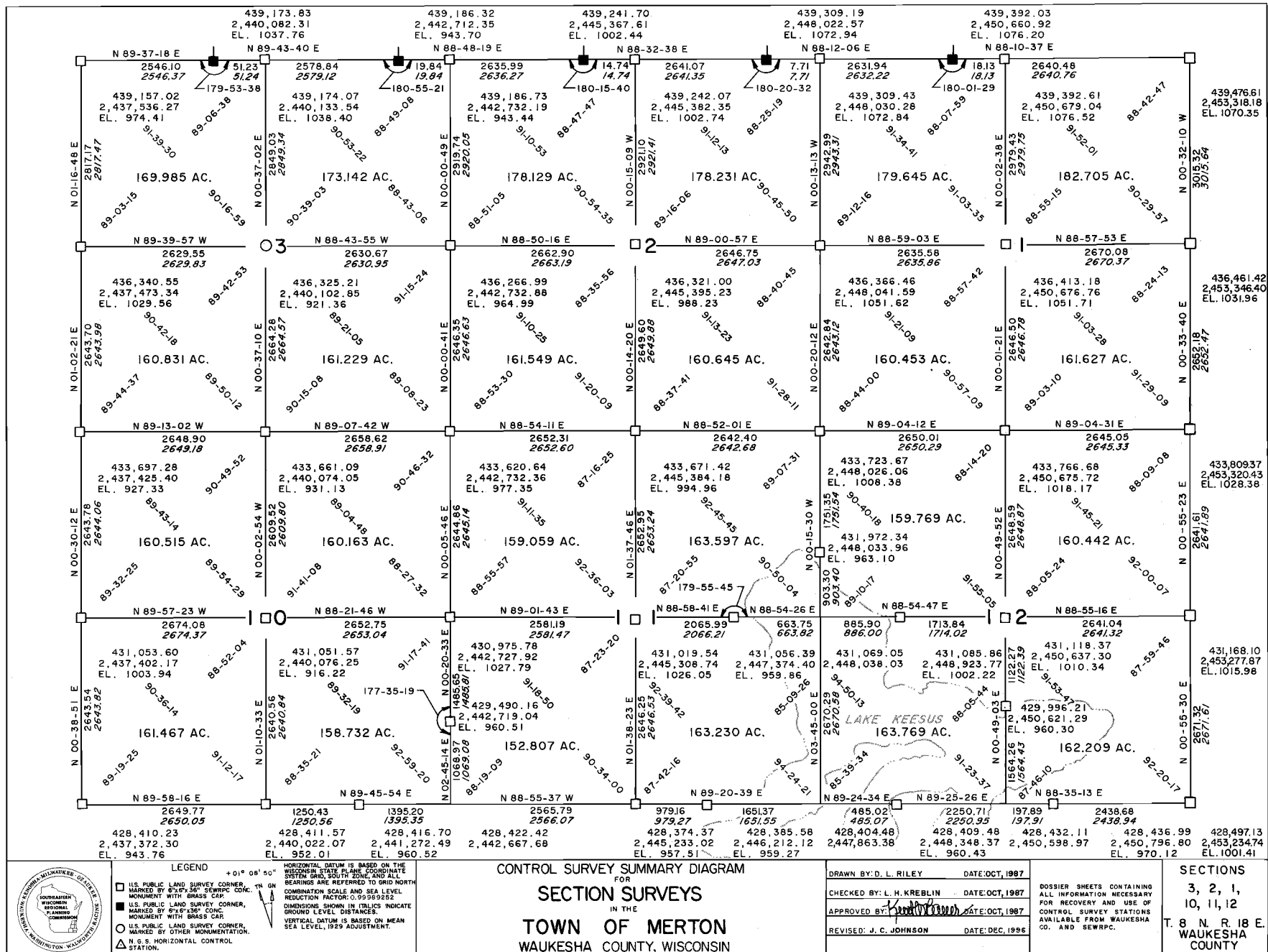


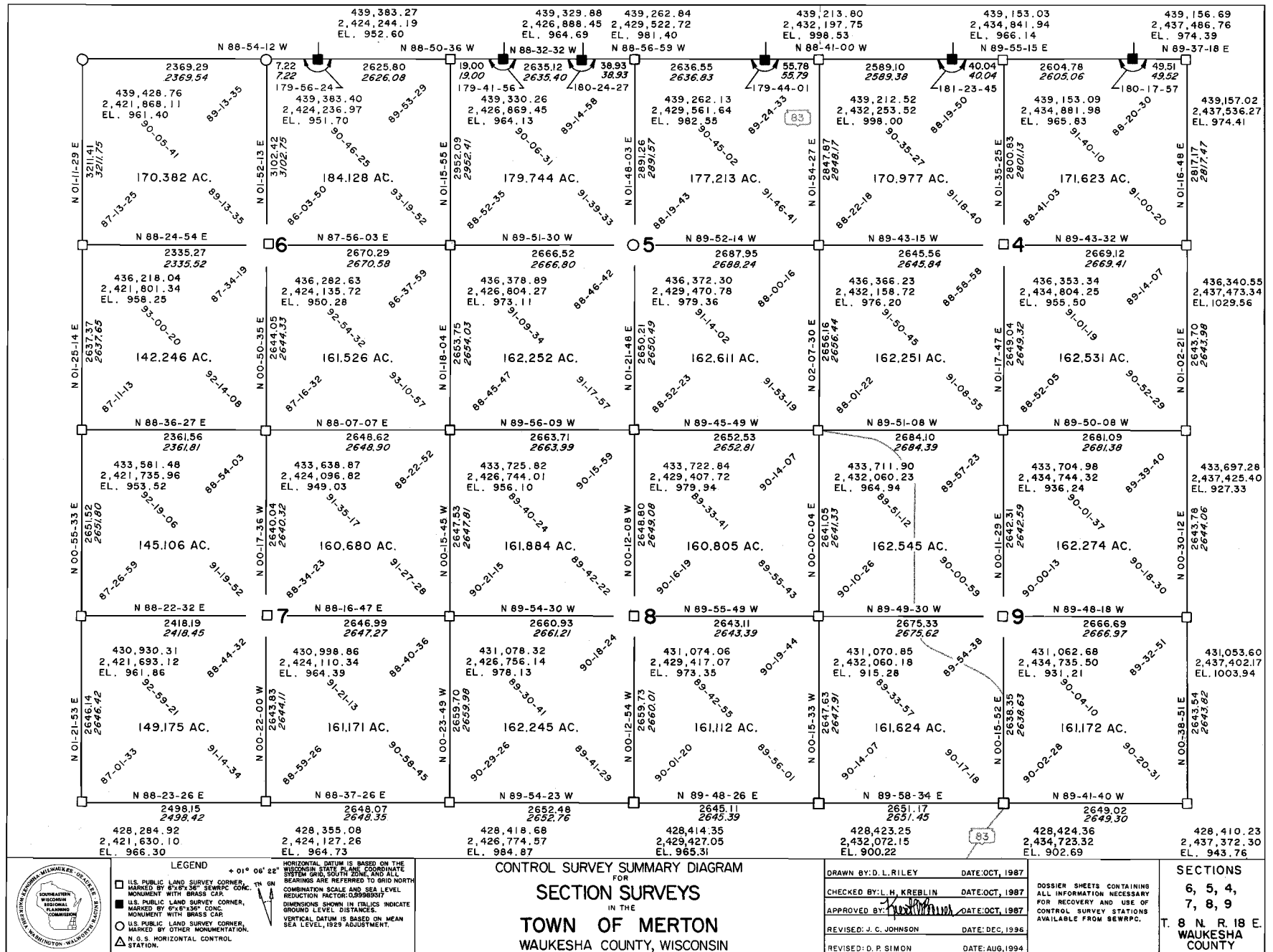


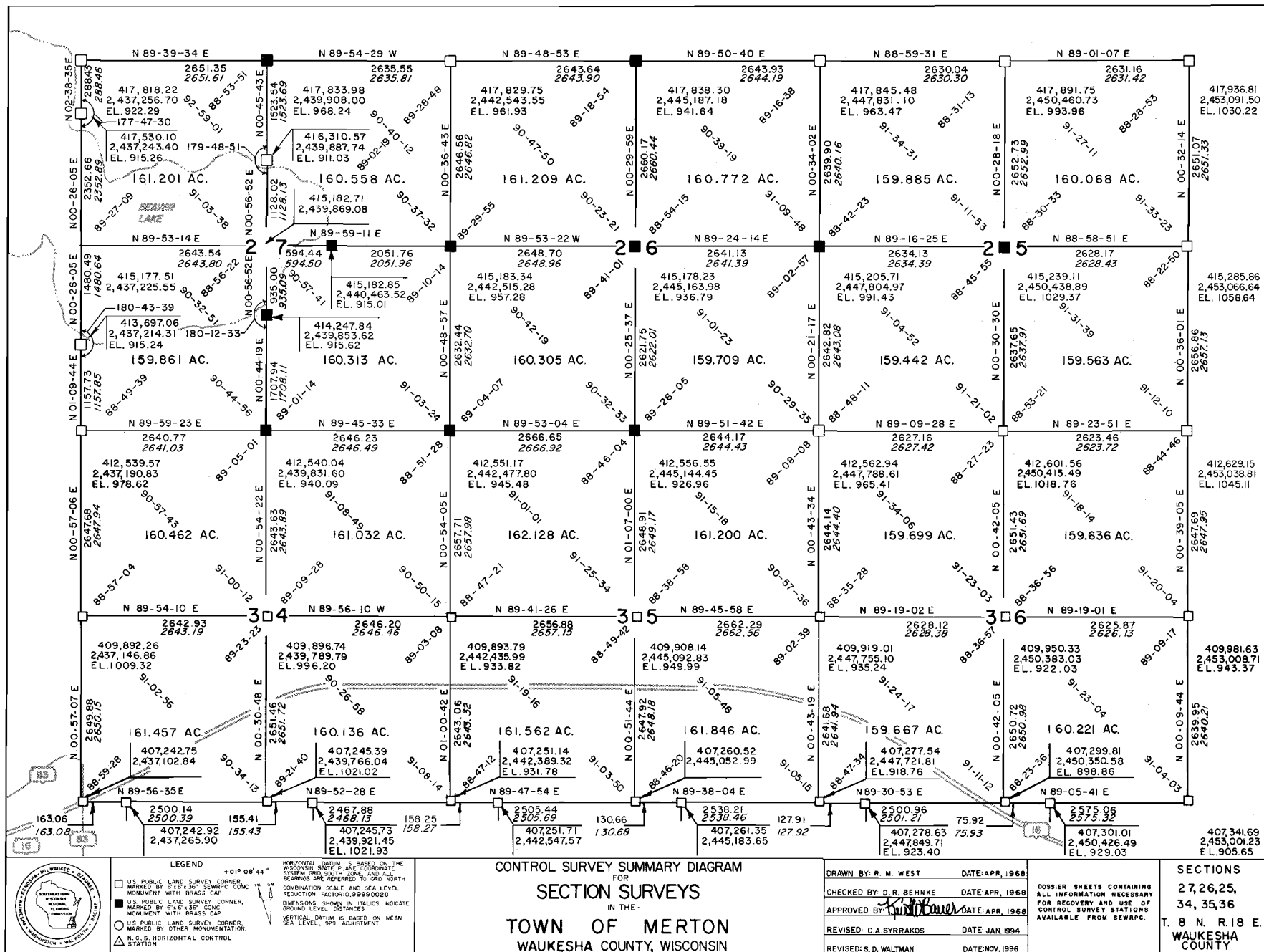


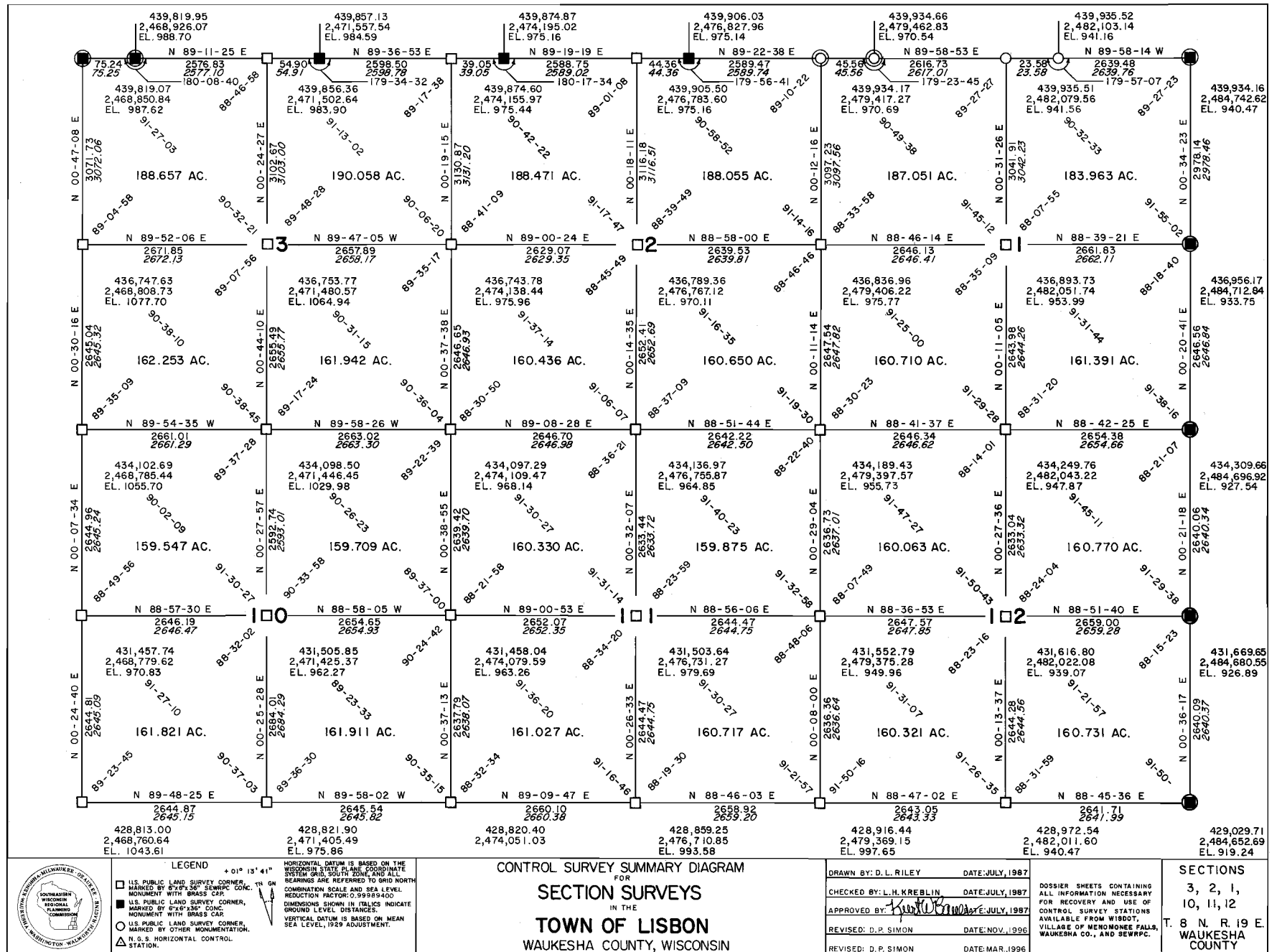


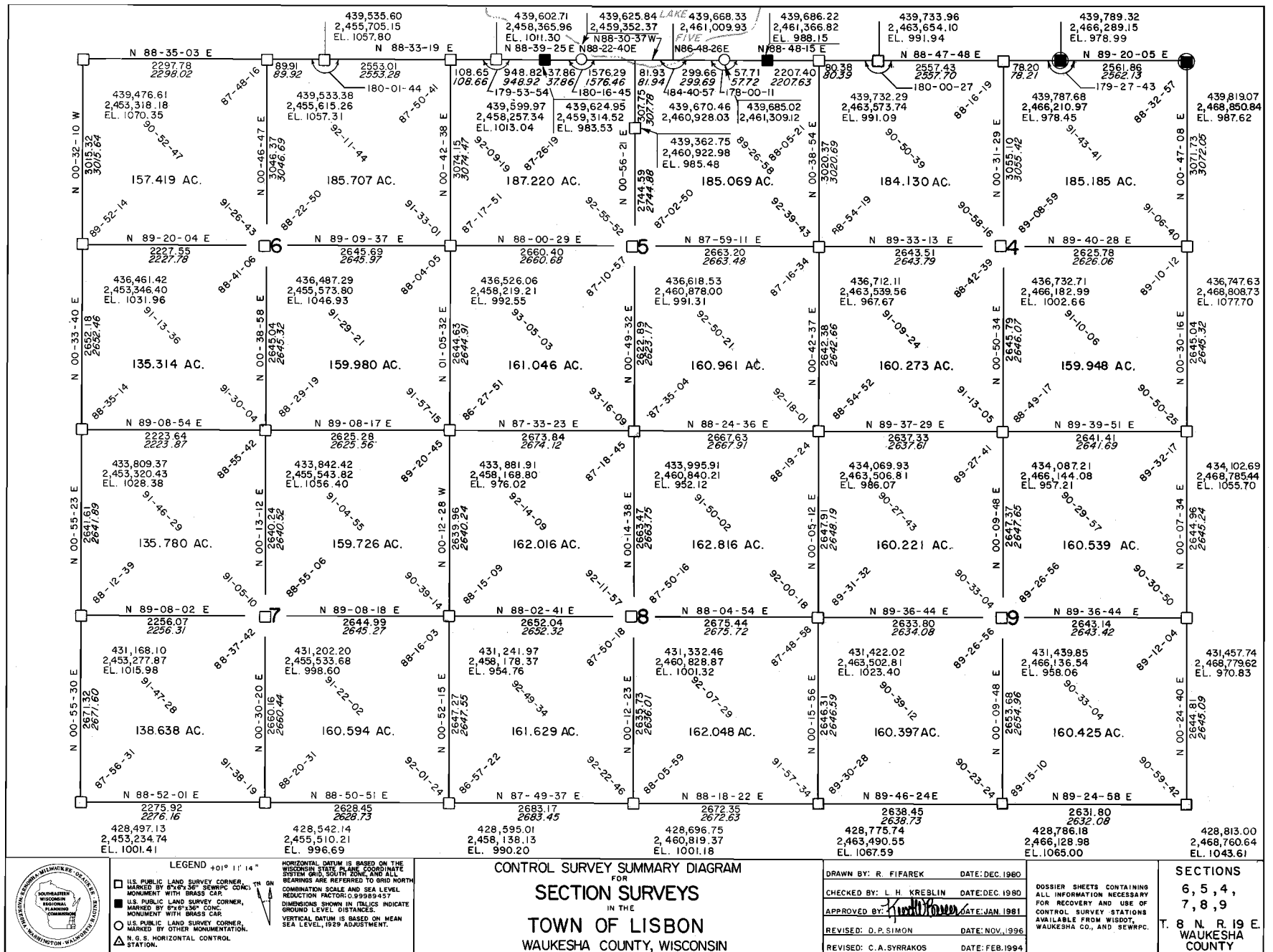


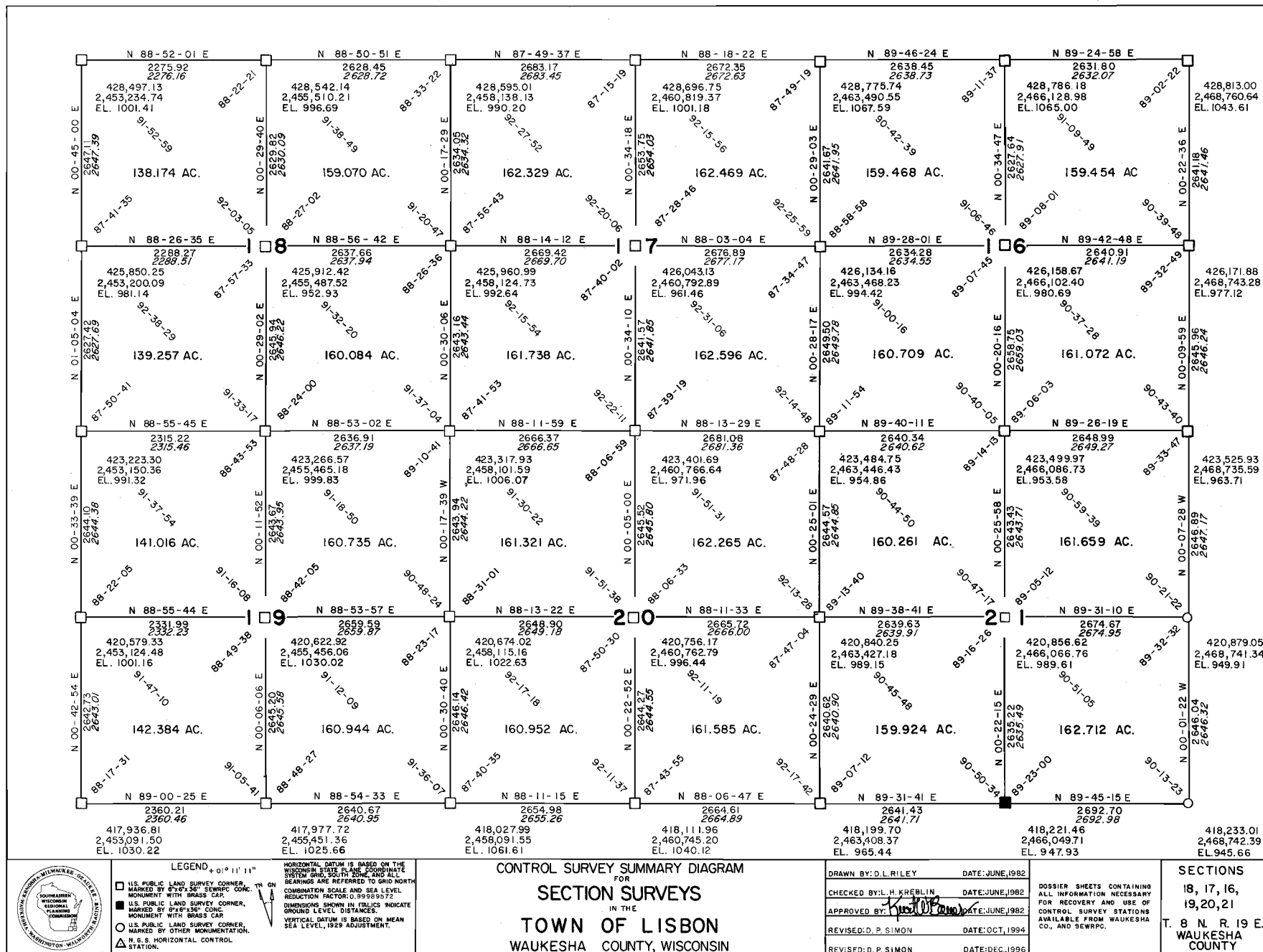


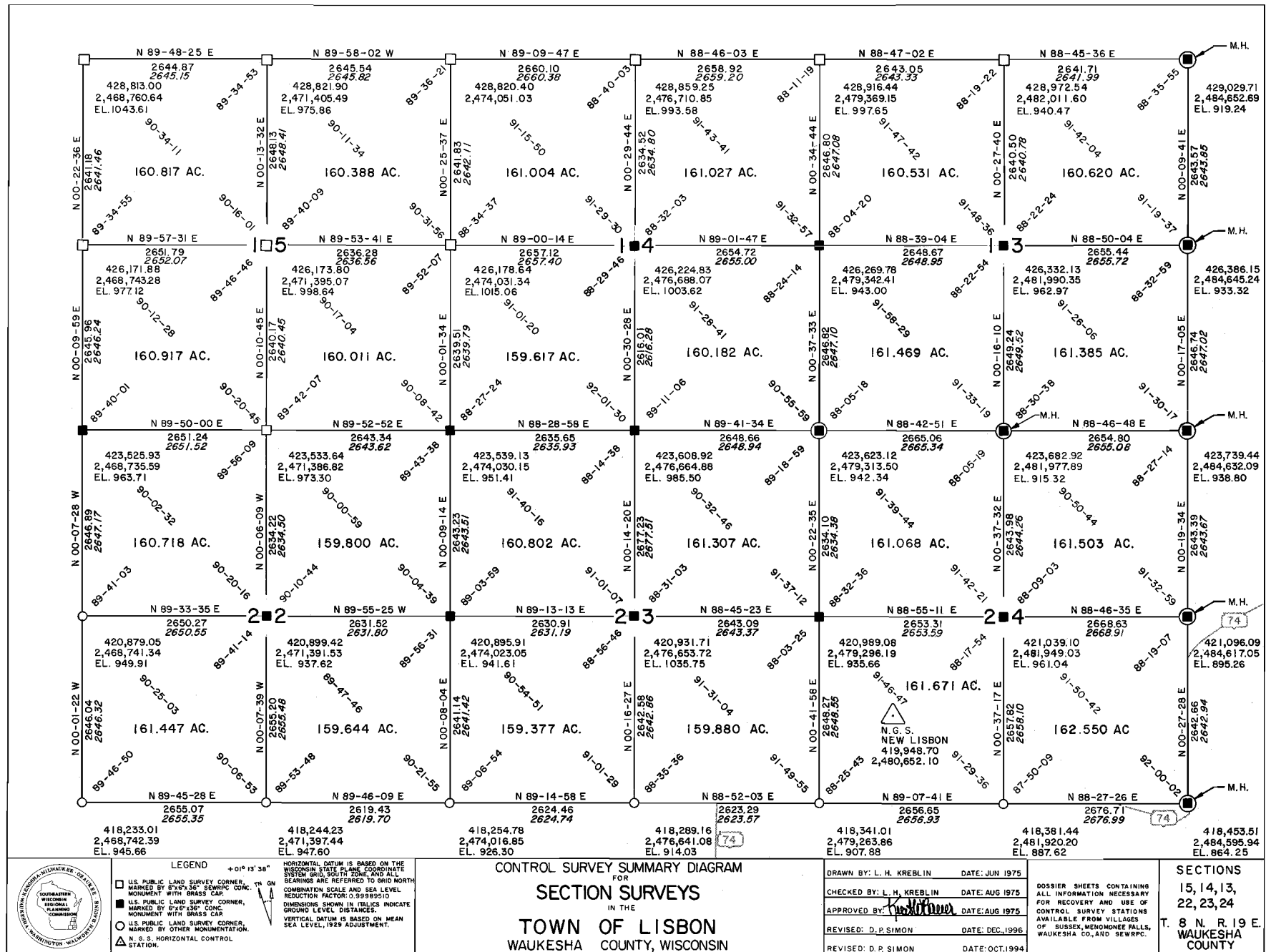


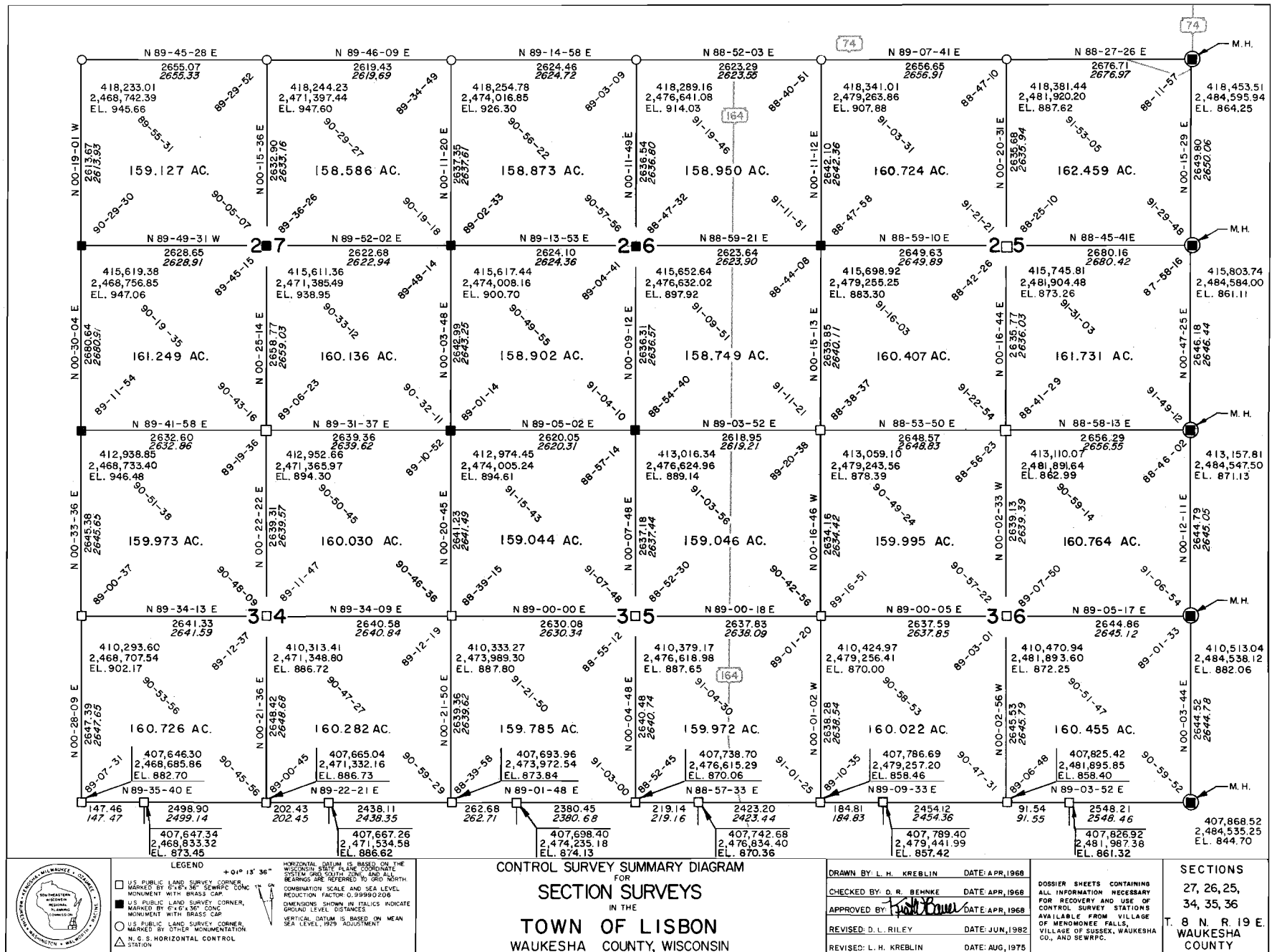


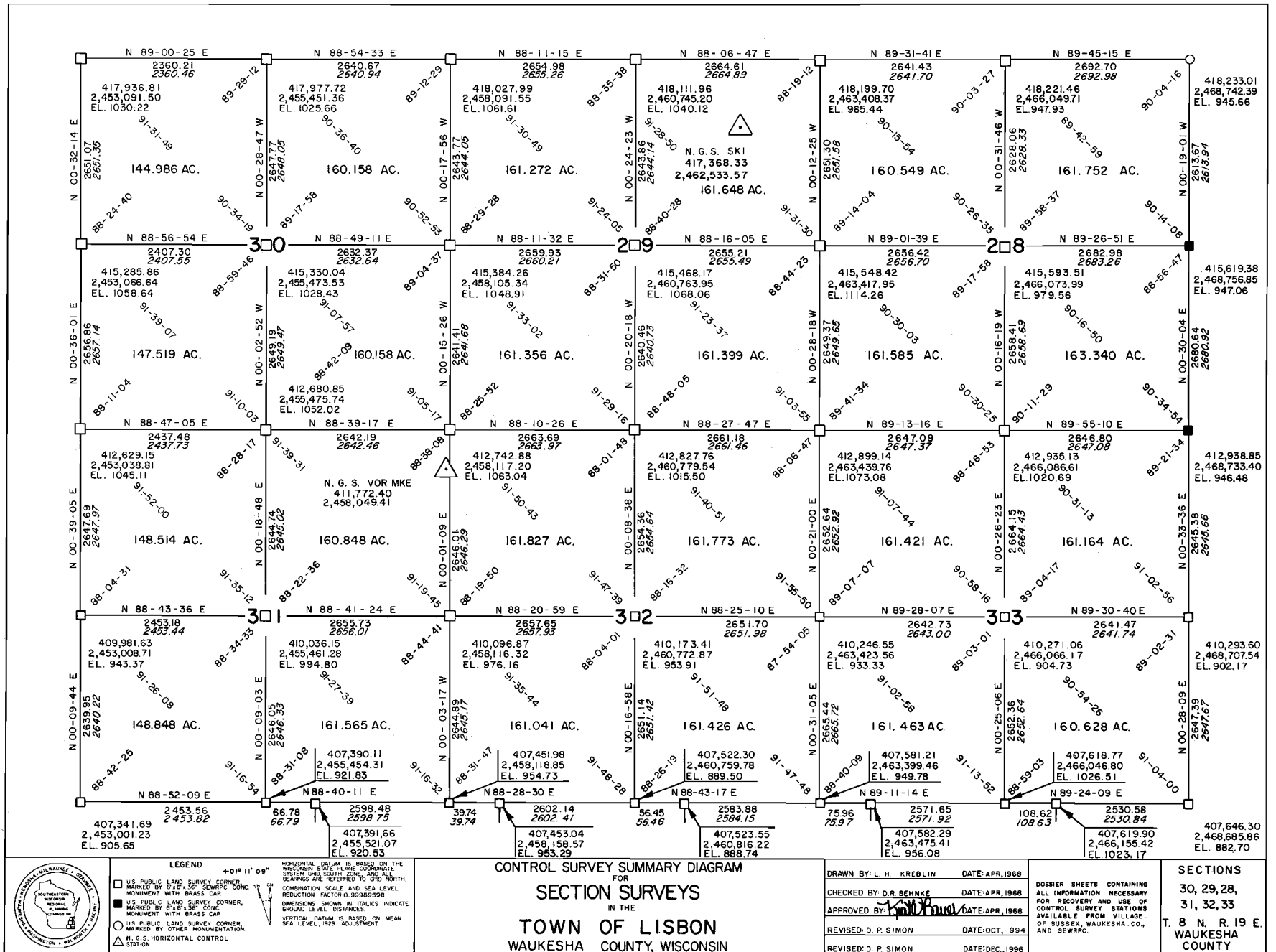


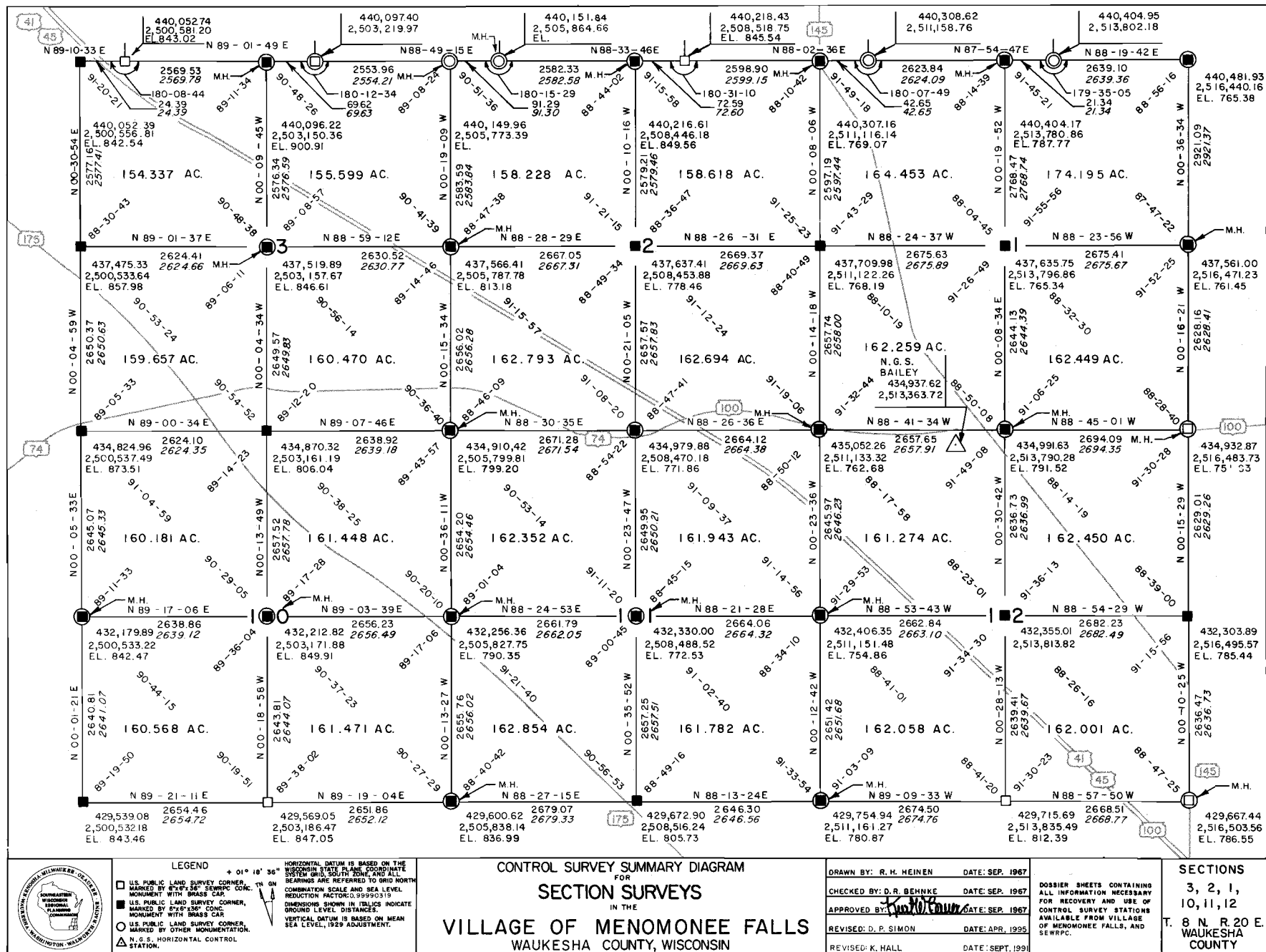


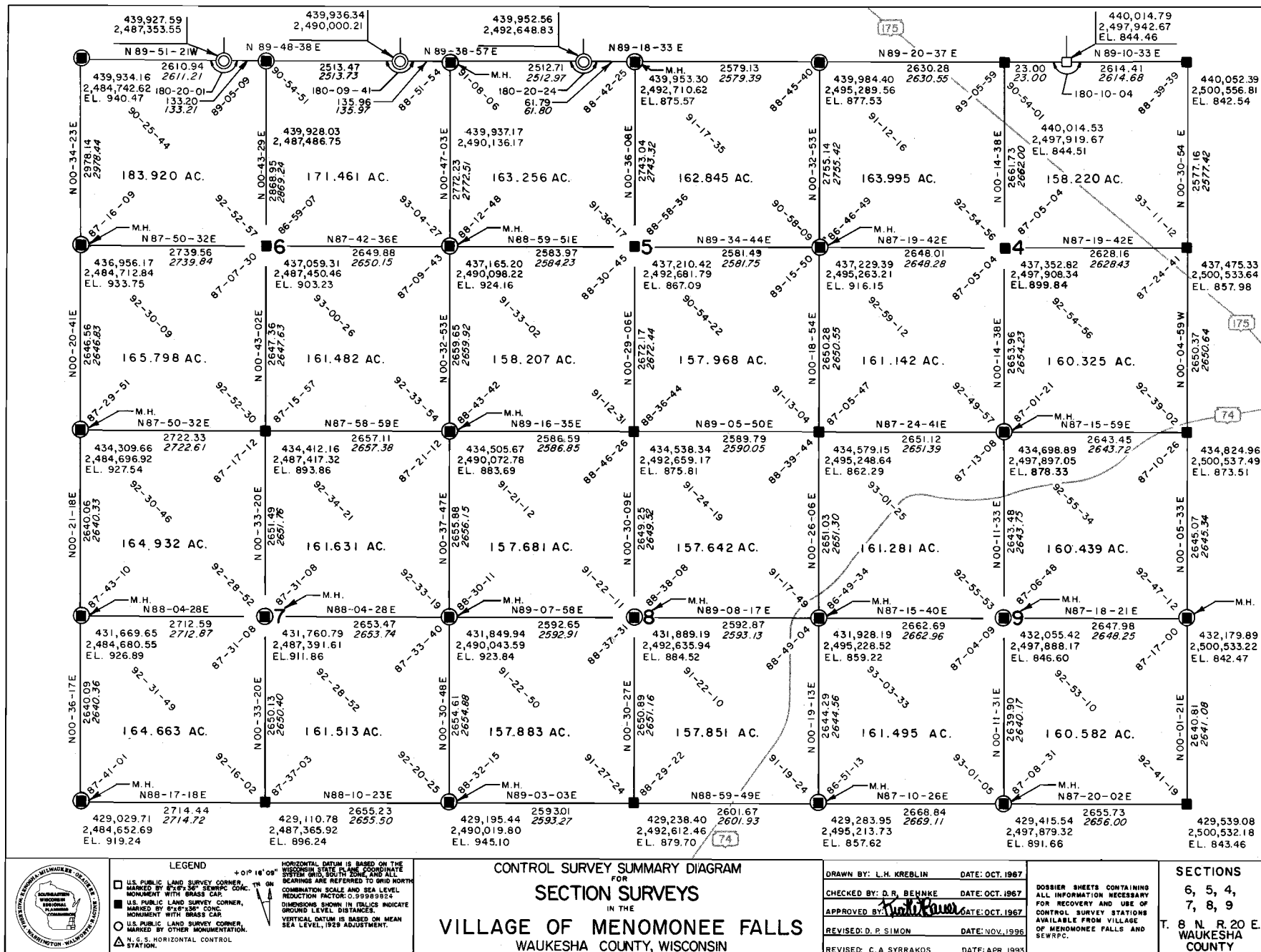


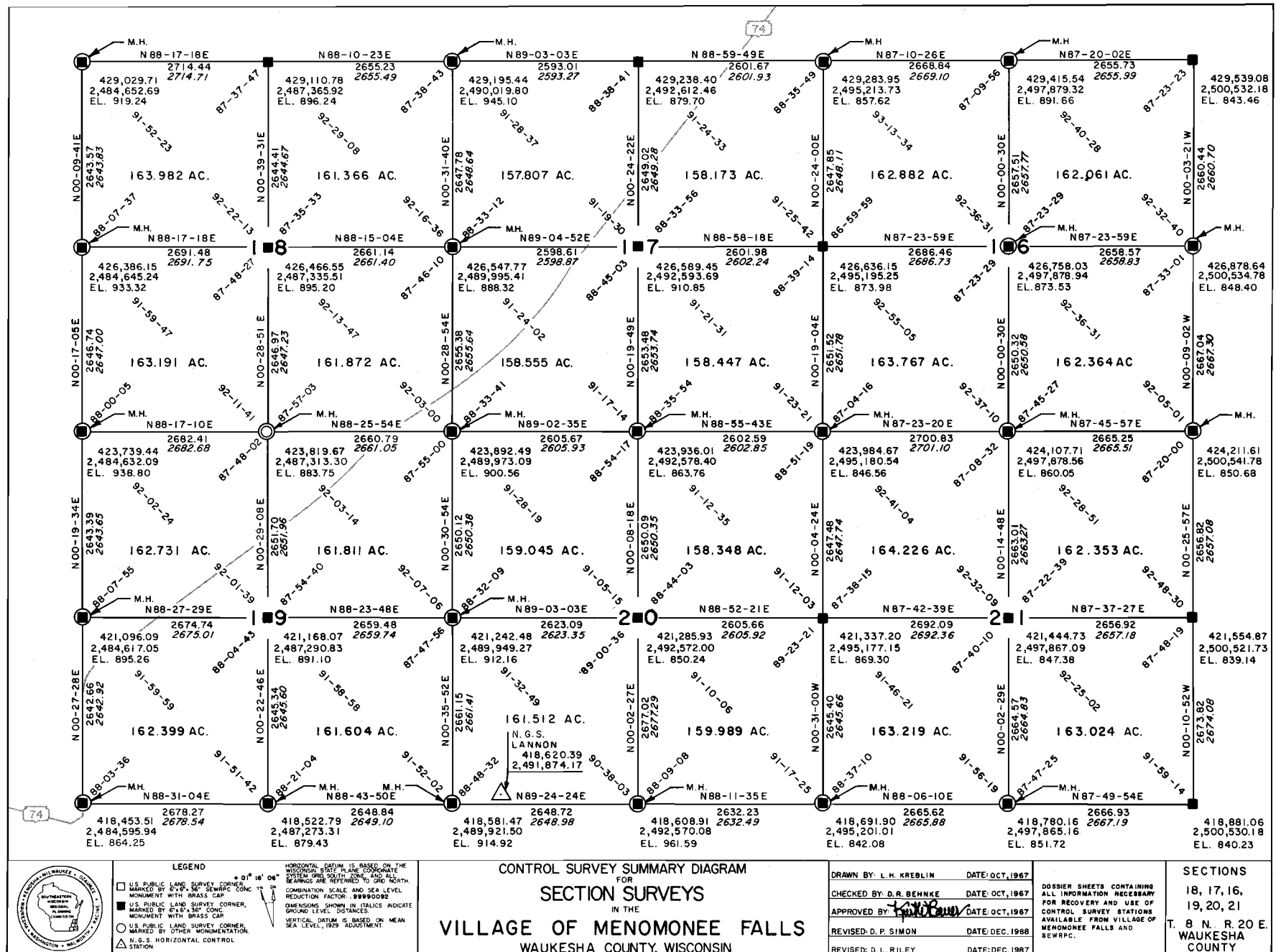


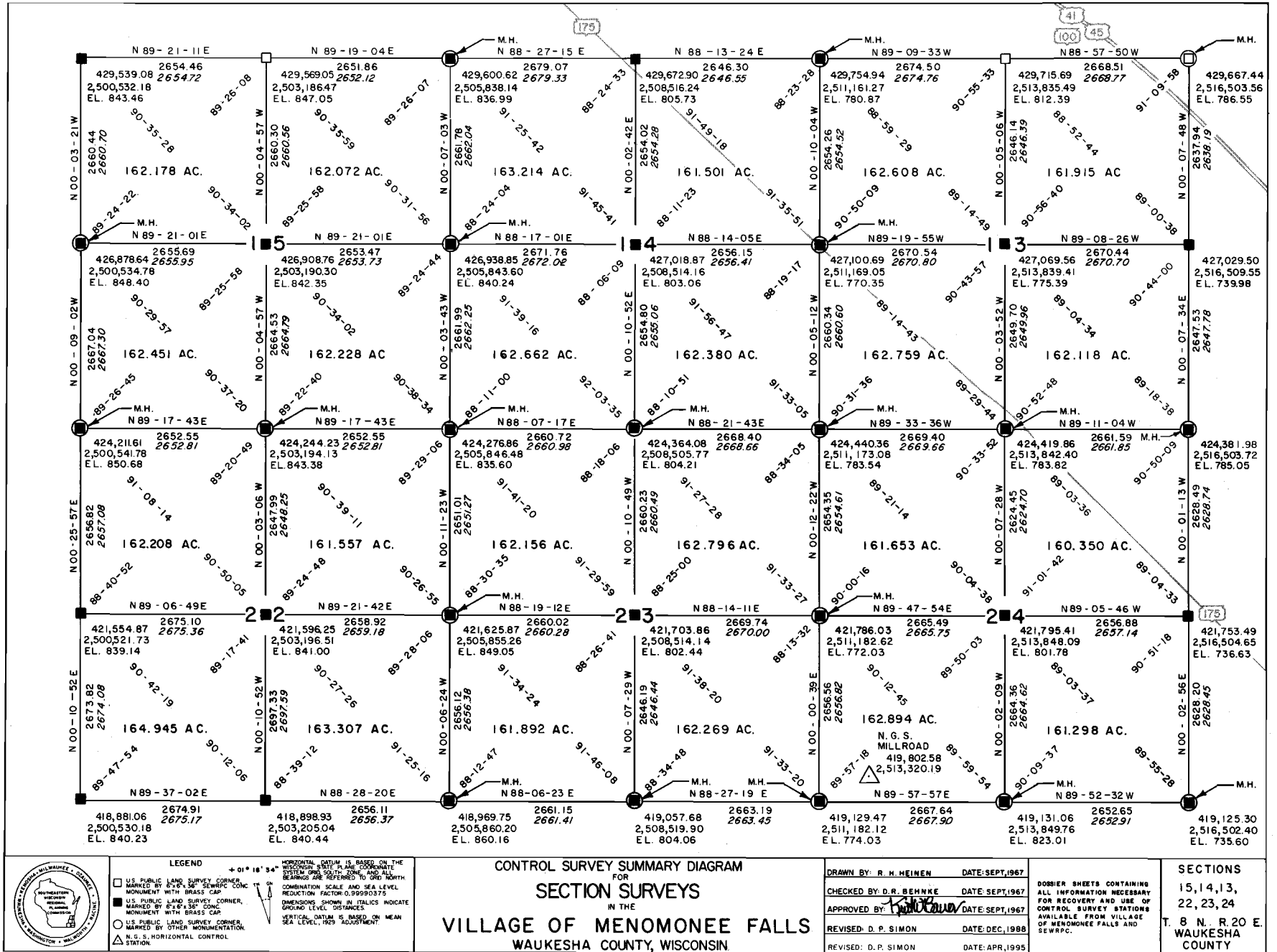


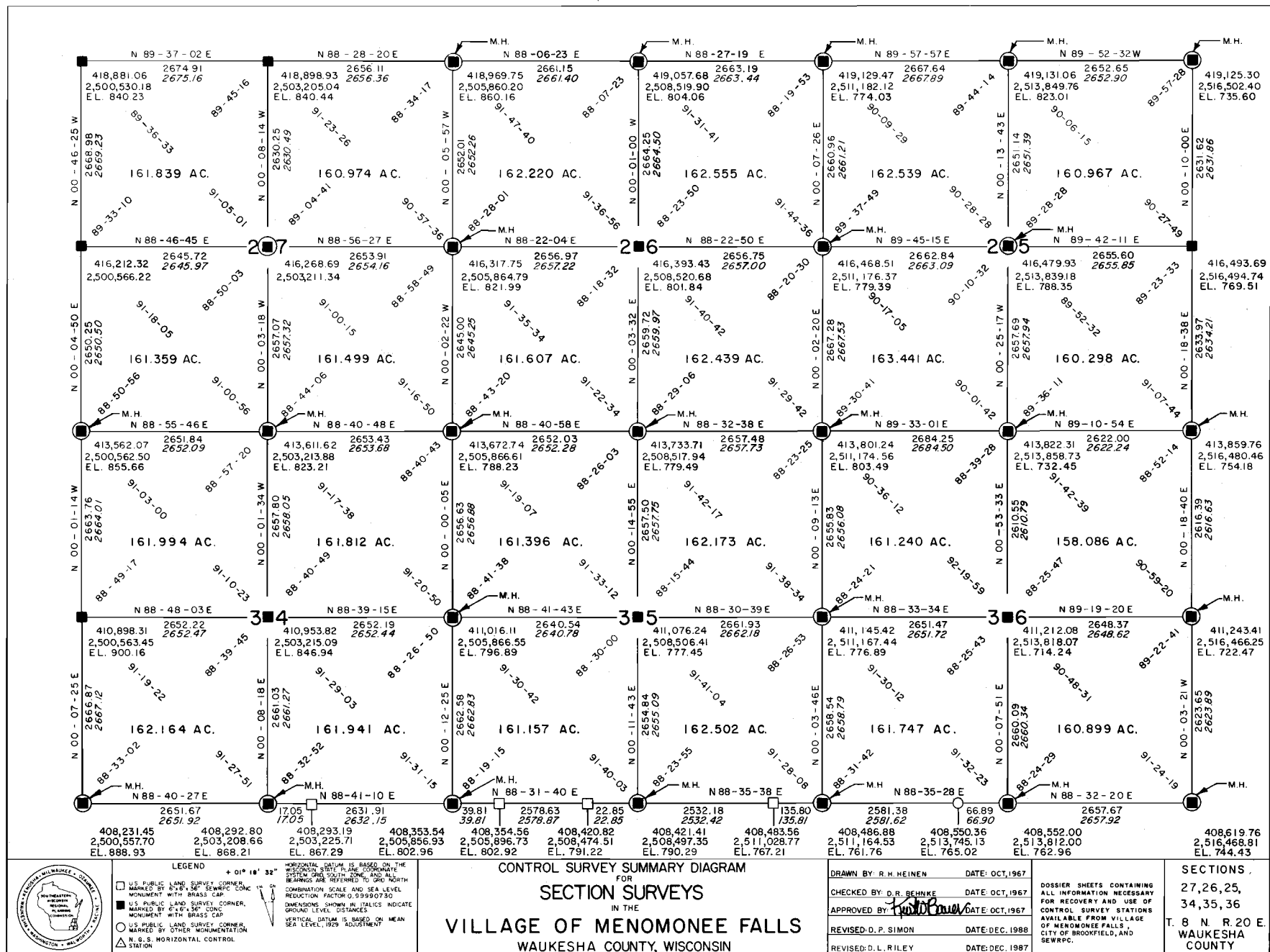


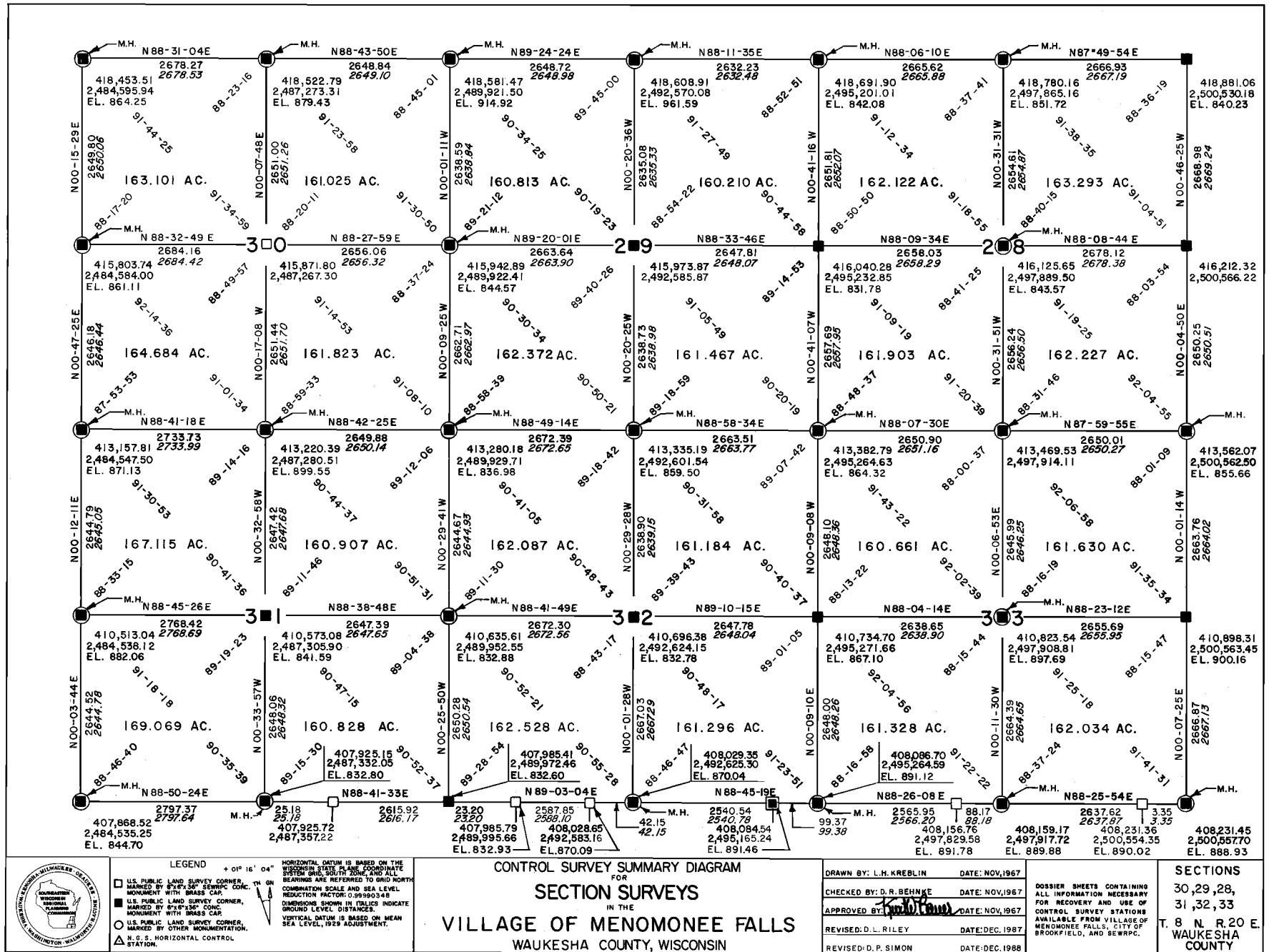


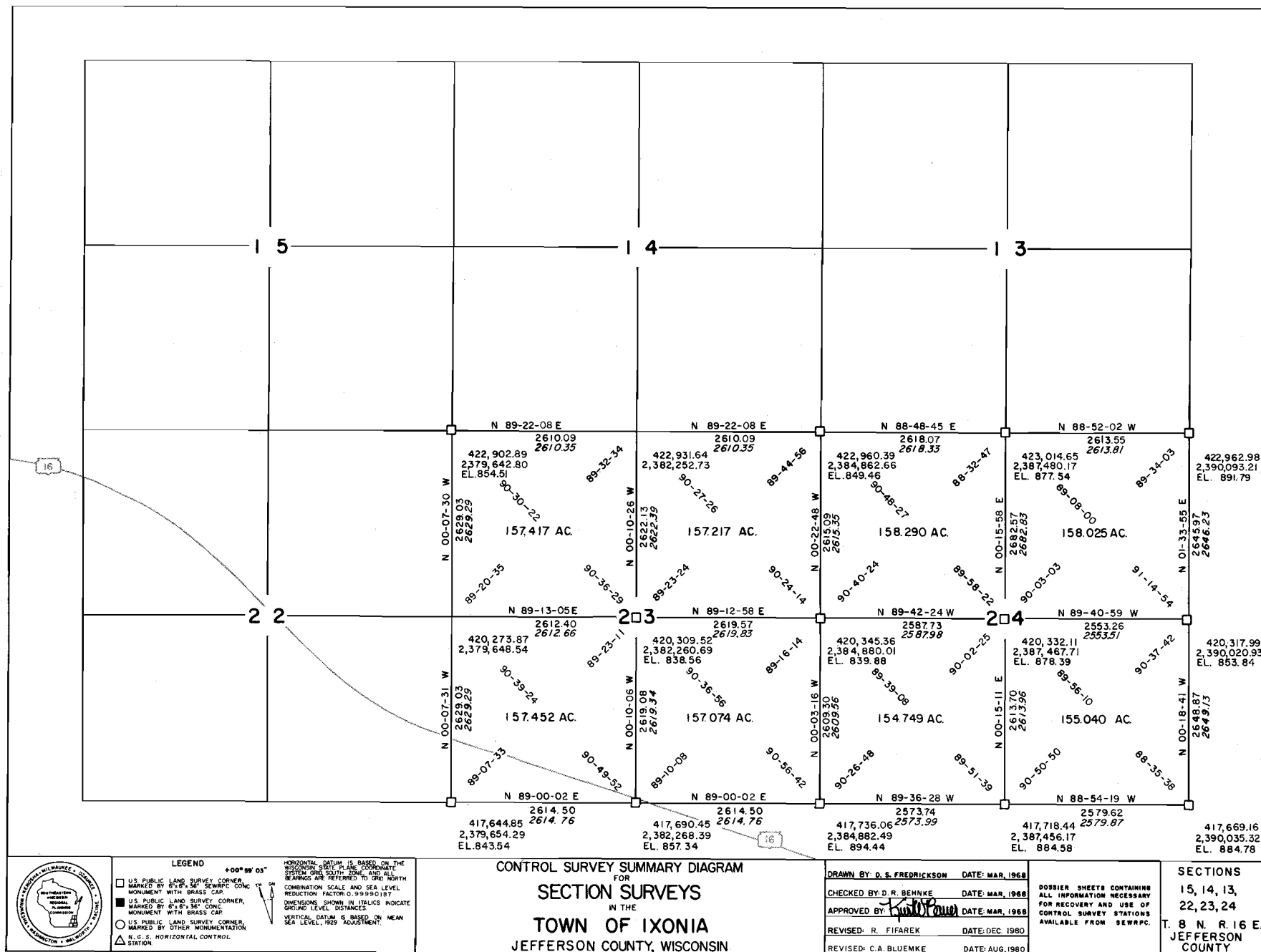


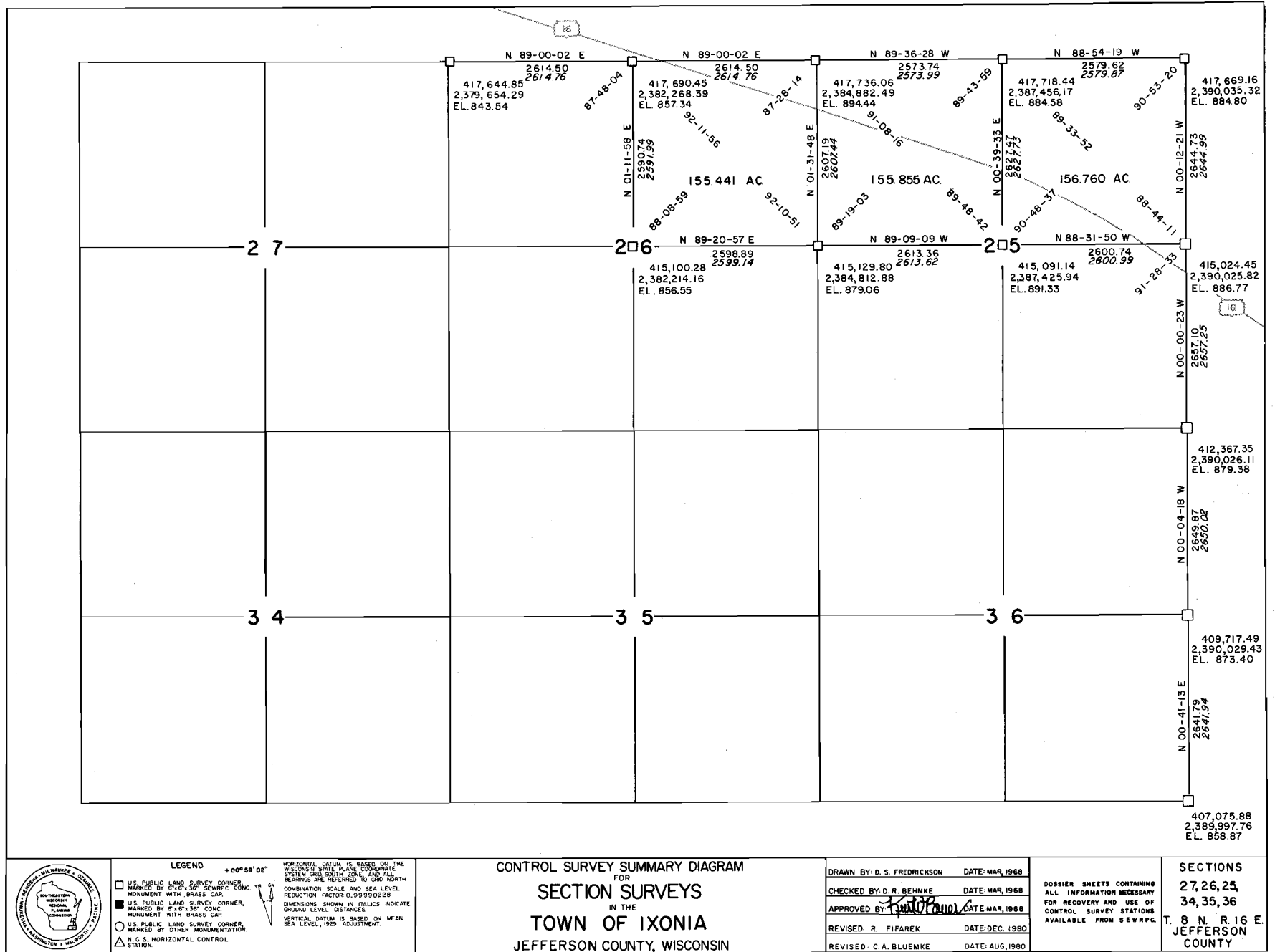




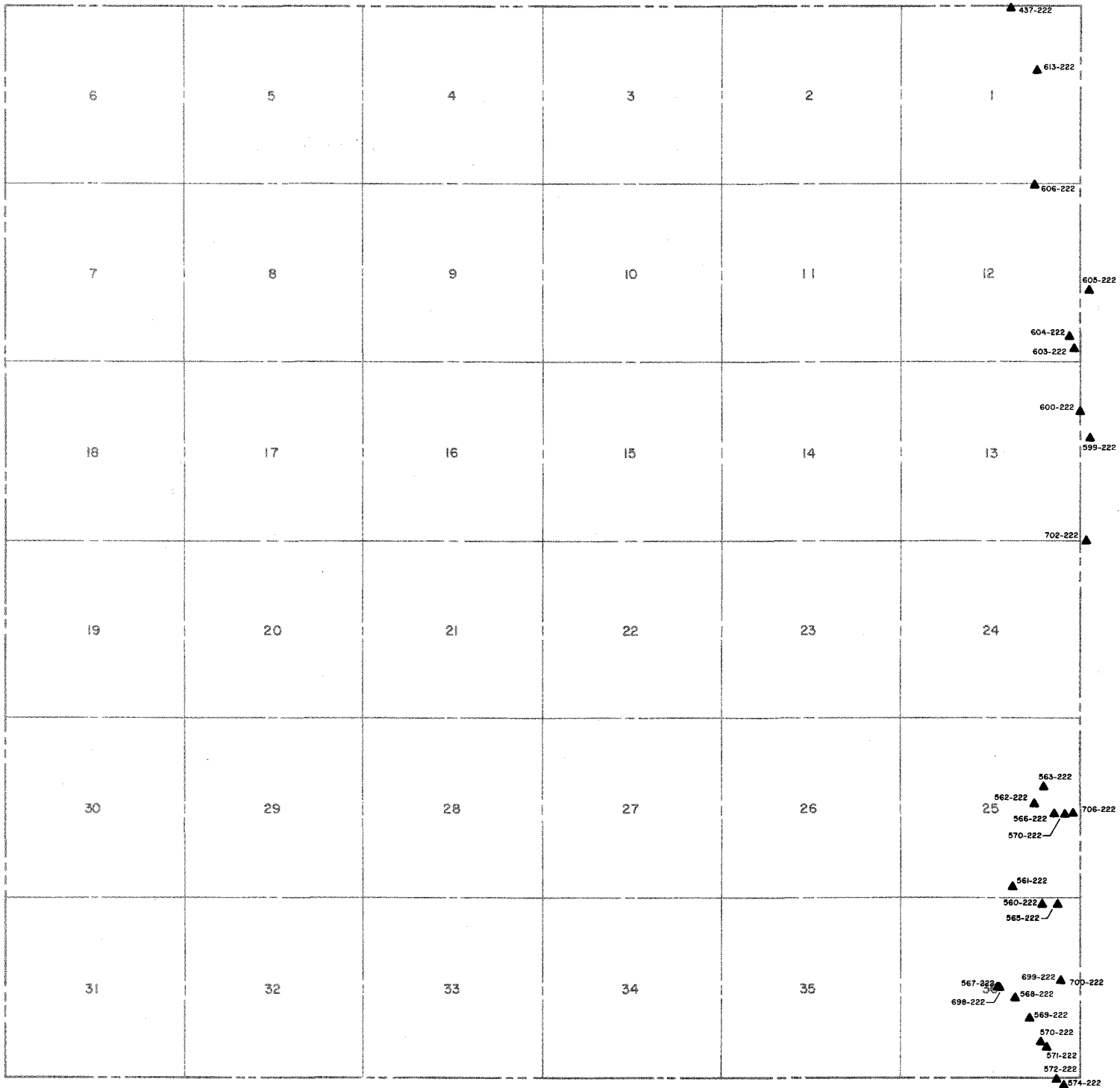




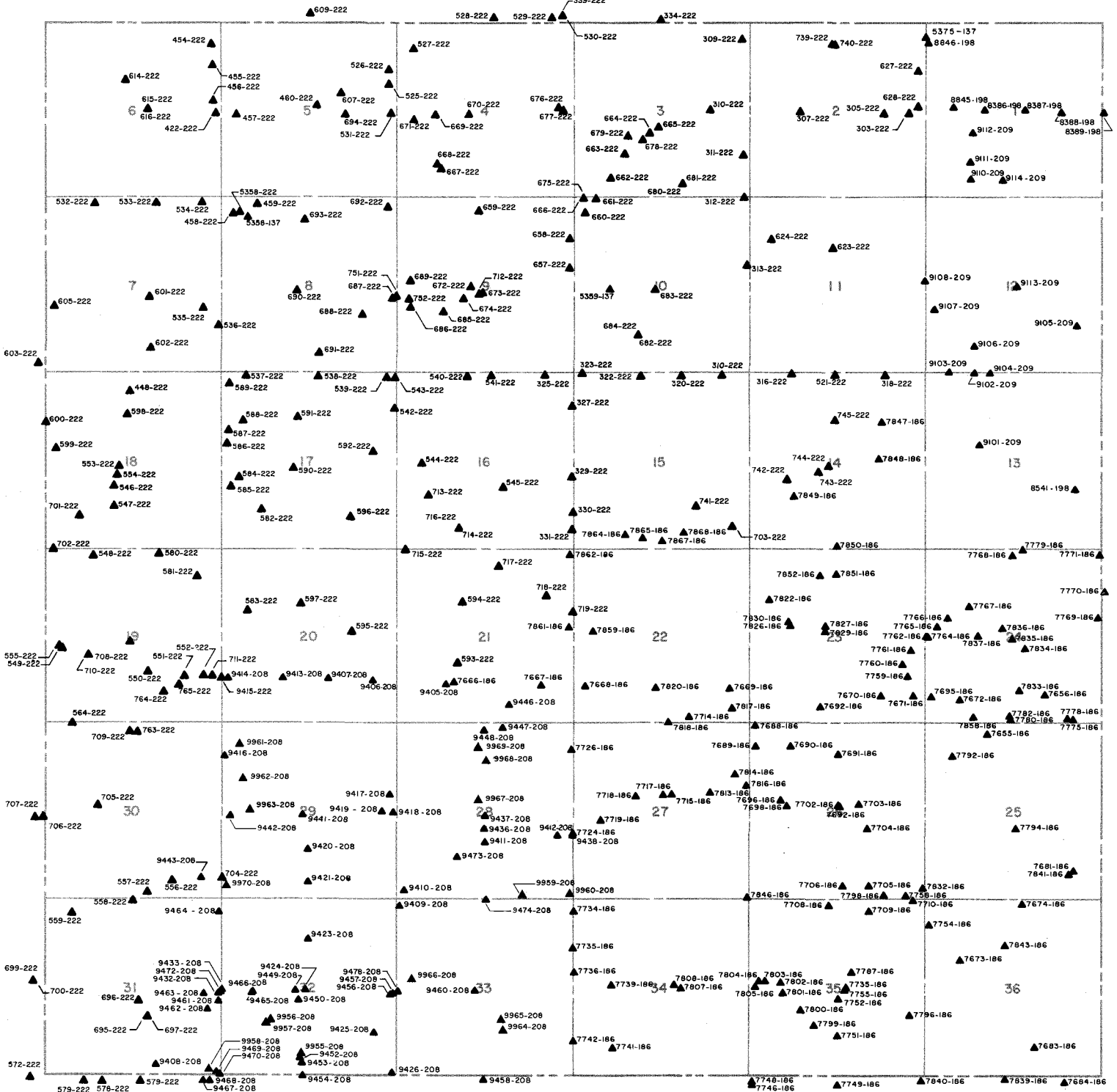




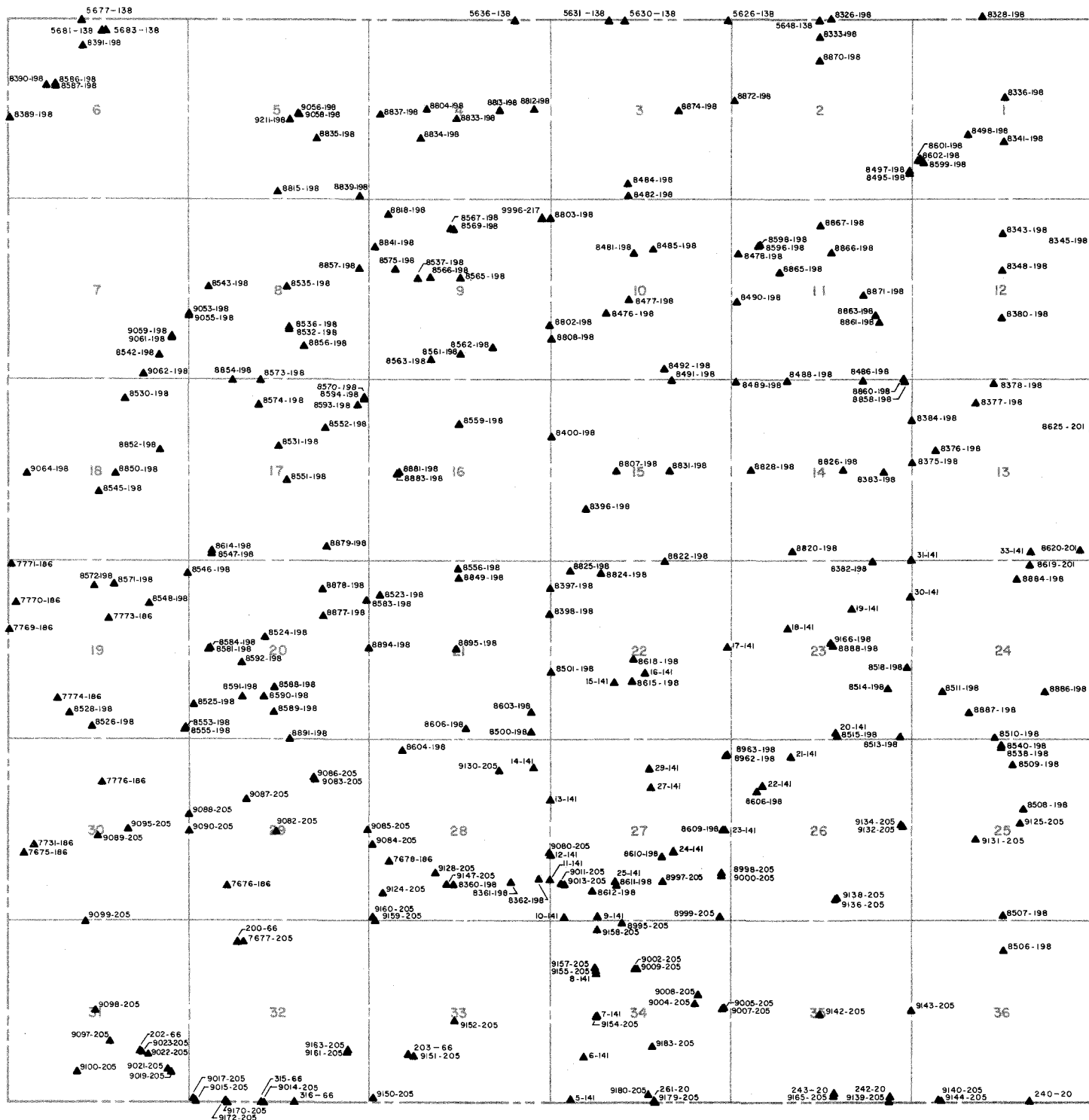
**TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 17 EAST
WAUKESHA COUNTY**



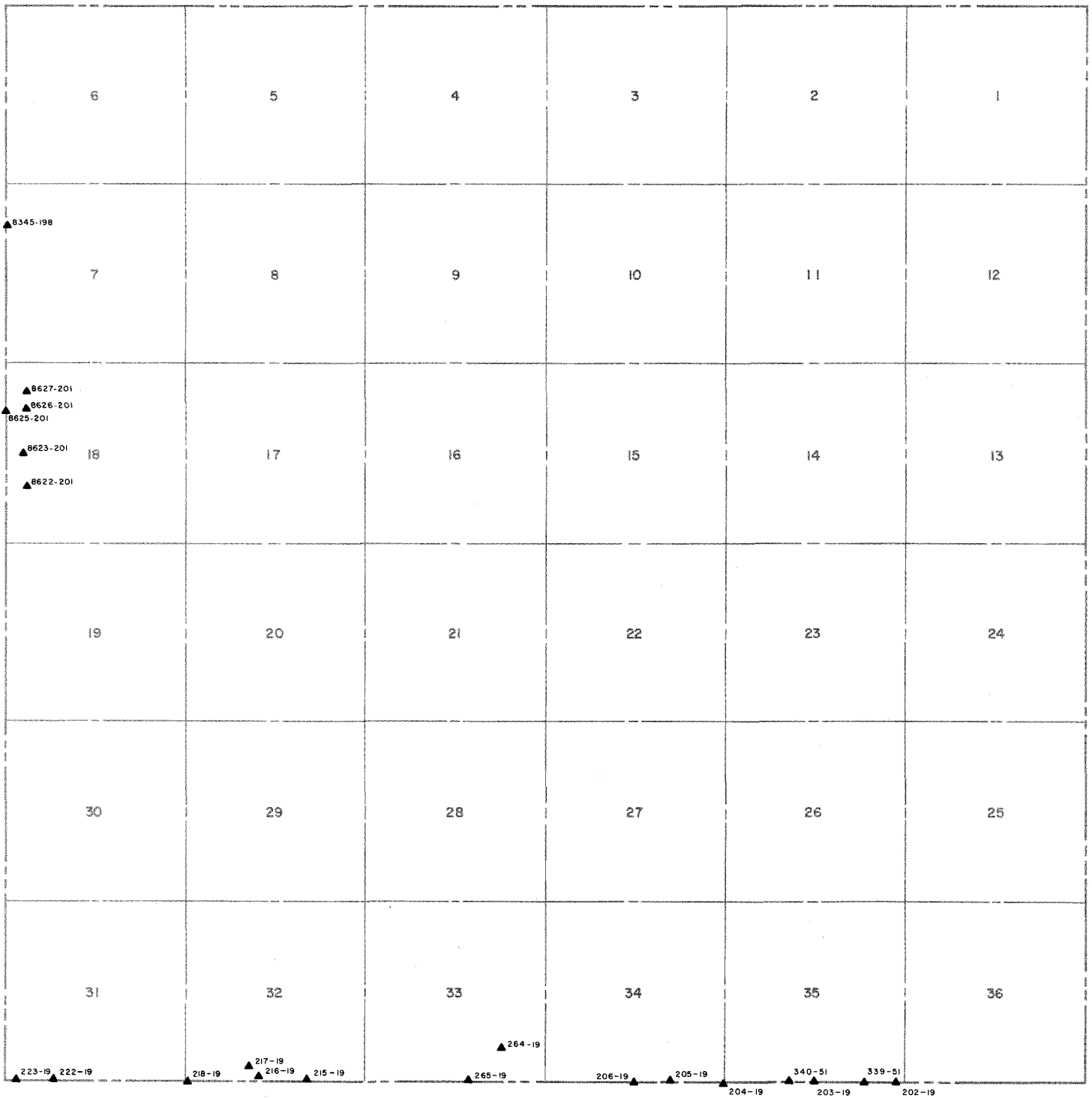
TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 18 EAST WAUKESHA COUNTY



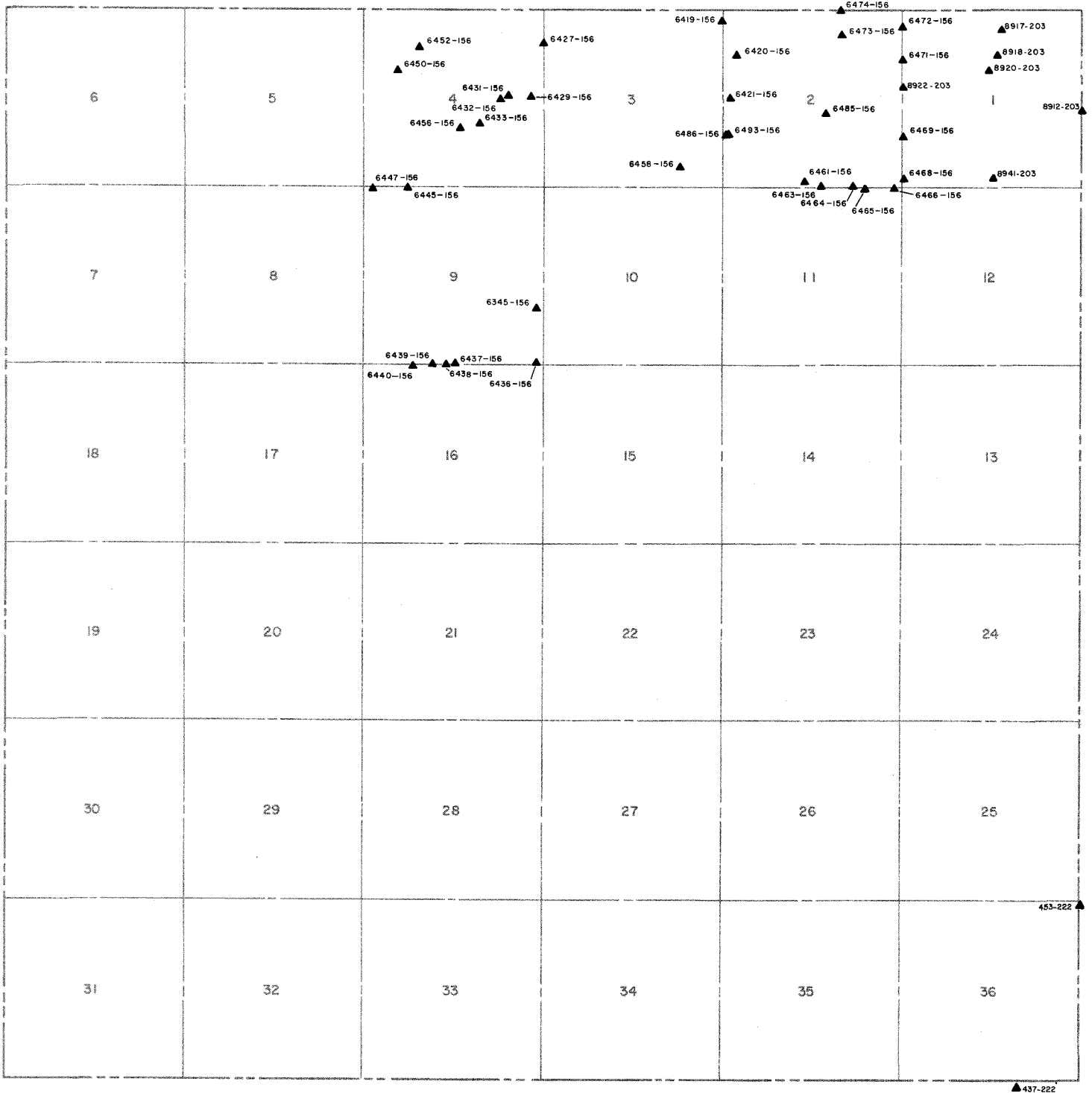
TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 19 EAST WAUKESHA COUNTY



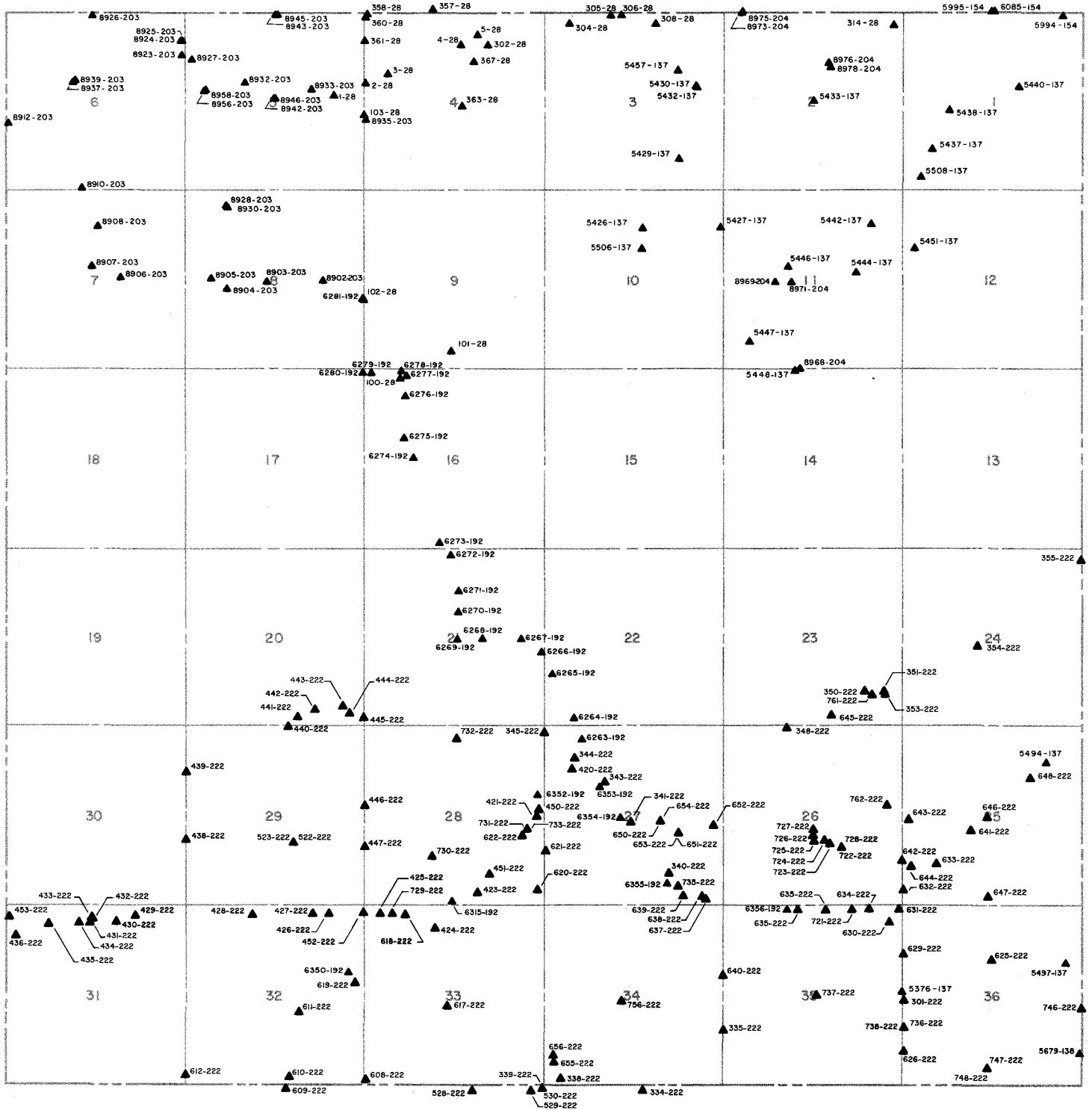
**TRAVERSE DIAGRAM, TOWNSHIP 5 NORTH, RANGE 20 EAST
WAUKESHA COUNTY**



TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 17 EAST
WAUKESHA COUNTY



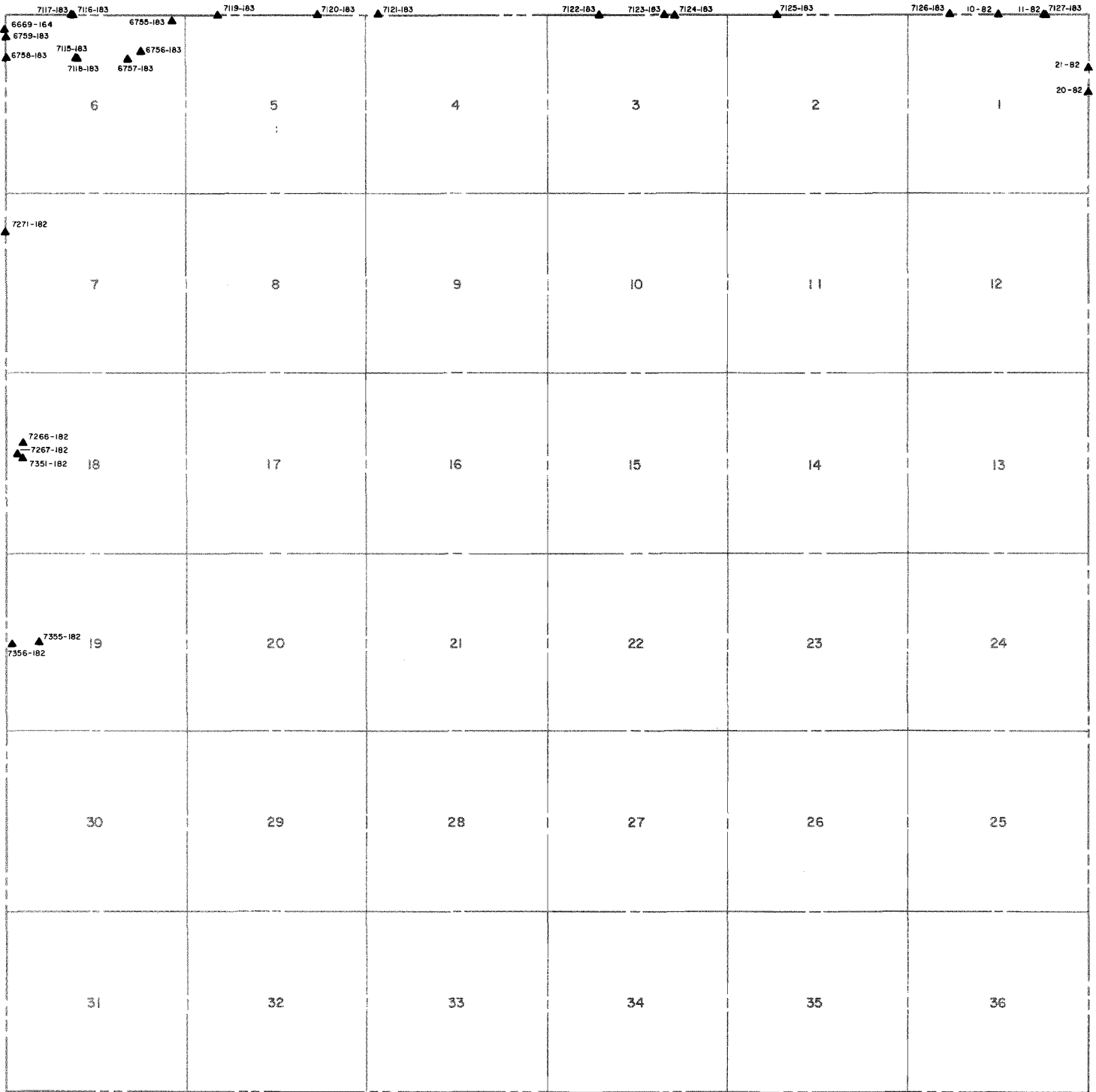
TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 18 EAST WAUKESHA COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 19 EAST
WAUKESHA COUNTY



TRAVERSE DIAGRAM, TOWNSHIP 6 NORTH, RANGE 20 EAST WAUKESHA COUNTY



This map displays a grid of numbered squares (1-36) across the Pacific Ocean region, from 10°N to 30°N latitude and 120°E to 180° longitude. The grid is overlaid on a latitude/longitude grid. Numerous data points are plotted, each marked with a triangle and an alphanumeric code. The codes are organized into groups, such as 2909-74, 2924-74, 2934-74, 2935-74, 2936-74, 2937-74, 2939-74, 2942-74, 2943-74, 2944-74, 2945-74, 2946-74, 2947-74, 2948-74, 2949-74, 2950-74, 2951-74, 2952-74, 2953-74, 2954-74, 2955-74, 2956-74, 2957-74, 2958-74, 2959-74, 2960-74, 2961-74, 2962-74, 2963-74, 2964-74, 2965-74, 2966-74, 2967-74, 2968-74, 2969-74, 2970-74, 2971-74, 2972-74, 2973-74, 2974-74, 2975-74, 2976-74, 2977-74, 2978-74, 2979-74, 2980-74, 2981-74, 2982-74, 2983-74, 2984-74, 2985-74, 2986-74, 2987-74, 2988-74, 2989-74, 2990-74, 2991-74, 2992-74, 2993-74, 2994-74, 2995-74, 2996-74, 2997-74, 2998-74, 2999-74, 3000-74, 3001-74, 3002-74, 3003-74, 3004-74, 3005-74, 3006-74, 3007-74, 3008-74, 3009-74, 3010-74, 3011-74, 3012-74, 3013-74, 3014-74, 3015-74, 3016-74, 3017-74, 3018-74, 3019-74, 3020-74, 3021-74, 3022-74, 3023-74, 3024-74, 3025-74, 3026-74, 3027-74, 3028-74, 3029-74, 3030-74, 3031-74, 3032-74, 3033-74, 3034-74, 3035-74, 3036-74, 3037-74, 3038-74, 3039-74, 3040-74, 3041-74, 3042-74, 3043-74, 3044-74, 3045-74, 3046-74, 3047-74, 3048-74, 3049-74, 3050-74, 3051-74, 3052-74, 3053-74, 3054-74, 3055-74, 3056-74, 3057-74, 3058-74, 3059-74, 3060-74, 3061-74, 3062-74, 3063-74, 3064-74, 3065-74, 3066-74, 3067-74, 3068-74, 3069-74, 3070-74, 3071-74, 3072-74, 3073-74, 3074-74, 3075-74, 3076-74, 3077-74, 3078-74, 3079-74, 3080-74, 3081-74, 3082-74, 3083-74, 3084-74, 3085-74, 3086-74, 3087-74, 3088-74, 3089-74, 3090-74, 3091-74, 3092-74, 3093-74, 3094-74, 3095-74, 3096-74, 3097-74, 3098-74, 3099-74, 3100-74, 3101-74, 3102-74, 3103-74, 3104-74, 3105-74, 3106-74, 3107-74, 3108-74, 3109-74, 3110-74, 3111-74, 3112-74, 3113-74, 3114-74, 3115-74, 3116-74, 3117-74, 3118-74, 3119-74, 3120-74, 3121-74, 3122-74, 3123-74, 3124-74, 3125-74, 3126-74, 3127-74, 3128-74, 3129-74, 3130-74, 3131-74, 3132-74, 3133-74, 3134-74, 3135-74, 3136-74, 3137-74, 3138-74, 3139-74, 3140-74, 3141-74, 3142-74, 3143-74, 3144-74, 3145-74, 3146-74, 3147-74, 3148-74, 3149-74, 3150-74, 3151-74, 3152-74, 3153-74, 3154-74, 3155-74, 3156-74, 3157-74, 3158-74, 3159-74, 3160-74, 3161-74, 3162-74, 3163-74, 3164-74, 3165-74, 3166-74, 3167-74, 3168-74, 3169-74, 3170-74, 3171-74, 3172-74, 3173-74, 3174-74, 3175-74, 3176-74, 3177-74, 3178-74, 3179-74, 3180-74, 3181-74, 3182-74, 3183-74, 3184-74, 3185-74, 3186-74, 3187-74, 3188-74, 3189-74, 3190-74, 3191-74, 3192-74, 3193-74, 3194-74, 3195-74, 3196-74, 3197-74, 3198-74, 3199-74, 3200-74, 3201-74, 3202-74, 3203-74, 3204-74, 3205-74, 3206-74, 3207-74, 3208-74, 3209-74, 3210-74, 3211-74, 3212-74, 3213-74, 3214-74, 3215-74, 3216-74, 3217-74, 3218-74, 3219-74, 3220-74, 3221-74, 3222-74, 3223-74, 3224-74, 3225-74, 3226-74, 3227-74, 3228-74, 3229-74, 3230-74, 3231-74, 3232-74, 3233-74, 3234-74, 3235-74, 3236-74, 3237-74, 3238-74, 3239-74, 3240-74, 3241-74, 3242-74, 3243-74, 3244-74, 3245-74, 3246-74, 3247-74, 3248-74, 3249-74, 3250-74, 3251-74, 3252-74, 3253-74, 3254-74, 3255-74, 3256-74, 3257-74, 3258-74, 3259-74, 3260-74, 3261-74, 3262-74, 3263-74, 3264-74, 3265-74, 3266-74, 3267-74, 3268-74, 3269-74, 3270-74, 3271-74, 3272-74, 3273-74, 3274-74, 3275-74, 3276-74, 3277-74, 3278-74, 3279-74, 3280-74, 3281-74, 3282-74, 3283-74, 3284-74, 3285-74, 3286-74, 3287-74, 3288-74, 3289-74, 3290-74, 3291-74, 3292-74, 3293-74, 3294-74, 3295-74, 3296-74, 3297-74, 3298-74, 3299-74, 3300-74, 3301-74, 3302-74, 3303-74, 3304-74, 3305-74, 3306-74, 3307-74, 3308-74, 3309-74, 3310-74, 3311-74, 3312-74, 3313-74, 3314-74, 3315-74, 3316-74, 3317-74, 3318-74, 3319-74, 3320-74, 3321-74, 3322-74, 3323-74, 3324-74, 3325-74, 3326-74, 3327-74, 3328-74, 3329-74, 3330-74, 3331-74, 3332-74, 3333-74, 3334-74, 3335-74, 3336-74, 3337-74, 3338-74, 3339-74, 3340-74, 3341-74, 3342-74, 3343-74, 3344-74, 3345-74, 3346-74, 3347-74, 3348-74, 3349-74, 3350-74, 3351-74, 3352-74, 3353-74, 3354-74, 3355-74, 3356-74, 3357-74, 3358-74, 3359-74, 3360-74, 3361-74, 3362-74, 3363-74, 3364-74, 3365-74, 3366-74, 3367-74, 3368-74, 3369-74, 3370-74, 3371-74,

This map displays a grid of numbered squares (1-35) across the Pacific Ocean region, from 10°N to 30°N latitude and 120°E to 180° longitude. Each square contains various data points marked with triangles and alphanumeric codes, such as 1577-227, 1576-227, 1575-227, 1540-227, 1548-227, 1547-227, 1546-227, 1545-227, 1544-227, 1543-227, 1542-227, 1541-227, 1540-227, 1539-227, 1538-227, 1537-227, 1536-227, 1535-227, 1534-227, 1533-227, 1532-227, 1531-227, 1530-227, 1529-227, 1528-227, 1527-227, 1526-227, 1525-227, 1524-227, 1523-227, 1522-227, 1521-227, 1520-227, 1519-227, 1518-227, 1517-227, 1516-227, 1515-227, 1514-227, 1513-227, 1512-227, 1511-227, 1510-227, 1509-227, 1508-227, 1507-227, 1506-227, 1505-227, 1504-227, 1503-227, 1502-227, 1501-227, 1500-227, 1499-227, 1498-227, 1497-227, 1496-227, 1495-227, 1494-227, 1493-227, 1492-227, 1491-227, 1490-227, 1489-227, 1488-227, 1487-227, 1486-227, 1485-227, 1484-227, 1483-227, 1482-227, 1481-227, 1480-227, 1479-227, 1478-227, 1477-227, 1476-227, 1475-227, 1474-227, 1473-227, 1472-227, 1471-227, 1470-227, 1469-227, 1468-227, 1467-227, 1466-227, 1465-227, 1464-227, 1463-227, 1462-227, 1461-227, 1460-227, 1459-227, 1458-227, 1457-227, 1456-227, 1455-227, 1454-227, 1453-227, 1452-227, 1451-227, 1450-227, 1449-227, 1448-227, 1447-227, 1446-227, 1445-227, 1444-227, 1443-227, 1442-227, 1441-227, 1440-227, 1439-227, 1438-227, 1437-227, 1436-227, 1435-227, 1434-227, 1433-227, 1432-227, 1431-227, 1430-227, 1429-227, 1428-227, 1427-227, 1426-227, 1425-227, 1424-227, 1423-227, 1422-227, 1421-227, 1420-227, 1419-227, 1418-227, 1417-227, 1416-227, 1415-227, 1414-227, 1413-227, 1412-227, 1411-227, 1410-227, 1409-227, 1408-227, 1407-227, 1406-227, 1405-227, 1404-227, 1403-227, 1402-227, 1401-227, 1400-227, 1399-227, 1398-227, 1397-227, 1396-227, 1395-227, 1394-227, 1393-227, 1392-227, 1391-227, 1390-227, 1389-227, 1388-227, 1387-227, 1386-227, 1385-227, 1384-227, 1383-227, 1382-227, 1381-227, 1380-227, 1379-227, 1378-227, 1377-227, 1376-227, 1375-227, 1374-227, 1373-227, 1372-227, 1371-227, 1370-227, 1369-227, 1368-227, 1367-227, 1366-227, 1365-227, 1364-227, 1363-227, 1362-227, 1361-227, 1360-227, 1359-227, 1358-227, 1357-227, 1356-227, 1355-227, 1354-227, 1353-227, 1352-227, 1351-227, 1350-227, 1349-227, 1348-227, 1347-227, 1346-227, 1345-227, 1344-227, 1343-227, 1342-227, 1341-227, 1340-227, 1339-227, 1338-227, 1337-227, 1336-227, 1335-227, 1334-227, 1333-227, 1332-227, 1331-227, 1330-227, 1329-227, 1328-227, 1327-227, 1326-227, 1325-227, 1324-227, 1323-227, 1322-227, 1321-227, 1320-227, 1319-227, 1318-227, 1317-227, 1316-227, 1315-227, 1314-227, 1313-227, 1312-227, 1311-227, 1310-227, 1309-227, 1308-227, 1307-227, 1306-227, 1305-227, 1304-227, 1303-227, 1302-227, 1301-227, 1300-227, 1299-227, 1298-227, 1297-227, 1296-227, 1295-227, 1294-227, 1293-227, 1292-227, 1291-227, 1290-227, 1289-227, 1288-227, 1287-227, 1286-227, 1285-227, 1284-227, 1283-227, 1282-227, 1281-227, 1280-227, 1279-227, 1278-227, 1277-227, 1276-227, 1275-227, 1274-227, 1273-227, 1272-227, 1271-227, 1270-227, 1269-227, 1268-227, 1267-227, 1266-227, 1265-227, 1264-227, 1263-227, 1262-227, 1261-227, 1260-227, 1259-227, 1258-227, 1257-227, 1256-227, 1255-227, 1254-227, 1253-227, 1252-227, 1251-227, 1250-227, 1249-227, 1248-227, 1247-227, 1246-227, 1245-227, 1244-227, 1243-227, 1242-227, 1241-227, 1240-227, 1239-227, 1238-227, 1237-227, 1236-227, 1235-227, 1234-227, 1233-227, 1232-227, 1231-227, 1230-227, 1229-227, 1228-227, 1227-227, 1226-227, 1225-227, 1224-227, 1223-227, 1222-227, 1221-227, 1220-227, 1219-227, 1218-227, 1217-227, 1216-227, 1215-227, 1214-227, 1213-227, 1212-227, 1211-227, 1210-227, 1209-227, 1208-227, 1207-227, 1206-227, 1205-227, 1204-227, 1203-227, 1202-227, 1201-227, 1200-227, 1199-227, 1198-227, 1197-227, 1196-227, 1195-227, 1194-227, 1193-227, 1192-227, 1191-227, 1190-227, 1189-227, 1188-227, 1187-227, 1186-227, 1185-227, 1184-227, 1183-227, 1182-227, 1181-227, 1180-227, 1179-227, 1178-227, 1177-227, 1176-227, 1175-227, 1174-227, 1173-227, 1172-227, 1171-227, 1170-227, 1169-227, 1168-227, 1167-227, 1166-227, 1165-227, 1164-227, 1163-227, 1162-227, 1161-227, 1160-227, 1159-227, 1158-227, 115

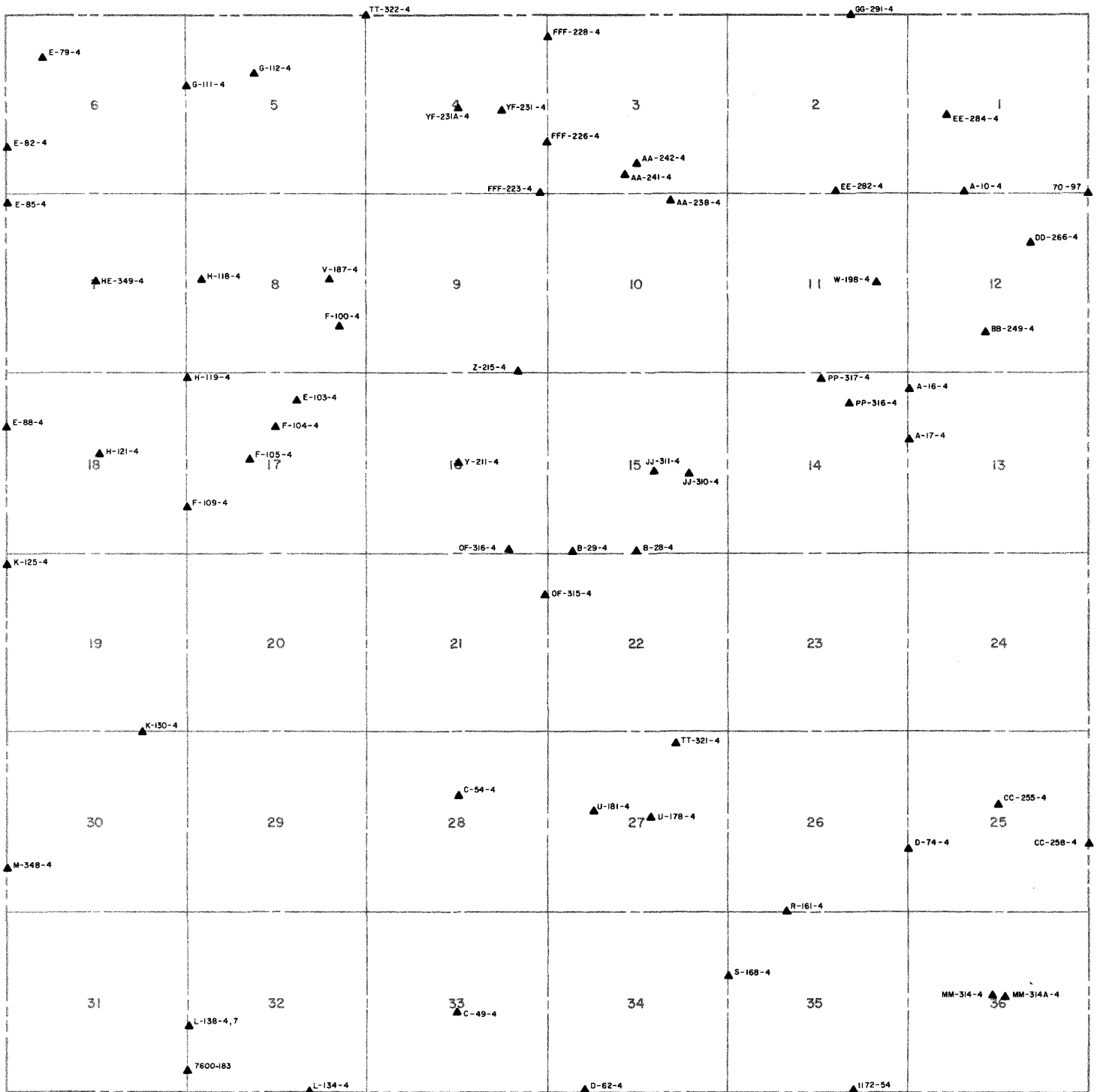
This map displays the contiguous United States divided into a grid of 36 numbered regions. Each region contains various labeled points, often with a year suffix (e.g., 7603-183, 1178-54, 7101-83). The points are distributed across the map, with some regions containing multiple points. The map also shows state boundaries and a coordinate system.

This map displays the Pacific Northwest region, including parts of Washington, Oregon, and British Columbia. A grid of numbered locations (1-36) is overlaid on the map. The locations are marked with black triangles and labeled with their respective numbers. The map also shows major cities, rivers, and the coastline. The grid covers an area from approximately 120°W to 125°W and 45°N to 50°N.

The numbered locations are distributed across the map as follows:

- 1: 1716-236
- 2: 1742-236, 1743-236, 1744-236, 1745-236, 1747-236
- 3: 1736-236, 2053, 2065-236
- 4: 1724-236, 2037-236, 2036-236, 2035-236, 2034-236
- 5: 1722-236, 2067-236, 1733-236
- 6: 1719-236
- 7: 1715-236, 2071-236, 1714-236, 1895-78, 1896-78, 1897-78, 1898-78, 2042-236, 1893-78, 1892-78, 1891-78, 1890-78, 1889-78, 1710-236, 1852-78, 1879-78, 1880-78, 1881-78, 1882-78, 1883-78, 1884-78, 1885-78, 1886-78, 1887-78, 1888-78, 1889-78, 1890-78, 1891-78, 1892-78, 1893-78, 1894-78, 1895-78, 1896-78, 1897-78, 1898-78, 1899-78, 1900-78, 1901-78, 1902-78, 1903-78, 1904-78, 1905-78, 1906-78, 1907-78, 1908-78, 1909-78, 1910-78, 1911-78, 1912-78, 1913-78, 1914-78, 1915-78, 1916-78, 1917-78, 1918-78, 1919-78, 1920-78, 1921-78, 1922-78, 1923-78, 1924-78, 1925-78, 1926-78, 1927-78, 1928-78, 1929-78, 1930-78, 1931-78, 1932-78, 1933-78, 1934-78, 1935-78, 1936-78, 1937-78, 1938-78, 1939-78, 1940-78, 1941-78, 1942-78, 1943-78, 1944-78, 1945-78, 1946-78, 1947-78, 1948-78, 1949-78, 1950-78, 1951-78, 1952-78, 1953-78, 1954-78, 1955-78, 1956-78, 1957-78, 1958-78, 1959-78, 1960-78, 1961-78, 1962-78, 1963-78, 1964-78, 1965-78, 1966-78, 1967-78, 1968-78, 1969-78, 1970-78, 1971-78, 1972-78, 1973-78, 1974-78, 1975-78, 1976-78, 1977-78, 1978-78, 1979-78, 1980-78, 1981-78, 1982-78, 1983-78, 1984-78, 1985-78, 1986-78, 1987-78, 1988-78, 1989-78, 1990-78, 1991-78, 1992-78, 1993-78, 1994-78, 1995-78, 1996-78, 1997-78, 1998-78, 1999-78, 2000-78, 2001-78, 2002-78, 2003-78, 2004-78, 2005-78, 2006-78, 2007-78, 2008-78, 2009-78, 2010-78, 2011-78, 2012-78, 2013-78, 2014-78, 2015-78, 2016-78, 2017-78, 2018-78, 2019-78, 2020-78, 2021-78, 2022-78, 2023-78, 2024-78, 2025-78, 2026-78, 2027-78, 2028-78, 2029-78, 2030-78, 2031-78, 2032-78, 2033-78, 2034-78, 2035-78, 2036-78, 2037-78, 2038-78, 2039-78, 2040-78, 2041-78, 2042-78, 2043-78, 2044-78, 2045-78, 2046-78, 2047-78, 2048-78, 2049-78, 2050-78, 2051-78, 2052-78, 2053-78, 2054-78, 2055-78, 2056-78, 2057-78, 2058-78, 2059-78, 2060-78, 2061-78, 2062-78, 2063-78, 2064-78, 2065-78, 2066-78, 2067-78, 2068-78, 2069-78, 2070-78, 2071-78, 2072-78, 2073-78, 2074-78, 2075-78, 2076-78, 2077-78, 2078-78, 2079-78, 2080-78, 2081-78, 2082-78, 2083-78, 2084-78, 2085-78, 2086-78, 2087-78, 2088-78, 2089-78, 2090-78, 2091-78, 2092-78, 2093-78, 2094-78, 2095-78, 2096-78, 2097-78, 2098-78, 2099-78, 2100-78, 2101-78, 2102-78, 2103-78, 2104-78, 2105-78, 2106-78, 2107-78, 2108-78, 2109-78, 2110-78, 2111-78, 2112-78, 2113-78, 2114-78, 2115-78, 2116-78, 2117-78, 2118-78, 2119-78, 2120-78, 2121-78, 2122-78, 2123-78, 2124-78, 2125-78, 2126-78, 2127-78, 2128-78, 2129-78, 2130-78, 2131-78, 2132-78, 2133-78, 2134-78, 2135-78, 2136-78, 2137-78, 2138-78, 2139-78, 2140-78, 2141-78, 2142-78, 2143-78, 2144-78, 2145-78, 2146-78, 2147-78, 2148-78, 2149-78, 2150-78, 2151-78, 2152-78, 2153-78, 2154-78, 2155-78, 2156-78, 2157-78, 2158-78, 2159-78, 2160-78, 2161-78, 2162-78, 2163-78, 2164-78, 2165-78, 2166-78, 2167-78, 2168-78, 2169-78, 2170-78, 2171-78, 2172-78, 2173-78, 2174-78, 2175-78, 2176-78, 2177-78, 2178-78, 2179-78, 2180-78, 2181-78, 2182-78, 2183-78, 2184-78, 2185-78, 2186-78, 2187-78, 2188-78, 2189-78, 2190-78, 2191-78, 2192-78, 2193-78, 2194-78, 2195-78, 2196-78, 2197-78, 2198-78, 2199-78, 2200-78, 2201-78, 2202-78, 2203-78, 2204-78, 2205-78, 2206-78, 2207-78, 2208-78, 2209-78, 2210-78, 2211-78, 2212-78, 2213-78, 2214-78, 2215-78, 2216-78, 2217-78, 2218-78, 2219-78, 2220-78, 2221-78, 2222-78, 2223-78, 2224-78, 2225-78, 2226-78, 2227-78, 2228-78, 2229-78, 2230-78, 2231-78, 2232-78, 2233-78, 2234-78, 2235-78, 2236-78, 2237-78, 2238-78, 2239-78, 2240-78, 2241-78, 2242-78, 2243-78, 2244-78, 2245-78, 2246-78, 2247-78, 2248-78, 2249-78, 2250-78, 2251-78, 2252-78, 2253-78, 2254-78, 2255-78, 2256-78, 2257-78, 2258-78, 2259-78, 2260-78, 2261-78, 2262-78, 2263-78, 2264-78, 2265-78, 2266-78, 2267-78, 2268-78, 2269-78, 2270-78, 2271-78,

TRAVERSE DIAGRAM, TOWNSHIP 8 NORTH, RANGE 20 EAST WAUKESHA COUNTY



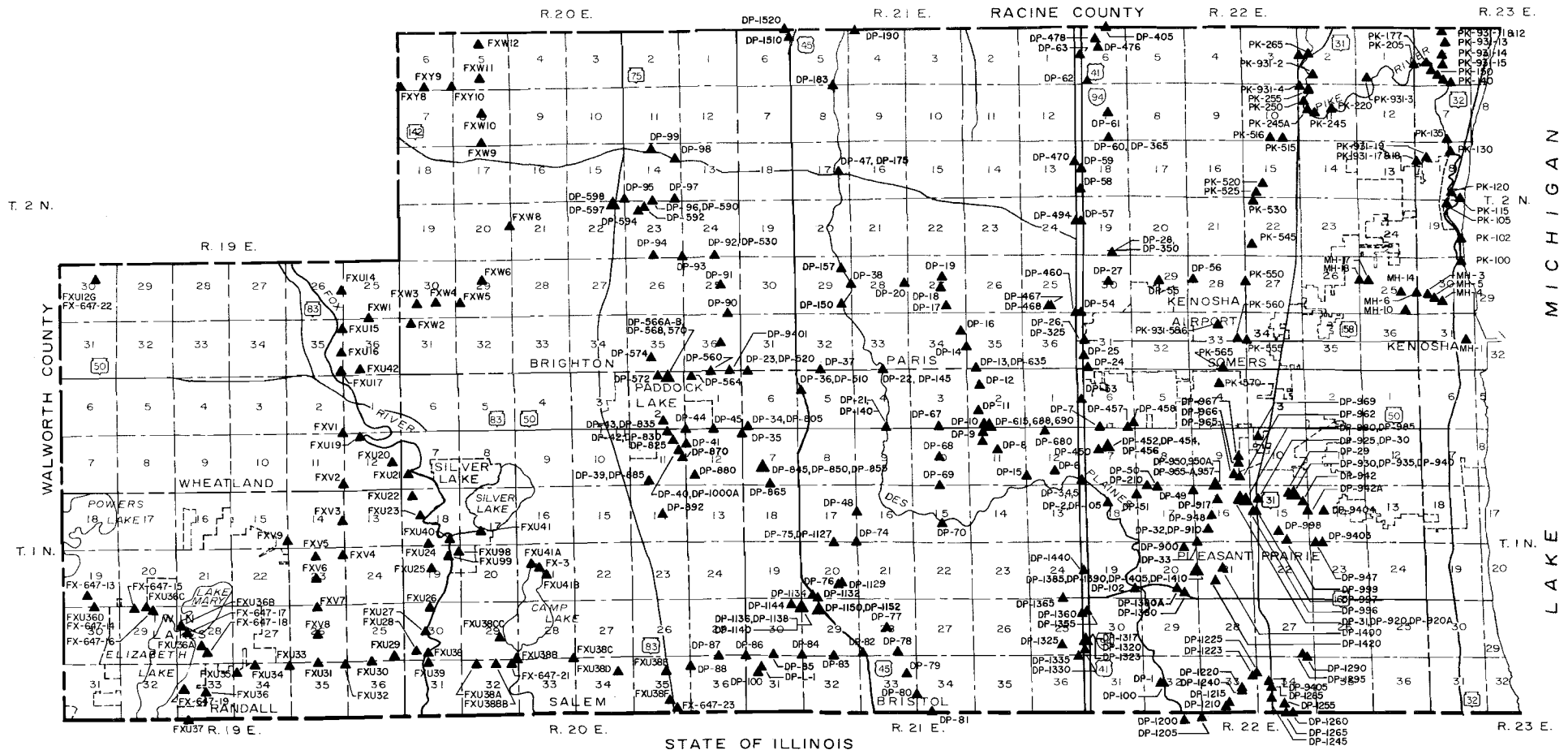
APPENDICES

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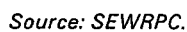
Appendix D
SUPPLEMENTARY VERTICAL CONTROL SURVEY DATA

Map D-1

SUPPLEMENTARY BENCH MARK INDEX FOR KENOSHA COUNTY, WISCONSIN



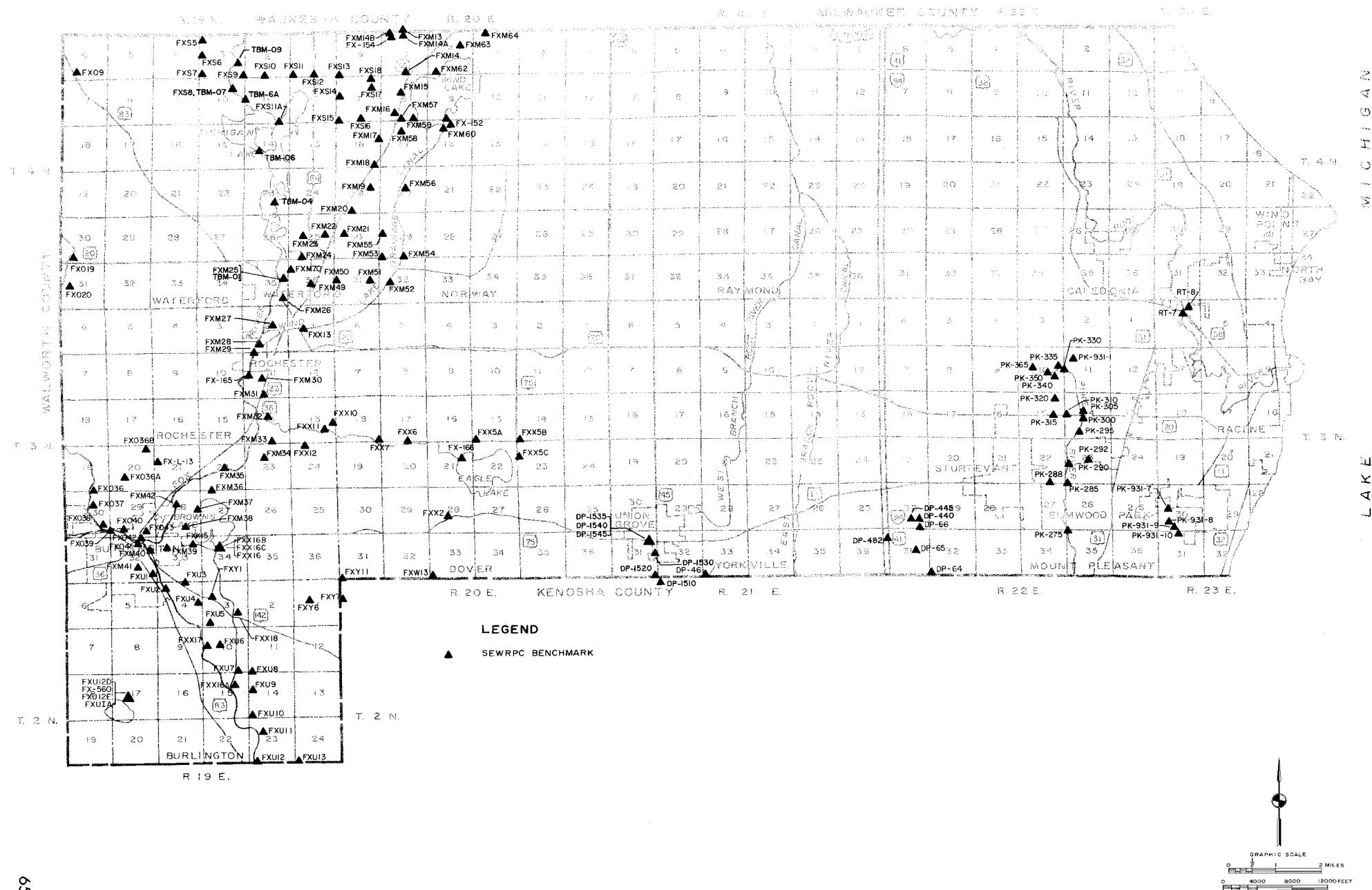
SUPPLEMENTARY BENCH MARK INDEX FOR MILWAUKEE COUNTY, WISCONSIN



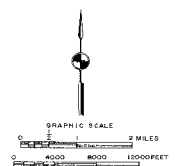
SUPPLEMENTARY BENCH MARK INDEX FOR OZAUKEE COUNTY, WISCONSIN

Source: SEWRPC.

Source: SEWRPC.



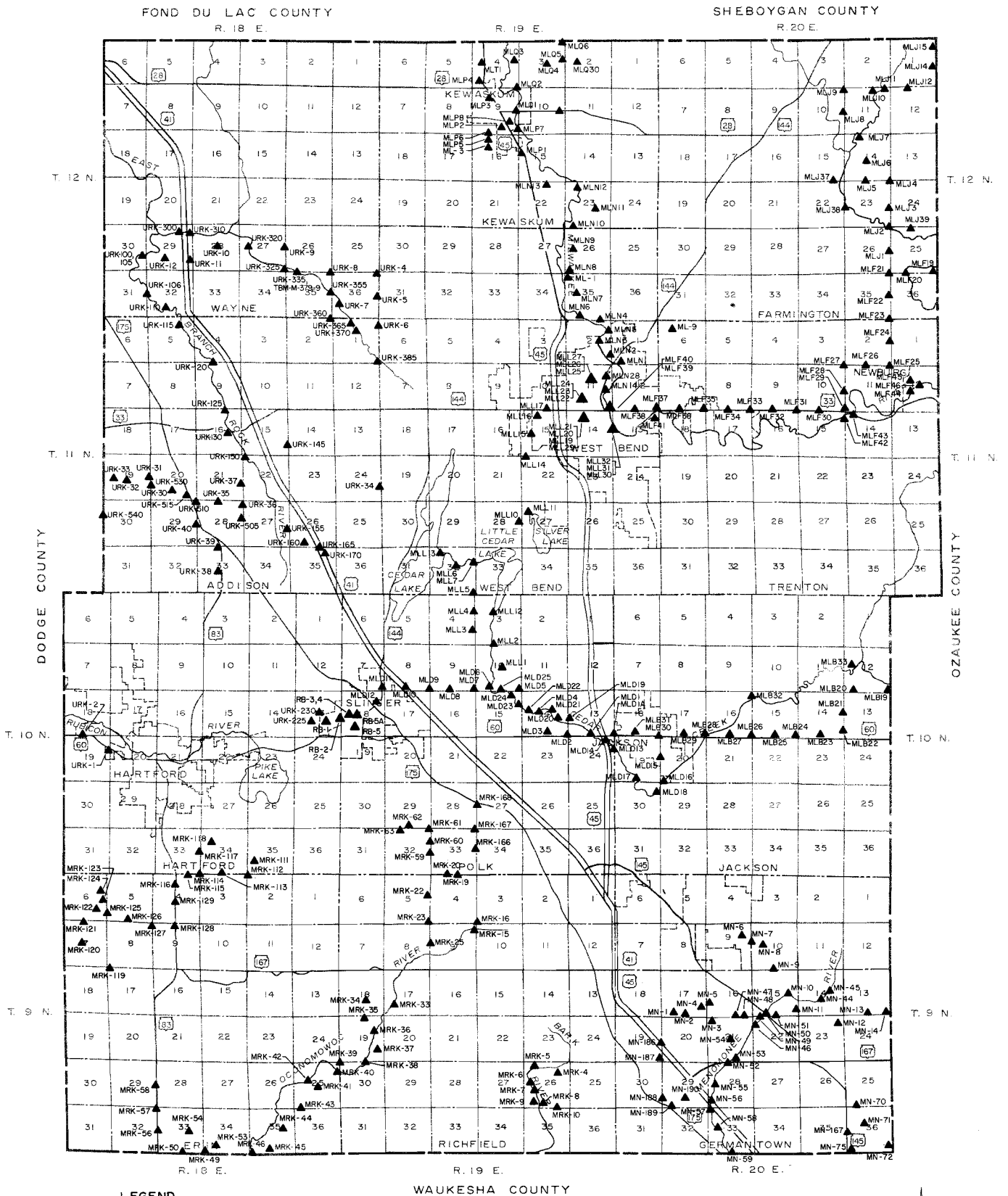
SUPPLEMENTARY BENCH MARK INDEX FOR WALWORTH COUNTY, WISCONSIN



654

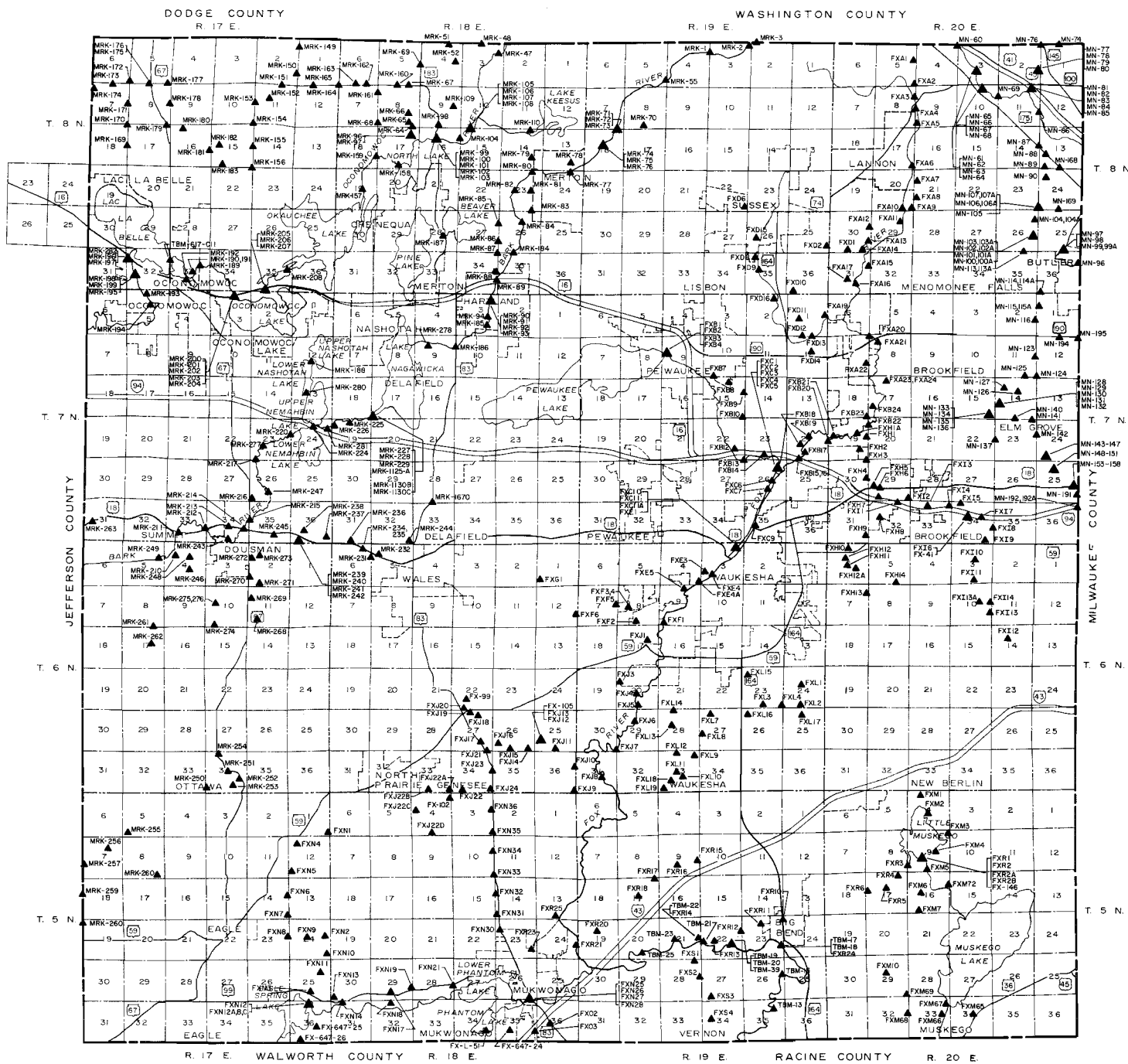
Map D-6

SUPPLEMENTARY BENCH MARK INDEX FOR WASHINGTON COUNTY, WISCONSIN



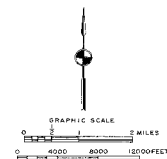
Map D-7

SUPPLEMENTARY BENCH MARK INDEX FOR WAUKESHA COUNTY, WISCONSIN



LEGEND

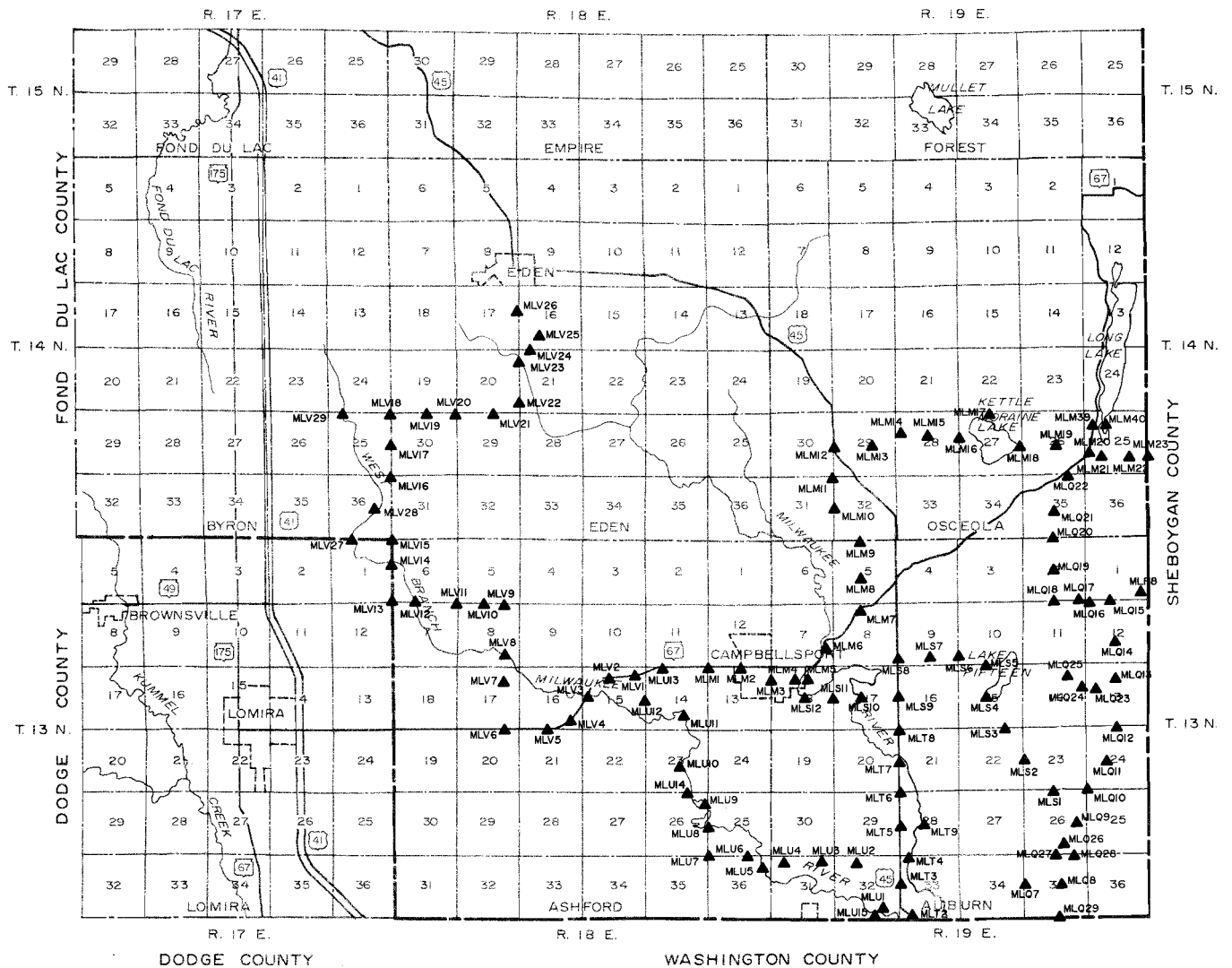
▲ SEWRPC BENCHMARK



Source: SEWRPC.

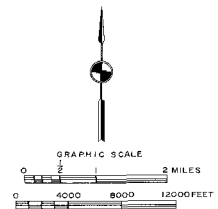
Map D-8

SUPPLEMENTARY BENCH MARK INDEX FOR FOND DU LAC COUNTY, WISCONSIN



LEGEND

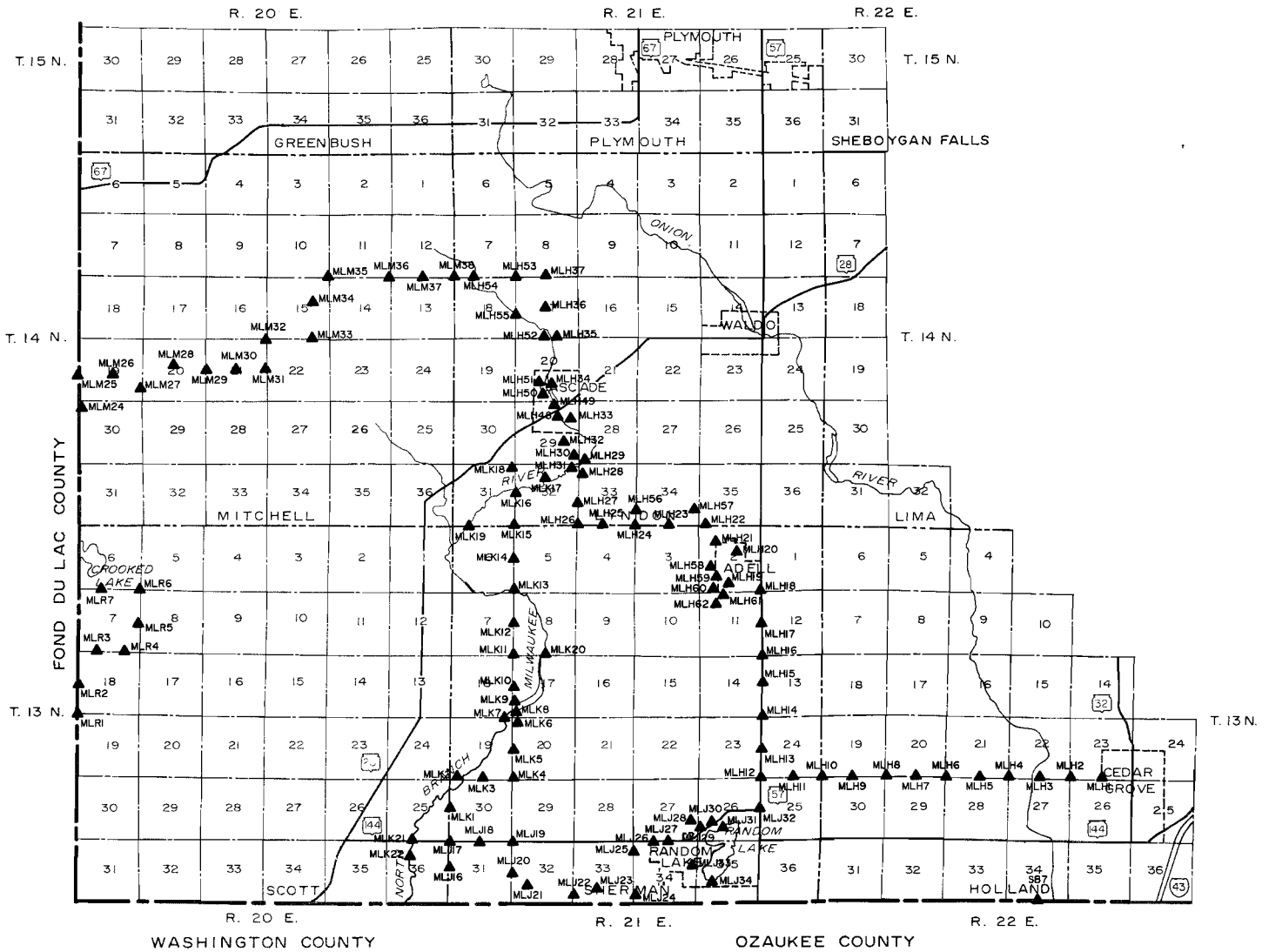
▲ SEWRPC BENCHMARK



Source: SEWRPC.

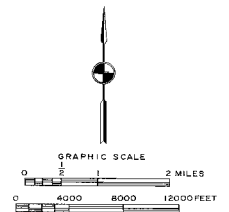
Map D-9

SUPPLEMENTARY BENCH MARK INDEX FOR SHEBOYGAN COUNTY, WISCONSIN



LEGEND

▲ SEWRPC BENCHMARK



Source: SEWRPC.

Figure D-1

RECORD OF VERTICAL CONTROL STATION

SECTION 6, TOWNSHIP 2 N, RANGE 23 E

KENOSHA COUNTY

BENCH MARK NO. PK 931-15 ELEVATION 604.702'

REFERENCE BENCH MARK NO. RK 931-14 & 15 ELEVATION 602.904'

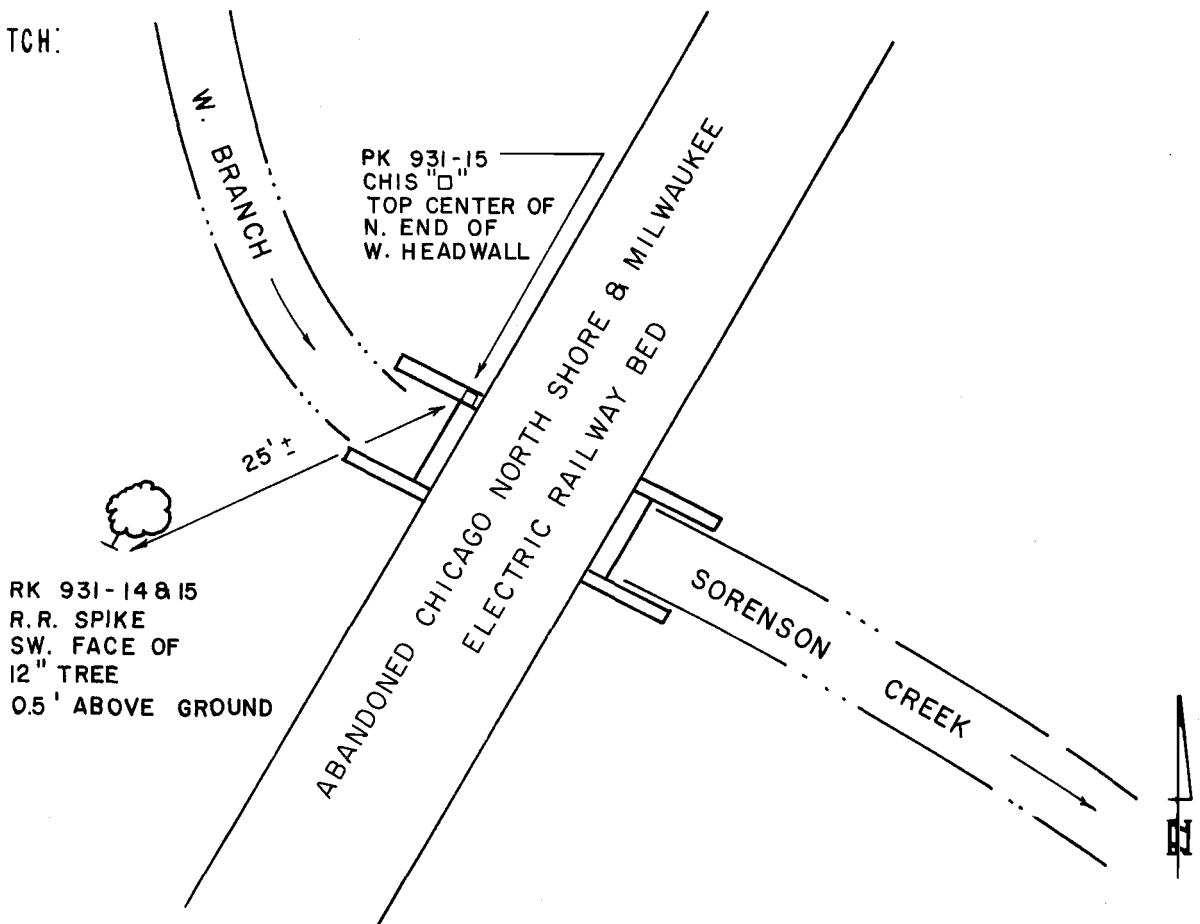
SET BY: ALSTER & ASSOCIATES, INC., ENGINEERS, MADISON, WISCONSIN

VERTICAL DATUM: MEAN SEA LEVEL, 1929 ADJUSTMENT

VERTICAL CONTROL ACCURACY: THIRD ORDER

DATE OF SURVEY: NOVEMBER 1979

LOCATION SKETCH:



DETAILED DESCRIPTION: LOCATED ABOUT 300' EAST AND 100' NORTH OF THE CENTER OF
SECTION 6, T 2 N, R 23 E.

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APPENDICES

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Appendix E
STANDARDS AND SPECIFICATIONS
FOR GEODETIC CONTROL NETWORKS

NOTE: The Federal Geodetic Control Committee had not, as of the date of publication of this report, approved standards and specifications for Global Positioning System (GPS) control survey techniques. Preliminary standards and specifications, however, have been issued in a document entitled "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques," Federal Geodetic Committee, August 1989. It is expected that these standards and specifications will undergo refinement and revision and eventually will be published as an integral part of the overall Federal standards and specifications for geodetic control networks.

FEDERAL GEODETIC CONTROL COMMITTEE, ROCKVILLE, MARYLAND, SEPTEMBER 1984

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1. Introduction

The Government of the United States makes nationwide surveys, maps, and charts of various kinds. These are necessary to support the conduct of public business at all levels of government, for planning and carrying out national and local projects, the development and utilization of natural resources, national defense, land management, and monitoring crustal motion. Requirements for geodetic control surveys are most critical where intense development is taking place, particularly offshore areas, where surveys are used in the exploration and development of natural resources, and in delineation of state and international boundaries.

State and local governments and industry regularly cooperate in various parts of the total surveying and mapping program. In surveying and mapping large areas, it is first necessary to establish frameworks of horizontal, vertical, and gravity control. These provide a common basis for all surveying and mapping operations to ensure a coherent product. A reference system, or datum, is the set of numerical quantities that serves as a common basis. Three National Geodetic Control Networks have been created by the Government to provide the datums. It is the responsibility of the National Geodetic Survey (NGS) to actively maintain the National Geodetic Control Networks (appendix A).

These control networks consist of stable, identifiable points tied together by extremely accurate observations. From these observations, datum values (coordinates or gravity) are computed and published. These datum values provide the common basis that is so important to surveying and mapping activities.

As stated, the United States maintains three control networks. A horizontal network provides geodetic latitudes and longitudes in the North American Datum reference system; a vertical network furnishes elevations in the National Geodetic Vertical Datum reference system; and a gravity network supplies gravity values in the U.S. absolute gravity reference system. A given station may be a control point in one, two, or all three control networks.

It is not feasible for all points in the control networks to be of the highest possible accuracy. Different levels of accuracy are referred to as the "order" of a point. Orders are often subdivided further by a "class" designation. Datum values for a station are assigned an order (and class) based upon the appropriate classification standard for each of the three control networks. Horizontal and

vertical standards are defined in reasonable conformance with past practice. The recent development of highly accurate absolute gravity instrumentation now allows a gravity reference standard. In the section on "Standards," the classification standards for each of the control networks are described, sample computations performed, and monumentation requirements given.

Control networks can be produced only by making very accurate measurements which are referred to identifiable control points. The combination of survey design, instrumentation, calibration procedures, observational techniques, and data reduction methods is known as a measurement system. The section on "Specifications" describes important components and states permissible tolerances for a variety of measurement systems.

Clearly, the control networks would be of little use if the datum values were not published. The section entitled "Information" describes the various products and formats of available geodetic data.

Upon request, the National Geodetic Survey will accept data submitted in the correct formats with the proper supporting documentation (appendix C) for incorporation into the national networks. When a survey is submitted for inclusion into the national networks, the survey measurements are processed in a quality control procedure that leads to their classification of accuracy and storage in the National Geodetic Survey data base. To fully explain the process we shall trace a survey from the planning stage to admission into the data base. This example will provide an overview of the standards and specifications, and how they work together.

The user should first compare the distribution and accuracy of current geodetic control with both immediate and long-term needs. From this basis, requirements for the extent and accuracy of the planned survey are determined. The classification standards of the control networks will help in this formulation. Hereafter, the requirements for the accuracy of the planned survey will be referred to as the "intended accuracy" of the survey. A measurement system is then chosen, based on various factors such as: distribution and accuracy of present control; region of the country; extent, distribution, and accuracy of the desired control; terrain and accessibility of control; and economic factors.

Upon selection of the measurement system, a survey design can be started. The design will be strongly depen-

dent upon the "Network Geometry" specifications for that measurement system. Of particular importance is the requirement to connect to previously established control points. If this is not done, then the survey cannot be placed on the national datum. An adequate number of existing control point connections are often required in the specifications in order to ensure strong network geometry for other users of the control, and to provide several closure checks to help measure accuracy. NGS can certify the results of a survey only if it is connected to the national network.

Situations will arise where one cannot, or prefers not to, conform to the specifications. NGS may downgrade the classification of a survey based upon failure to adhere to the measurement system specifications if the departure degrades the precision, accuracy, or utility of the survey. On the other hand, if specification requirements for the desired level of accuracy are exceeded, it may be possible to upgrade a survey to a higher classification.

Depending upon circumstances, one may wish to go into the field to recover old control and perform reconnaissance and site inspection for the new survey. Monumentation may be performed at this stage. Instruments should be checked to conform to the "Instrumentation" specifications, and to meet the "Calibration Procedures" specifications. Frequent calibration is an excellent method to help ensure accurate surveys.

In the field, the "Field Procedures" specifications are used to guide the methods for taking survey measurements. It must be stressed that the "Field Procedures" section is not an exhaustive account of how to perform observations. Reference should be made also to the appropriate manuals of observation methods and instruments.

Computational checks can be found in the "Field Procedures" as well as in the "Office Procedures" specifications, since one will probably want to perform some of the computations in the field to detect blunders. It is not necessary for the user to do the computations described in the "Office Procedures" specifications, since they will be done by NGS. However, it is certainly in the interest of the user to compute these checks before leaving the field, in case reobservations are necessary. With the tremendous increase in programmable calculator and small computer technology, any of the computations in the "Office Procedures" specifications could be done with ease in the field.

At this point the survey measurements have been collected, together with the new description and recovery notes of the stations in the new survey. They are then placed into the formats specified in the Federal Geodetic Control Committee (FGCC) publications *Input Formats and Specifications of the National Geodetic Survey Data Base*. Further details of this process can be found in appendix C, "Procedures for Submitting Data to the National Geodetic Survey."

The data and supporting documentation, after being received at NGS, are processed through a quality control

procedure to make sure that all users may place confidence in the new survey points. First, the data and documentation are examined for compliance with the measurement system specifications for the intended accuracy of the new survey. Then office computations are performed, including a minimally constrained least squares adjustment. (See appendix B for details.) From this adjustment, accuracy measures can be computed by error propagation. The accuracy classification thus computed is called the "provisional accuracy" of the survey.

The provisional accuracy is compared to the intended accuracy. The difference indicates the departure of the accuracy of the survey from the specifications. If the difference is small, the intended accuracy has precedence because a possible shift in classification is not warranted. However, if the difference is substantial, the provisional accuracy will supersede the intended accuracy, either as a downgrade or an upgrade.

As the final step in the quality control procedure, the variance factor ratio computation using established control, as explained in the section on "Standards," is determined for the new survey. If this result meets the criteria stated there, then the survey is classified in accordance with the provisional accuracy (or intended accuracy, whichever has precedence).

Cases arise where the variance factor ratio is significantly larger than expected. Then the control network is at fault, or the new survey is subject to some unmodeled error source which degrades its accuracy. Both the established control measurements and the new survey measurements will be scrutinized by NGS to determine the source of the problem. In difficult cases, NGS may make diagnostic measurements in the field.

Upon completion of the quality control check, the survey measurements and datum values are placed into the data base. They become immediately available for electronic retrieval, and will be distributed in the next publication cycle by the National Geodetic Information Branch of NGS.

A final remark bears on the relationship between the classification standards and measurement system specifications. Specifications are combinations of rules of thumb and studies of error propagation, based upon experience, of how to best achieve a desired level of quality. Unfortunately, there is no guarantee that a particular standard will be met if the associated specifications are followed. However, the situation is ameliorated by a safety factor of two incorporated in the standards and specifications. Because of this safety factor, it is possible that one may fail to meet the specifications and still satisfy the desired standard. This is why the geodetic control is not automatically downgraded when one does not adhere to the specifications. Slight departures from the specifications can be accommodated. In practice, one should always strive to meet the measurement system specifications when extending a National Geodetic Control Network.

2. Standards

The classification standards of the National Geodetic Control Networks are based on accuracy. This means that when control points in a particular survey are classified, they are certified as having datum values consistent with all other points in the network, not merely those within that particular survey. It is not observation closures within a survey which are used to classify control points, but the ability of that survey to duplicate already established control values. This comparison takes into account models of crustal motion, refraction, and any other systematic effects known to influence the survey measurements.

The NGS procedure leading to classification covers four steps:

1. The survey measurements, field records, sketches, and other documentation are examined to verify compliance with the specifications for the intended accuracy of the survey. This examination may lead to a modification of the intended accuracy.
2. Results of a minimally constrained least squares adjustment of the survey measurements are examined to ensure correct weighting of the observations and freedom from blunders.
3. Accuracy measures computed by random error propagation determine the provisional accuracy. If the provisional accuracy is substantially different from the intended accuracy of the survey, then the provisional accuracy supersedes the intended accuracy.
4. A variance factor ratio for the new survey combined with network data is computed by the Iterated Almost Unbiased Estimator (IAUE) method (appendix B). If the variance factor ratio is reasonably close to 1.0 (typically less than 1.5), then the survey is considered to check with the network, and the survey is classified with the provisional (or intended) accuracy. If the variance factor ratio is much greater than 1.0 (typically 1.5 or greater), then the survey is considered to not check with the network, and both the survey and network measurements will be scrutinized for the source of the problem.

2.1 Horizontal Control Network Standards

When a horizontal control point is classified with a particular order and class, NGS certifies that the geodetic latitude and longitude of that control point bear a

relation of specific accuracy to the coordinates of all other points in the horizontal control network. This relation is expressed as a distance accuracy, 1:a. A distance accuracy is the ratio of the relative positional error of a pair of control points to the horizontal separation of those points.

Table 2.1—Distance accuracy standards

<i>Classification</i>	<i>Minimum distance accuracy</i>
First-order	1:100,000
Second-order, class I	1: 50,000
Second-order, class II	1: 20,000
Third-order, class I	1: 10,000
Third-order, class II	1: 5,000

A distance accuracy, 1:a, is computed from a minimally constrained, correctly weighted, least squares adjustment by:

$$a = d/s$$

where

a=distance accuracy denominator

s=propagated standard deviation of distance between survey points obtained from the least squares adjustment

d=distance between survey points

The distance accuracy pertains to all pairs of points (but in practice is computed for a sampling of pairs of points). The worst distance accuracy (smallest denominator) is taken as the provisional accuracy. If this is substantially larger or smaller than the intended accuracy, then the provisional accuracy takes precedence.

As a test for systematic errors, the variance factor ratio of the new survey is computed by the Iterated Almost Unbiased Estimator (IAUE) method described in appendix B. This computation combines the new survey measurements with existing network data, which are assumed to be correctly weighted and free of systematic error. If the variance factor ratio is substantially greater than unity then the survey does not check with the network, and both the survey and the network data will be examined by NGS.

Computer simulations performed by NGS have shown that a variance factor ratio greater than 1.5 typically indicates systematic errors between the survey and the network. Setting a cutoff value higher than this could allow undetected systematic error to propagate into the national network. On the other hand, a higher cutoff value might be considered if the survey has only a small number of connections to the network, because this circumstance would tend to increase the variance factor ratio.

In some situations, a survey has been designed in which different sections provide different orders of control. For these multi-order surveys, the computed distance accuracy denominators should be grouped into sets appropriate to the different parts of the survey. Then, the smallest value of a in each set is used to classify the control points of that portion, as discussed above. If there are sufficient connections to the network, several variance factor ratios, one for each section of the survey, should be computed.

Horizontal Example

Suppose a survey with an intended accuracy of first-order (1:100,000) has been performed. A series of propagated distance accuracies from a minimally constrained adjustment is now computed.

Line	s (m)	d (m)	$1:a$
1-2	0.141	17,107	1:121,326
1-3	0.170	20,123	1:118,371
2-3	0.164	15,505	1: 94,543
.....	.	.	.
.....	.	.	.
.....	.	.	.

Suppose that the worst distance accuracy is 1:94,543. This is not substantially different from the intended accuracy of 1:100,000, which would therefore have precedence for classification. It is not feasible to precisely quantify "substantially different." Judgment and experience are determining factors.

Now assume that a solution combining survey and network data has been obtained (as per appendix B), and that a variance factor ratio of 1.2 was computed for the survey. This would be reasonably close to unity, and would indicate that the survey checks with the network. The survey would then be classified as first-order using the intended accuracy of 1:100,000.

However, if a variance factor of, say, 1.9 was computed, the survey would not check with the network. Both the survey and network measurements then would have to be scrutinized to find the problem.

Monumentation

Control points should be part of the National Geodetic Horizontal Network only if they possess permanence, horizontal stability with respect to the Earth's crust, and a

horizontal location which can be defined as a point. A 30-centimeter-long wooden stake driven into the ground, for example, would lack both permanence and horizontal stability. A mountain peak is difficult to define as a point. Typically, corrosion resistant metal disks set in a large concrete mass have the necessary qualities. First-order and second-order, class I, control points should have an underground mark, at least two monumented reference marks at right angles to one another, and at least one monumented azimuth mark no less than 400 m from the control point. Replacement of a temporary mark by a more permanent mark is not acceptable unless the two marks are connected in timely fashion by survey observations of sufficient accuracy. Detailed information may be found in C&GS *Special Publication* 247, "Manual of geodetic triangulation."

2.2 Vertical Control Network Standards

When a vertical control point is classified with a particular order and class, NGS certifies that the orthometric elevation at that point bears a relation of specific accuracy to the elevations of all other points in the vertical control network. That relation is expressed as an elevation difference accuracy, b . An elevation difference accuracy is the relative elevation error between a pair of control points that is scaled by the square root of their horizontal separation traced along existing level routes.

Table 2.2—Elevation accuracy standards

Classification	Maximum elevation difference accuracy
First-order, class I	0.5
First-order, class II	0.7
Second-order, class I	1.0
Second-order, class II	1.3
Third-order	2.0

An elevation difference accuracy, b , is computed from a minimally constrained, correctly weighted, least squares adjustment by

$$b = S/\sqrt{d}$$

where

d =approximate horizontal distance in kilometers between control point positions traced along existing level routes.

S =propagated standard deviation of elevation difference in millimeters between survey control points obtained from the least squares adjustment. Note that the units of b are (mm)/ $\sqrt{(\text{km})}$.

The elevation difference accuracy pertains to all pairs of points (but in practice is computed for a sample). The worst elevation difference accuracy (largest value) is taken

as the provisional accuracy. If this is substantially larger or smaller than the intended accuracy, then the provisional accuracy takes precedence.

As a test for systematic errors, the variance factor ratio of the new survey is computed by the Iterated Almost Unbiased Estimator (IAUE) method described in appendix B. This computation combines the new survey measurements with existing network data, which are assumed to be correctly weighted and free of systematic error. If the variance factor ratio is substantially greater than unity, then the survey does not check with the network, and both the survey and the network data will be examined by NGS.

Computer simulations performed by NGS have shown that a variance factor ratio greater than 1.5 typically indicates systematic errors between the survey and the network. Setting a cutoff value higher than this could allow undetected systematic error to propagate into the national network. On the other hand, a higher cutoff value might be considered if the survey has only a small number of connections to the network, because this circumstance would tend to increase the variance factor ratio.

In some situations, a survey has been designed in which different sections provide different orders of control. For these multi-order surveys, the computed elevation difference accuracies should be grouped into sets appropriate to the different parts of the survey. Then, the largest value of b in each set is used to classify the control points of that portion, as discussed above. If there are sufficient connections to the network, several variance factor ratios, one for each section of the survey, should be computed.

Vertical Example

Suppose a survey with an intended accuracy of second-order, class II has been performed. A series of propagated elevation difference accuracies from a minimally constrained adjustment is now computed.

Line	S (mm)	d (km)	b (mm)/ $\sqrt{(km)}$
1-2	1.574	1.718	1.20
1-3	1.743	2.321	1.14
2-3	2.647	4.039	1.32
.....	.	.	.
.....	.	.	.
.....	.	.	.

Suppose that the worst elevation difference accuracy is 1.32. This is not substantially different from the intended accuracy of 1.3 which would therefore have precedence for classification. It is not feasible to precisely quantify "substantially different." Judgment and experience are determining factors.

Now assume that a solution combining survey and network data has been obtained (as per appendix B), and

that a variance factor ratio of 1.2 was computed for the survey. This would be reasonably close to unity and would indicate that the survey checks with the network. The survey would then be classified as second-order, class II, using the intended accuracy of 1.3.

However, if a survey variance factor ratio of, say, 1.9 was computed, the survey would not check with the network. Both the survey and network measurements then would have to be scrutinized to find the problem.

Monumentation

Control points should be part of the National Geodetic Vertical Network only if they possess permanence, vertical stability with respect to the Earth's crust, and a vertical location that can be defined as a point. A 30-centimeter-long wooden stake driven into the ground, for example, would lack both permanence and vertical stability. A rooftop lacks stability and is difficult to define as a point. Typically, corrosion resistant metal disks set in large rock outcrops or long metal rods driven deep into the ground have the necessary qualities. Replacement of a temporary mark by a more permanent mark is not acceptable unless the two marks are connected in timely fashion by survey observations of sufficient accuracy. Detailed information may be found in *NOAA Manual NOS NGS 1*, "Geodetic bench marks."

2.3 Gravity Control Network Standards

When a gravity control point is classified with a particular order and class, NGS certifies that the gravity value at that control point possesses a specific accuracy.

Gravity is commonly expressed in units of milligals (mGal) or microgals (μGal) equal, respectively, to (10^{-5}) meters/sec², and (10^{-6}) meters/sec². Classification order refers to measurement accuracies and class to site stability.

Table 2.3—Gravity accuracy standards

Classification	Gravity accuracy (μGal)
First-order, class I	20 (subject to stability verification)
First-order, class II	20
Second-order	50
Third-order	100

When a survey establishes only new points, and where only absolute measurements are observed, then each survey point is classified independently. The standard deviation from the mean of measurements observed at that point is corrected by the error budget for noise sources in accordance with the following formula:

$$c^2 = \sum_{i=1}^n \frac{(x_i - x_m)^2}{n-1} + e^2$$

where

c = gravity accuracy

x_i = gravity measurement

n = number of measurements

$$x_m = (\sum_{i=1}^n x_i) / n$$

e = external random error

The value obtained for c is then compared directly against the gravity accuracy standards table.

When a survey establishes points at which both absolute and relative measurements are made, the absolute determination ordinarily takes precedence and the point is classified accordingly. (However, see Example D below for an exception.)

When a survey establishes points where only relative measurements are observed, and where the survey is tied to the National Geodetic Gravity Network, then the gravity accuracy is identified with the propagated gravity standard deviation from a minimally constrained, correctly weighted, least squares adjustment.

The worst gravity accuracy of all the points in the survey is taken as the provisional accuracy. If the provisional accuracy exceeds the gravity accuracy limit set for the intended survey classification, then the survey is classified using the provisional accuracy.

As a test for systematic errors, the variance factor ratio of the new survey is computed by the Iterated Almost Unbiased Estimator (IAUE) method described in appendix B. This computation combines the new survey measurements with existing network data which are assumed to be correctly weighted and free of systematic error. If the variance factor ratio is substantially greater than unity, then the survey does not check with the network, and both the survey and the network data will be examined by NGS.

Computer simulations performed by NGS have shown that a variance factor ratio greater than 1.5 typically indicates systematic errors between the survey and the network. Setting a cutoff value higher than this could allow undetected systematic error to propagate into the national network. On the other hand, a higher cutoff value might be considered if the survey has only a minimal number of connections to the network, because this circumstance would tend to increase the variance factor ratio.

In some situations, a survey has been designed in which different sections provide different orders of control. For these multi-order surveys, the computed gravity accuracies should be grouped into sets appropriate to the different parts of the survey. Then, the largest value of c in each set is used to classify the control points of that portion, as discussed above. If there are sufficient connections to the network, several variance factor ratios, one for each part of the survey, should be computed.

Gravity Examples

Example A. Suppose a gravity survey using absolute measurement techniques has been performed. These points are then unrelated. Consider one of these survey points.

Assume $n = 750$

$$\sum_{i=1}^{750} (x_i - x_m)^2 = .169 \text{ mGal}^2$$

$$e = 5 \text{ } \mu\text{Gal}$$

$$c^2 = \frac{0.169}{750-1} + (.005)^2$$

$$c = 16 \text{ } \mu\text{Gal}$$

The point is then classified as first-order, class II.

Example B. Suppose a relative gravity survey with an intended accuracy of second-order (50 μGal) has been performed. A series of propagated gravity accuracies from a minimally constrained adjustment is now computed.

Station	Gravity standard deviation (μGal)
1	38
2	44
3	55
.	.
.	.
.	.

Suppose that the worst gravity accuracy was 55 μGal . This is worse than the intended accuracy of 50 μGal . Therefore, the provisional accuracy of 55 μGal would have precedence for classification, which would be set to third-order.

Now assume that a solution combining survey and network data has been obtained (as per appendix B) and that a variance factor of 1.2 was computed for the survey. This would be reasonably close to unity, and would indicate that the survey checks with the network. The survey would then be classified as third-order using the provisional accuracy of 55 μGal .

However, if a variance factor of, say, 1.9 was computed, the survey would not check with the network. Both the survey and network measurements then would have to be scrutinized to find the problem.

Example C. Suppose a survey consisting of both absolute and relative measurements has been made at the same points. Assume the absolute observation at one of the points yielded a classification of first-order, class II, whereas the relative measurements produced a value to second-order standards. The point in question would be classified as first-order, class II, in accordance with the absolute observation.

Example D. Suppose we have a survey similar to Case C, where the absolute measurements at a particular point

yielded a third-order classification due to an unusually noisy observation session, but the relative measurements still satisfied the second-order standard. The point in question would be classified as second-order, in accordance with the relative measurements.

Monumentation

Control points should be part of the National Geodetic Gravity Network only if they possess permanence, horizontal and vertical stability with respect to the Earth's crust, and a horizontal and vertical location which can be defined as a point. For all orders of accuracy, the mark should be imbedded in a stable platform such as flat, horizontal concrete. For first-order, class I stations, the platform should be imbedded in stable, hard rock, and

checked at least twice for the first year to ensure stability. For first-order, class II stations, the platform should be located in an extremely stable environment, such as the concrete floor of a mature structure. For second and third-order stations, standard bench mark monumentation is adequate. Replacement of a temporary mark by a more permanent mark is not acceptable unless the two marks are connected in timely fashion by survey observations of sufficient accuracy. Detailed information is given in *NOAA Manual NOS NGS 1*, "Geodetic bench marks." Monuments should not be near sources of electromagnetic interference.

It is recommended, but not necessary, to monument third-order stations. However, the location associated with the gravity value should be recoverable, based upon the station description.

3. Specifications

3.1 Introduction

All measurement systems regardless of their nature have certain common qualities. Because of this, the measurement system specifications follow a prescribed structure as outlined below. These specifications describe the important components and state permissible tolerances used in a general context of accurate surveying methods. The user is cautioned that these specifications are not substitutes for manuals that detail recommended field operations and procedures.

The observations will have spatial or temporal relationships with one another as given in the "Network Geometry" section. In addition, this section specifies the frequency of incorporation of old control into the survey. Computer simulations could be performed instead of following the "Network Geometry" and "Field Procedures" specifications. However, the user should consult the National Geodetic Survey before undertaking such a departure from the specifications.

The "Instrumentation" section describes the types and characteristics of the instruments used to make observations. An instrument must be able to attain the precision requirements given in "Field Procedures."

The section "Calibration Procedures" specifies the nature and frequency of instrument calibration. An instrument must be calibrated whenever it has been damaged or repaired.

The "Field Procedures" section specifies particular rules and limits to be met while following an appropriate method of observation. For a detailed account of how to perform observations, the user should consult the appropriate manuals.

Since NGS will perform the computations described under "Office Procedures," it is not necessary for the user to do them. However, these computations provide valuable checks on the survey measurements that could indicate the need for some reobservations. This section specifies commonly applied corrections to observations, and computations which monitor the precision and accuracy of the survey. It also discusses the correctly weighted, minimally constrained least squares adjustment used to ensure that the survey work is free from blunders and able to achieve the intended accuracy. Results of the least squares adjustment are used in the quality control and accuracy classification procedures. The adjustment

performed by NGS will use models of error sources, such as crustal motion, when they are judged to be significant to the level of accuracy of the survey.

3.2 Triangulation

Triangulation is a measurement system comprised of joined or overlapping triangles of angular observations supported by occasional distance and astronomic observations. Triangulation is used to extend horizontal control.

Network Geometry

Order Class	First	Second I	Second II	Third I	Third II
Station spacing not less than (km)	15	10	5	0.5	0.5
Average minimum distance angle† of figures not less than	40°	35°	30°	30°	25°
Minimum distance angle† of all figures not less than	30°	25°	25°	20°	20°
Base line spacing not more than (triangles)	5	10	12	15	15
Astronomic azimuth spacing not more than (triangles)	8	10	10	12	15

† Distance angle is angle opposite the side through which distance is propagated.

The new survey is required to tie to at least four network control points spaced well apart. These network points must have datum values equivalent to or better than the intended order (and class) of the new survey. For example, in an arc of triangulation, at least two network control points should be occupied at each end of the arc. Whenever the distance between two new unconnected survey points is less than 20 percent of the distance between those points traced along existing or new connections, then a direct connection should be made between those two survey points. In addition, the survey should tie into any sufficiently accurate network control points within the station spacing distance of the survey. These network stations should be occupied and sufficient observations taken to make these stations integral parts of the survey. Nonredundant geodetic connections to the network stations are not considered sufficient ties. Nonredundantly

determined stations are not allowed. Control stations should not be determined by intersection or resection methods. Simultaneous reciprocal vertical angles or geodetic leveling are observed along base lines. A base line need not be observed if other base lines of sufficient accuracy were observed within the base line spacing specification in the network, and similarly for astronomic azimuths.

Instrumentation

Only properly maintained theodolites are adequate for observing directions and azimuths for triangulation. Only precisely marked targets, mounted stably on tripods or supported towers, should be employed. The target should have a clearly defined center, resolvable at the minimum control spacing. Optical plummets or collimators are required to ensure that the theodolites and targets are centered over the marks. Microwave-type electronic distance measurement (EDM) equipment is not sufficiently accurate for measuring higher-order base lines.

Order Class	First	Second I	Second II	Third I	Third II
Theodolite, least count	0.2"	0.2"	1.0"	1.0"	1.0"

Calibration Procedures

Each year and whenever the difference between direct and reverse readings of the theodolite depart from 180° by more than 30", the instrument should be adjusted for collimation error. Readjustment of the cross hairs and the level bubble should be done whenever their misadjustments affect the instrument reading by the amount of the least count.

All EDM devices and retroreflectors should be serviced regularly and checked frequently over lines of known distances. The National Geodetic Survey has established specific calibration base lines for this purpose. EDM instruments should be calibrated annually, and frequency checks made semiannually.

Field Procedures

Theodolite observations for first-order and second-order, class I surveys may only be made at night. Reciprocal vertical angles should be observed at times of best atmospheric conditions (between noon and late afternoon) for all orders of accuracy. Electronic distance measurements need a record at both ends of the line of wet and dry bulb temperatures to $\pm 1^\circ\text{C}$, and barometric pressure to ± 5 mm of mercury. The theodolite and targets should be centered to within 1 mm over the survey mark or eccentric point.

Order Class	First	Second I	Second II	Third I	Third II
Directions					
Number of positions	16	16	8 or 12†	4	2

Order Class	First	Second I	Second II	Third I	Third II
Standard deviation of mean not to exceed	0.4"	0.5"	0.8"	1.2"	2.0"
Rejection limit from the mean	4"	4"	5"	5"	5"
Reciprocal Vertical Angles (along distance sight path)					
Number of independent observations					
direct/reverse	3	3	2	2	2
Maximum spread	10"	10"	10"	10"	20"
Maximum time interval between reciprocal angles (hr)	1	1	1	1	1
Astronomic Azimuths					
Observations per night	16	16	16	8	4
Number of nights	2	2	1	1	1
Standard deviation of mean not to exceed	0.45"	0.45"	0.6"	1.0"	1.7"
Rejection limit from the mean	5"	5"	5"	6"	6"
Electro-Optical Distances					
Minimum number of days ..	2*	2*	1	1	1
Minimum number of measurements/day	2§	2§	2§	1	1
Minimum number of concentric observations/measurement	2	2	1	1	1
Minimum number of offset observations/measurement	2	2	2	1	1
Maximum difference from mean of observations (mm)	40	40	50	60	60
Minimum number of readings/observation (or equivalent)	10	10	10	10	10
Maximum difference from mean of readings (mm) ..	‡	‡	‡	‡	‡
Infrared Distances					
Minimum number of days ..	—	2*	1	1	1
Minimum number of measurements	—	2§	2§	1	1
Minimum number of concentric observations/measurement	—	1	1	1	1
Minimum number of offset observations/measurement	—	2	1	1	1
Maximum difference from mean of observations (mm)	—	5	5	10	10
Minimum number of readings/observation (or equivalent)	—	10	10	10	10
Maximum difference from mean of readings (mm) ..	—	‡	‡	‡	‡
Microwave Distances					
Minimum number of measurements	—	—	—	2	1
Minimum time span between measurements (hr)	—	—	—	8	—

Order Class	First	Second I	Second II	Third I	Third II
Maximum difference between measurements (mm)	—	—	—	100	—
Minimum number of con- centric observations/ measurement	—	—	—	2**	1**
Maximum difference from mean of observations (mm)	—	—	—	100	150
Minimum number of readings/observation (or equivalent)	—	—	—	20	20
Maximum difference from mean of readings (mm) ..	—	—	—	‡	‡

† 8 if 0.2", 12 if 1.0" resolution.

* two or more instruments.

§ one measurement at each end of the line.

‡ as specified by manufacturer.

** carried out at both ends of the line.

Measurements of astronomic latitude and longitude are not required in the United States, except perhaps for first-order work, because sufficient information for determining deflections of the vertical exists. Detailed procedures can be found in Hoskinson and Duerksen (1952).

Office Procedures

Order Class	First	Second I	Second II	Third I	Third II
Triangle Closure					
Average not to exceed	1.0"	1.2"	2.0"	3.0"	5.0"
Maximum not to exceed	3"	3"	5"	5"	10"
Side Checks					
Mean absolute correction by side equation not to exceed	0.3"	0.4"	0.6"	0.8"	2.0"

A minimally constrained least squares adjustment will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation in this correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models which account for the following:

semimajor axis of the ellipsoid($a = 6378137$ m)
reciprocal flattening of the ellipsoid($1/f = 298.257222$)
mark elevation above mean sea level(known to ± 1 m)
geoid heights(known to ± 6 m)
deflections of the vertical(known to $\pm 3''$)
geodesic correction
skew normal correction
height of instrument
height of target
sea level correction

arc correction
geoid height correction
second velocity correction
crustal motion

3.3 Traverse

Traverse is a measurement system comprised of joined distance and theodolite observations supported by occasional astronomic observations. Traverse is used to densify horizontal control.

Network Geometry

Order Class	First	Second I	Second II	Third I	Third II
Station spacing not less than (km)	10	4	2	0.5	0.5
Maximum deviation of main traverse from straight line	20°	20°	25°	30°	40°
Minimum number of bench mark ties	2	2	2	2	2
Bench mark tie spacing not more than (segments)	6	8	10	15	20
Astronomic azimuth spacing not more than (segments)	6	12	20	25	40
Minimum number of network control points	4	3	2	2	2

The new survey is required to tie to a minimum number of network control points spaced well apart. These network points must have datum values equivalent to or better than the intended order (and class) of the new survey. Whenever the distance between two new unconnected survey points is less than 20 percent of the distance between those points traced along existing or new connections, then a direct connection must be made between those two survey points. In addition, the survey should tie into any sufficiently accurate network control points within the station spacing distance of the survey. These ties must include EDM or taped distances. Nonredundant geodetic connections to the network stations are not considered sufficient ties. Nonredundantly determined stations are not allowed. Reciprocal vertical angles or geodetic leveling are observed along all traverse lines.

Instrumentation

Only properly maintained theodolites are adequate for observing directions and azimuths for traverse. Only precisely marked targets, mounted stably on tripods or supported towers, should be employed. The target should have a clearly defined center, resolvable at the minimum control spacing. Optical plummets or collimators are required to ensure that the theodolites and targets are centered over the marks. Microwave-type electronic distance measurement equipment is not sufficiently accurate for measuring first-order traverses.

Order Class	First	Second I	Second II	Third I	Third II
Theodolite, least count	0.2"	1.0"	1.0"	1.0"	1.0"

Calibration Procedures

Each year and whenever the difference between direct and reverse readings of the theodolite depart from 180° by more than 30", the instrument should be adjusted for collimation error. Readjustment of the cross hairs and the level bubble should be done whenever their misadjustments affect the instrument reading by the amount of the least count.

All electronic distance measuring devices and retroreflectors should be serviced regularly and checked frequently over lines of known distances. The National Geodetic Survey has established specific calibration base lines for this purpose. EDM instruments should be calibrated annually, and frequency checks made semiannually.

Field Procedures

Theodolite observations for first-order and second-order, class I surveys may be made only at night. Electronic distance measurements need a record at both ends of the line of wet and dry bulb temperatures to $\pm 1^\circ\text{C}$ and barometric pressure to ± 5 mm of mercury. The theodolite, EDM, and targets should be centered to within 1 mm over the survey mark or eccentric point.

Order Class	First	Second I	Second II	Third I	Third II
Directions					
Number of positions	16	8 or 12†	6 or 8*	4	2
Standard deviation of mean					
not to exceed	0.4"	0.5"	0.8"	1.2"	2.0"
Rejection limit from the mean	4"	5"	5"	5"	5"
Reciprocal Vertical Angles (along distance sight path)					
Number of independent					
observations direct/reverse	3	3	2	2	2
Maximum spread	10"	10"	10"	10"	20"
Maximum time interval between reciprocal angles (hr)	1	1	1	1	1
Astronomic Azimuths					
Observations per night	16	16	12	8	4
Number of nights	2	2	1	1	1
Standard deviation of mean					
not to exceed	0.45"	0.45"	0.6"	1.0"	1.7"
Rejection limit from the mean	5"	5"	5"	6"	6"

Electro-Optical Distances

Minimum number of					
measurements	1	1	1	1	1
Minimum number of concentric					
observations/measurement	1	1	1	1	1
Minimum number of offset					
observations/measurement	1	1	—	—	—
Maximum difference from					
mean of observations (mm)	60	60	—	—	—

Order Class	First	Second I	Second II	Third I	Third II
Minimum number of readings/ observation (or equivalent)	10	10	10	10	10
Maximum difference from mean of readings (mm)	\$	\$	\$	\$	\$
Infrared Distances					
Minimum number of					
measurements	1	1	1	1	1
Minimum number of concentric					
observations/measurement	1	1	1	1	1
Minimum number of offset					
observations/measurement	1	1	1‡	—	—
Maximum difference from mean of observations (mm)	10	10	10‡	—	—
Minimum number of readings/ observation	10	10	10	10	10
Maximum difference from mean of readings (mm)	\$	\$	\$	\$	\$
Microwave Distances					
Minimum number of					
measurements	—	1	1	1	1
Minimum number of concentric					
observations/measurement	—	2**	1**	1**	1**
Maximum difference from mean of observations (mm)	—	150	150	200	200
Minimum number of readings/ observation	—	20	20	10	10
Maximum difference from mean of readings (mm)	—	\$	\$	\$	\$

† 8 if 0.2", 12 if 1.0" resolution.

* 6 if 0.2", 8 if 1.0" resolution.

\$ as specified by manufacturer.

‡ only if decimal reading near 0 or high 9's.

** carried out at both ends of the line.

Measurements of astronomic latitude and longitude are not required in the United States, except perhaps for first-order work, because sufficient information for determining deflections of the vertical exists. Detailed procedures can be found in Hoskinson and Duerksen (1952).

Office Procedures

Order Class	First	Second I	Second II	Third I	Third II
Azimuth closure					
at azimuth					
check point					
(seconds of arc) .	1.7√N	3.0√N	4.5√N	10.0√N	12.0√N
Position closure	0.04√K	0.08√K	0.20√K	0.40√K	0.80√K
after azimuth ...	or	or	or	or	or
adjustment†	1:100,000	1:50,000	1:20,000	1:10,000	1:5,000

(N is number of segments, K is route distance in km)

† The expression containing the square root is designed for longer lines where higher proportional accuracy is required. Use the formula that gives the smallest permissible closure. The closure (e.g., 1:100,000) is obtained by computing the difference between the computed and fixed values, and dividing this difference by K.

Note: Do not confuse closure with distance accuracy of the survey.

A minimally constrained least squares adjustment will be checked for blunders by examining the normalized residuals. The observation weights will be checked by

inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation in a correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models which account for the following:

semimajor axis of the ellipsoid	($a = 6378137$ m)
reciprocal flattening of the ellipsoid	($1/f = 298.257222$)
mark elevation above mean sea level	(known to ± 1 m)
geoid heights	(known to ± 6 m)
deflections of the vertical	(known to $\pm 3''$)
geodesic correction	
skew normal correction	
height of instrument	
height of target	
sea level correction	
arc correction	
geoid height correction	
second velocity correction	
crustal motion	

3.4 Inertial Surveying

Inertial surveying is a measurement system comprised of lines, or a grid, of Inertial Surveying System (ISS) observations. These specifications cover use of inertial systems only for horizontal control.

Network Geometry

Order Class	Second I	Second II	Third I	Third II
Station spacing not less than (km)	10	4	2	1
Maximum deviation from straight line connecting endpoints	20°	25°	30°	35°

Each inertial survey line is required to tie into a minimum of four horizontal network control points spaced well apart and should begin and end at network control points. These network control points must have horizontal datum values better than the intended order (and class) of the new survey. Whenever the shortest distance between two new unconnected survey points is less than 20 percent of the distance between those points traced along existing or new connections, then a direct connection should be made between those two survey points. In addition, the survey should connect to any sufficiently accurate network control points within the distance specified by the station spacing. The connections may be measured by EDM or tape traverse, or by another ISS line. If an ISS line is used, then these lines should follow the same specifications as all other ISS lines in the survey.

For extended area surveys by ISS, a grid of intersecting lines that satisfies the 20 percent rule stated above can be designed. There must be a mark at each intersection of the lines. This mark need not be a permanent monument; it may be a stake driven into the ground. For a position to

receive an accuracy classification, it must be permanently monumented.

A grid of intersecting lines should contain a minimum of eight network points, and should have a network control point at each corner. The remaining network control points may be distributed about the interior or the periphery of the grid. However, there should be at least one network control point at an intersection of the grid lines near the center of the grid. If the required network points are not available, then they should be established by some other measurement system. Again, the horizontal datum values of these network control points must have an order (and class) better than the intended order (and class) of the new survey.

Instrumentation

ISS equipment falls into two types: analytic (or strapdown) and semianalytic. Analytic inertial units are not considered to possess geodetic accuracy. Semianalytic units are either "space stable" or "local level." Space stable systems maintain the orientation of the platform with respect to inertial space. Local level systems continuously torque the accelerometers to account for Earth rotation and movement of the inertial unit, and also torque the platform to coincide with the local level. This may be done on command at a coordinate update, or whenever the unit achieves zero velocity (Zero velocity UPdaTe, or "ZUPT"). Independently of the measurement technique, the recorded data may be filtered by an onboard computer. Because of the variable quality of individual ISS instruments, the user should test an instrument with existing geodetic control beforehand.

An offset measurement device accurate to within 5 mm should be affixed to the inertial unit or the vehicle.

Calibration Procedures

A static calibration should be performed yearly and immediately after repairs affecting the platform, gyroscopes, or accelerometers.

A dynamic or field calibration should be performed prior to each project or subsequent to a static calibration. The dynamic calibration should be performed only between horizontal control points of first-order accuracy and in each cardinal direction. The accelerometer scale factors from this calibration should be recorded and, if possible, stored in the onboard computer of the inertial unit.

Before each project or after repairs affecting the offset measurement device or the inertial unit, the relation between the center of the inertial unit and the zero point of the offset measurement device should be established.

Field Procedures

When surveying in a helicopter, the helicopter must come to rest on the ground for all ZUPT's and all measurements.

Order Class	Second I	Second II	Third I	Third II
Minimum number of complete runs per line	2	1	1	1
Maximum deviation from a uniform rate of travel (including ZUPT)	15%	20%	25%	30%
Maximum ZUPT interval (ZUPT to ZUPT) (sec)	200	240	300	300

A complete ISS measurement consists of measurement of the line while traveling in one direction, followed by measurement of the same line while traveling in the reverse direction (double-run). A coordinate update should not be performed at the far point or at midpoints of a line, even though those coordinates may be known.

The mark offset should be measured to the nearest 5 mm.

Office Procedures

Order Class	Second I	Second II	Third I	Third II
Maximum difference of smoothed coordinates between forward and reverse run (cm)	60	60	70	80

A minimally constrained least squares adjustment of the raw or filtered survey data will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation in this correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use the best available model for the particular inertial system. Weighted averages of individually smoothed lines are not considered substitutes for a combined least squares adjustment to achieve geodetic accuracy.

3.5 Geodetic Leveling

Geodetic leveling is a measurement system comprised of elevation differences observed between nearby rods. Leveling is used to extend vertical control.

Network Geometry

Order Class	First I	First II	Second I	Second II	Third
Bench mark spacing not more than (km)	3	3	3	3	3
Average bench mark spacing not more than (km)	1.6	1.6	1.6	3.0	3.0

<i>Order Class</i>	<i>First I</i>	<i>First II</i>	<i>Second I</i>	<i>Second II</i>	<i>Third</i>
Line length between network control points not more than (km)	300	100	50	50	25
				(double-run)	25
					(single-run) 10

New surveys are required to tie to existing network bench marks at the beginning and end of the leveling line. These network bench marks must have an order (and class) equivalent to or better than the intended order (and class) of the new survey. First-order surveys are required to perform check connections to a minimum of six bench marks, three at each end. All other surveys require a minimum of four check connections, two at each end. "Check connection" means that the observed elevation difference agrees with the adjusted elevation difference within the tolerance limit of the new survey. Checking the elevation difference between two bench marks located on the same structure, or so close together that both may have been affected by the same localized disturbance, is not considered a proper check. In addition, the survey is required to connect to any network control points within 3 km of its path. However, if the survey is run parallel to existing control, then the following table specifies the maximum spacing of extra connections between the survey and the control. At least one extra connection should always be made.

Distance, survey to network	Maximum spacing of extra connections (km)
0.5 km or less	5
0.5 km to 2.0 km	10
2.0 km to 3.0 km	20

Instrumentation

Order Class	First I	First II	Second I	Second II	Third
Leveling instrument					
Minimum repeatability of line of sight	0.25"	0.25"	0.50"	0.50"	1.00"
Leveling rod construction	IDS	IDS	IDS† or ISS	ISS	Wood or Metal
Instrument and rod resolution (combined)					
Least count (mm)	0.1	0.1	0.5-1.0*	1.0	1.0

(IDS—Invar, double scale)

(ISS—Invar, single scale)

† if optional micrometer is used.

* 1.0 mm if 3-wire method, 0.5 mm if optical micrometer.

Only a compensator or tilting leveling instrument with an optical micrometer should be used for first-order leveling. Leveling rods should be one piece. Wooden or metal rods may be employed only for third-order work. A turning point consisting of a steel turning pin with a driving cap should be utilized. If a steel pin cannot be driven, then a turning plate ("turtle") weighing at least 7 kg should be substituted. In situations allowing neither turning pins nor turning plates (sandy or marshy soils), a long wooden stake with a double-headed nail should be driven to a firm depth.

Calibration Procedures

Order Class	First I	First II	Second I	Second II	Third
Leveling instrument					
Maximum collimation error, single line of sight (mm/m)	0.05	0.05	0.05	0.05	0.10
Maximum collimation error, reversible compensator type instruments, mean of two lines of sight (mm/m)	0.02	0.02	0.02	0.02	0.04
Time interval between collimation error determinations not longer than (days)					
Reversible compensator	7	7	7	7	7
Other types	1	1	1	1	7
Maximum angular difference between two lines of sight, reversible compensator	40"	40"	40"	40"	60"
Leveling rod					
Minimum scale calibration standard	N	N	N	M	M
Time interval between scale calibrations (yr)	1	1	—	—	—
Leveling rod bubble verticality maintained to within	10'	10'	10'	10'	10'

(N—National standard)

(M—Manufacturer's standard)

Compensator-type instruments should be checked for proper operation at least every 2 weeks of use. Rod calibration should be repeated whenever the rod is dropped or damaged in any way. Rod levels should be checked for proper alignment once a week. The manufacturer's calibration standard should, as a minimum, describe scale behavior with respect to temperature.

Field Procedures

Order Class	First I	First II	Second I	Second II	Third
Minimal observation					
method	micro-meter	micro-meter	micro-meter or 3-wire	3-wire	center wire
Section running					
	SRDS or DR or SP	SRDS or DR or SP	SRDS or DR† or SP	SRDS or DR* or DR§	SRDS or DR§

Field Procedures—Continued

Order Class	First I	First II	Second I	Second II	Third
Difference of forward and backward sight lengths never to exceed					
per setup (m)	2	5	5	10	10
per section (m)	4	10	10	10	10
Maximum sight length (m) ..	50	60	60	70	90
Minimum ground clearance of line of sight (m)					
	0.5	0.5	0.5	0.5	0.5
Even number of setups when not using leveling rods with detailed calibration					
	yes	yes	yes	yes	—
Determine temperature gradient for the vertical range of the line of sight at each setup					
	yes	yes	yes	—	—
Maximum section misclosure (mm)	3√D	4√D	6√D	8√D	12√D
Maximum loop misclosure (mm)	4√E	5√E	6√E	8√E	12√E
Single-run methods					
Reverse direction of single runs every half day					
	yes	yes	yes	—	—
Nonreversible compensator leveling instruments					
Off-level/relevel instrument between observing the high and low rod scales					
	yes	yes	yes	—	—
3-wire method					
Reading check (difference between top and bottom intervals) for one setup not to exceed (tenths of rod units)					
	—	—	2	2	3
Read rod 1 first in alternate setup method ...					
	—	—	yes	yes	yes
Double scale rods					
Low-high scale elevation difference for one setup not to exceed (mm)					
With reversible compensator					
	0.40	1.00	1.00	2.00	2.00
Other instrument types:					
Half-centimeter rods	0.25	0.30	0.60	0.70	1.30
Full-centimeter rods ...	0.30	0.30	0.60	0.70	1.30

(SRDS—Single-Run, Double Simultaneous procedure)

(DR—Double-Run)

(SP—SPur, less than 25 km, double-run)

D—shortest length of section (one-way) in km

E—perimeter of loop in km

† Must double-run when using 3-wire method.

* May single-run if line length between network control points is less than 25 km.

§ May single-run if line length between network control points is less than 10 km.

Double-run leveling may always be used, but single-run leveling done with the double simultaneous procedure may be used only where it can be evaluated by loop closures. Rods should be leap-frogged between setups

(alternate setup method). The date, beginning and ending times, cloud coverage, air temperature (to the nearest degree), temperature scale, and average wind speed should be recorded for each section plus any changes in the date, instrumentation, observer or time zone. The instrument need not be off-leveled/releveled between observing the high and low scales when using an instrument with a reversible compensator. The low-high scale difference tolerance for a reversible compensator is used only for the control of blunders.

With double scale rods, the following observing sequence should be used:

backsight, low-scale
backsight, stadia
foresight, low-scale
foresight, stadia
off-level/relevel or reverse compensator
foresight, high-scale
backsight, high-scale

Office Procedures

Order Class	First I	First II	Second I	Second II	Third
Section misclosures (backward and forward)					
Algebraic sum of all corrected section misclosures of a leveling line not to exceed (mm)	3√D	4√D	6√D	8√D	12√D
Section misclosure not to exceed (mm)	3√E	4√E	6√E	8√E	12√E
Loop misclosures					
Algebraic sum of all corrected misclosures not to exceed (mm)	4√F	5√F	6√F	8√F	12√F
Loop misclosure not to exceed (mm)	4√F	5√F	6√F	8√F	12√F

(D—shortest length of leveling line (one-way) in km)
(E—shortest one-way length of section in km)
(F—length of loop in km)

The normalized residuals from a minimally constrained least squares adjustment will be checked for blunders. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Elevation difference standard errors computed by error propagation in a correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models that account for:

gravity effect or orthometric correction
rod scale errors
rod (Invar) temperature
refraction—need latitude and longitude to 6" or vertical temperature difference observations between 0.5 and 2.5 m above the ground
earth tides and magnetic field
collimation error
crustal motion

3.6 Photogrammetry

Photogrammetry is a measurement system comprised of photographs taken by a precise metric camera and measured by a comparator. Photogrammetry is used for densification of horizontal control. The following specifications apply only to analytic methods.

Network Geometry

Order Class	Second I	Second II	Third I	Third II
Forward overlap not less than	66%	66%	60%	60%
Side overlap not less than	66%	66%	20%	20%
Intersecting rays per point not less than (design criteria)	9	8	3	3

The photogrammetric survey should be areal: single strips of photography are not acceptable. The survey should encompass, ideally, a minimum of eight horizontal control points and four vertical points spaced about the perimeter of the survey. In addition, the horizontal control points should be spaced no farther apart than seven air bases. The horizontal control points should have an order (and class) better than the intended order (and class) of the survey. The vertical points need not meet geodetic control standards. If the required control points are not available, then they must be established by some other measurement system.

Instrumentation

Order Class	Second I	Second II	Third I	Third II
Metric Camera				
Maximum warp of platen not more than (μm)	10	10	10	10
Dimensional control not less than	reseau with maximum spacing of 2 cm	8 fiducials	8 fiducials	8 fiducials
Comparator				
Least count (μm)	1	1	1	1

The camera should be of at least the quality of those employed for large-scale mapping. A platen should be included onto which the film must be satisfactorily flattened during exposure. Note that a reseau should be used for second-order, class I surveys.

Calibration Procedures

Order Class	Second I	Second II	Third I	Third II
Metric camera				
Root mean square of calibrated radial distortion not more than (μm)	1	3	3	5

Calibration Procedures—Continued

Order Class	Second I	Second II	Third I	Third II
Root mean square of calibrated decentering distortion not more than (μm)	1	5†	5†	5†
Root mean square of reseau coordinates not more than (μm)	1	1	3	3
Root mean square of fiducial coordinates not more than (μm)	—	1	3	3

† not usually treated separately in camera calibration facilities; manufacturer's certification is satisfactory.

The metric camera should be calibrated every 2 years, and the comparator should be calibrated every 6 months. These instruments should also be calibrated after repair or modifications.

Characteristics of the camera's internal geometry (radial symmetric distortion, decentered lens distortion, principal point and point of symmetry coordinates, and reseau coordinates) should be determined using recognized calibration techniques, like those described in the current edition of the *Manual of Photogrammetry*. These characteristics will be applied as corrections to the measured image coordinates.

Field Procedures

Photogrammetry involves hybrid measurements: a metric camera photographs targets and features in the field, and a comparator measures these photographs in an office environment. Although this section is entitled "Field Procedures," it deals with the actual measurement process and thus includes comparator specifications.

Order Class	Second I	Second II	Third I	Third II
Targets				
Control points targeted	yes	yes	yes	yes
Pass points targeted	yes	yes	optional	optional
Comparator				
Pointings per target not less than	4	3	2	2
Pointings per reseau (or fiducial) not less than	4	3	2	2
Number of different reseau intersections per target not less than	4	—	—	—
Rejection limit from mean of pointings per target (μm)	3	3	3	3

Office Procedures

Order Class	Second I	Second II	Third I	Third II
Root mean square of adjusted photocoordinates not more than (μm)	4	6	8	12

A least squares adjustment of the photocoordinates, constrained by the coordinates of the horizontal and vertical control points, will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation in this correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models that incorporate the quantities determined by calibration.

3.7 Satellite Doppler Positioning

Satellite Doppler positioning is a three-dimensional measurement system based on the radio signals of the U.S. Navy Navigational Satellite System (NNSS), commonly referred to as the TRANSIT system. Satellite Doppler positioning is used primarily to establish horizontal control.

The Doppler observations are processed to determine station positions in Cartesian coordinates, which can be transformed to geodetic coordinates (geodetic latitude and longitude and height above reference ellipsoid). There are two methods by which station positions can be derived: point positioning and relative positioning.

Point positioning, for geodetic applications, requires that the processing of the Doppler data be performed with the precise ephemerides that are supplied by the Defense Mapping Agency. In this method, data from a single station is processed to yield the station coordinates.

Relative positioning is possible when two or more receivers are operated together in the survey area. The processing of the Doppler data can be performed in four modes: simultaneous point positioning, translocation, semishort arc, and short arc. The specifications for relative positioning are valid only for data reduced by the semishort or short arc methods. The semishort arc mode allows up to 5 degrees of freedom in the ephemerides; the short arc mode allows 6 or more degrees of freedom. These modes allow the use of the broadcast ephemerides in place of the precise ephemerides.

The specifications quoted in the following sections are based on the experience gained from the analysis of Doppler surveys performed by agencies of the Federal government. Since the data are primarily from surveys performed within the continental United States, the precisions and related specifications may not be appropriate for other areas of the world.

Network Geometry

The order of a Doppler survey is determined by: the spacing between primary Doppler stations, the order of the base network stations from which the primaries are established, and the method of data reduction that is used. The order and class of a survey cannot exceed the

lowest order (and class) of the base stations used to establish the survey.

The primary stations should be spaced at regular intervals which meet or exceed the spacing required for the desired accuracy of the survey. The primary stations will carry the same order as the survey.

Supplemental stations may be established in the same survey as the primary stations. The lowest order (and class) of a supplemental station is determined either by its spacing with, or by the order of, the nearest Doppler or other horizontal control station. The processing mode determines the allowable station spacing.

In carrying out a Doppler survey, one should occupy, using the same Doppler equipment and procedures, at least two existing horizontal network (base) stations of order (and class) equivalent to, or better than, the intended order (and class) of the Doppler survey. If the Doppler survey is to be first-order, at least three base stations must be occupied. If relative positioning is to be used, all base station base lines must be directly observed during the survey. Base stations should be selected near the perimeter of the survey, so as to encompass the entire survey.

Stations which have a precise elevation referenced by geodetic leveling to the National Geodetic Vertical Datum (NGVD) are preferred. This will allow geoidal heights to be determined. As many base stations as possible should be tied to the NGVD. If a selection is to be made, those stations should be chosen which span the largest portion of the survey.

If none of the selected base stations is tied to the NGVD, at least two, preferably more, bench marks of the NGVD should be occupied. An attempt should be made to span the entire survey area.

Datum shifts for transformation of point position solutions should be derived from the observations made on the base stations.

The minimum spacing, D , of the Doppler stations may be computed by a formula determined by the processing mode to be employed. This spacing is also used in conjunction with established control, and other Doppler control, to determine the order and class of the supplemental stations.

By using the appropriate formula, tables can be constructed showing station spacing as a function of point or relative one-sigma position precision (s_p or s_r) and desired survey (or station) order.

Point Positioning

$$D = 2\sqrt{2} s_p a$$

where

a = denominator of distance accuracy classification standard (e.g., $a = 100,000$ for first-order standard).

Order Class	First I	Second II	Second II	Third I	Third II
s_p (cm)	D (km)				
200	566	242	114	56	28
100	283	141	57	28	14
70	200	100	40	20	10
50	141	71	26	14	7

Relative Positioning

$$D = 2 s_r a$$

where

a = denominator of distance accuracy classification standard (e.g., $a = 100,000$ for first-order standard).

Order Class	First I	Second II	Second II	Third I	Third II
s_r (cm)	D (km)				
50	100	50	20	10	5
35	70	35	14	7	4
20	40	20	8	4	2

However, the spacing for relative positioning should not exceed 500 km.

Instrumentation

The receivers should receive the two carrier frequencies transmitted by the NNSS. The receivers should record the Doppler count of the satellite, the receiver clock times, and the signal strength. The integration interval should be approximately 4.6 sec. Typically six or seven of these intervals are accumulated to form a 30-second Doppler count observation. The reference frequency should be stable to within $5.0(10^{-11})$ per 100 sec. The maximum difference from the average receiver delay should not exceed 50 μ sec. The best estimate of the mean electrical center of the antenna should be marked. This mark will be the reference point for all height-of-antenna measurements.

Calibration Procedures

Receivers should be calibrated at least once a year, or whenever a modification to the equipment is made. It is desirable to perform a calibration before every project to verify that the equipment is operational. The two-receiver method explained next is preferred and should be used whenever possible.

Two-Receiver Method

The observations are made on a vector base line, of internal accuracy sufficient to serve as a comparison standard, 10 to 50 m in length. The base line should be located in an area free of radio interference in the 150 and 400 MHz frequencies. The procedures found in the table on relative positioning in "Field Procedures" under the 20 cm column heading will be used. The data are reduced by either shortarc or semishort arc methods. The receivers

will be considered operational if the differences between the Doppler and the terrestrial base line components do not exceed 40 cm (along any coordinate axis).

Single-Receiver Method

Observations are made on a first-order station using the procedures found in the table on relative positioning in "Field Procedures" under the 50 cm column heading. The data are reduced with the precise ephemerides. The resultant position must agree within 1 m of the network position.

Field Procedures

The following tables of field procedures are valid only for measurements made with the Navy Navigational Satellite System (TRANSIT).

Point Positioning

s_p (precise ephemerides)	50 cm	70 cm	100 cm	200 cm
Max. standard deviation of mean of counts/pass (cm), broadcast ephemerides	25	25	25	25
Period of observation not less than (hr)	48	36	24	12
Number of observed passes not less than†	40	30	15	8
Number of acceptable passes (evaluated by on-site point processing) not less than	30	20	9	4
Minimum number of acceptable passes within each quadrant*	6	4	2	1
Frequency standard warm-up time (hr)				
crystal	48	48	24	24
atomic	1.5	1.5	1.0	1.0
Maximum interval between meteorological observations (hr)....	6	§	§	§

† Number of passes refers to those for which the precise ephemerides are available for reduction.

* There should be a nearly equal number of northward and southward passes.

§ Each setup, visit and takedown.

Relative positioning

s_r	20 cm	35 cm	50 cm
Maximum standard deviation of mean of counts/pass (cm), broadcast ephemerides ...	25	25	25
Period of observation not less than (hr)	48	36	24
Number of observed passes not less than†	40	30	15
Number of acceptable passes (evaluated by on-site point position processing) not less than	30	20	9
Minimum number of acceptable passes within each quadrant*	6	4	2
Frequency standard warm-up time (hr)			
crystal	48	48	48
atomic	1.5	1.5	1.5
Maximum interval between meteorological observations (hr)	6	6	§

† Number of observed passes refers to all satellites available for tracking and reduction with the broadcast or precise ephemerides.

* Number of northward and southward passes should be nearly equal.

§ Each setup, visit and takedown.

The antenna should be located where radio interference is minimal for the 150 and 400 MHz frequencies. Medium frequency radar, high voltage power lines, transformers, excessive noise from automotive ignition systems, and high power radio and television transmission antennas should be avoided. The horizon should not be obstructed above 7.5°.

The antenna should not be located near metal structures, or, when on the roof of a building, less than 2 m from the edge. The antenna must be stably located within 1 mm over the station mark for the duration of the observations. The height difference between the mark and the reference point for the antenna phase center should be measured to the nearest millimeter. If an antenna is moved while a pass is in progress, that pass is not acceptable. If moved, the antenna should be relocated within 5 mm of the original antenna height; otherwise the data may have to be processed as if two separate stations were established. In the case of a reoccupation of an existing Doppler station, the antenna should be relocated within 5 mm of the original observing height.

Long-term reference frequency drift should be monitored to ensure it does not exceed the manufacturer's specifications.

Observations of temperature and relative humidity should be collected, if possible, at or near the height of the phase center of the antenna. Observations of wet-bulb and dry-bulb temperature readings should be recorded to the nearest 0.5°C. Barometric readings at the station site should be recorded to the nearest millibar and corrected for difference in height between the antenna and barometer.

Office Procedures

The processing constants and criteria for determining the quality of point and relative positioning results are as follows:

1. For all passes for a given station occupation, the average number of Doppler counts per pass should be at least 20 (before processing).
2. The cutoff angle for both data points and passes should be 7.5°.
3. For a given pass, the maximum allowable rejection of counts, 3 sigma postprocessing, will be 10.
4. Counts rejected (excluding cutoff angle) for a solution should be less than 10 percent.
5. Depending on number of passes and quality of data, the standard deviation of the range residuals for all passes of a solution should range between:

Point positioning—10 to 20 cm

Relative positioning—5 to 20 cm

A minimally constrained least squares adjustment will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Distance standard errors computed by error propagation between points in this correctly weighted least squares adjustment will indicate the maximum achiev-

able accuracy classification. The formula presented in "Standards" will be used to arrive at the actual classification. The least squares adjustment will use models which account for:

- tropospheric scale bias, 10 percent uncertainty
- receiver time delay
- satellite/receiver frequency offset
- precise ephemeris
- tropospheric refraction
- ionospheric refraction
- long-term ephemeris variations
- crustal motion

3.8 Absolute Gravimetry

Absolute gravimetry is a measurement system which determines the magnitude of gravity at a station at a specific time. Absolute gravity measurements are used to establish and extend gravity control. Within the context of a geodetic gravity network, as discussed in "Standards," a series of absolute measurements at a control point is in itself sufficient to establish an absolute gravity value for that location.

The value of gravity at a point is time dependent, being subject to dynamic effects in the Earth. The extent of gravimetric stability can be determined only by repeated observations over many years.

Network Geometry

Network geometry cannot be systematized since absolute observations at a specific location are discrete and uncorrelated with other points. In absolute gravimetry, a network may consist of a single point.

A first-order, class I station must possess gravimetric stability, which only repeated measurements can determine. This gravimetric stability should not be confused with the accuracy determined at a specific time. It is possible for a value to be determined very precisely at two different dates and for the values at each of these respective dates to differ. Although the ultimate stability of a point cannot be determined by a single observation session, an attempt should be made to select sites which are believed to be tectonically stable, and sufficiently distant from large bodies of water to minimize ocean tide coastal loading.

The classification of first-order, class I is reserved for network points which have demonstrated long-term stability. To ensure this stability, the point should be reobserved at least twice during the year of establishment and thereafter at sufficient intervals to ensure the continuing stability of the point. The long-term drift should indicate that the value will not change by more than 20 μGal for at least 5 years. A point intended as first-order, class I will initially be classified as first-order, class II until stability during the first year is demonstrated.

Instrumentation

The system currently being used is a ballistic-laser device and is the only one at the current state of technolo-

gy considered sufficiently accurate for absolute gravity measurements. An absolute instrument measures gravity at a specific elevation above the surface, usually about 1 m. For this reason, the gravity value is referenced to that level. A measurement of the vertical gravity gradient, using a relative gravity meter and a tripod, must be made to transfer the gravity value to ground level. The accuracy of the relative gravimeter must satisfy the gravity gradient specifications found in "Field Procedures."

Calibration Procedures

Ballistic-laser instruments are extremely delicate and each one represents a unique entity with its own characteristics. It is impossible to identify common systematic errors for all instruments. Therefore, the manufacturer's recommendations for individual instrument calibration should be followed rigorously.

To identify any possible bias associated with a particular instrument, comparisons with other absolute devices are strongly recommended whenever possible. Comparisons with previously established first-order, class I network points, as well as first-order, class II network points tied to the class I points, are also useful.

Field Procedures

The following specifications were determined from results of a prototype device built by J. Faller and M. Zumberge (Zumberge, M., "A Portable Apparatus for Absolute Measurements of the Earth's Gravity," Department of Physics, University of Colorado, 1981) and are given merely as a guideline. It is possible that some of these values may be inappropriate for other instruments or models. Therefore, exceptions to these specifications are allowed on a case-by-case basis upon the recommendation of the manufacturer. Deviations from the specifications should be noted upon submission of data for classification.

Order Class	First I	First II	Second	Third
Absolute measurement				
Standard deviation of each accepted measurement set not to exceed (μGal)	20	20	50	100
Minimum number of sets/ observation	5	5	5	5
Maximum difference of a measurement set from mean of all measurements (μGal)	12	12	37	48
Barometric pressure standard error (mbar)	4	4	—	—
Gradient measurement				
Standard deviation of measurement of vertical gravity gradient at time of observation ($\mu\text{Gal}/\text{m}$)	5	5	5	5
Standard deviation of height of instrument above point (mm)	1	1	5	10

Office Procedures

The manufacturer of an absolute gravity instrument usually provides a reduction process which identifies and accounts for error sources and identifiable parameters. This procedure may be sufficient, making further office adjustments unnecessary.

A least squares adjustment will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Gravity value standard deviations computed by error propagation in a correctly weighted, least squares adjustment will indicate the provisional accuracy classification. The least squares adjustment, as well as digital filtering techniques and/or sampling, should use models which account for:

- atmospheric mass attraction
- microseismic activity
- instrumental characteristics
- lunisolar attraction
- elastic and plastic response of the Earth (tidal loading)

3.9 Relative Gravimetry

Relative gravimetry is a measurement system which determines the difference in magnitude of gravity between two stations. Relative gravity measurements are used to extend and densify gravity control.

Network Geometry

A first-order, class I station must possess gravimetric stability, which only repeated measurements can determine. This gravimetric stability should not be confused with the accuracy determined at a specific time. It is possible for a value to be determined very precisely at two different dates, and for the values at each of these respective dates to differ. Although the ultimate stability of a point cannot be determined by a single observation session, an attempt should be made to select sites which are believed to be tectonically stable.

The classification of first-order, class I is reserved for network points that have demonstrated long-term stability. To ensure this stability, the point should be reobserved at least twice during the year of establishment and thereafter at sufficient intervals. The long-term drift should indicate that the value will not change by more than the 20 μGal for at least 5 years. A point intended as first-order, class I will initially be classified as first-order, class II until stability during the first year is demonstrated.

The new survey is required to tie at least two network points, which should have an order (and class) equivalent to or better than the intended order (and class) of the new survey. This is required to check the validity of existing network points as well as to ensure instrument calibration. Users are encouraged to exceed this minimal requirement. However, if one of the network stations is a first-order, class I mark, then that station alone can satisfy the

minimum connecting requirement if the intended order of the new survey is less than first-order.

Instrumentation

Regardless of the type of a relative gravimeter, the internal error is of primary concern.

Order Class	First I	First II	Second	Third
Minimum instrument internal error (one-sigma), (μGal)	10	10	20	30

The instrument's internal accuracy may be determined by performing a relative survey over a calibration line (see below) and examining the standard deviation of a single reading. This determination should be performed after the instrument is calibrated using the latest calibration information. Thus the internal error is the measure of instrument uncertainty after all possible systematic error sources have been eliminated by calibration.

Calibration Procedures

An instrument should be properly calibrated before a geodetic survey is performed. The most important calibration item is the determination of the mathematical model that relates dial units, voltage, or some other observable to milligals. This may consist only of a scale factor. In other cases the model may demonstrate nonlinearity or periodicity. Most manufacturers provide tables or scale factors with each instrument. Care must be taken to ensure the validity of these data over time.

When performing first-order work, this calibration model should be determined by a combination of bench tests and field measurements. The bench tests are specified by the manufacturer. A field calibration should be performed over existing control points of first-order, class I or II. The entire usable gravimeter range interval should be sampled to ensure an uncertainty of less than 5 μGal . FGCC member agencies have established calibration lines for this specific purpose.

The response of an instrument to air pressure and temperature should be determined. The meter should be adjusted or calibrated for various pressures and temperatures so that the allowable uncertainty from these sources does not exceed the values in the table below.

The manufacturer's recommendations should be followed to ensure that all internal criteria, such as galvanometer sensitivity, long and cross level or tilt sensitivity, and reading line, are within the manufacturer's allowable tolerances.

The response of an instrument due to local orientation should also be determined. Systematic differences may be due to an instrument's sensitivity to local magnetic variations. Manufacturers attempt to limit or negate such a response. However, if a meter displays a variation with

respect to orientation, then one must either have the instrument repaired by the manufacturer, or minimize the effect by fixing the orientation of the instrument throughout a survey.

Order Class	First I	First II	Second	Third
Necessary for user to determine calibration model	Yes	Yes	Yes	No
Allowable uncertainty of calibration model (μGal)	5	5	10	15
Allowable uncertainty due to external air temperature changes (μGal)	1	1	3	—
Maximum uncertainty due to external air pressure changes (μGal)	1	1	2	—
Allowable uncertainty due to other factors (μGal)	3	3	5	—

Field Procedures

A relative gravity survey is performed using a sequence of measurements known as a loop sequence. There are three common types: ladder, modified ladder, and line.

The ladder sequence begins and ends at the same network point, with the survey points being observed twice during the sequence: once in forward running and once in backward running. Of course, more than one network point may be present in a ladder sequence.

Order Class	First I	First II	Second	Third
Minimum number of instruments used in survey	2	2	2	1
Recommended number of instruments used in survey	3	3	2	1
Allowable loop sequence	a	a	a,b	a,b,c
Minimum number of readings at each observation/instrument	5	5	2†	1
Standard deviation of consecutive readings (unclamped) from mean* not to exceed (μGal)	2	2	5	—
Monitor external temperature and air pressure	Yes	Yes	No	No
Standard deviation of temperature measurements ($^{\circ}\text{C}$)	0.1	0.1	—	—
Standard deviation of air pressure measurement (mbar)	1	1	—	—
Standard deviation of height of instrument above point (mm)	1	1	5	10

(a—ladder) (b—modified ladder) (c—line)

† Although two readings are required, only one reading need be recorded.

* corrected for lunisolar attraction.

The modified ladder sequence also begins and ends at the same network point. However, not all the survey points are observed twice during the sequence. Again, more than one network point may be observed in the sequence.

The line sequence begins at a network point and ends at a different network point. A survey point in a line sequence is usually observed only once.

One should always monitor the internal temperature of the instrument to ensure it does not fluctuate beyond the manufacturer's recommended limits. The time of each reading should be recorded to the nearest minute.

Office Procedures

Order	First I	First II	Second	Third
Rejection Limits				
Maximum standard error of a gravity value (μGal)	20	20	50	100
Total allowable instrument uncertainty (μGal)	10	10	20	30
Model Uncertainties				
Uncertainty of atmospheric mass model (μGal)	0.5	0.5	—	—
Uncertainty of lunisolar attraction (μGal)	1	1	5	5
Uncertainty of Earth elastic and plastic response to tidal loading (μGal)	2	2	5	—

A least squares adjustment, constrained by the network configuration and precision of established gravity control, will be checked for blunders by examining the normalized residuals. The observation weights will be checked by inspecting the postadjustment estimate of the variance of unit weight. Gravity standard errors computed by error propagation in a correctly weighted least squares adjustment will indicate the provisional accuracy classification. A survey variance factor ratio will be computed to check for systematic error. The least squares adjustment will use models which account for:

instrument calibrations

- 1) conversion factors (linear and higher order)
- 2) thermal response (if necessary)
- 3) atmospheric pressure response (if necessary)

instrument drift

- 1) static
- 2) dynamic

atmospheric mass attraction (if necessary)

Earth tides

- 1) lunisolar attraction
- 2) Earth elastic and plastic response (if necessary)

4. Information

Geodetic control data and cartographic information that pertain to the National Geodetic Control Networks are widely distributed by a component of the National Geodetic Survey, the National Geodetic Information Branch (NGIB). Users of this information include Federal, State, and local agencies, universities, private companies, and individuals. Data are furnished in response to individual orders, or by an automatic mailing service (the mechanism whereby users who maintain active geodetic files automatically receive newly published data for specified areas). Electronic retrieval of data can be carried out directly from the NGS data base by a user.

Geodetic control data for the national networks are primarily published as standard quadrangles of 30' in latitude by 30' in longitude. However, in congested areas, the standard quadrangles are 15' in latitude by 15' in longitude. In most areas of Alaska, because of the sparseness of control, quadrangle units are 1° in latitude by 1° in longitude. Data are now available in these formats for all horizontal control and approximately 65 percent of the vertical control. The remaining 35 percent are presented in the old formats; i.e., State leveling lines and description booklets. Until the old format data have been converted to the standard quadrangle formats, the vertical control data in the unconverted areas will be available only by complete county coverage. Field data and recently adjusted projects with data in manuscript form are available from NGS upon special request. The National Geodetic Control Networks are cartographically depicted on approximately 850 different control diagrams. NGS provides other related geodetic information: e.g., geoid heights, deflections of the vertical, calibration base lines, gravity values, astronomic positions, horizontal and vertical data for crustal movement studies, satellite-derived positions, UTM coordinates, computer programs, geodetic calculator programs, and reference materials from the NGS data bases.

The NGIB receives data from all NOAA geodetic field operations and mark-recovery programs. In addition, other

Federal, State, and local governments, and private organizations contribute survey data from their field operations. These are incorporated into the NGS data base. NOAA has entered into formal agreements with several Federal and State Government agencies whereby NGIB publishes, maintains, and distributes geodetic data received from these organizations. Guidelines and formats have been established to standardize the data for processing and inclusion into the NGS data base. These formats are available to organizations interested in participating in the transfer of their files to NOAA (appendix C).

Upon completion of the geodetic data base management system, information generated from the data base will be automatically revised. A new data output format is being designed for both horizontal and vertical published control information. These formats, which were necessitated by the requirements of the new adjustments of the horizontal and vertical geodetic networks, will be more comprehensive than the present versions.

New micropublishing techniques are being introduced in the form of computer-generated microforms. Some geodetic data are available on magnetic tape, microfilm, and microfiche. These services will be expanded as the automation system is fully implemented. Charges for digital data are determined on the basis of the individual requests, and reflect processing time, materials, and postage. The booklets *Publications of the National Geodetic Survey* and *Products and Services of the National Geodetic Survey* are available from NGIB.

For additional information, write:

Chief, National Geodetic Information

Branch, N/CG17

National Oceanic and Atmospheric Administration

Rockville, MD 20852

To order by telephone:

data: 301-443-8631

publications: 301-443-8316

computer programs or digital data: 301-443-8623

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APPENDIX A

Governmental Authority

A.1 Authority

The U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is responsible for establishing and maintaining the basic national horizontal, vertical, and gravity geodetic control networks to meet the needs of the Nation. Within NOAA this task is assigned to the National Geodetic Survey, a Division of the Office of Charting and Geodetic Services within the National Ocean Service. This responsibility has evolved from legislation dating back to the Act of February 10, 1807 (2 Stat. 413, which created the first scientific Federal agency, known as the "Survey of the Coast." Current authority is contained in United States Code, Title 33, USC 883a, as amended, and specifically defined by Executive Directive, Bureau of the Budget (now the Office of Management and Budget) Circular No. A-16, Revised (Bureau of the Budget 1967).

To coordinate national mapping, charting, and surveying activities, the Board of Surveys and Maps of the Federal Government was formed December 30, 1919, by Executive Order No. 3206. "Specifications for Horizontal and Vertical Control" were agreed upon by Federal surveying and mapping agencies and approved by the Board on May 9, 1933. When the Board was abolished March 10, 1942, its functions were transferred to the Bureau of the Budget, now the Office of Management and Budget, by Executive Order No. 9094. The basic survey specifications continued in effect. Bureau of the Budget Circular No. A-16, published January 16, 1953, and revised May 6, 1967 (Bureau of the Budget 1967), provides for the coordination of Federal surveying and mapping activities. "Classification and Standards of Accuracy of Geodetic Control Surveys," published March 1, 1957, replaced the 1933 specifications. Exhibit C to Circular A-16, dated October 10, 1958 (Bureau of the Budget 1958), established procedures for the required coordination of Federal geodetic and control surveys performed in accordance with the Bureau of the Budget classifications and standards.

The Federal Geodetic Control Committee (FGCC) was chartered December 11, 1968, and a Federal Coordinator

for Geodetic Control and Related Surveys was appointed April 4, 1969. The FGCC Circular No. 1, "Exchange of Information," dated October 16, 1972, prescribes reporting procedures for the committee (vice Exhibit C of Circular A-16) (Federal Geodetic Control Committee 1972).

The Federal Coordinator for Geodetic Control and Related Surveys, Department of Commerce, is responsible for coordinating, planning, and executing national geodetic control surveys and related survey activities of Federal agencies, financed in whole or in part by Federal funds. The Executive Directive (Bureau of the Budget 1967: p. 2) states:

- (1) The geodetic control needs of Government agencies and the public at large are met in the most expeditious and economical manner possible with available resources; and
- (2) all surveying activities financed in whole or in part by Federal funds contribute to the National Networks of Geodetic Control when it is practicable and economical to do so.

The Federal Geodetic Control Committee assists and advises the Federal Coordinator for Geodetic Control and Related Surveys.

A.2 References

Bureau of the Budget, 1967: Coordination of surveying and mapping activities. *Circular* No. A-16, Revised, May 6, 3 pp. Executive Office of the President, Bureau of the Budget (now Office of Management and Budget), Washington, D.C. 20503.

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APPENDIX B

Variance Factor Estimation

B.1 Introduction

The classification accuracies for the National Geodetic Control Networks measure how well a survey can provide position, elevation, and gravity. (More specifically, a distance accuracy is used for horizontal networks, and an elevation difference accuracy is used for vertical networks.) The interpretation of what is meant by "how well" contains two parts. A survey must be precise, i.e., fairly free of random error; it must also be accurate, i.e., relatively free of systematic error. This leads to a natural question of how to test for random and systematic error.

Testing for random error is an extremely broad subject, and is not examined here. It is assumed that the standard deviation of distance, elevation difference, or gravity provides an adequate basis to describe the amount of random error in a survey. Further, it is assumed that the selection of the worst instance of the classification accuracy computed at all points (or between all pairs of points) provides a satisfactory means of classifying a new survey. This procedure may seem harsh, but it allows the user of geodetic control to rely better upon a minimum quality of survey work. The nominal quality of a survey could be much higher.

Consider the method of observation equations (see Mikhail (1976) for a general discussion):

$$L_a = F(X_a)$$

where

L_a is a vector of computed values for the observations of dimension n ,

X_a is a vector of coordinate and model parameters of dimension u , and

F is a vector of functions that describes the observations in terms of the parameters.

The design matrix, A , is defined as

$$A = \left. \frac{\partial F}{\partial X_a} \right|_{X_a = X_0}$$

where A is a matrix of differential changes in the observation model F with respect to the parameters, X_a , evaluated at a particular set of parameter values, X_0 . A vector of observation misclosures is

$$L = L_b - L_a$$

where L_b is the vector of actual observations and L_a is the vector described above.

Associated with the observation vector L_b is a symmetric variance-covariance matrix Σ_{L_b} , which contains information on observation precision and correlation.

The observation equation may now be written in linearized form

$$AX = L + V$$

where V is a vector of residual errors and X is a vector of corrections to the parameter vector X_a . The least squares estimate of X is

$$X = (A^t(\Sigma_{L_b})^{-1}A)^{-1} A^t(\Sigma_{L_b})^{-1}L$$

where the superscripts t and -1 denote transpose and inverse (of a matrix) respectively.

The estimate provides a new set of values for the parameters by

$$X_a + X \rightarrow X_a$$

If the observation model $F(X_a)$ is nonlinear (that is, A is not constant for any set of X_a), then the entire process, starting with the first equation, must be iterated until the vector X reaches a stationary point.

Once convergence is achieved, L_a , computed from the first equation, is the vector of adjusted observations. The vector of observation residual errors, V , is

$$V = L_a - L_b$$

Estimates of parameter precision and correlations are given by the adjusted parameter variance-covariance matrix, Σ_{X_a} computed by

$$\Sigma_{X_a} = (A^t(\Sigma_{L_b})^{-1}A)^{-1}$$

The precision of any other quantity that can be derived from the parameters may also be computed. Suppose one wishes to compute a vector of quantities, S ,

$$S = S(X_a)$$

from the adjusted parameters, X_a . A geometry matrix, G , is defined as

$$G = \frac{\partial S}{\partial X_a} \Big|_{X_a = X_0}$$

where G is a matrix of differential changes in the functions, S , with respect to the parameters, X_a , evaluated at a particular set of parameter values, X_0 . By the principle of linear error propagation,

$$\Sigma_S = G \Sigma_{X_a} G^t$$

or

$$\Sigma_S = G(A^t(\Sigma_{L_b})^{-1}A)^{-1}G^t$$

where Σ_S is the variance-covariance matrix of the computed quantities.

This last equation is important since its terms are variances and covariances such as those for distance or height difference. Use of this equation assumes that the model is not too nonlinear, that the parameter vector X_a has been adequately estimated by the method of least squares, that the design matrix A , the geometry matrix G , and the variance-covariance matrix of the observations Σ_{L_b} are known. This last assumption is the focal point for the remainder of this appendix.

We must somehow estimate the $n(n+1)/2$ elements of Σ_L . Usually, we know Σ_L subject to some global variance factor, f . We would then assume that

$$\Sigma_L = f \Sigma_L^0$$

where

Σ_L = the "true" variance-covariance matrix of the observations

Σ_L^0 = initial estimate of variance-covariance matrix of the observations

Our assumption about the structure of Σ_L^0 relative to a single factor usually suffices. But this assumption can be improved if we generalize the idea. Consider a partition of the observations into k homogeneous groups. We now estimate k different local variance factors

$$\Sigma_L = \begin{pmatrix} f_1 \Sigma_{L_1}^0 & & 0 \\ & f_2 \Sigma_{L_2}^0 & \\ 0 & & f_k \Sigma_{L_k}^0 \end{pmatrix}$$

As will be discussed later, we may also detect systematic error if one of the variance components is based on certified network observations.

B.2 Global Variance Factor Estimation ($k = 1$)

The global variance factor, f , is simply the a posteriori variance of unit weight, $\hat{\sigma}_0^2$, when given an a priori variance of unit weight, σ_0^2 , equal to 1.

It can be shown that

$$E(V^t(\Sigma_L)^{-1}V) = n - u. \quad (\text{Mikhail 1976: p. 287})$$

For a single variance factor

$$\Sigma_L = f \Sigma_L^0$$

so that

$$\frac{1}{f} \Sigma(V^t(\Sigma_L^0)^{-1}V) = n - u$$

or for f to be unbiased (Hamilton 1964, p. 130)

$$f = \frac{E(V^t(\Sigma_L^0)^{-1}V)}{n - u} = \frac{V^t(\Sigma_L^0)^{-1}V}{n - u}$$

This is identical to the form $\hat{\sigma}_0^2 = \frac{V^t P V}{n - u}$, where P is defined as $\sigma_0^2(\Sigma_L^0)^{-1}$

Since we are given that $\sigma_0^2 = 1$, then $P = (\Sigma_L^0)^{-1}$. Then $f = \hat{\sigma}_0^2$, as we wished to prove.

The derivation assumes that there is no bias in the residuals (Mikhail 1976), i.e.,

$$E(V) = 0.$$

However, outliers, as well as systematic errors, can produce a biased global variance factor. We must be satisfied that the observations contain no blunders, and that our mathematical model is satisfactory in order to use the global variance factor.

Particular types of systematic errors—global scale or orientation errors—are not detectable in a survey adjustment. They will not bias the residuals and will not influence the global variance factor. For example, to detect a global scale error, it must be transformed into a local scale error by addition of more data or measurements that can discriminate between global and local.

B.3 Local Variance Factor Estimation ($k = 2, 3, \dots$)

Let us separate our observations into k homogeneous groups, and assume that we know the variance-covariance matrices of all k groups, $\Sigma_{L_i}^0$, subject to k local variance factors, f_i . Then

$$\Sigma_L = \begin{pmatrix} f_1 \Sigma_{L_1}^0 & & 0 \\ & f_2 \Sigma_{L_2}^0 & \\ 0 & & f_k \Sigma_{L_k}^0 \end{pmatrix}$$

A variety of methods has been proposed that can be used to estimate local variance factors. Among them are Minimum Norm Quadratic Unbiased Estimation (MINQUE) (Rao 1971), Iterated Minimum Norm Quadratic Estimation (IMINQE) (Rao 1972), Almost Unbiased Estimation (AUE) (Horn et al. 1975), and Iterated Almost Unbiased Estimation (IAUE) (Lucas 1984). Underlying these methods is the assumption that there is no bias in any group of residuals; that is

$$E(V_k) = 0.$$

This assumption can be turned to our advantage in the detection of local systematic error.

Consider the partition of observations into a network group, subscript N , and a survey group, subscript s ($k = 2$). Then

$$\Sigma_L = \begin{pmatrix} f_N \Sigma_N^0 & 0 \\ 0 & f_s \Sigma_s^0 \end{pmatrix}$$

For an adjustment of the network only, we may estimate

$$\Sigma'_N = f'_N \Sigma_N^0$$

and for an adjustment of the survey only, we may estimate

$$\Sigma'_s = f'_s \Sigma_s^0$$

where f'_s is the global variance factor of the survey observations computed by a least squares adjustment free of outliers and known systematic errors.

With perfect information and an unbiased model we compute $f'_N = f'_N$ and $f'_s = f'_s$. On the other hand, if our model is biased, this may not be the case. In other words, we have a linkage between systematic error and consistent estimation of local variance factors.

Now assume that our network observations are certified as having no systematic error, and that we have perfect knowledge of their weights. Then $f'_N = 1$ and $\Sigma'_N = \Sigma_N^0$. In the absence of residual bias in the survey, we should compute $f'_N = 1$ and $f'_s = f'_s$. In fact, we could impose a constraint on the computation, $f'_N = 1$, to ensure this result. A survey systematic error could then manifest itself as an increase in f'_s over f'_s .

There is no guarantee that systematic error in a survey will increase f'_s over f'_s . For example, a survey may be connected to the network at only one control point. A scale error local to the survey would remain undetectable with combined variance factor estimation. With a second connection to the network, the survey scale error will begin to be detectable. As the survey is more closely connected to the network, the capability to detect a survey scale error becomes much better. We see that systematic error in a survey that is well-connected to a certified geodetic net-

work can be discovered by local variance factor estimation. Of course a systematic error, such as a scale factor influencing both the network and the survey, would continue to remain hidden.

B.4 Iterated Almost Unbiased Estimation (IAUE)

The IAUE method (Lucas 1984) can be used to estimate covariance elements as well as the variance elements of Σ_L . However, in testing for systematic error we are concerned only with the survey and the network variance factors ($k = 2$).

As suggested by the title, the method is iterative. We start with the initial values

$$f_s^0 \text{ and } \Sigma_s^0, \text{ with } f_N^0 \text{ set to } 1.$$

Let

$$\Sigma_L^0 = \begin{pmatrix} f_N^0 \Sigma_N^0 & 0 \\ 0 & f_s^0 \Sigma_s^0 \end{pmatrix}$$

$$P_L^0 = (\Sigma_L^0)^{-1} = \begin{pmatrix} P_N^0 & 0 \\ 0 & P_s^0 \end{pmatrix}$$

We now iterate from $i = 0$ to convergence

- 1) Perform least squares adjustment for

$$\hat{X} = (A'P_L^i A)^{-1} A'P_L^i L.$$

- 2) $\Sigma_{V_s}^i = (P_s^i)^{-1} - A_s(A'P_L^i A)^{-1} A_s^t.$

- 3) $f_s^{i+1} = \frac{(V_s^i)' P_s^i V_s^i}{\text{tr}(\Sigma_{V_s}^i P_s^i)}$

where tr is the trace function.

- 4) $\Sigma_s^{i+1} = f_s^{i+1} \Sigma_s^i.$

We test for convergence by

$$\frac{f_s^{i+1} - f_s^i}{f_s^i} < \epsilon$$

where ϵ is a preset quantity > 0 . The local survey variance factor is

$$f_s = \prod_{i=0}^m f_s^i$$

where m is the number of iterations to convergence. We can then compute a survey variance factor ratio,

$$f_s/f'_s$$

Computer simulations have shown that when the survey variance factor ratio exceeds 1.5, then the survey contains systematic error. This rule becomes less reliable when a survey is minimally connected to a network.

We note that for $k = 1$, the third step of the method yields

$$f^{i+1} = \frac{(V'PV)^i}{n - u}$$

It is immediately recognized as the a posteriori estimate of the variance of unit weight. In this special case, IAUE convergence is correct, immediate, and unbiased.

The IAUE method is particularly attractive from a computational point of view. If Σ_L is diagonal, or nearly so, then the requisite elements of Σ_L may be computed from elements of Σ_X that lie completely within the profile

of the normal equations. Thus, the usual apparatus of sparse least squares adjustments can be retained.

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APPENDIX C

Procedures for Submitting Data to the National Geodetic Survey

The National Geodetic Survey (NGS) has determined that the value to the national network of geodetic observations performed by other Federal, State, and local organizations compensates for the costs of analyzing, adjusting, and publishing the associated data. Consequently, a procedure has been established for data from horizontal, vertical, and gravity control surveys to be submitted to NGS. Persons submitting data must adhere to the requirements stated herein, but in any event, the final decision of acceptance on data will be the responsibility of the Chief, NGS.

The survey data must be submitted in the format specified in the Federal Geodetic Control Committee (FGCC) publication, *Input Formats and Specifications of the National Geodetic Survey Data Base*, which describes the procedures for submission of data for adjustment and assimilation into the National Geodetic Survey data base. Volume I (Horizontal control data), volume II (Vertical control data) or volume III (Gravity control data) may be purchased from:

National Geodetic Information Branch (N/CG17x2)
National Oceanic and Atmospheric Administration
Rockville, MD 20852

Horizontal control surveys must be accomplished to at least third-order, class I standards and tied to the National Geodetic Horizontal Network. Vertical control surveys must be accomplished in accordance with third-order or higher standards and tied to the National Geodetic Verti-

cal Network. Gravity control surveys must be accomplished to at least second-order standards and tied to the National Geodetic Gravity Network. Third-order gravity surveys ("detail" surveys) will be accepted by NGS for inclusion into the NGS Gravity Working Files only in accordance with the above mentioned FGCC publication. A clear and accurate station description should be provided for all control points.

The original field records (or acceptable copies), including sketches, record books, and project reports, are required. NGS will retain these records in the National Archives. This is necessary if questions arise concerning the surveys on which the adjusted data are based. In lieu of the original notes, high quality photo copies and microfilm are acceptable. The material in the original field books or sheets are needed, not the abstracts or intermediate computations.

Reconnaissance reports should be submitted before beginning the field measurements, describing proposed connections to the national network, the instrumentation, and the field procedures to be used. This will enable NGS to comment on the proposed survey, drawing on the information available in the NGS data base concerning the accuracy and condition of these points, and to determine if the proposed survey can meet its anticipated accuracy. This project review saves the submitting agency the expense of placing data that would fail to meet accuracy criteria into computer-readable form.

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APPENDICES

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Appendix F

UNITED STATES NATIONAL MAP ACCURACY STANDARDS¹

With a view of the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. Horizontal accuracy--For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. "Well-defined" points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers such as bench marks or property boundary monuments; intersections of roads, railroads, etc.; and corners of large buildings or structures (or center points of small buildings). In general, what is "well-defined" will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus, while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would be timber lines, soil boundaries, and so on.
2. Vertical accuracy, applied to contour maps on all publication scales shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.
3. The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.
4. Published maps meeting these accuracy requirements shall note this fact in their legends, as follows:

"This map complies with the national standard accuracy requirements."²
5. Published maps whose errors exceed those aforesaid shall omit from their legends all mention of standard accuracy.
6. When a published map is a considerable enlargement of a map drawing ("manuscript") or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."
7. To facilitate ready interchange and use of basic information for map construction among all federal map-making agencies, manuscript maps and published maps, wherever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, of 7-1/2 minutes, or 3-3/4 minutes, in size.

¹Promulgated by the U. S. Bureau of the Budget as standards of accuracy for a national map production program. See: *Manual of Photogrammetry, Volume Two, Third Edition*; American Society of Photogrammetry; Fall Church, Va., 1966, pp. 1180-1184.

²Wording of accuracy compliance statement reads, "This map complies with national map accuracy standards" in revision of June 17, 1947.

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APPENDICES

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Appendix G

GEODETTIC DATUMS

INTRODUCTION AND BASIC CONCEPTS

A datum may be defined as a mathematical model used in surveying and mapping operations for determining the location of points on the surface of the earth and for the computation of the relationship between such points. Surveying operations may be classified as plane or geodetic based upon the underlying model used to represent the Earth. Two conflicting objectives model are: simplicity and appropriateness.

Datum for Plane Surveying

In plane surveying, a very simple model is used, the surface of the earth being represented by a horizontal plane oriented perpendicular to the local plumb line. This very simple model is applicable over only very small portions of the earth's surface—generally over areas of less than 100 square miles—as it does not appropriately accommodate the curvature of the earth's surface. In plane surveying, the horizontal location of any point is defined in terms of rectangular coordinates. The corresponding vertical location is defined as the elevation, that is the perpendicular distance, above or below a level surface referenced to mean sea level; or, more often, to an arbitrary bench mark. As surveying and mapping operations are extended over large portions of the earth's surface, a more complex model is required.

Datum for Geodetic Surveying

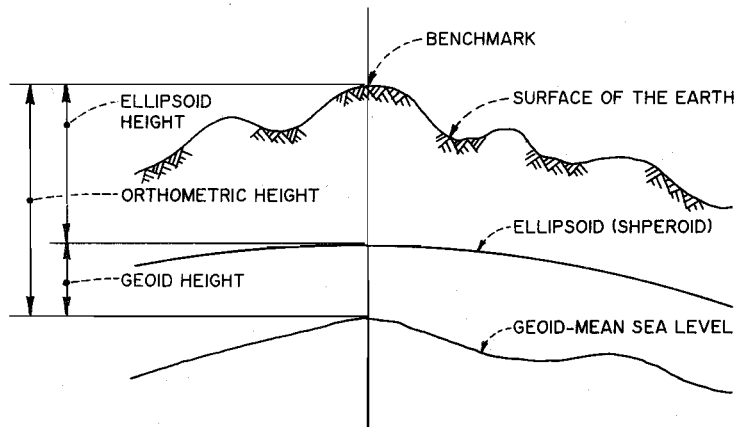
In geodetic surveying, a more complex model is used, which conceptualizes the surface of the earth as a spheroid—or ellipsoid—of revolution having specified major and minor axes. Horizontal positions on the surface of the earth are defined in terms of spherical coordinates—latitude, the angular distance north or south of the equator, and longitude—the angular distance east or west of the prime meridian through Greenwich, England. The observations and measurements required to determine the latitude and longitude of a point are, of course, made on the surface of the earth but are referred to the geoid—or to a mathematical approximation of the geoid—a surface approximating mean sea level—that is, the level that the oceans would take if all currents and tides ceased to exist. This surface is everywhere perpendicular to the direction of gravity and is, therefore, an irregular surface. Surveying instruments are oriented to this surface by means of such devices as spirit levels. Because of the irregular nature of the geoid, mathematical computations of distances and directions between points of known latitude and longitude cannot be readily made on the geoid. This necessitates the fitting, as closely as possible, to the geoid of a mathematically definable figure—the spheroid—to the geoid. The spheroid is thus used to approximate the geoid, thereby facilitating accurate and precise computations of geodetic distances and directions.

Conceptually, vertical positions on the surface of the earth could be specified by the elevation, or vertical distance, above or below the spheroid. The relationship between the spheroid and the geoid at any given location, however, would have to be known with sufficient accuracy and precision. Therefore, a simpler appropriate model for vertical position is used; that is, the elevation, or vertical distance, above or below mean sea level—that is, above or below the geoid. This distance is known as the orthometric height. The relationships concerned are illustrated in Figure G-1.

In geodetic surveying horizontal and vertical datums have been defined and maintained separately, in part because the associated measurements on the surface of the earth—historically by triangulation and traverse and by differential leveling—were made separately and the results of the measurements published separately for horizontal survey control stations and for vertical survey control benchmarks. It is entirely appropriate to continue to use separate horizontal and vertical datums. If, however, consistent simplifying assumptions are made with respect to both the horizontal and vertical datums, and if the combined coordinate system enjoys well defined mathematical integrity, an integrated horizontal and vertical control system can be developed and information from it used with confidence. The Regional Planning Commission has, in effect,

Figure G-1

**RELATIONSHIP OF SURFACES
USED FOR VERTICAL POSITION**



Source: SEWRPC.

integrated the horizontal and vertical geodetic control survey systems within the seven-county Southeastern Wisconsin Region by publishing precise horizontal and vertical positions for common survey control stations.

The spheroid used as a basis for the National Geodetic Horizontal Datum of 1927—known as the North American Datum of 1927 (NAD-27)—is the Clarke Spheroid of 1866 adopted by the U. S. Coast and Geodetic Survey in 1880 as the basis for the conduct of geodetic surveys in North America. The Clarke Spheroid provides a good fit to the geoid underlying the North American continent. Other reference ellipsoids—or spheroids—were used for other continents. The defining parameters of the Clarke Spheroid of 1866 are:

Semi-major axis= 20,926,062 feet (6,378,206.4 meters)

Semi-minor axis= 20,855,121 feet (6,356,583.8 meters)

The North American Datum of 1927 was marked upon the surface of the earth by a national network of high order triangulation and traverse stations, each with an assigned latitude and longitude. The adjusted network had as its origin triangulation station “Meades Ranch,” Kansas; the station at which the Clarke spheroid was taken to be coincident with the undulating geoid, and the accumulation of differences between the spheroid and geoid—the geoid heights—throughout the network were all related to that origin. Throughout the continental United States, the magnitude of the geoid heights ranged from about minus 30 meters to about plus 17 meters. In Southeastern Wisconsin, the geoid heights were much smaller, being in the range of zero to minus 2 meters. Clearly, the North American Datum of 1927 models the geoid very well in Southeastern Wisconsin; and the system of survey control consistently recommended by the Commission over the past 30 years is based upon that datum.

Map Projections

In order to properly prepare maps, it is necessary to use a map projection—that is, a set of mathematical equations for converting the curved surface of the earth to a flat surface upon which the maps can be constructed, and which can be used to convert the spherical geometry of the mapping spheroid to the plane geometry of the flat mapping surface. In this process, the surface of the earth, which is irregularly curved and as a practical matter mathematically undefinable, is represented by a mapping spheroid and related geodetic survey datum, the same spheroid and datum used for the reduction of geodetic survey measurements. The map projection must be carefully designed to minimize distortions in angles, areas, and

distances so that such distortions will not adversely affect the utility of the finished maps. Such conformal mapping accommodates only two dimensions, the third dimension being undefined, but in practice being related to a system of orthometric heights.

Often a rectangular coordinate system is utilized in conjunction with the map projection to simplify the measurement of the relative positions of various map features and to provide a simplified mechanism for accurately transferring the location of features on the ground to their correct locations on the map. The State Plane Coordinate System—a set of map projections and ancillary rectangular coordinate systems—was developed for this purpose by the U. S. Coast and Geodetic Survey in the 1930s. The System was developed to assist public and private organizations in the preparation of accurate large-scale maps of relatively small geographic areas, as well as to facilitate the conduct of land and engineering surveys using plane surveying, rather than geodetic surveying, techniques. The State Plane Coordinate System was developed upon the North American Datum of 1927, which, as already noted, is based upon the Clarke Spheroid of 1866. Thus, the map projection and State Plane Coordinate System in use within the Region are based upon that datum and spheroid.

In this respect, it should be noted that the Universal Transverse Mercator Coordinate System—used by some state agencies and private utilities within Wisconsin—is, like the State Plane Coordinate System, a set of map projections and ancillary rectangular coordinate systems. It, too, is developed upon the North American Datum of 1927 and the Clarke Spheroid of 1866. Therefore, it is possible to mathematically convert, accurately and precisely, coordinates between the Universal Transverse Mercator and State Plane Coordinate Systems.

As already noted, the physical expression of the spherical coordinate system is an extensive network of monumented points of known latitude and longitude, which constitute the National Geodetic Reference System. The angles and distances between adjacent points in this network have been precisely measured in Southeastern Wisconsin. This was done by the Federal government, generally by triangulation utilizing optical surveying instruments to measure angles and high-precision steel tapes to measure the lengths of base lines.¹ The established latitudes and longitudes of the points—or stations—have been published by the Federal government for use in surveying and mapping work. The triangulation stations of this high-order National Geodetic Reference System provided the points of beginning for the lower order traverse surveys used to determine the positions of the remonumented U. S. Public Land Survey corners within Southeastern Wisconsin under the control survey system recommended by the Commission. Thus, all of the positions of those corners—expressed as State Plane Coordinates but convertible with a specified level of accuracy to latitude and longitude—are referenced to the North American Datum of 1927.

The geodetic positions of the stations, which constitute the North American Datum of 1927 were determined by a simultaneous adjustment of all of the geodetic survey measurements completed prior to the date of adjustment. The System then served as a basis for the subsequent extension of geodetic control surveys in the United States. Primarily because of small unavoidable errors in the original survey measurements, the System contained distortions. These distortions became troublesome as the System expanded into areas of the United States where the original triangulation and traverse networks were widely spaced—a situation not true in Southeastern Wisconsin. For this and other reasons, the Federal government determined to readjust the entire network of stations comprising the National Geodetic Reference System. In addition to the readjustment of all positions of the stations of the national network, it was also determined to utilize a

¹*It is interesting to note that the basic geodetic control survey network within Southeastern Wisconsin, consisting of a triangulation network, was put in place by two Federal agencies—the U. S. Lake Survey of the U. S. Army Corps of Engineers and the U. S. Coast and Geodetic Survey—utilizing classic geodetic survey techniques. This is unusual within the United States and may account for the high quality of the basic geodetic control network in the Region.*

new reference spheroid known as the Geodetic Reference System of 1980. The center of the new reference spheroid was selected so as to coincide with the earth's center of mass. The parameters of the spheroid are:

Semi-major axis = 6,378,137 meters (defining)

Semi-minor axis = 6,356,752.3141 meters (derived)

On a global scale, the new spheroid fits the geoid better than does the Clarke Spheroid of 1866. Within Southeastern Wisconsin, however it does not; the geoid heights on the new Geodetic Reference System of 1980 ranging from about a minus 33 to a minus 36 meters. The new spheroid serves as the basis for a new geodetic datum, the North American Datum of 1983 (NAD-83), a datum created to replace the North American Datum of 1927.

During the 10-year period required to readjust the national control survey network, satellite positioning systems became operable, which made it possible to collect survey data which were more accurate than the new datum to which they were expected to be attached. Accordingly, a decision was made to undertake, on a State-by-State basis, a further readjustment of the geodetic control network, resulting in what is known as the High Accuracy Reference Network (HARN). The High Accuracy Reference Network was completed in Wisconsin in 1991 and the resultant values are identified as NAD-83(91) coordinates. The High Accuracy Reference Network in Wisconsin is based upon a network of 80 new geodetic control stations, the positions of which are determined utilizing Global Positioning System (GPS) technology. The positions of these stations were based upon the NAD-83 reference spheroid; that is, the geodetic reference system of 1980 spheroid, but was independently adjusted from the National Geodetic Reference Stations, and, therefore, NAD-83 positions. This network thus, in effect, constitutes a third horizontal datum in Wisconsin, a variant of NAD-83.

The amount of distortion in the readjusted 1983 national geodetic control system is usually less than that in the 1927 adjustment because the former contains more geodetic survey measurements and some measurements of higher accuracy. The published values of the latitude and longitude of each station in the National Geodetic Reference System for the 1983 adjustment are, of course, quite different from those for the 1927 adjustment. The Commission has tabulated the shifts in the positions of stations on the North American Datum of 1983 as readjusted in 1991—NAD-83(91)—versus the positions on the North American Datum of 1927 (NAD-27). It should be noted that the maximum shift in latitude within the Region approximates 11 feet, while the maximum shift in longitude approximates 40 feet. Clearly, the shifts between positions on the NAD-83(91) and on the NAD-27 are significant within the Region and cannot be ignored either in mapping or in control survey applications (see Maps G-1 and G-2).

COMPARISON OF THE NAD-27 AND NAD-83 DATUMS WITHIN SOUTHEASTERN WISCONSIN

One of the issues relevant to the selection of horizontal datum for use in Southeastern Wisconsin relates to the accuracy of the distances derived by inverse computations from the positions of stations on the North American Datum of 1927 and of stations on the North American Datum of 1983.

Table G-1 presents data comparing distances within Southeastern Wisconsin derived from global positioning technology, between North American Datum of 1927 station positions, and North American Datum of 1983 as readjusted in 1991—NAD-83(91)—station positions. The station locations are shown on Map G-3. The table indicates that in all but two cases the distances derived from the NAD-83(91) data fit the distances derived from the GPS-determined positions better than do the distances derived from the NAD-27 positions. The ratios of the GPS-determined distances to the NAD-83(91) derived distances range from a low of one part in 51,476,700 to a high of one part in 42,200. Similar ratios for the comparison of GPS-derived data to NAD-27 data range from a low of one part in 1,500,000 to a high of one part in 33,000. It is important to note that, for all practical purposes, the differences between distances determined on the NAD-27 and NAD-83(91) Datums are not significant. It should be further noted that the comparisons of the GPS-derived to the NAD-27-derived distances are all well within the one part in 10,000 long considered adequate for land and engineering surveying purposes and used as a standard for the Commission-recommended control survey system. This comparison clearly indicates that, in terms of the accuracies required for land and ordinary engineering surveys, there is no reason to convert within Southeastern Wisconsin to the NAD-83(91).

COSTS AND BENEFITS

Within the seven-county Southeastern Wisconsin Region, the replacement of the NAD-27 by the NAD-83(91) would adversely affect literally tens of thousands of existing maps and associated public records in hard copy and digital format. This replacement would require that new horizontal coordinates be computed—utilizing original control survey measurements—for the approximately 8,800 monuments now marking U. S. Public Land Survey corners within the Region. The dossier sheets for each of these corners would require revisions to reflect the results of these recomputations, as would the summary diagrams that tie these monuments together into an integrated network. New grid distances and grid bearings would have to be computed for thousands of affected section and quarter-section lines, and new interior angles and areas computed for all of the U. S. Public Land Survey quarter sections concerned. As of the date of publication of this report, these changes would, in turn, have to be carried over to approximately 6,300 individual large-scale topographic and cadastral maps that have been prepared on the NAD-27 within the Region over the past approximately 30 years.

In addition, the utility of thousands of subdivision plats, certified survey maps, plats of surveys, and survey records referenced to the NAD-27 would be adversely affected. Thousands of sheets of interpreted aerial photography containing land use, soil, wildlife habitat, wetland, floodland, and environmental corridor delineations referenced to the NAD-27 would also be adversely affected by a conversion to the NAD-83. All digital map files developed by government agencies and by private utilities within the Region over the past 15 years would have to be redone to fit the NAD-83(91).

In Counties, such as Kenosha, Milwaukee, Racine, and Waukesha, where substantial effort has been put forth in the development of high-order horizontal and vertical control surveys; of both analog and digital topographic, planimetric, and cadastral maps; and of digital inventories of land use, such as soils, wildlife habitat, wetlands, floodlands, and environmental corridors, it is conservatively estimated that the cost of converting from the NAD-27 to the NAD-83(91) would approximate one to two million dollars in each of these Counties. Proponents of the conversion to the NAD-83(91) have yet to document any benefits that would offset these conversion costs. Therefore, it must be concluded at this time that the cost-benefit ratio associated with a conversion to the NAD-83(91) in Southeastern Wisconsin would be far less than one.

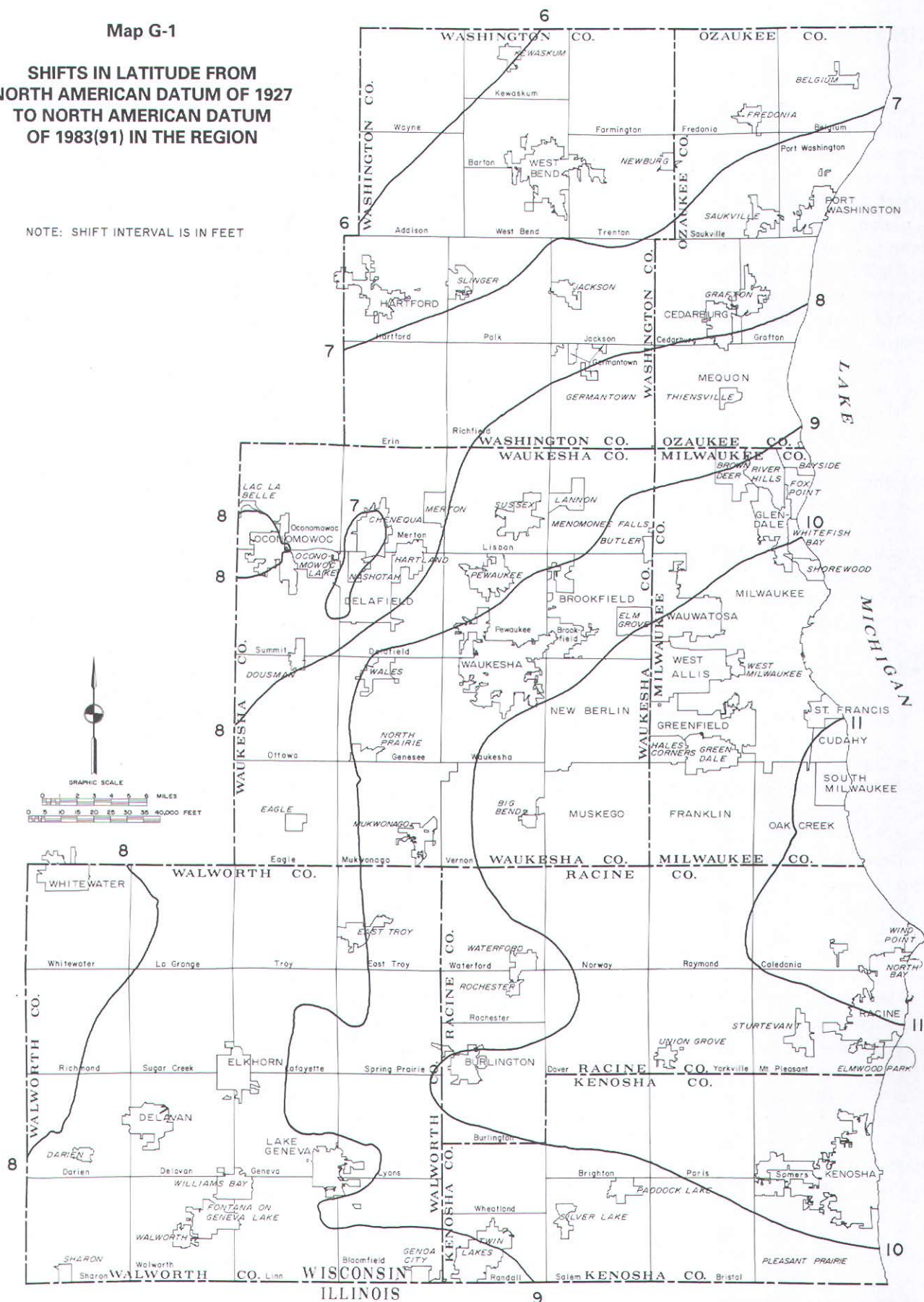
In addition to the issue of cost and benefits, there has been no thorough evaluation of whether or not the use of the NAD-83(91) within the Region would represent any significant improvement over the continued use of the NAD-27 as a mapping datum for local area mapping. In this regard, it should be noted that the rationale for changing mapping datums at the Federal level relates largely to military considerations, such as missile guidance and satellite surveillance systems, and to consideration of intercontinental navigation of both commercial and military aircraft and ocean vessels. While these may be important considerations at the national level, they have no bearing on local area mapping.

Certain arguments advanced in support of the conversion to the NAD-83(91) either have explicitly stated, or have implied, that the use of NAD-83(91) will in some way result in the preparation of "more accurate" maps. This assertion is patently absurd. Map accuracy is determined by the specifications to which maps are prepared and by such factors as the scale of the map data compiled and of the map reproduction. Such factors are independent of the coordinate system utilized in the map production.

The quality of spatial information stored in a geographical information system is similarly determined specifically by the precision of the physical measurements added to the database. Deficiencies of any applied computational model or the datum to which the data are attached can result in the reduced spatial accuracy of defined points, but the act of expressing results in or attaching spatial measurements to a newer datum does not, in itself, endue the results with increased accuracy or integrity.

Unless and until the quality of spatial data—both horizontal and vertical—in the existing Commission database is determined to be deficient for the purposes for which it was established—for topographic mapping, cadastral survey control and mapping, and the development of public works infrastructure—the fact that more precise spatial data can now be collected and the fact that newer datums have been defined do not constitute compelling reasons to abandon use of the North American Datum of 1927 in favor of the

SHIFTS IN LATITUDE FROM NORTH AMERICAN DATUM OF 1927 TO NORTH AMERICAN DATUM OF 1983(91) IN THE REGION

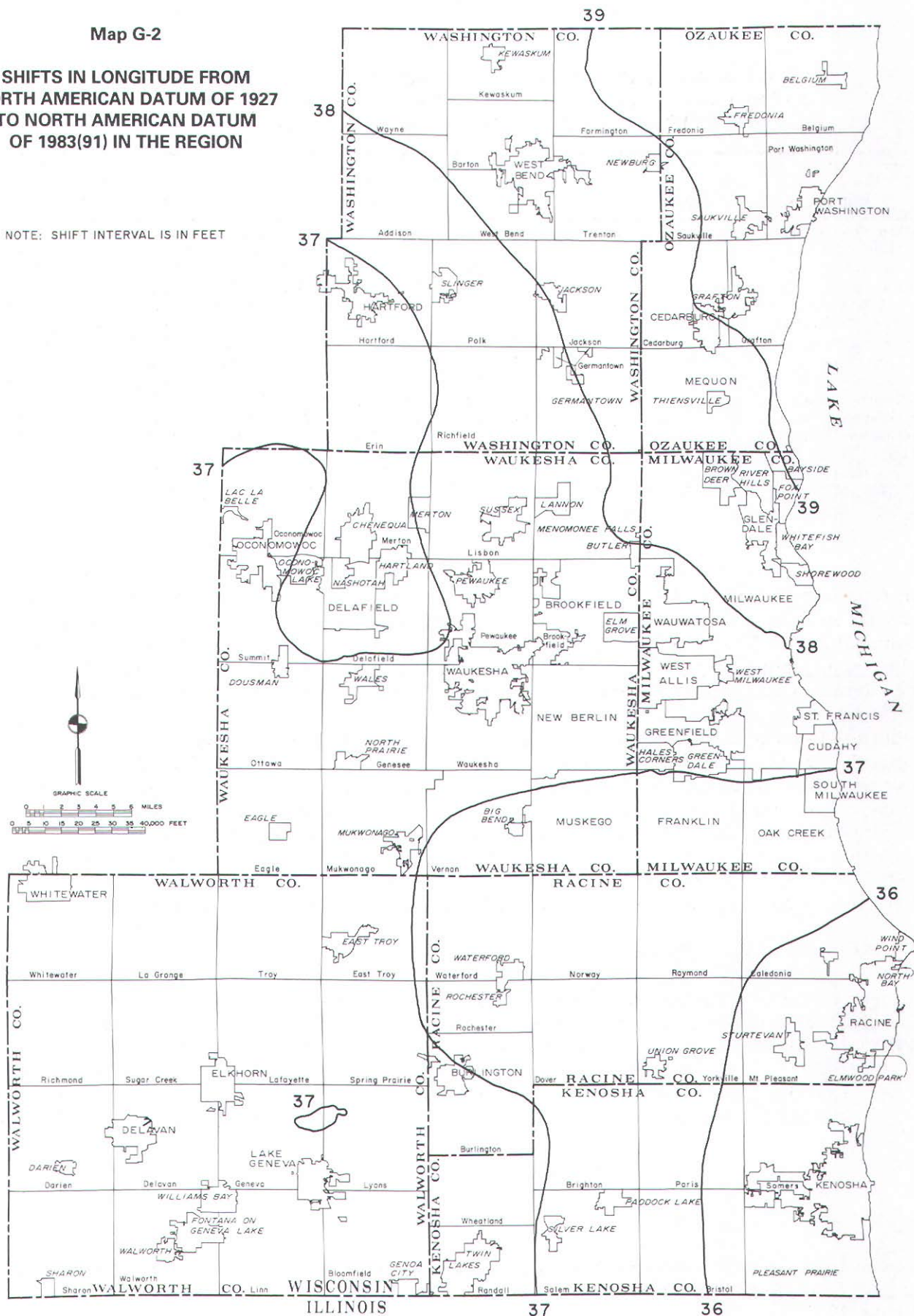


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Map G-2

**SHIFTS IN LONGITUDE FROM
NORTH AMERICAN DATUM OF 1927
TO NORTH AMERICAN DATUM
OF 1983(91) IN THE REGION**

NOTE: SHIFT INTERVAL IS IN FEET



Source: Earl F. Burkholder and SEWRPC.

Table G-1

**DATA COMPARING DISTANCES DERIVED FROM GLOBAL POSITIONING TECHNOLOGY,
NORTH AMERICAN DATUM OF 1927 STATION POSITIONS, AND NORTH AMERICAN DATUM
OF 1983(91) 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	1:1,979,600

Source: Wisconsin Department of Transportation and SEWRPC.

North American Datum of 1983 or 1983(91). The mathematical relationship between the two horizontal datums has been determined and documented by the Southeastern Wisconsin Regional Planning Commission in Technical Report No. 34, A Mathematical Relationship Between NAD-27 and NAD-83(91) State Plane Coordinates in Southeastern Wisconsin, December 1994, and users who wish to share compatible horizontal location data may do so efficiently and reliably using the procedures documented in this report.

It should also be noted that the issue of replacing the NAD-27 with the NAD-83—and therefore, presumably, NAD-83(91)—in the State of Wisconsin was examined in the period 1985 to 1987 by the Wisconsin Land Records Committee as part of its examination of issues affecting land records modernization in the State.² Following considerable discussion, that Committee made no recommendation on this issue, instead reporting that the question of conversion was technically complex and potentially costly, and that a decision to convert should be preceded by a careful and complete study of the costs of conversion and a careful and thoughtful evaluation of whether or not such a conversion was warranted. To date, the type of systematic study of this issue recommended by the Wisconsin Land Records Committee has yet to be undertaken.

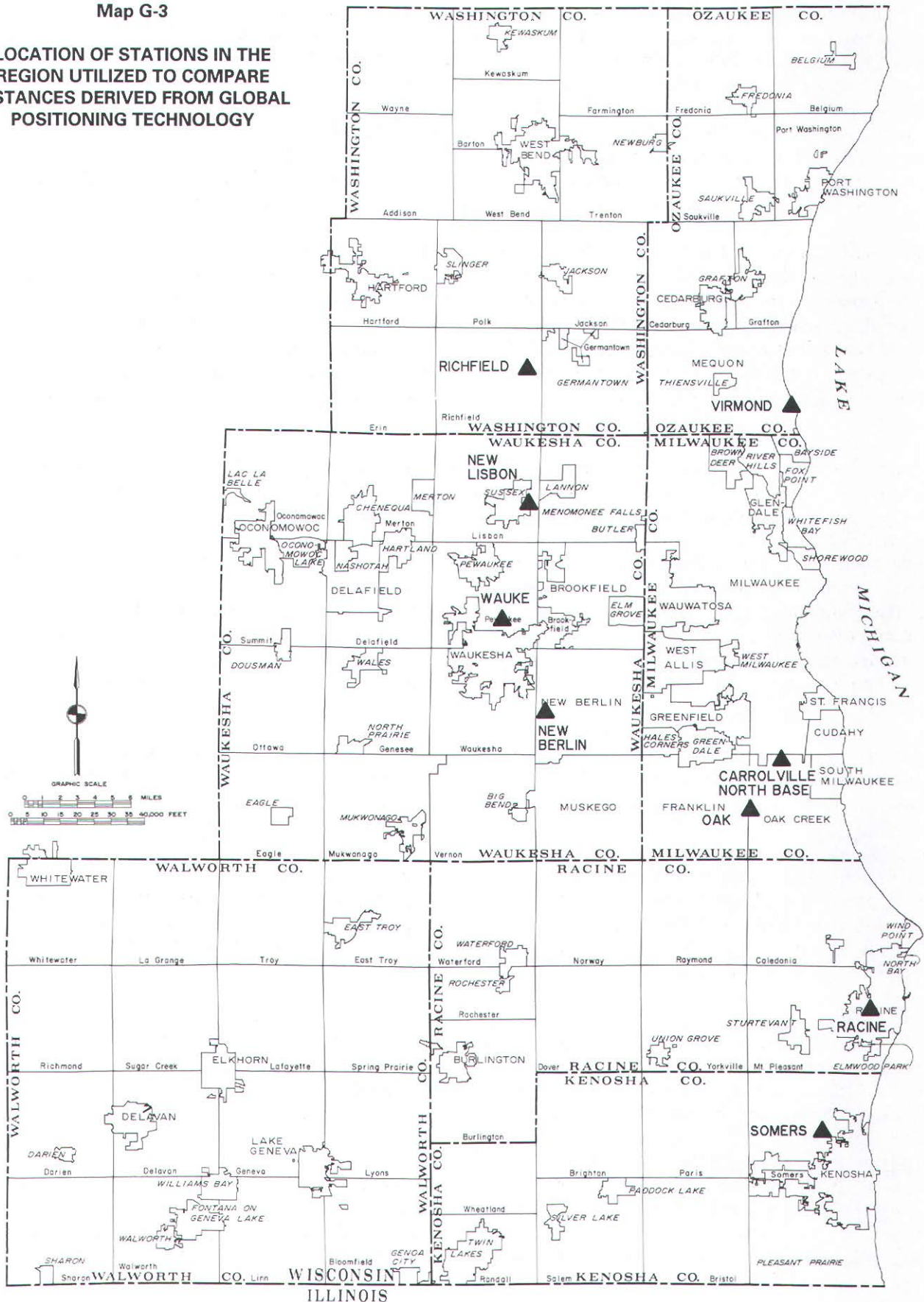
VERTICAL GEODETIC DATUMS

The Federal government has also undertaken an adjustment of the National Geodetic Vertical Datum of 1929 (NGVD-29). The application of the new vertical datum known as the North American Vertical Datum of 1988 (NAVD-88) has the affect of changing the elevations of literally thousands of benchmarks within the Region and has far reaching implications for certain regulatory programs, such as floodplain zoning, which are based upon established flood profiles along hundreds of miles of streams and water courses and lakeshore lines, as well as for the planning, design, construction, operation, and maintenance of public works facilities of all

²Wisconsin Land Records Committee, *Final Report of the Wisconsin Land Records Committee, Modernizing Wisconsin's Land Records*, University of Wisconsin-Madison, Center for Land Information Studies, Madison, Wisconsin, 1987.

Map G-3

**LOCATION OF STATIONS IN THE
REGION UTILIZED TO COMPARE
DISTANCES DERIVED FROM GLOBAL
POSITIONING TECHNOLOGY**



Source: Wisconsin Department of Transportation and SEWRPC.

kinds. The potential chaotic affect of this readjustment is as great as that entailed in the readjustment of the horizontal reference system. As in that latter readjustment, great costs will be entailed in a conversion having no known offsetting benefits for land surveying and ordinary municipal public works engineering purposes. As is the case with respect to the horizontal datum, the Commission, and county and local units of government, State and Federal Agencies, utility companies, and land surveyors and consulting engineers have developed extensive files, records, maps, and data bases, all having elevations referenced to the National Geodetic Vertical Datum of 1929. Changing the reference elevations for those maps and records would be an even more onerous and costly a task than that involved in changing the records with respect to the horizontal datum used. Those costs cannot be justified on the basis of any known benefits within the Region.

The differences between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988 within the seven-county Southeastern Wisconsin Region range from about 0.1 to about 0.4 foot. For some uses these differences are small enough to have no significant impact, but in other cases, such as establishing grades for gravity sewer line construction, or for the regulation of development in flood hazard areas where the Wisconsin Administrative Code requires flooding easements to be acquired if the proposed modification of a bridge or culvert, or of a stream channel, results in an upstream or downstream increase in flood elevation of 0.01 foot or more—the confusion of elevations between these two datums could have severe consequences.

There are two other areawide vertical datums in use within the Region so that, in effect, in addition to a number of local datums, four areawide datums are in use. An understanding of these datums and of their interrelationship is important to land surveyors and engineers working within the Region.

A vertical datum may be defined as a fundamental elevation to which other elevations are referenced. The most basic such fundamental elevation in use within the United States is an equipotential surface called the geoid. The geoid, as already noted, may be thought of as approximating mean sea level. The geoid may also be further described as an imaginary frictionless surface along which a unit mass can move without expenditure of work; implying that the vertical distances between successive positions of a moving mass center do not change. Since work is defined as a force acting through a distance, an equipotential surface is a level surface.

Geodetic leveling has been conducted throughout the United States by the Federal government with the leveling results reported as elevations with respect to mean sea level, or in some cases other defined datums. As already noted, four such datums are relevant within Southeastern Wisconsin.

Mean Sea Level Datum of 1929

The Mean Sea Level Datum of 1929 was based upon computation and adjustment of over 65,000 miles of differential spirit leveling loops in the United States and Canada connected to 26 tide gauging stations. This datum was originally called the “Sea Level Datum of 1929” because it was based upon mean sea level as determined by a history of tide gauge readings prior to the 1929 adjustment. The elevations were, therefore, considered to be orthometric heights.

National Geodetic Vertical Datum of 1929

The National Geodetic Vertical Datum of 1929 is, except for the name, identical to the Mean Sea Level Datum of 1929. To eliminate confusion because by the implication that “zero elevation” on an ocean beach could be used to determine coastal boundary lines and offshore jurisdictional limits, the name was changed in 1973 to eliminate the words “sea level” from the title.

International Great Lakes Datum of 1955

Due to the fact that level surfaces are not parallel, the orthometric elevation—the distance above the geoid—of the southern end of Lake Michigan is higher than the elevation of the northern end by nearly 0.25 foot when, in fact, the hydraulic gradient is zero. In order to accommodate the apparent discrepancy, a more specific definition of the water surface is given in terms of geopotential numbers which reflect the unchanging

work potential of the level surface and dynamic heights which can be used to compute correct hydraulic gradients throughout the Great Lakes system. The International Great Lakes Datum of 1955 (IGLD-55) was developed as a joint effort between the United States and Canada to provide a means for the more accurate measurement of geopotential hydraulic head between points on the shorelines of the Great Lakes.

International Great Lakes Datum of 1985

Due to melting and retreat of the glaciers from the upper Mid-west and the Hudson Bay area in Canada, the earth continues to “rebound” with removal of that load from the earth’s crust. This means elevations will change with time throughout the region affected as will the hydraulic characteristics of the Great Lakes system. Therefore, it was expected that the International Great Lakes Datum would have to be revised every 25 to 35 years. Elevations based upon more recent data, modern surveying technology and refined adjustment techniques have been published as a new datum, the International Great Lakes Datum of 1985.

North American Vertical Datum of 1988

Concurrent with the revision of the International Great Lakes Datum, the National Geodetic Survey initiated a project in October 1977 to readjust the vertical survey control network throughout North America. The new datum was to be known as the North American Vertical Datum of 1988 (NAVD-88). The leveling adjustment projects overlapped and shared data and features such that the geopotential numbers published for the North American Vertical Datum of 1988 and the International great Lakes Datum of 1985 are identical. Both datums are based upon the same primary tidal bench mark located at Father Point-Rimouski, Quebec, Canada. Data on the North American Datum of 1988 were published in 1991.

Notwithstanding activities at the Federal level with regard to vertical datums, the Commission has consistently recommended and used the National Geodetic Vertical Datum of 1929 (NGVD-29)—formerly known as the Mean Sea Level Datum of 1929—as the basis of elevations throughout the seven-county Region. The mathematical relationship between two of the four areawide vertical datums in use within Southeastern Wisconsin—NGVD-29 and NAVD-88—has been determined and documented by the Southeastern Wisconsin Regional Planning Commission in Technical Report No. 35, Vertical Datum Differences in Southeastern Wisconsin, December 1995, and users who may wish to share compatible vertical location data may do so efficiently and reliably using the procedures documented in this report.

As described in Chapter IV of this report, there are other “local” vertical datums in use within the Region. Differences between the local vertical datums and the NGVD-29 are documented in Chapter IV for the benefit of affected users. With publication of the North American Vertical Datum of 1988 by the National Geodetic Survey, yet another vertical datum relationship needed to be defined and documented for affected users of vertical data within the Region.

COMMISSION PROVISIONS FOR TRANSFORMATION OF SURVEY DATA

As already noted, recognizing the value of existing spatial information and acknowledging the need to share compatible data, the Commission has supported development of bi-directional procedures whereby State Plane Coordinates can be reliably transformed between the North American Datum of 1927 (NAD-27) and North American Datum of 1983(91) (NAD-83(91)) and whereby elevations can be reliably transformed between the National Geodetic Vertical Datum of 1929 (NGVD-29) and North American Vertical Datum of 1988 (NAVD-88). In each case, the transformations are not mathematically exact, but represent carefully tested and proven procedures whereby the conversions may be performed at a documented level of accuracy. The State Plane Coordinate transformation procedures are documented in the aforereferenced SEWRPC Technical Report No. 34 and the elevation transformation procedures are documented in the aforereferenced SEWRPC Technical Report No. 35. Following is a summary of the transformation procedures contained in each report.

Horizontal: The procedure for transforming NAD-27 coordinates to NAD-83(91) values or NAD-83(91) coordinates to NAD-27 values consists of applying a set of four transformation parameters unique to a given

Table G-2

TRANSFORMATION PARAMETERS FOR THE SOUTHEASTERN WISCONSIN REGION

County (Area)	Northing Translation	Easting Translation	Scale: Unit Conversion ^a	Rotation: Seconds
Ozaukee (Entire)	-0.590 m	-9,598.068 m	0.304795128718	-1.518645
Washington (North half)	-5.260 m	-9,600.871 m	0.304796556791	-2.553476
Washington (South half)	1.808 m	-9,596.422 m	0.304794291549	-0.949075
Milwaukee (North half)	-8.214 m	-9,598.934 m	0.304795950476	-3.492291
Milwaukee (South half)	-9.331 m	-9,609.516 m	0.304800108763	-3.403161
Waukesha (NE quarter)	-2.559 m	-9,600.196 m	0.304796052668	-1.942071
Waukesha (SE quarter)	-4.546 m	-9,605.690 m	0.304798339692	-2.267438
Waukesha (SW quarter)	-6.047 m	-9,609.556 m	0.304799930427	-2.497101
Waukesha (NW quarter)	-3.659 m	-9,602.463 m	0.304796992107	-2.123928
Walworth (North half)	-4.811 m	-9,614.744 m	0.304801819276	-2.017859
Walworth (South half)	-3.858 m	-9,612.638 m	0.304800856344	-1.820220
Racine (West half)	-0.913 m	-9,616.239 m	0.304802270072	-0.960376
Racine (East half)	-4.291 m	-9,620.262 m	0.304804050643	-1.762366
Kenosha (Entire)	-2.316 m	-9,625.585 m	0.304806024072	-1.112379

^a This value was found in the "best fit" computation and very nearly equals meters per foot. It is not an exact unit conversion and is to be used only as one of the transformation parameters in the specified area.

Source: Earl F. Burkholder and SEWRPC.

county, or portion thereof, to the coordinates to be converted. The same parameters are used in each case, whether converting from NAD-27 to NAD-83(91), or from NAD-83(91) to NAD-27. The following transformation parameters for the various areas are listed in Table G-2.

- N(t) = Northing translation, meters
- E(t) = Easting translation, meters
- O = Rotation angle from NAD-27 to NAD-83(91)
(Positive rotation is counterclockwise)
- S = Scalar (feet to meters)

The following conventions were followed in development of the transformation equations:

X/Y = NAD-27 State Plane Coordinates in U. S. Survey Foot units.
 N/E = NAD-83(91) State Plane Coordinates in meters.

If, after converting NAD-27 coordinates to NAD-83(91) values, a user desires NAD-83(91) values in foot units, the applicable unit conversion is 12 meters equals 39.37 U. S. Survey Feet exactly.

Equations (1) and (2) are to be used with existing NAD-27 coordinates (XY values in U. S. Survey Foot units) to determine NAD-83(91) N/E values in meters.

$$N = -X(S) \sin O + Y(S) \cos O + N(t)(1)$$

$$E = X(S) \sin O + Y(S) \cos O + E(t)(2)$$

Equations (3) and (4) are to be used with existing NAD-83(91) coordinates (N/E values in meters) to determine NAD-27 values in U. S. Survey Foot units.

$$X = \frac{(E - E(t)) \cos O - (N - N(t)) \sin O}{S} \quad (3)$$

$$Y = \frac{(E - E(t)) \sin O + (N - N(t)) \cos O}{S} \quad (4)$$

With respect to these transformation equations, it should be noted:

- Cosine values for small angles change slowly. Therefore, the rotation angle is given to six decimal places of seconds to preserve computational integrity.
- In equations (3) and (4) the last step is to divide a large number by S, the scaler. In order to obtain 10 significant digits in the answer, the value of S must have at least that many significant digits. The value of S is given to 12 digits.
- The scaler S is very nearly meters per foot and was uniquely determined in a best fit computation for each specific area. Therefore, in equations (1) to (4), the value of S—not the standard conversion—should be used and used only in each given area.

Vertical: The procedure for transforming elevations from the NGVD-29 to NAVD-88 and vice versa depends upon the intended accuracy of the result. Understandably, it is not possible to improve the accuracy of an elevation being transformed but, depending on the accuracy to be achieved and the accuracy of the elevation to be converted, the following options are recommended:

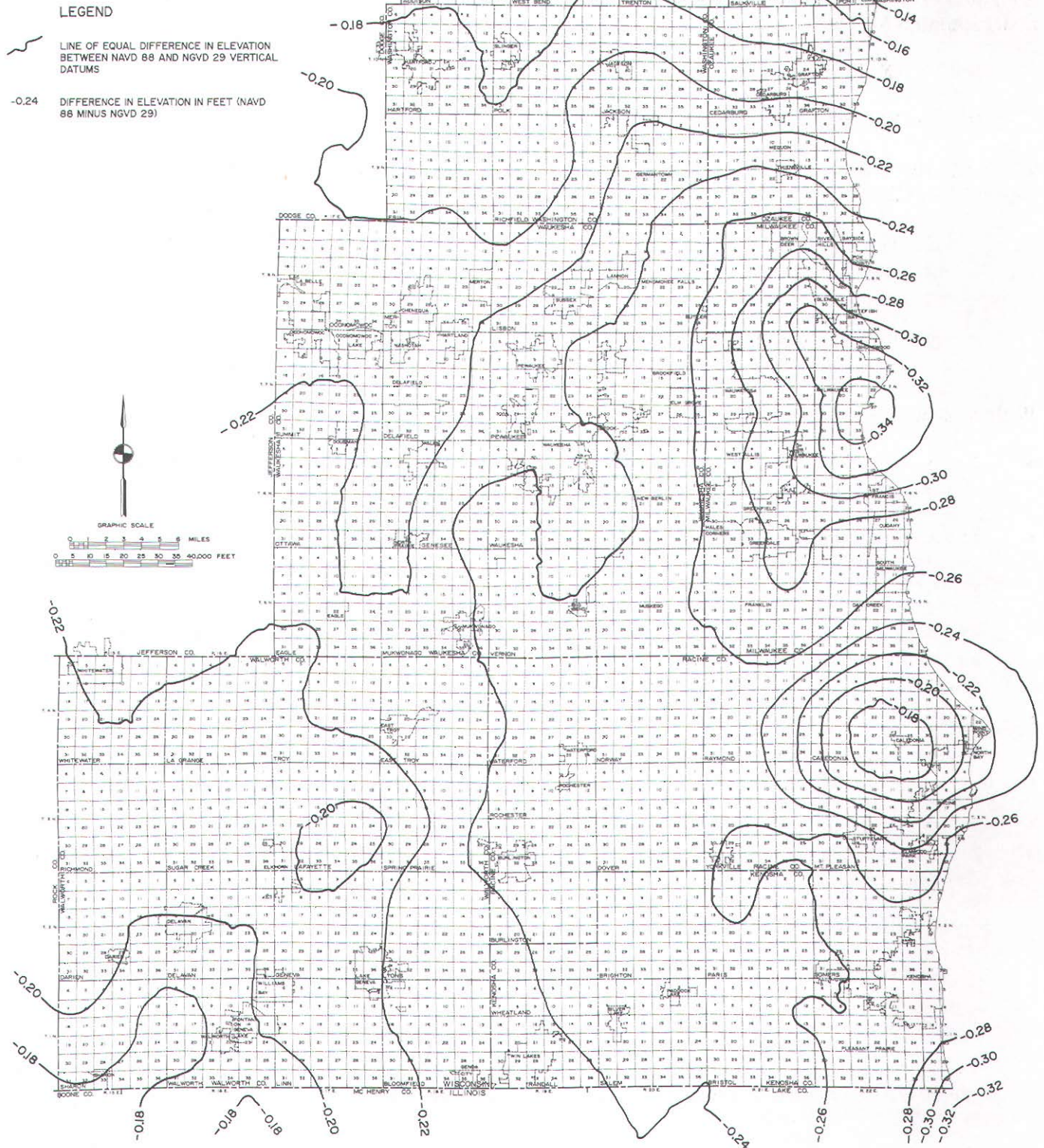
- Third-order elevations can be converted using datum difference values interpolated from the Iso-Hypsometric Map (G-4) of the seven-county Southeastern Wisconsin Region. The values shown on the map are all negative which means the NAVD-88 elevations are all lower than the NGVD-29 elevations. Specifically,

NAVD-88 elev. = NGVD-29 elev. minus the absolute iso line value shown on Map G-4

NGVD-29 elev. = NAVD-88 elev. plus the absolute iso line value shown on Map G-4

- Second-Order elevations can be converted from one datum to the other using the program VERTCON (Version 2.0 or higher) available from the National Geodetic Survey, Silver Spring, Maryland. Second-

ISO-HYPSOMETRIC MAP OF VERTCON 2.0 PREDICTIONS FOR SOUTHEASTERN WISCONSIN



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Order Class II accuracy is generally achieved using VERTCON as a stand-alone procedure. However, if Second-Order Class II accuracy is needed, the user is expected to perform test comparisons on existing common datum bench marks in the general area of the bench marks being transformed to document the quality of results actually achieved.

- No provision is made for converting First-Order elevations from one datum to another. If first-order elevations on a different datum are needed, the user is expected to attach observed first-order elevation differences (from one point to another) to a known first-order elevation published on the target datum.

CONCLUSIONS

1. The control survey system consistently recommended by the Commission over the past 30 years is still valid, functional, and appropriate for use within the Region into the foreseeable future. Survey data within existing data bases can be converted to newer datums by anyone desiring to do so using the procedures identified by the Commission.
2. Use of newer datums, either the North American Datum of 1983(91) or the North American Vertical Datum of 1988, will not improve the quality or accuracy of survey data within the existing data base. The accuracy of spatial data is determined by the application and enforcement of appropriate standards and specifications governing the conduct of surveying operations and to the mathematical manipulation of the resulting measurements.

In this respect, available comparisons of distances derived by the latest positioning technology—global positioning system observations—and distances derived from the positions of control survey stations on the North American Datum of 1927 and of those same stations on the North American Datum of 1983(91) within the Region indicate that the differences between the datums have no practical significance with respect to the conduct of land and ordinary engineering surveying. Those comparisons, moreover, indicate that the distances derived from the positions of stations on the North American Datum of 1927 and such distances derived from global positioning system observations are all well within the level of accuracy and precision intended to be provided by the Commission-recommended horizontal control survey network.

3. The use of the North American Datum of 1983(91) and the North American Vertical Datum of 1988 will not provide more accurate or precise large-scale topographic or cadastral maps within Southeastern Wisconsin. The accuracy and precision of such maps are determined by the specifications governing the preparation of the maps and by the scale of the maps.
4. The horizontal shifts in latitude and longitude between the position of stations on the North American Datum of 1983(91) and on the North American Datum of 1927 (NAD-27) within the Region approximate 11 feet in latitude and 40 feet in longitude, shifts which clearly cannot be ignored for control for control survey purposes, for topographic and cadastral mapping purposes, or for the creation of geographic information systems or parcel-based land information systems. There is no accurate and precise method for mathematically converting horizontal positions on the North American Datum of 1927 to the North American Datum of 1983(91) short of either resurveying or reprocessing the original survey data. Methods for converting positions between the two datums must depend upon comparative modeling.
5. There is also no accurate and precise method for mathematically converting elevations on the National Geodetic Vertical Datum of 1929 to the North American Vertical Datum of 1988 short of either resurveying or reprocessing the original survey data. Because the two datums are not parallel, methods for converting positions between the two datums must also depend upon comparative modeling. The shift in elevation between benchmarks on the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988 within the Region ranges from about 0.1 to about 0.4 foot. These shifts in the vertical datums within the Region may be

considered inconsequential for some applications. The ongoing danger is that the data shifts may be ignored or misapplied in critical applications, such as the provision of grade for the construction of large sanitary sewers or the interpretation of flood stages for flood hazard area regulation.

6. The Commission has established relationships between the horizontal and vertical datums in use within the Region, and has published recommended procedures for converting data from one datum to the other with sufficient accuracy to maintain the integrity of the control survey systems concerned. Therefore, there is no need to re-compile existing topographic or cadastral maps, to recompute hydraulic flood flow profiles, or to resurvey the U. S. Public Land Survey section and quarter-section corners to establish their coordinates and elevations. Existing survey and spatial data can readily be reliably converted on an "as needed" basis by the various users concerned.
7. With additional data options available and with differing datums being used within the Region, it will become increasingly important with time that each spatial data set or spatial data product be clearly identified as to which datum was used in its definition.
8. The survey system recommended by the Commission is technically compatible and logically positioned to support implementation of an integrated digital parcel-based land information system within the Region.

Because the user communities concerned deal, in effect, with coordinate differences rather than absolute coordinates, there are no known benefits to be realized by the local users of the control survey data, nor no known benefits to be obtained through the preparation and use of topographic and cadastral maps based upon such data by conversion of the existing data to either the North American Datum of 1983(91) or the North American Vertical Datum of 1988. Indeed, the use of a difference datum imposes an additional burden on those who need to share and use compatible spatial data. To quote a publication of the U. S. Coast and Geodetic Survey—the predecessor agency to the National Geodetic Survey:

"Expediency weighs heavily against any change from the Clarke ellipsoid now in official use for the whole of North America on account of the immense amount of labor in transforming the very large number of geographic positions already determined on the Clarke ellipsoid and the confusion that would arise from the simultaneous use of two sets of geographic coordinates on two different ellipsoids."³

³U. S. Department of Commerce, *Formulas and Tables for the Computation of Geodetic Positions*, Seventh Edition, 1952.